Report of the Committee on Electrical Equipment of Industrial Machinery

Michael I. Callanan, Chair
National Joint Apprentice & Training Committee, MD [L]
Rep. International Brotherhood of Electrical Workers

John F. Bloodgood, JBF Enterprises, WI [SE]
Dick Bromstad, Commonwealth Electric of Minnesota, MN [IM]
Rep. National Electrical Contractors Association
Frank C. DeFelice, Jr., Cytec Industries, Inc., CT [U]
Paul Dobrowsky, Eastman Kodak Company, NY [U]
Drake A. Drobnick, Vistec Corporation, MI [U]
Craig J. Fabbo, Speedline Technologies, Inc., MA [M]
Bruce Faust, Earth Tech Microelectronics, CA [RT]
Rep. National Electrical Manufacturers Association
John Freudenberg, Teradyne, MA [M]
Glyn R. Garside, TUV Rheinland of North America, Inc., IL [RT]

Thomas J. Garvey, State of Wisconsin, WI [E]
Rep. International Association of Electrical Inspectors
John Knecht, Intertek Testing Services, NA Inc., IL [RT]
Robert E. Lichtner, Underwriters Laboratories Inc., IL [RT]
Gary J. Locke, Lockheed Martin Systems Integration, NY [U]
Robert C. Monteith, Milacron Inc., OH [M]
Rep. Society of the Plastics Industry Inc.
Larry D. Munson, Universal Instruments Corporation, NY [M]
Doug Norman, Electro-Test, Inc., Kobe [RT]
Carl E. Padgett, Jr., Milford, OH [M]
Rep. The Association for Manufacturing Technology
Thomas Pilz, Pilz Automation Safety L.P., MI [M]
Daniel L. Roberson, Delphi-Delco Automotive System, IN [U]
Marvin A. Salzenstein, Polytechnic Inc., FL [SE]
Melvin K. Sanders, Things Electrical Co., Inc. dba (TECo., Inc), IA [U]

Lynn F. Saunders, GM Worldwide Facilities Group, MI [U]
Wayman L. Withrow, Cincinnati Inc., OH [M]

Alternates

James C. Carroll, Square D Company, TN [M]
(Alt. to D. S. Fisher)
Pat Hodge, Canton, MI [U]
(Alt. to D. A. Drobnick)
Thomas J. Kiihr, Jr., Delphi Automotive Systems, MI [U]
(Alt. to D. L. Roberson)
Loren Mills, Van Dorn Demag Corporation, OH [M]
(Alt. to R. C. Monteith)
Jim F. Pierce, Intertek Testing Services NA Inc., OR [RT]
(Alt. to J. Knecht)

Warren Stanford, General Motors Corporation, MI [U]
(Alt. to L. F. Saunders)
Paul R. Warndorf, AMT-The Association For Manufacturing Technology, VA [M]
(Alt. to C. E. Padgett)
Marvin J. Winrich, Underwriters Laboratories Inc., NY [RT]
(Alt. to R. E. Lichtner)

Staff Liaison: Joseph V. Sheehan

Committee Scope: This Committee shall have primary responsibility for documents intended to minimize the potential hazard of electric shock and electrical fire hazards of industrial metalworking machine tools, woodworking machinery, plastics machinery and mass production equipment, not portable by hand. Reports to the Association through the Technical Correlating Committee of the National Electrical Code Committee.

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the front of this book.

The Report of the Technical Committee on Electrical Equipment of Industrial Machinery is presented for adoption.


This Report has been submitted to letter ballot of the Technical Committee on Electrical Equipment of Industrial Machinery, which consists of 26 voting members. The results of the balloting, after circulation of any negative votes, can be found in the report.

This Report has been submitted to letter ballot of the National Electrical Code Technical Correlating Committee which consists of 11 voting members, of whom all 11 voted affirmatively.
79-1 - (Entire Document): Accept
SUBMITTER: Technical Committee on Electrical Equipment of Industrial Machinery
RECOMMENDATION: Globally replace the term “safety related function” with “safety function” throughout the entire document.
SUBSTANTIATION: Utilize a defined term as it appears in Clause 5.
COMMITTEE ACTION: Accept.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman
COMMENT ON AFFIRMATIVE:
FREUDENBERG: Seems editorial in nature. Need to verify each usage before final determination.

79-2 - (Entire Document): Accept in Principle
SUBMITTER: Heinrich Moedden, German Machine Tool Builders Association (VDW)
RECOMMENDATION: Revise text as follows:
In all clauses the International SI Units based on [m] meter, [sec] second, [kg] kilogram shall be used.
SUBSTANTIATION: SI Units are International Standards.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: SI units will appear in the published document according to the NFPA Manual of Style. See Committee Proposal 79-5 (Log #CP2), which deals with the NFPA Manual of Style.
NUMER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman
COMMENT ON AFFIRMATIVE:
FREUDENBERG: See support of the style manual as long as both SI and English units are shown.

79-3 - (Entire Document): Reject
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Divide NFPA-79 into two - a general purpose industrial machine tool section, and a specific section to apply to the machine tools identified by ANSI B11 series of Standards.
SUBSTANTIATION: The standard has become very general in nature to cover all varieties of industrial machinery, from traditional manufacturing shops to “electronic component clean rooms.” What is appropriate for one “industrial manufacturing climate” is not suitable for the other.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The proposal does not comply with the Regulations Governing Committee projects, Section 4.3.3(c) since the submitter has not provided the specific recommended text.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman
EXPLANATION OF NEGATIVE:
FREUDENBERG: NFPA 79 is a generic standard applicable across many different industries and NFPA rules have no classifications to ensure equal representation of each industry. NFPA needs a plan to action to either ensure equal committee representation or a plan of action to generate industry specific standards.

79-4 - (Entire Document): Accept
TCC NOTE: The TCC notes that the submitter’s recommendation is not practical to implement for a single document within an entire family of codes and standards. The TCC directs that the proposal be reported as “reject” and that the proposal be forwarded to the NFPA Standards Council for consideration as part of the NFPA Manual Style.

79-5 - (Entire Document): Accept
RECOMMENDATION: Identify definitions where used throughout the text of the standard. Defined words can be highlighted with capitals, bold font, underline, or any other manner acceptable to the NFPA Style manual.
SUBSTANTIATION: User of the document may be unaware of definitions when interpreting the requirements of each section, often misunderstanding the intended meaning of the section when defined words are used.
COMMITTEE ACTION: Accept.
COMMITTEE STATEMENT: The committee desires that the editorial staff of NFPA somehow identify (italics, bold, or any other method) each defined term in Clause 3 where it appears elsewhere in the body (or Annexes) of the document.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman
EXPLANATION OF NEGATIVE:
BLOODGOOD: Since there are 122 proposed definitions and each term is used an average of over 10 times this will result in a large number of “highlighted” terms which will either be ignored or cause confusion. In either case I do not feel that this is helpful to the user of the standard <2>
COMMENT ON AFFIRMATIVE:
ANDERSON: Words are defined in the document because the intended meaning is different than normal usage [e.g. Webster’s Collegiate Dictionary, 10th edition]. The defined word, a technical term, is used in this document in a special sense and, I suggest, would fall under one type of “Special Terminology” in The Chicago Manual of Style, 14th edition.
First type is for the word found in the definition chapter, this case would fall under “TECHNICAL TERMS IN SPECIAL SENSES” 6.74: “...In such instances the term is often enclosed in quotation marks.” Thus following the proposal, words whose definition is found in chapter 3 would be shown in quotations. Thus as an example the definition for “emergency switching off” is in 3.39 and if the present 9.2.5.4.1 would be revised to remove the second sentence, which duplicates 3.39, then 9.2.5.4.1 would read:
9.2.5.4.1 General. This standard specifies the requirements for the emergency stop and “emergency switching off” functions, each of which is, in this standard, initiated by a single human action. For other safety related stop functions see 11.3.4.
Second type is for words defined in the immediate text and would fall under “TECHNICAL TERMS” 6.72: “...A technical term, especially when accompanied by its definition, is often set in italics the first time is appears in a discussion, and in roman thereafter.” Thus as an example the definition for “emergency switching off” in the present 9.2.5.4.1 would read:
9.2.5.4.1 General. This standard specifies the requirements for the emergency stop and emergency switching off functions, each of which is, in this standard, initiated by a single human action. Emergency switching off is an emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved. For other safety related stop functions see 11.3.4.
DOBROWSKY: This is an excellent proposal. Other documents accomplish this by using italics. In this standard italics are primarily used for exceptions which are required to be complete sentences. Highlighting terms that are defined in this document does not create a conflict and will improve usability.
FREUDENBERG: A simple editorial process to somehow identify defined words is extremely useful to all users of the document, especially first time users who are unaware of defined words and its significant impact on the meaning of a given requirement.
4. All mandatory sections of the document must be evaluated for usability, adoptability, and enforceability language. Generate necessary committee proposals.
5. All units of measure in document are converted to SI units with inch/pound units in parentheses.
6. Appendices restructured and renamed as "Annexes."

See draft of NFPA 79 starting on page 1835.


COMMITTEE ACTION: Accept

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON FINAL AFFIRMATIVE:

FREUDENBERG: Support use of the style manual.

RECOMMENDATION: Retain current preface with minor editorial changes and new title (Introduction) as follows:
NFPA 79: 2002 Introduction (proposed)

<12> This edition of NFPA 79, Electrical Standard for Industrial Machinery, was prepared by the Technical Committee on Electrical Equipment of Industrial Machinery and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 16-18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994, and supersedes all previous editions.

<13> The 1992 edition of this document has been approved by the American National Standards Institute.

<14> Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 79


<16> In September 1941, the metalworking machine tool industry wrote its first electrical standard to make machine tools safer to operate, more productive, less costly to maintain, and to improve the quality and performance of their electrical components. That particular standard served as an American "War Standard."

<17> To study the special electrical problems involved with machine tools, in 1941 the Electrical Division of the National Fire Protection Association sanctioned a Special Subcommittee on Wiring, Overcurrent Protection, and Control of Motor-Operated Machine Tools. This Subcommittee, cooperating with machine tool builders, manufacturers of control equipment, and Underwriters Laboratories Inc., conducted tests and investigated the peculiar conditions involved with machine tools that might warrant exception to certain specific National Electrical Code requirements. This investigation resulted, on August 4, 1942, in a Tentative Interim Amendment and first appeared in a 1943 supplement to the 1940 edition of the National Electrical Code as Article 670, "Machine Tools." It remained essentially unchanged through the 1959 edition.

<18> Meanwhile, manufacturers of other types of industrial equipment erroneously began to follow the specialized practices permitted by Article 670. Late in 1952, a Technical Subcommittee on Fundamentals of Electrically Operated Production Machinery and Material Handling and Processing Equipment for Fixed Locations was organized to attempt to group the special requirements of this broad field into one article. The extremely broad scope introduced so many problems that, in December 1956, this Technical Subcommittee was reorganized into an NFPA Committee whose scope was limited to machine tools and whose objective was the preparation of this NFPA standard with corresponding revisions in Article 670 in the National Electrical Code.

<19> Modern machine tool electrical equipment may vary from that of single-motor machines, such as drill presses, that perform simple, repetitive operations, to that of very large, multimotor automatic machines that involve highly complex electrical control systems, including electronic and solid-state devices and equipment. Generally these machines are especially designed, factory-wired, and tested by the builder and then erected in the plant in which they will be used. Because of their importance to plant production and their usually high cost, they are customarily provided with many safeguards and other devices not often incorporated in the usual motor and control application as contemplated by the National Electrical Code.

<20> Although these machines may be completely automatic, they are constantly attended when operating, by highly skilled operators. The machine usually incorporates many special devices to protect the operator, protect the machine and building against fires of electrical origin, protect the machine and work in process against damage due to electrical failures, to provide against loss of production due to failure of a machine component. To provide these safeguards, it may be preferable to deliberately sacrifice a motor or some other component, rather than to chance injury to the operator, the work, or the machine. It is because of such considerations that this standard varies from the basic concepts of motor protection as contained in the National Electrical Code.

<21> As NFPA 79 evolved, it became apparent that certain classes of light industrial machinery (e.g., small drill presses, bench grinders, sanders) were not appropriately covered. The 1977 edition of the standard recognized this problem and purposely excluded tools powered by two horsepower or less. The 1977 edition also included many additional references to international standards. The 1981 edition of NFPA 79 reflects this activity, and appropriate requirements are now included in the standard.

<22> In 1975, the Society of the Plastics Industry requested that this standard be enlarged in scope to include plastics machinery. A formal request was made to NFPA in 1976, and the NFPA Standards Council approved the request subject to comments and appropriate requirements are now included in the 1981 edition.

<23> In June 1978, the Joint Industrial Council (JIC) Board of Directors acknowledged the dated state of the electrical and electronic standards and requested that NFPA 79 incorporate into its standard the material and topics covered by the JIC electrical (EMP-1-67, EGP-1-67) and electronic (EMP-2-67) standards with the intention that the JIC standards eventually would be declared superseded. The NFPA Standards Council approved the request with the stipulation that the material and topics incorporated from the JIC standards be limited to areas related to electrical shock and fire hazards. The 1985 edition reflected the incorporation of the appropriate material from the JIC electrical (EMP-1-67, EGP-1-67) standards not previously covered. The 1991 edition includes additional references to international standards.

<24> The 1991 edition was reorganized to align with the ANSI style manual which included the moving the terms and definitions to clause 3 thus making them part of the normative text.

<25> The 2002 revision was significantly modified so that the NFPA 79 standard now complies with the International standard IEC 60204-1. These modifications are based largely on the work done by the SAE/IS 1738 Committee.

To better coordinate its work, this Committee reports to the Association through the Correlating Committee of the National Electrical Code Committee. The primary reason is to correlate this standard and the National Electrical Code, especially with respect to Article 670 thereof.

SUBSTANTIATION: Editorial New dates - to be filled in

COMMITTEE ACTION: Accept in Principle.

Editorially revise the last sentence of <15> to read as follows:
"The 1991, 1994 and 1997 editions include additional references to international standards and reflect the committee's efforts in harmonization."

COMMITTEE STATEMENT:

Editorial corrections were made to revise the last sentence. The committee understands that the contents of the published Preface is the sole function of NFPA staff and the final selection of text contained in the Preface is NOT a Committee function.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

FREUDENBERG: The Northeast Product Safety Society (NPSS) concept of harmonization is to facilitate shipment of one product worldwide without eliminating conflicts and reducing differences between NFPA79 and other standards.
Modifications to adopt automobile industry practices from SAE/HS 1738 is some cases supported harmonization and other cases prevented harmonization.

COMMITTEE STATEMENT: The new paragraph was inserted to provide guidance in the use of the document and provides clarity in use of terms throughout the standard. The committee understands that the contents of the published Forward is the sole function of NFPA staff and the selection of text contained in the Forward is NOT a committee function.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1

EXPLANATION OF NEGATIVE:
MONTEITH: Based on the extensive changes to this standard and the time it takes manufacturers to change their product designs, we believe the effective date of this standard should be two years from the date of issuance. This time period would allow manufacturers to be aware of the standard and to have time to comply with the standard.

The effective date is also common practice in many ANSI standards.

Note: Supporting material available for review upon request at NFPA headquarters.

COMMENT ON AFFIRMATIVE:
BLOODGOOD: I believe the word is 'Foreword' as in the preface or introduction to a book, story or document not 'Forward' which is as in to move in the desired direction (Motto of the State of Wisconsin). The penultimate paragraph was erroneously carried forward from a previous edition and should be deleted or modified. The list of annexes in the 3rd paragraph will have to be modified.

I strongly support the addition of the new second to the last sentence proposed by the Committee and prefer this to the modification (2 paragraph of Note) to Clause 3 (see Proposal 79-11 (Log #37)).

DOBROWSKY: (1) The first paragraph including the three bulleted items should be deleted.
(2) The term "Clause" should be replaced with the term "Chapter" to comply with the NFPA Manual of Style.
(3) The phrase "and requirements" (in the second sentence of the fourth paragraph) should be deleted because recommendations are not permitted in this standard.
(4) I'm not sure if the word "should" is appropriate in a "Foreword".
(5) The Committee desired to match the numbering format of IEC 60204-1 as much as possible. Adding a statement in the Foreword or elsewhere, describing the concept in 3.7.2.8 of the NFPA MOS, then inserting the dashes at the appropriate vacant cells would help maintain this concept.

FREUDENBERG: The explanation of USA terminology with IEC terminology in parenthesis adds clarity.

79-7 - (Foreword [Forward]): Accept in Principle
SUBMITTER: John F. Bloodgood, JFB Enterprises
RECOMMENDATION: Use foreword from current document with minor editorial revisions. Delete second paragraph of current text:

Foreword
This edition of NFPA 79 has been reformatted in accordance with the ANSI style manual (8th edition), which includes the use of the following terms:
- Clause for the term Chapter
- Subclause for the term Section
- Annex for the term Appendix.

The referenced standards previously found in chapter 19 are now found in Clause 2 - Normative references. The definitions (previously found in Appendix A) have been moved to Clause 3 - Definitions, making the terms and their definitions part of this standard. Figures and tables have been numbered consecutively starting with 1.

Annexes (appendices) A, B, C, D, E, F and G are provided for informational purposes and should not be considered as part of the requirements of this standard.

This standard is intended to apply to electrical equipment used with a wide variety of machines and a group of machines working together in a coordinated manner. Therefore, the requirements and recommendations in this standard may not be relevant in all cases.

The risks associated with the hazards relevant to the electrical equipment should be assessed as part of the overall requirements for risk assessment of the machine. This will determine the acceptable level of risk and necessary protective measures for personnel who can be exposed to these hazards while still maintaining an acceptable level of performance of the machine and its equipment.

Hazards can include but are not limited to the following:
- Failures or faults in the electrical equipment resulting in the possibility of electrical shock or electrical fire.
- Failures or faults in control circuits (or components and devices associated with these circuits) resulting in malfunctioning of the machine.
- Disturbances or disruptions in external power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine.
- Electrical interferences (e.g., electromagnetic, electrostatic, radio interference) either from outside the electrical equipment or internally generated.
- Stored energy (either electrical or mechanical).
- Audible noise at levels that cause health problems to personnel.

Safety measures are a combination of the measures incorporated at the design state and those measures required to be implemented by the user.

Design and development should be the first consideration in the reduction of risks. Where this is not possible, safeguarding should be considered. Safeguarding includes the use of safeguards, awareness means, and safe working procedures.

This edition of NFPA 79, Electrical Standard for Industrial Machinery, was prepared by the Technical Committee on Electrical Equipment of Industrial Machinery and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 16-18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of this standard has been approved by the American National Standards Institute.

SUBSTANTIATION: No longer required, was pertinent to 1997 edition.

COMMITTEE ACTION: Accept in Principle.

Accept the proposed text. In addition, insert this text as a new second to last sentence to read as follows:

Terms may have been provided, in parenthesis, for some terms to provide an equivalent or approximately equivalent term that is used in some other countries.
industrial manufacturing system is covered by NFPA 70, National Electrical Code. Exception: Wiring of component machines of an industrial manufacturing system that is supplied by the manufacturer and is an integral part of the system, is adequately protected and supported, and meets the requirements of this standard.

1.5 On any point for which specific provisions are not made in this standard (e.g., some requirements for the application of Design E motors) the provisions of NFPA 70, National Electrical Code, are to shall be observed.

NOTE: Motor design letter designations are found in ANSI/NEMA MG 1 and ANSI/IEEE 100.

1.6 The purpose of this electrical equipment. This standard is to provide detailed information for the application of electrical/electronic equipment, apparatus, or systems supplied as part of industrial machines that will promote safety to life and property.

1.7 This standard is not intended to limit or inhibit the advancement of the state of the art. Each type of machine has unique requirements that shall be accommodated to provide adequate safety.

SUBSTANTIATION: 1.1 Editorial - the word shall is not appropriate in the Scope. The Committee felt that the word 'point' is more appropriate than place.

1.2 Editorial the word shall is not appropriate in the Scope

1.5 editorial - the word 'shall' is not appropriate for the scope

1.6 Editorial

1.7 Editorial - the word 'shall' is not appropriate for the scope

COMMITTEE ACTION: Accept.

1. Editorial correct by adding the additional strikethrough in 1.1 of the word shall to read as "...The provisions of this standard shall apply..."

2. Editorial correct by adding the word "be" in 1.7 to read as "...to be accommodated..."

COMMITTEE STATEMENT: The corrections are only editorial.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24

NEGATIVE: 1

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

FREUDENBERG: Paragraph 1.2 does not adequately exclude all types of hazardous process material (HPM). Not all hazardous process material is considered a hazardous (classified) location for the risk of explosion. Need new "1.X This standard does not include the additional requirements for machines which use hazardous process materials (HPM)."

COMMENT ON AFFIRMATIVE:

DOBROWSKY: Section 1.5 should be revised as follows:

"If specific provisions are not covered by this Standard, see NFPA 70, National Electrical Code." or delete the parenthetical phrase. Reason: All of the information in the NEC does not need to be included in this Standard. Issues that are commonly encountered on machinery should be provided and the NEC should be referenced for the remaining requirements.

COMMITTEE STATEMENT:

The corrections are only editorial.

AFFIRMATIVE: 24

NEGATIVE: 1

NOT RETURNED: 1 Norman

EXPLANATION OF AFFIRMATIVE:

John F. Bloodgood, JFB Enterprises

RECOMMENDATION: Modify Clause 2 in accordance with references cited in the revised normative text.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements subject to this standard should apply the most recent editions of the normative documents listed below.


2.2 IEC 34-3: 1991, Rotating electrical machines - Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP codes).


2.5 EV 441: 1984, International Electrotechnical Vocabulary - Chapter 441: Switchgear, Control Gear, and Fuses

2.6 IEC 826: 1982, International Electrotechnical Vocabulary - Chapter 826: Electrical Installation of Buildings

2.7 IEC 73: 1991, Coding of indicating devices and actuators by colours and supplementary means.

2.8 IEC 60204-1: 1993, Safety of machinery - Electrotechnical aspects - Part 1: General requirements

2.9 IEC 60309-1: 1988, Plugs, socket-outlets, and couplers for industrial purposes - Part 1: General requirements

2.10 IEC 60947-1: 1979, Tests on electric cables under fire conditions, - Part 1: Test on a single vertical insulated wire or cable.

2.11 IEC 60417M: 1985, Graphical Symbols for Use on Equipment

2.12 IEC 60529: 1989, Degrees of protection provided by enclosures (IP Code).

2.13 IEC 60536: 1976, Classification of electrical and electronic equipment with regard to protection against electric shock.


2.15 IEC 60947-7-1: 1989, Low-voltage switchgear and controlgear - Part 7: Auxiliary equipment.
Chapter 441: Switchgear, Control Gear, and Fuses


2.2 ANSI/IEEE 100: 1992, Standard Dictionary of Electrical and Electronic Terms


2.0 Reference to this standard is found in the normative part of the document

COMMITTEE ACTION: Accept in Principle.

Modify Clause 2 in accordance with references cited in the revised normative text. Clause 2 to read as follows:

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements subject to this standard should apply the most recent editions of the normative documents listed below.


2.2 IEC 34-5: 1991, Rotating electrical machines - Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code).


2.4 IEV 191: 1990, International Electrotechnical Vocabulary - Chapter 191: Dependability and Quality Service

2.5 IEV 441: 1984, International Electrotechnical Vocabulary - Chapter 441: Switchgear, Control Gear, and Fuses

2.6 IEV 826: 1982, International Electrotechnical Vocabulary - Chapter 826: Electrical Installation of Buildings

2.7 IEC 73: 1991, Coding of indicating devices and actuators by colours and supplementary meanings.

2.8 IEC 60204-1: 1979, Safety of machinery - Electrotechnical aspects - Part 1: General requirements

2.9 IEC 60392-1: 1988, Plugs, socket-outlets, and couplers for industrial purposes - Part 1: General requirements.

2.10 IEC 60417: 1985, Graphical Symbols for Use on Equipment - Index, Survey, and Single Sheets

2.11 IEC 60529: 1989, Degrees of protection provided by enclosures (IP Code).

2.12 IEC 60536: 1976, Classification of electrical and electronic equipment with regard to protection against electric shock.


2.14 IEC 60947-7-1: 1989, Low-voltage switchgear and controlgear - Part 7: Ancillary equipment.

2.15 ISO 3864: 1984, Safety Colors and Safety Signs

2.16 ANSI/UL 1682: 1988, Plugs, socket-outlets, and cable connectors of the pin and sleeve type.


2.18 ANSI/NEMA FB 1-1988, Fittings, Cast Metal Boxes, and Electronics Diagrams

2.19 ANSI/IEEE 315-1989, Graphical Symbols for Electrical and Electronic Terms

2.20 Reference to this standard is found in the normative part of the document

2.21 IEEE 100: 1992, National Electrical Code

2.22 ANSI/NEMA FB 1-1988, Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies

2.23 ANSI/NEMA FB 1-1988, Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies


2.27 ASTM B 8-1986, Standard for Concentric Lay Stranded Copper Conductors Hard, Medium-Hard, or Soft

2.28 ASTM B 33-1981 (R 1985), Tinned Soft or Annealed Copper Wire for Electrical Purposes

2.29 ASTM B 174-1971 (R 1985), Specification for Bunch-Stranded Copper Conductors for Electrical Conductors

2.30 ASTM B 286-1989, Copper Conductors for Use in Hookup Wire for Electronic Equipment

NOTE: A list of standards that may provide additional information related to electrical equipment of industrial machines is found in annex A - Bibliography.

SUBSTANTIATION: Changes in the normative text have resulted in changes to the normative references.

2.1 Reference to this standard is found in the normative part of the document

2.2 Reference to this standard is found in the normative part of the document

2.3 Reference to this standard is found in the normative part of the document

2.4 Reference to this standard is found in the normative part of the document

2.5 Reference to this standard is found in the normative part of the document

2.6 Reference to this standard is found in the normative part of the document

2.7 Reference to this standard is found in the normative part of the document

2.8 Reference to this standard is found in the normative part of the document

2.9 Reference to this standard is found in the normative part of the document

2.10 Reference to this standard is found in the normative part of the document

2.11 Reference to this standard is found in the normative part of the document

2.12 Reference to this standard is found in the normative part of the document

2.13 Reference to this standard is found in the normative part of the document

2.14 Reference to this standard is found in the normative part of the document

2.15 Reference to this standard is found in the normative part of the document

2.16 Reference to this standard is found in the normative part of the document

COMMITTEE ACTION: Accept in Principle.

Modify Clause 2 in accordance with references cited in the revised normative text. Clause 2 to read as follows:


2.2 ANSI/IEEE 100: 1992, Standard Dictionary of Electrical and Electronic Terms


2.0 Reference to this standard is no longer found in the normative part of the document

COMMITTEE ACTION: Accept in Principle.

TCC NOTE: The TCC directs the committee to consider the comments expressed in the voting. This action will be considered by the committee as a public comment.

SUBMITTER: John F. Bloodgood, JFB Enterprises

RECOMMENDATION: Modify Clause 3 - Definitions to reflect changes in the use of normative terms.

4 Proposal

3. Definitions

3.1 accessible (as applied to equipment): Admitting close approach; not guarded by locked doors, elevation, or other effective means. [NFPA 70]

3.2 accessible, readily (readily accessible): Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, etc. [NFPA 70]

3.3 actuator: The part of the actuating system to which an external actuating force is applied. [IEV 441-15-22]
3.4 adjustable speed drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner. This includes ac and dc voltage modes and frequency mode controls. Belt, chain, or roller shifting controllers are not included.

3.5 ambient temperature: The temperature of the air or other medium where the equipment is to be used. [IEV 826-01-04] NOTE—Ambient air temperature as applied to an enclosure or housing is the average temperature of the surrounding air that comes in contact with the enclosure or housing. Ambient air temperature as applied to a component or device within the enclosure is the average temperature of the surrounding air that comes in contact with the component.

3.6 ampacity: The current, in amperes, that a conductor can carry continuously under the conditions of use, without exceeding the design limits for the temperature rating of the insulation, the conductor and the wire termination.

3.7 approved: Acceptable to the authority having jurisdiction. [NFPA 70]

NOTE: The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the “authority having jurisdiction” may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The “authority having jurisdiction” may also refer to the listings or labeling practices of an organization that is concerned with product safety or performance and appropriate standards for the current production of listed items.

3.8 attachment plug (plug cap) (plug): A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [NFPA 70]

3.9 Authority Having Jurisdiction — The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase “authority having jurisdiction” is used in NFPA documents in a broad manner because jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

3.10 barrier: A part providing protection against direct contact from any usual direction of access. [IEV 826-03-13.]

3.11 bonding (bonded): The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct any current likely to be imposed. [NFPA 70]

Note: See “protective bonding circuit.”

3.12 branch circuit: The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [NFPA 70]

3.13 cable tray system: A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways. [NFPA 70]

3.14 cable trunking system: A system of enclosures comprised of a base and a removable cover intended for the complete surrounding of insulated conductors, cables, and cords [IEV 826-06-04, modified]

Note: See “wireway.”

3.15 circuit breaker: A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [NFPA 70]

3.16 concurrent: Acting in conjunction; used to describe a situation wherein two or more control devices exist in an actuated condition at the same time (but not necessarily simultaneously).

3.17 conduit, intermediate metal: A listed steel raceway of circular cross-section with integral or associated couplings, connectors, and fittings approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [NFPA 70]

3.18 conduit, rigid metal: Rigid metal conduit is a listed metal raceway of circular cross-section with integral or associated couplings, approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [NFPA 70]

3.19 conduit, rigid nonmetallic: A type of conduit and fittings of suitable nonmetallic material that is resistant to moisture and chemical atmospheres, flame retardant, resistant to impact and crushing, and resistant to distortion from heat or low temperatures under conditions likely to be encountered in service. [NFPA 70]

3.20 control circuit (of a machine): The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller but does not carry the main power current.

Note: Power circuit protection can be provided by control shunt-tripping.

3.21 control circuit transformer: A voltage transformer utilized to supply a voltage suitable for the operation of control devices. [IEEE 100]

3.22 control circuit voltage: The voltage utilized for the operation of control devices.

3.23 control device: A device connected into the control circuit and used for controlling the operation of the machine (e.g. position sensor, manual control switch, relay, magnetically operated valve). [IEC 60924–1]

3.24 controlled stop: The stopping of machine motion while retaining power to the machine actuators during the stopping process.

3.25 controlgear: A general term covering switching devices and their combination with associated control, measuring, protective, and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures, and supporting structures, intended in principle for the control of electrical energy-consuming equipment. [IEV 441-11-08]

Possible alternate term: control equipment: Operating elements such as relays, contactors, circuit breakers, switches, solenoids, brakes and similar types of components, intended to govern or perform a given function in the operation, including measuring, sensing, monitoring, protection, and regulation of machinery

3.26 controller: A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. [NFPA 70]

3.27 cord (flexible): Flexible cords are constructed as described in, and listed for use in accordance with Article 400 of the National Electrical Code (NFPA 70). All conductors are stranded copper.
3.28 device: A unit of an electrical system that is intended to carry but not utilize electric energy. (NFPA 70)

3.29 digital: Operated by the use of discrete signals to represent data in the form of numbers or other characters. [IEC-60204-1]

3.30 direct contact: Contact of persons or livestock with live parts. [IEV 826-05:05]

3.31 disconnecting means: A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [NFPA 70]

3.32 dry location: A location not normally subject to dampness or wetness. Note: A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction. [NFPA 70]

3.33 duct: An enclosed channel designed expressly for holding and protecting electrical conductors, cables, and busbars. NOTE—Conduits, cable trunking systems (see 3.10) and underfloor channels are types of duct. See “raceway.”

3.34 dwelling unit: One or more rooms for the use of one or more persons as a housekeeping unit with space for eating, living and sleeping, and permanent provisions for cooking and sanitation. (NFPA 70)

3.35 earth: See “ground.”

3.36 electromechanical: Applied to any device in which electrical energy is used to magnetically cause mechanical movement.

3.37 electrical operating area: A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons, by the opening of a door or the removal of a barrier without the use of a key or tool, and which is clearly marked by appropriate warning signs.

3.38 electronic equipment: That part of the electrical equipment containing circuitry mainly based on electronic devices and components.

3.39 Emergency switching off: An emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved.

3.40 enclosed electrical operating area: A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs.

3.41 enclosure: A surrounding case constructed to provide a degree of protection against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

3.42 energized: Electrically connected to a source of potential difference (NFPA 70).

3.43 equipment: A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation. [NFPA 70]

3.44 exposed (as applied to live parts): Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. [NFPA 70]

3.45 failure [of equipment]: The termination of the ability of an item to perform a required function.

NOTES—
1 After failure the item has a fault.
2 “Failure” is an event, as distinguished from “fault”, which is a state.

3 This concept as defined does not apply to items consisting of software only. [IEV 191-04:01]

3.46 fault: The state of an item characterized by inability to perform a required function, excluding the inability, during preventive maintenance or other planned actions, or due to lack of external resources.

NOTE: A fault is often the result of a failure of the item itself, but may exist without prior failure. [IEV 191-05:01]

3.47 feeder: All circuit conductors between the service equipment or the source of a separately derived system and the final branch-circuit overcurrent device. (NFPA 70)

3.48 flame retardant: So constructed or treated that it will not support flame. [IEEE 100]

3.49 ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth. [NFPA 70]

3.50 grounded: Connected to earth or to some conducting body that serves in place of the earth. [NFPA 70]

3.51 grounded conductor: A system or circuit conductor that is intentionally grounded. [NFPA 70]

3.52 grounding conductor: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes. [NFPA 70]

3.53 grounding conductor, equipment: The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system. [NFPA 70]

3.54 grounding electrode conductor: The conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, to or both, of the circuit as the service equipment or at the source of a separately derived system. [NFPA 70]

3.55 guard: Part of a machine specifically used to provide protection by means of a physical barrier. Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard. [ISO/TR 12100-1, 3.22, modified]

3.56 harm: Physical injury or damage to health.

3.57 hazard: A source of possible injury or damage to health; [ISO/TR 12100-1, 3.5, modified]

3.58 hazardous situation: A circumstance in which a person is exposed to a hazard(s). The exposure can immediately or over a long period of time have the potential to result in harm.

3.59 identified (as applied to equipment): Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular code requirement. (See “equipment.”)

NOTE—Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeling or listing. [NFPA 70]

3.60 indirect contact: Contact of persons exposed conductive parts which have become live under fault conditions. [IEV 826-05:06]

3.61 industrial machine: A power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting, forming, pressure, electrical, thermal, or optical techniques, lamination, or a combination of these processes. It
3.74 live part (as applied to being energized during normal use): A conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor.

3.77 marking: Signs or inscriptions for the identification of the type of a component or device attached by the manufacturer of the component or device.

3.80 output: 1. The terminals where current, voltage, power, or driving force may be applied to a circuit or device; 2. The state or sequence of states occurring on a specific input channel; 3. The device or collective set of devices used for bringing data into another device. [IEC 60204–1]

3.82 overload: Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or a ground fault, is not an overload. (See "overcurrent.") [NFPA 70]

NOTE—Overload should not be used as a synonym for overcurrent.

3.83 plug/socket combination: A plug and socket-outlet, a cable coupler, or an appliance coupler, in accordance with IEC 60309-1.

3.84 point of operation: The location in the (machine) where the material or workpiece is positioned and work is performed.

3.85 positive opening operation (of a contact element): The achievement of contact separation as the direct result of a specific movement of the switch actuator through non-resilient members (e.g. not dependent upon springs). [IEC 60947-5-1, chapter 3, 2.2]

3.86 power circuit: A circuit used for supplying power from the supply network to units of equipment used for productive operation and to transformers supplying control circuits.

3.87 programmable electronic system (PES): A system based on one or more central processing units (CPUs), connected to sensors or actuators, or both, for the purpose of control or monitoring.

NOTE—The term PES includes all elements in the system extending from sensors to other input devices via data highway or other communication paths to the actuators or other output devices.

3.88 protective bonding circuit: The whole of the protective conductors and conductive parts used for protection against electric shock in the event of an insulation failure. See "bonding.

3.89 protective conductor: A conductor required by some measures for protection against electric shock for electrically connecting any of the following parts: — exposed conductive parts; — extraneous conductive parts; — main earthing terminal. [IEV 826-04-05, modified]

3.90 qualified person: At a minimum, a qualified person shall be trained and knowledgeable of the construction and operation of...
equipment or a specific work method, and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools and test equipment. [NFPA 70E]

See “(electrically) instructed person” and “(electrically) skilled person.”

3.91 raceway: An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, wireways, and busways.

3.92 receptacle: A contact device installed at the outlet for the connection of a attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke. [NFPA 70]

See “socket.”

3.93 redundancy: The application of more than one device or system, or part of a device or system, with the objective of ensuring that in the event of one failing to perform its function another is available to perform that function.

3.94 reference designation: A distinctive code which serves to identify an item in a diagram, list, chart, and on the equipment.

3.95 relative humidity: The ratio between the amount of water vapor in the gas at the time of measurement and the amount of water vapor that could be in the gas when condensation begins, at a given temperature. [IEEE 100]

3.96 risk: A combination of the probability and the degree of possible injury or damage to health in a hazardous situation. [ISO/TR 12100-1]

3.97 safe working procedure: A method of working that reduces risk. [IEC 60924-1]

3.98 safeguard: A guard or protective device used as a safety measure to protect persons from a present or impending hazard. [IEEE 100]

3.99 safeguarding: Those safety measures consisting of the use of specific means called safeguards to protect persons from hazards that cannot reasonably be removed or are not sufficiently limited by design.

3.100 safety distance: The distance between the pinch point or point-of-operation and the presence sensing safety device (PSSD) sensing field which ensures that the operator cannot reach the danger point before the machine comes to a full stop.

3.101 safety function [safety measure]: A means that eliminates or reduces a hazard. [IEEE 60924-1]

3.102 servicing level: Location on which persons normally stand when operating or maintaining the electrical equipment.

3.103 shall: Indicates a mandatory requirement.

3.104 short-circuit current: An overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit. [IEV 441-11-07]

3.105 should: Indicates a recommendation or that which is advised but not required.

3.106 (electrically) skilled person: A person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create. [IEV 826-09-01, modified]

3.107 socket—See “receptacle.”

3.108 supplier: An entity (e.g., manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine.

NOTE—The user may also act in the capacity of a supplier to himself.

3.109 subassembly: An assembly of electrical devices connected together which forms a simple functional unit in itself.

3.110 subplate: An internal metal surface separate from the walls of an enclosure or controller on which various component parts of the controller are mounted and wired. [IEEE 100]

3.111 supplementary overcurrent protective device: A device where protection is required for lighting fixtures, appliances, and other equipment or for internal circuits and components of equipment. It shall not be used as a substitute for power circuit overcurrent devices in place of the power circuit protection.

3.112 switching device: A device designed to make or break the current in one or more electric circuits. [IEV 441-14-01]

3.113 tap conductor: a conductor that has overcurrent protection ahead of its point of supply, that exceeds the value permitted for similar conductors that are protected as described elsewhere in this standard.

3.114 terminal: A conductive part of a device provided for electrical connection to circuits external to the device.

3.115 tight (suffix): So constructed that the specified material is excluded under specified conditions. (ANSI/IEEE Standard No 100)

3.116 uncontrolled stop: The stopping of machine motion by removing power to the machine actuators, all brakes and/or other mechanical stopping devices being activated. [IEC 60601-1]

3.117 undervoltage protection: The effect of a device that operates on the reduction or failure of voltage, to cause and maintain the interruption of power.

NOTE—The principal objective of this device is to prevent automatic restarting of the equipment. Standard undervoltage or low-voltage protection devices are not designed to become effective at any specific degree of voltage reduction.

3.118 user: An entity who utilizes the machine and its associated electrical equipment.

3.119 variable speed drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner. This includes ac and dc voltage modes and frequency mode controls. Belt, chain, or roller shifting controllers are not included.

3.120 ventilated: Provided with a means to permit circulation of air sufficient to remove excess heat, fumes, or vapors. [NFPA 70]

3.121 wet location: Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle washing areas, and locations exposed to weather and unprotected. [NFPA 70]

3.122 wireway: A sheet-metal or flame retardant nonmetallic trough with hinged or removable covers for housing and protecting electric wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system. [NFPA 70]

SUBSTANTIATION: Same as in current standard, except reference to IEV has been added

3.124 OLDTerm is no longer used <>

3.5 Note has been added for clarity

3.7 Both the definition and note recommended here are NFPA official definitions taken from the Regulations Governing Committee Projects. This definition leaves the final decision of what is acceptable and what is not acceptable up to the authority having jurisdiction.

3.9 Both the definition and note provided here are NFPA official definitions taken from the Regulations Governing Committee Projects. Since NFPA 79 is a voluntary standard in many cases, often times the question is asked: “Who is the authority having jurisdiction (AHJ)?” This definition will assist the user in making that determination.
3.11 Same definition except for the note.
3.13 Term is used in the document
3.14 Term is used in the document
3.17 Use of definition from the NEC
3.18 Use of definition from the NEC
3.20 Note added to provide an example
3.22 Better expresses the opinion of the Committee
3.24 Better expresses the opinion of the Committee
3.25 Term is used in the document
3.27 The terms "cord" and "cable" are distinctively different wiring methods. Having a definition for cords coordinates with the different permitted uses in Clause 14.
3.32 The second sentence is more appropriate as a note.
3.33 Term is used in the document
3.39 Term is used in the document
3.40 Term is used in the document
3.41 Definition better reflects the opinion of the Committee
3.42 The use of the NEC definition will eliminate any perceived conflict.
3.43 Editorial to bring it in line with the current NFPA 70
3.37 OLD Delete: exposed conductive part: This term introduces a complicated concept that generally applies to high voltage mobile machinery typically related to earth moving. These are engineering based concepts that require sophisticated analysis (Mathematical analysis of gradient voltage problems). Also, this concept is not specifically addressed in the NEC. Bonding plus quick acting overcurrent protection together are considered sufficient to render these parts harmless. Neither this committee (nor the NEC panels) is aware of any accidents related to ground fault gradients during the occurrence of a short circuit for circuits not exceeding 600 volts.
3.49 This term is used in the document
3.56 Term is used in the document
3.58 Term is used in the document
3.66 Term is used in the document
3.67 Term is used in the document
3.68 Term is used in the document
3.72 Term is used in the document. The definition is consistent with the NEC.
3.73 The Committee felt that theIEV definition better fit the use of the term in the document.
3.74 The committee felt that the term was used in two different ways and hence required two definitions
3.77 The term is used in the document
3.62 OLD The term is no longer used in the document
3.78 The term is used in the document
3.79 The term is used in the document
3.83 Term is used in the document
3.84 The term is used in the document
3.86 The Committee felt that the NOTE was no longer necessary
3.88 The term is used in the document
3.88 The term is used in the document
3.90 The Committee felt that this definition from NFPA 70E was more appropriate to this document
3.93 This term is used in the document
3.94 This term is used in the document
3.95 This term is used in the document
3.72 OLD This term is no longer used in the document
3.100 The term is used in the document
3.102 The term is used in the document
3.103 The term is used in the document
3.104 Term is used in the document
3.105 Term is used in the document
3.78 OLD The term is no longer used in the document
3.106 The term is used in the document
3.79 OLD The term is no longer used in the document
3.80 OLD The term is no longer used in the document
3.80 Old The term is used in the document
3.108 The term is used in the document
3.109 The term is used in the document
3.81 OLD The term is no longer used in the document
3.110 The term is used in the document
3.13 The term is used in the document
3.14 The term is used in the document
3.118 This term is used in the document
3.119 This term is used in the document.

COMMITTEE ACTION: Accept in Principle.

Modified to read as follows:

3. Definitions

Note: Chapter 3, “Definitions,” contains only those definitions essential to the proper application of this Standard. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. In general, only those terms that are used in two or more places are defined. Other definitions are included in the article in which they are used. Spelling and definitions of general words and terms follow Webster’s Collegiate Dictionary, 10th edition.

The terms in parenthesis, used throughout this standard are from the English version of IEC 60042-1, and are based on the Oxford English dictionary.<end note>

3.1 accessible (as applied to equipment): Admitting close approach; not guarded by locked doors, elevation, or other effective means. [NFPA 70]

3.2 accessible, readily (readily accessible): Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, etc. [NFPA 70]

3.3 actuator: The part of the actuating system to which an external actuating force is applied. [IEV 441-15-22]

NOTES—
1 The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.
2 There are some actuating means that do not require an external actuating force but only an action.
3 See also 3.74 “machine actuator.”

3.4 adjustable speed drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner. This includes ac and dc voltage modes and frequency mode controls. Belt, chain, or roller shifting controllers are not included.

3.5 ambient temperature: The temperature of the air or other medium where the equipment is to be used. [IEV 626-01-04]

NOTE—Ambient air temperature as applied to an enclosure or housing is the average temperature of the surrounding air that comes in contact with the enclosure or housing. Ambient air temperature as applied to a component or device within the enclosure is the average temperature of the surrounding air that comes in contact with the component.

3.6 ampacity: The current, in amperes, that a conductor can carry continuously under the conditions of use, without exceeding the design limits for the temperature rating of the insulation, the conductor and the wire termination.

3.6 ampacity: The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating. (NFPA 70)

3.7 approved: Acceptable to the authority having jurisdiction. (NFPA 70)

NOTE: The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the “authority having jurisdiction” may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The “authority having jurisdiction” may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

3.8 attachment plug (plug cap) (plug): A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [NFPA 70]

3.9 Authority Having Jurisdiction: The organization, office, or individual responsible for approving equipment, an installation, or a procedure.
3.10 barrier: A part providing protection against direct contact from any usual direction of access. [IEV 826-03-13]

3.10 Barrier. A physical obstruction that is intended to prevent contact with equipment or live parts or to prevent unauthorized access to a work area. [NFPA 70E-2000]

3.11 bonding (bonded): The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct any current likely to be imposed. [NFPA 70]

Note: See “protective bonding circuit.”

3.12 branch circuit: The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). (NFPA 70)

3.13 cable tray system: A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cable and raceways. [NFPA 70]

3.14 cable trunking system: A system of enclosures comprised of a base and a removable cover intended for the complete surrounding of insulated conductors, cables, and cords [IEV 826-06-04, modified]

Note: See “wireway.”

3.15 circuit breaker: A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [NFPA 70]

3.16 concurrent: Acting in conjunction; used to describe a situation wherein two or more control devices exist in an actuated condition at the same time (but not necessarily simultaneously).

3.17 conduit, intermediate metal: A listed steel raceway of circular cross-section with integral or associated couplings, connectors, and fittings approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [NFPA 70]

3.18 conduit, rigid metal: Rigid metal conduit is a listed metal raceway of circular cross section with integral or associated couplings, approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [NFPA 70]

3.19 conduit, rigid nonmetallic: A type of conduit and fittings of suitable nonmetallic material that is resistant to moisture and chemical atmospheres, flame retardant, resistant to impact and crushing, and resistant to distortion from heat or low temperatures under conditions likely to be encountered in service. [NFPA 70]

3.20 control circuit (of a machine): The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller but does not carry the main power current.

Note: Power circuit protection can be provided by control shunt-tripping.

3.21 control circuit transformer: A voltage transformer utilized to supply a voltage suitable for the operation of control devices. [IEEE 100]

3.22 control circuit voltage: The voltage utilized for the operation of control devices.

3.23 control device: A device connected into the control circuit and used for controlling the operation of the machine (e.g. position sensor, manual control switch, relay, magnetically operated valve). [IEC 60929-1]

3.24 controlled stop: The stopping of machine motion, while retaining power to the machine actuators during the stopping process.

3.25 controlgear: A general term covering switching devices and their combination with associated control, measuring, protective, and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures, and supporting structures, intended in principle for the control of electrical energy-consuming equipment. [IEV 441-11-03]

Note: A device of controlgear: A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [NFPA 70]

3.26 controlled stop: The stopping of machine motion, while retaining power to the machine actuators during the stopping process.

3.27 cord (flexible): Flexible cords are constructed as described in, and listed for use in accordance with Article 400 of the National Electrical Code (NFPA 70). All conductors are stranded copper.

3.28 device: A unit of an electrical system that is intended to carry but not utilize electric energy. (NFPA 70)

3.29 digital: Operated by the use of discrete signals to represent data in the form of numbers or other characters. [IEC 60000-1]

3.30 direct contact: Contact of persons or livestock with live parts. [IEV 826-05-05]

3.31 disconnecting means: A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [NFPA 70]

3.32 dry location: A location not normally subject to dampness or wetness. [IEV 826-05-05]

Note: An area classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction. [NFPA 70]

3.33 duct: An enclosed channel designed expressly for holding and protecting electrical conductors, cables, and busbars.

NOTE: Conduits, cable trunking systems (see 3.10) and underfloor channels are types of duct. See “raceway.”

3.34 dwelling unit: One or more rooms for the use of one or more persons as a housekeeping unit with space for eating, living, and sleeping, and permanent provisions for cooking and sanitation. (NFPA 70)

3.35 earth: See “ground.”

3.36 electromechanical: Applied to any device in which electrical energy is used to magnetically cause mechanical movement.

3.37 electrical operating area: A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons, by the opening of a door or the removal of a barrier without the use of a key or tool, and which is clearly marked by appropriate warning signs.

3.38 electronic equipment: That part of the electrical equipment containing circuitry mainly based on electronic devices and components.
3.39 Emergency switching off: An emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved.

3.40 enclosed electrical operating area: A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs.

3.41 enclosure: A surrounding case constructed to provide a degree of protection against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

3.42 energized: Electrically connected to a source of potential difference (NFPA 70).

3.43 equipment: A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation. [NFPA 70]

3.44 exposed (as applied to live parts): Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, insulated, or insulated. [NFPA 70]

3.45 failure [of equipment]: The termination of the ability of an item to perform a required function.

NOTES—
1. After failure the item has a fault.
2. "Failure" is an event, as distinguished from "fault", which is a state.
3. This concept as defined does not apply to items consisting of software only. [IEV 191-04-01]

3.46 fault: The state of an item characterized by inability to perform a required function, excluding the inability, during preventive maintenance or other planned actions, or due to lack of external resources.

NOTE: A fault is often the result of a failure of the item itself, but may exist without prior failure [IEV 191-05-01]

3.47 feeder: All circuit conductors between the service equipment or the source of a separately derived system and the final branch-circuit overcurrent device. (NFPA 70)

3.48 flame retardant: So constructed or treated that it will not support flame. [IEEE 100]

3.49 ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth. [NFPA 70]

3.50 grounded: Connected to earth or to some conducting body that serves in place of the earth. [NFPA 70]

3.51 grounded conductor: A system or circuit conductor that is intentionally grounded. [NFPA 70]

3.52 grounding conductor: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes. [NFPA 70]

3.53 grounding conductor, equipment: The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system. [NFPA 70]

3.54 grounding electrode conductor: The conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system. [NFPA 70]

3.55 guard: Part of a machine specifically used to provide protection by means of a physical barrier. Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard. [ISO/TR 12100-1, 3.22, modified]

3.56 harm: Physical injury or damage to health.

3.57 hazard: A source of possible injury or damage to health. [ISO/TR 12100-1, 3.5, modified]

3.58 hazardous condition situation: A circumstance in which a person is exposed to a hazard(s), the exposure can immediately or over a long period of time have the potential to result in harm.

3.59 identified (as applied to equipment): Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular code requirement. (See "equipment.")

NOTE—Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeling or listing. [NFPA 70]

3.60 indirect contact: Contact of persons with exposed conductive parts which have become live under fault conditions. [IEV 826-03-06]

3.61 industrial machine: A power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting, forming, pressure, electrical, thermal, or optical techniques, lamination, or a combination of these processes. It can include associated equipment used to transfer material or tooling (including fixtures), assemble/disassemble, inspect or test or package. (The associated electrical equipment including the logic controller(s) and associated software or logic together with the machine actuators and sensors are considered as part of the industrial machine.)

3.62 industrial manufacturing system: A systematic array of one or more industrial machines that are not portable by hand and that includes any associated material handling, manipulating, gauging, measuring, or inspection equipment.

3.63 Input
1. The terminals where current, voltage, power, or driving force may be applied to a circuit or device.
2. The state or sequence of states occurring on a specific input channel.
3. The device or collective set of devices used for bringing data into another device. [IEC 60924-1]

3.64 In sight from, within sight from, within sight: Where this standard specifies that one equipment shall be "in sight from," "within sight from," or "within sight," etc., of another equipment, one of the equipments specified is to be visible and not more than 50 ft (15.24 m) distant from the other. (NFPA 70)

3.65 inrush current (solenoid): The inrush current of a solenoid is the steady-state current taken from the line at rated voltage and frequency with the plunger blocked in the rated maximum open position.

3.66 inrush locked rotor current (motor): See "locked rotor motor current."

3.67 (electrically) instructed person: A person adequately advised or supervised by an electrically skilled person to enable him or her to perceive risks and to avoid hazards which electricity can create. [IEV 826-09-02, modified]

3.68 (electrically) skilled person: A person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create. [IEV 826-09-01, modified]

3.69 interlock (for safeguarding): An arrangement that interconnects guard(s) or device(s) with the control system or all or part of the electrical energy distributed to the machine.

3.70 interrupting rating: The highest current at rated voltage that a device is intended to interrupt under standard test conditions.
3.71 jogging (inching): The quickly repeated closure of the circuit to start a motor from rest for the purpose of accomplishing small movements of the driven machine. [IEEE 100]

3.72 Labeled: Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner. [NFPA 70]

3.73 live part (as applied to being energized during normal use): A conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor.

NOTE—This term does not necessarily imply a risk of electric shock. [IEV 826-03-01]

3.74 live parts: Energized conductive components. [NFPA 70-2002] (as applied to exposure to an existing shock hazard): Electric conductors, busbar terminals, or components that are uninsulated or exposed and a shock hazard exists

3.75 locked rotor motor current: The steady-state current taken from the line with the rotor locked and with rated voltage (and rated frequency in the case of alternating-current motors) applied to the motor. [IEEE 100]

3.76 machine actuator: A power mechanism used to effect motion of the machine.

3.77 marking: Signs or inscriptions for the identification of the type of a component or device attached by the manufacturer of the component or device.

3.78 neutral conductor (symbol N): A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy. [IEV 820-01-03]

3.79 obstacle: A part preventing unintentional direct contact, but not preventing direct contact by deliberate action. [IEEE 826-03-14]

3.80 output: 1. The terminals where current, voltage, power, or driving force may be delivered by a circuit or device; 2. The state or sequence of states occurring on a specific output channel; 3. The device or collective set of devices used for taking data out of another device.

3.81 overcurrent: Any current in excess of the rated current of the equipment or the rated ampacity (current-carrying capacity) of the conductor. It may result from overload, short circuit, or electrical fault. [NFPA 70]

3.82 overload: Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or overheating. A fault, such as a short circuit or a ground fault, is not an overload. (See "overcurrent.") [NFPA 70]
water vapor that could be in the gas when condensation begins, at a given temperature. [IEEE 100]

3.96 risk: A combination of the probability and the degree of possible injury or damage to health in a hazardous situation. [ISO/TR 12100-1]

3.97 safe working procedure: A method of working that reduces risk. [IEC 60204–1]

3.98 safeguard: A guard or protective device used as a safety measure to protect persons from a present or impending hazard. [IEC 60204–1]

3.99 safeguarding: Those safety measures consisting of the use of specific means called safeguards to protect persons from hazards that cannot reasonably be removed or are not sufficiently limited by design.

3.100 safety distance: The distance between the pinch point or point-of-operation and the presence sensing safety device (PSSD) sensing field which ensures that the operator cannot reach the danger point before the machine comes to a full stop.

3.101 safety function [safety measure]: A means that eliminates or reduces a hazard. [IEC 60204–1]

3.102 servicing level: Location on which persons normally stand when operating or maintaining the electrical equipment.

3.103 shall: Indicates a mandatory requirement.

3.104 short-circuit current: An overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit. [IEV 441-11-07]

3.105 should: Indicates a recommendation or that which is advised but not required.

3.106 (electrically) skilled person: A person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create. [IEV 826-09-01, modified]

3.107 socket: See "receptacle."

3.108 supplier: An entity (e.g., manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine.

3.109 subassembly: An assembly of electrical devices connected together which forms a simple functional unit in itself.

3.110 subplate: An internal metal surface separate from the walls of an enclosure or controller on which various component parts of the controller are mounted and wired. [IEEE 100]

3.111 supplementary overcurrent protective device: A device used where protection is required for lighting fixtures, appliances, and other equipment or for internal circuits and components of equipment. It shall not be used as a substitute for power circuit overcurrent devices in place of the power circuit protection.

3.102 switching device: A device designed to make or break the current in one or more electric circuits. [IEV 441-14-01.]

3.113 tap conductor: A conductor that has overcurrent protection ahead of its point of supply, that exceeds the value permitted for similar conductors that are protected as described elsewhere in this standard.

3.104 terminal: A conductive part of a device provided for electrical connection to circuits external to the device.

3.115 tight (suffix): So constructed that the specified material is excluded under specified conditions. (ANSI/IEEE Standard No. 100)
A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as a part of, or in connection with, an electrical installation.

Exposed (as applied to live parts) (preferred) NFPA 70
Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts that are not suitably guarded, isolated, or insulated.

Exposed (as applied to live parts) (secondary)
Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (NFPA 70.)

Feeder (preferred) NFPA 70
A single circuit or group of circuits that are all connected to the service equipment, the source of the separately derived system, or other power supply source and the final branch-circuit overcurrent device.

Feeder (secondary)
All circuit conductors between the service equipment or the source of a separately derived system and the final branch-circuit overcurrent device.

Interlock (preferred) NFPA 97
A device, or an arrangement of devices, in which the operation of one part or one mechanism of the device or arrangement controls the operation of another part or another mechanism.

Interlock (secondary)
A device, or an arrangement of devices, in which the operation of one part or one mechanism of the device or arrangement controls the operation of another mechanism.

Interrupting Rating (preferred) NFPA 70
The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

Interrupting Rating (secondary)
The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

Overcurrent (secondary)
A current in excess of rating may be accommodated by certain overcurrent devices without injury to itself when properly applied within its rating.

Overcurrent (primary)
A current in excess of the rated current of the equipment or the rated ampacity of the conductor. It may result from overload, such as horsepower or locked rotor current.

Overload (secondary)
Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit or ground fault.

Overload (primary)
A current in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

Qualified Person (secondary)
A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems relating to a particular subject matter, work, or project.

Qualified Person (preferred) NFPA 1500
A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems relating to a particular subject matter, work, or project.

Raceway (secondary)
An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this Code.

Raceway (preferred) NFPA 70
An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this Code.
functions as permitted in this standard. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, surface raceways, wireways, and busways.

Receptacle (preferred) NFPA 70
A receptacle is a contact device installed at the outlet for the connection of a single attachment plug. (NFPA 70.)

SUBSTANTIATION: Adoption of preferred definitions will assist the user by providing consistent, meaningful definitions throughout the National Fire Codes.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See Committee Action on Proposal 79-11 (Log #87) (Clause 3, Definitions). The committee has revised Clause 3 to incorporate the preferred definitions where they are appropriate.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

DOBROWSKI: See my Comment of Affirmative for Proposal 79-11 (Log #87).

FREUDENBERG: If 79-8 and/or 79-9 are revised add definition of "hazardous process material (HPM)" from Uniform Building Code. Text available upon request.

79-13 - (Chapter 3 labeled [Chapter 3 labeled]): Accept

TCC NOTE: The TCC directs the committee to consider the comments expressed in the voting. This action will be considered by the committee as a public comment.


RECOMMENDATION: Add new text as follows:

Add definition for "labeled" from NFPA 70 or NFPA official definitions taken from the Regulations Governing Committee Projects.

SUBSTANTIATION: Per my notes the TC79 committee had voted to add "labeled" as a defined term but inadvertently left "labeled" out of the latest draft of section 3. The term "labeled" is frequently used in the notes for the definitions of approved, identified and listed. This will align NFPA 70 definition for listed and related definitions with NFPA 70, indicating listed is not necessarily limited to the more commonly known practices of NRTL listed or UL listed.

3.7 approved: Acceptable to the authority having jurisdiction. (NFPA 70)

NOTE: The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the "authority having jurisdiction" may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The "authority having jurisdiction" may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

Substantiation for definition 3.7 approved. Both the definition and note recommended here are NFPA official definitions taken from the Regulations Governing Committee Projects. This definition leaves the final decision of what is acceptable and what is not acceptable up to the authority having jurisdiction.

3.7 Authority Having Jurisdiction - the organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner because jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company, representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installation, the commanding officer or departmental official may be the authority having jurisdiction.

Substantiation for definition 3.9 Authority having Jurisdiction. Both the definition and note provided here are NFPA official definitions taken from the Regulations Governing Committee Projects. Since NFPA 79 is a voluntary standard in many cases, often times the question is asked: "Who is the authority having jurisdiction?" This definition will assist the user in making that determination.

3.9 identified (as applied to equipment): Recognizable as suitable for the specific purpose, function, use, environment, application, etc. where described in a particular code requirement. (See "equipment").

NOTE - Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeling or listing. (NFPA 70)

3.72 listed: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets identified standards or has been tested and found suitable for specified purpose. (NFPA 70)

NOTE - The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product.

Substantiation for definition 3.72 listed Term is used in the document. The definition is consistent with the NEC.

COMMITTEE ACTION: Accept.

COMMITTEE STATEMENT: The committee understands that this proposal modifies the Action on Proposal 79-11 (Log #87).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

FISHER: The appropriate text is:

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

FREUDENBERG: The definition of labeled needs to be extracted from the NFPA Rules and included in NFPA79 to facilitate a better understanding of listed and labeled.

79-14 - (Chapter 3 electronic drive [Chapter 3 electronic drive ]): Accept in Part

SUBMITTER: John J. Kosay, Webster, NY

RECOMMENDATION: Revise text as follows:

Remove definitions for adjustable speed drives and variable speed drives and replace with new definition titled electronic drives. The new definition will include the same wording contained in the old definitions with just a title change.

3.6 adjustable speed drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner. This includes ac and dc voltage and frequency mode controls. Belt, chain, or roller shifting controllers are not included.

3.119 variable speed drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner. This includes ac and dc voltage and frequency mode controls. Belt, chain, or roller shifting controllers are not included.

1488
3.XXX electronic drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner. This includes ac and dc voltage modes and frequency mode controls. Belt, chain, or roller shifting controllers are not included.

**SUBSTANTIATION:** This change will provide clarity for the purpose in the proposed NFPA 79-2002 standard. The proposed NFPA 79-2002 does not have a reference to either a variable speed or adjustable speed drive. There is a reference to electronic drives in the proposed Section 11.4, titled Electronic Drives. This reference encompasses both of the previously mentioned drive types. Therefore the existing definition is used.

**COMMITTEE ACTION:** Accept in Part.

1) Retain the definition of Adjustable Speed Drive.

2) Delete the definition of Variable Speed Drive in 3.119.

3) Do not accept the new definition of electronic drive.

**COMMITTEE STATEMENT:** The committee accepts deleting the definition of Variable Speed Drive. The definition of Adjustable Speed Drives was retained because it matches the definition used in the NEC. The committee does not accept the proposed definition of Electronic Drive because it conflicts with the NEC. The committee understands that this proposal modifies the Committee Action on Proposal 79-11 (Log #57) [Clause 3, Definitions]

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**

**AFFIRMATIVE:** 25

**NEGATIVE:** 1 Norman

**NOT RETURNED:** 1 Norman

**EXPLANATION OF NEGATIVE:**

**BLOODGOOD:** This term was to be added to provide a definition for the proposed modification to new clause 9 (9.1.5, seq.) 79-63 (Log #153). Since the Committee Action for Proposal 79-63 (Log #153) is to reject the term no longer is being used and therefore should be added to clause 3. In addition, the term used throughout the standard is safety function.

**FISHER:** The definition is unnecessary and is possibly misleading. Safety components can be applied in any circuit but just utilizing a safety component does not ensure a safety circuit. The acceptance of this concept should be as part of an entire system as described in the comment on clause 79-73 in Log #156 and 79-77.

**MONTEITH:** I agree with the explanation of negative votes by Mr. Fisher and Mr. Saunders.

**PADGET:** I agree with Mr. Saunders’ Explanation of Negative Vote.

**SAUNDERS:** See the Committee Action on Proposal 79-63 (Log #46), which was rejected, and therefore eliminated the need for the new definition as agreed in Clause 3.

**COMMENTS ON AFFIRMATIVE:**

**DOBROWSKY:** I am not opposed to adding the term but the proposed (revised) definition may be confusing. A safety control circuit may not necessarily be part of another control circuit. The definition should be revised to remove the word “related.” The acceptance of Proposal 79-1 (Log #154), which globally replaces “safety related function” with “safety function.” There may be a need for the definition based on Proposal 79-63 (Log #153) being rejected.

**PILZ:** This comment is in support of the committee action to accept in principle to include a definition for safety control circuit. However, I suggest changing the wording of 3.X as follows:

3.X Safety Circuit. The part of the control circuit that incorporates the control devices intended to control the safety function of the machine protecting personnel from mechanical hazards.

**SUBSTANTIATION:** The suggested wording adds clarity to the user of the document. Historically, NFPA 79 was designed to protect against electrical hazards such as electrocution and fire. NFPA 79 was not intended to provide guidance on how to protect against mechanical hazards. However, through the inclusion of the functionality of the Emergency Stop, the scope of NFPA 79 has been extended to cover protection against mechanical hazards as long as they are electronically controllable. If the committee acknowledges this fact and decides to incorporate the newly proposed 9.1.5 which gives guidance of the design of such circuitry the above mentioned definition is necessary to be incorporated into the standard. Also, the term Safety (Stop) Circuit is currently used in the ANSI/RRIA 15-06 1999 edition (See page 18, clause 6.12 Robot system stopping circuits).

**EXPLANATION OF NEGATIVE:**

**BLOODGOOD:** This term was to be added to provide a definition for the proposed modification to new clause 9 (9.1.5, seq.) 79-63 (Log #153). Since the Committee Action for Proposal 79-63 (Log #153) is to reject the term no longer is being used and therefore should be added to clause 3. In addition, the term used throughout the standard is safety function.

**FISHER:** The definition is unnecessary and is possibly misleading. Safety components can be applied in any circuit but just utilizing a safety component does not ensure a safety circuit. The acceptance of this concept should be as part of an entire system as described in the comment on clause 79-73 in Log #156 and 79-77.

**MONTEITH:** I agree with the explanation of negative votes by Mr. Fisher and Mr. Saunders.

**PADGET:** I agree with Mr. Saunders’ Explanation of Negative Vote.

**SAUNDERS:** See the Committee Action on Proposal 79-63 (Log #46), which was rejected, and therefore eliminated the need for the new definition as agreed in Clause 3.

**COMMENTS ON AFFIRMATIVE:**

**DOBROWSKY:** I am not opposed to adding the term but the proposed (revised) definition may be confusing. A safety control circuit may not necessarily be part of another control circuit. The definition should be revised to remove the word “related.” The acceptance of Proposal 79-1 (Log #154), which globally replaces “safety related function” with “safety function.” There may be a need for the definition based on Proposal 79-63 (Log #153) being rejected.

**PILZ:** This comment is in support of the committee action to accept in principle to include a definition for safety control circuit. However, I suggest changing the wording of 3.X as follows:

3.X Safety Circuit. The part of the control circuit that incorporates the control devices intended to control the safety function of the machine protecting personnel from mechanical hazards.

**SUBSTANTIATION:** The suggested wording adds clarity to the user of the document. Historically, NFPA 79 was designed to protect against electrical hazards such as electrocution and fire. NFPA 79 was not intended to provide guidance on how to protect against mechanical hazards. However, through the inclusion of the functionality of the Emergency Stop, the scope of NFPA 79 has been extended to cover protection against mechanical hazards as long as they are electronically controllable. If the committee acknowledges this fact and decides to incorporate the newly proposed 9.1.5 which gives guidance of the design of such circuitry the above mentioned definition is necessary to be incorporated into the standard. Also, the term Safety (Stop) Circuit is currently used in the ANSI/RRIA 15-06 1999 edition (See page 18, clause 6.12 Robot system stopping circuits).
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-18 - (Clause 4 [Clause 17]): Accept in Principle
SUBMITTER: Carl E. Padgett, Jr., Padgett Consulting/Rep. The Association for Manufacturing Technology
RECOMMENDATION: Revise part of NFPA 79-1997 Clause 4 "Diagrams, instruction and nameplates" and subclause 11.10 "Warning marks." Issue as new Clause 17 "Markings, warning signs and reference designations."

17 Marking, warning signs and reference designations

17.1 General

17.1.1 The electrical equipment shall be marked with the supplier's name, trademark, or other identifying symbol and, where required, with a certification mark.

17.1.2 Warning signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.

17.2 Warning marking and signs

17.2.1 Enclosures that do not clearly show that they contain electrical devices shall be marked with a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol 60417-2:IEC 5056, the whole in accordance with sign B.3.6 of ISO 3864:

![Warning sign on enclosures](image)

17.2.2 The warning sign shall be plainly visible on the enclosure door or cover.

17.2.3 It is permitted to omit this warning sign on:
- an enclosure equipped with a supply disconnecting device;
- an operator-machine interface or control station;
- a single device with its own enclosure (e.g. position sensor)

17.2.4 A warning marking shall be provided adjacent to the disconnect operating handle(s) where the disconnect(s) that is interlocked with the enclosure door does not deenergize all exposed live parts when the disconnect(s) is in the "open (off)" position.

17.2.5 Where an attachment plug is used as the disconnecting means, a warning marking shall be attached to the control enclosure door or cover indicating that power shall be disconnected from the equipment before the enclosure is opened.

17.2.6 Where the disconnecting means is remote from the control enclosure, a warning marking shall be attached to the enclosure door or cover indicating that the power shall be disconnected from the equipment before the enclosure is opened and that the enclosure is to be closed before the power is restored.

17.3 Function identification

Control devices, visual indicators, and displays used in the machine interface shall be clearly and durably marked with regard to their functions either on or adjacent to the unit.

Note 1: Such markings may be as agreed between the user and the supplier of the equipment, see Annex B for additional information.

Note 2: For further information on symbols, see IEC 60417 and ISO 7006.

17.4 Machine nameplate data

17.4.1 Control equipment (e.g. controlgear assemblies) shall be legibly and durably marked in a way that it is plainly visible after the equipment is installed. A nameplate giving the following information shall be attached to the enclosure:
- name or trademark of supplier;
- certification mark, when required;
- serial number, where applicable;
- rated voltage, number of phases and frequency (if a.c.) and full-load current for each supply;
- amperage rating of the largest motor or load;
- short-circuit interrupting capacity of the machine disconnecting means where provided as part of the equipment;
- the electrical diagram number(s) or the number of the index to the electrical drawings.

17.4.2 The full-load current shown on the nameplate shall not be less than the full-load currents for all motors and other equipment that can in operation at the same time under normal condition of use. Where unusual loads or duty cycles, require oversize conductors, the required capacity shall be included in the full-load current specified on the nameplate.

17.4.3 Where more than one incoming supply circuit is to be provided, the nameplate shall state the above information for each circuit.

17.4.4 Where only a single motor or motor controller is used, the motor nameplate shall be permitted to serve as the electrical equipment nameplate where it is plainly visible.

17.4.5 Where overcurrent protection is provided in accordance with 7.2.3., the machine shall be marked “overcurrent protection provided at machine supply terminals.” A separate nameplate shall be permitted to be used for this purpose.

17.5 Equipment marking and identification

17.5.1 Where equipment is removed from its original enclosure or is so placed that the manufacturer's identification plate is not easily read, an additional identification plate shall be attached to the machine or enclosure.

17.5.2 Where a motor nameplate or connection diagram plate is not visible, additional identification shall be provided where it can be easily read.

17.5.3 Nameplates, identification plates, or warning markings shall not be removed from the equipment.

17.5.4 All control panel devices and components shall be plainly identified with the same designation as shown on the diagram(s) This identification shall be adjacent to (not on) the device or component.

Exception No. 1: Where the size or location of the devices make individual identification impractical, group identification shall be used.

Exception No. 2: This section shall not be required to apply to machine on which the equipment consists only of a single motor, motor controller pushbutton stations(s), and workslight(s).

17.5.5 All devices external to the control panel(s) shall be identified by a nameplate with the same designation as shown on the diagram(s) and mounted adjacent to (not on) the device.

Exception: Devices covered by 17.3

17.5.6 Terminations on multiconductor plugs and receptacle shall be plainly marked. The markings on the plug/receptacle and on drawings shall correspond.

17.5.7 Where group protection as provided for in 7.2.10 is used information specifying the short circuit protective device for each group protected motor branch circuit shall be included with the equipment.

Note 3: Consideration should be given to the use of IEC symbol for pushbuttons (see Annex C for examples).
SUBSTANTIATION: This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization – Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Importance of Issue – Harmonization

Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization – Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause 4 with IEC 60204-1 Clause 17. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber NFPA-79-1997 Clause 4 to correspond with IEC 60204-1 Clause 17. The task group proposes the following changes to further improve usability.

SUBSTANTIATION FOR NFPA 79-1997 REVISIONS TO PART OF CLAUSE 4 AND SUBCLAUSE 11.10

17 Marking, warning signs and reference designations

Add the IEC 60204-1 Clause 17 heading to the proposed NFPA 79-2002.

Substantiation: The proposed NFPA 79-2002 Clause 17 heading is added to harmonize with IEC 60204-1.

17.1 General

Add IEC 60204-1 subclause 17.1 heading to the proposed NFPA 79-2002.

Substantiation: The IEC subclause heading is added for general information on marking, warning signs and reference designations and to harmonize with IEC 60204-1.

17.1.1

(a) Add the subclause number 17.1.1 to be in compliance with the NFPA Manual of style.

(b) Delete NFPA 79-1997 subclause 4.6 heading “Machine Marking” and paragraph.

(c) Add the IEC 60204-1 subclause 17.1 first paragraph:

The electrical equipment shall be marked with the supplier's name, trademark, or other identifying symbol and, where required, with a certification mark.

Substantiation: The NFPA 79-1997 subclause 4.6 text is the same as the IEC 60204-1 subclause 17.1 first paragraph except “and, where required, with a certification mark” is added at the end of subclause 4.6 paragraph. This addition harmonizes NFPA 79 with IEC 60204-1.

17.1.2

(a) Add the subclause number 17.1.2 to be in compliance with the NFPA Manual of style.

(b) Delete NFPA 79-1997 subclause 4.4 heading and paragraph.

(c) Add IEC 60204-1 subclause 17.1 second paragraph:

Warning signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.

Substantiation: The NFPA 79-1997 subclause 4.4 text is the same as the IEC 60204-1 subclause 17.1 second paragraph except “Warning signs,” is added at the beginning of subclause 4.4 paragraph. This addition harmonizes NFPA 79 with IEC 60204-1.

17.2 Warning marking and signs


Substantiation: This revision combines NFPA 79-1997 subclause 4.5 Warning mark and IEC 60204-1 subclause 17.2 Warning signs in order to harmonize with IEC 60204-1.

17.2.1

(a) Add the subclause number 17.2.1 to be in compliance with the NFPA Manual of style.

(b) Delete the NFPA 79-1997 subclause 11.10 heading.

(c) Add the NFPA 79-1997 subclause 11.10 revised first paragraph:

Enclosures that do not clearly show that they contain electrical devices shall be marked with a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol 60417-2: IEC-5036, the whole in accordance with sign B.3.6 of ISO 3864.
17.2.2 Revise the NFPA 79-1997 Figure 3 to Figure XX.

17.2.3 (a) Add the subclause number 17.2.3 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 11.10 third paragraph without changes.

17.2.4 (a) Add the subclause number 17.2.4 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.5.1 paragraph without changes.

17.2.5 (a) Add the subclause number 17.2.5 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.5.2 paragraph without changes.

17.2.6 (a) Add the subclause number 17.2.6 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.5.3 paragraph without changes.

17.3 Function identification

(a) Add the NFPA 79-1997 subclause 4.9 heading.
(b) Revise the NFPA 79-1997 subclause 4.9 paragraph and note and add three notes as follows:

Control devices, visual indicators, and displays used in the man-machine interface shall be clearly and durably marked with regard to their functions either on or adjacent to the unit. Such markings may be as agreed between the user and the supplier of the equipment (see annex B).

Note 1: Such markings may be as agreed between the user and the supplier of the equipment, see Annex B for additional information.

Note 2: For further information on symbols, see IEC 60417 and ISO 7000.

Note 3: Consideration should be given to the use of IEC symbols for pushbuttons (see Annex C for examples).

Substantiation: The NFPA 79-1997 text was revised in order to harmonize with IEC 60204-1.

17.4 Machine nameplate data

Add the NFPA 79-1997 subclause 4.7 heading.

17.4.1 (a) Add the subclause number 17.4.1 to be in compliance with the NFPA Manual of style.
(b) Revise NFPA 79-1997 subclause 4.7.1 paragraph as follows:

Control equipment (e.g. controlgear assemblies) shall be legibly and durably marked in a way that it is plainly visible after the equipment is installed. A nameplate giving the following information shall be attached to the enclosure:
- name or trademark of supplier;
- certification mark, when required;
- serial number, where applicable;
- rated voltage, number of phases and frequency (if a.c.), and full-load current for each supply;
- ampere rating of the largest motor or load;
- short-circuit interrupting capacity of the machine disconnecting means where provided as part of the equipment;
- the electrical diagram number(s) or the number of the index to the electrical drawings.

Substantiation: This is a combination of NFPA 79 1997 subclause 4.7.1 and IEC 60204-1 subclause 17.4 first paragraph. The NFPA 79-1997 text was revised in order to harmonize with IEC 60204-1.

17.4.2 (a) Add the subclause number 17.4.2 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.7.2 paragraph without changes.

17.4.3 (a) Add the subclause number 17.4.3 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.7.1 last sentence without change.

17.4.4 (a) Add the subclause number 17.4.4 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.7.1 exception as a paragraph without text change.

17.4.5 (a) Add the subclause number 17.4.5 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.7.3 paragraph without change.

17.5 Equipment marking and identification

Add the NFPA 79-1997 subclause 4.8 heading.

17.5.1 (a) Add the subclause number 17.5.1 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.8.1 paragraph without change.

17.5.2 (a) Add the subclause number 17.5.2 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.8.2 paragraph without change.

17.5.3 (a) Add the subclause number 17.5.3 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.8.3 paragraph without change.

17.5.4 (a) Add the subclause number 17.5.4 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.8.4 paragraph and exceptions without change.

17.5.5 (a) Add the subclause number 17.5.5 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.8.5 paragraph without changes.
(c) Revise the subclause number in the exception from “4.9” to “17.5.”

17.5.6 (a) Add the subclause number 17.5.6 to be in compliance with the NFPA Manual of style.
(b) Add the NFPA 79-1997 subclause 4.8.6 paragraph without changes.
(a) Add the subclause number 17.5.7 to be in compliance with the NFPA Manual of style.

(b) Add the NFPA 79-1997 subclause 4.8.7 paragraph.

(c) Change the subclause reference number from "8.5.4" to "7.2.10."


<table>
<thead>
<tr>
<th>NFPA 79-1997</th>
<th>Proposed NFPA 79-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause</td>
<td>Heading or Text</td>
</tr>
<tr>
<td>4.4</td>
<td>Markings</td>
</tr>
<tr>
<td>4.5</td>
<td>Warning marking</td>
</tr>
<tr>
<td>11.10</td>
<td>Warning mark</td>
</tr>
<tr>
<td></td>
<td>First paragraph and symbol</td>
</tr>
<tr>
<td></td>
<td>Second paragraph and bullets</td>
</tr>
<tr>
<td>4.5.1</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.5.2</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.5.3</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.6</td>
<td>Machine marking</td>
</tr>
<tr>
<td>4.7</td>
<td>Machine nameplate data</td>
</tr>
<tr>
<td>4.7.1</td>
<td>Paragraph, except last sentence</td>
</tr>
<tr>
<td>4.7.2</td>
<td>Exception</td>
</tr>
<tr>
<td>4.7.3</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.8</td>
<td>Equipment marking and identification</td>
</tr>
<tr>
<td>4.8.1</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.8.2</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.8.3</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.8.4</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.8.5</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.8.6</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.8.7</td>
<td>Paragraph</td>
</tr>
<tr>
<td>4.9</td>
<td>Function identification</td>
</tr>
<tr>
<td></td>
<td>Paragraph and note</td>
</tr>
<tr>
<td>4.10</td>
<td>Last sentence of paragraph</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause</td>
<td>Heading or Text</td>
</tr>
<tr>
<td>17.1</td>
<td>Marking, warning signs and reference designations</td>
</tr>
<tr>
<td>17.1.1</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.1.2</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.2</td>
<td>Warning marking and signs</td>
</tr>
<tr>
<td>17.2.2</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.2.3</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.2.4</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.2.5</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.2.6</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.3</td>
<td>Function identification</td>
</tr>
<tr>
<td>17.4</td>
<td>Machine nameplate data</td>
</tr>
<tr>
<td>17.4.1</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.4.2</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.4.3</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.4.4</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.4.5</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.5</td>
<td>Equipment marking and identification</td>
</tr>
<tr>
<td>17.5.1</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.5.2</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.5.3</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.5.4</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.5.5</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.5.6</td>
<td>Paragraph</td>
</tr>
<tr>
<td>17.5.7</td>
<td>Paragraph</td>
</tr>
</tbody>
</table>

1493
## NFPA 79 — May 2002 ROP

### NFPA 79 CLAUSE 4 (PARTS) AND SUBCLAUSE 11.10 CROSS REFERENCE TO PROPOSED NFPA 79-2000

<table>
<thead>
<tr>
<th>NFPA 79-1997</th>
<th>Proposed NFPA 79-2002</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 Marking, warning signs and reference designations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.1 General</td>
<td>Add IEC 60204-1 Clause 17 heading.</td>
<td></td>
</tr>
<tr>
<td>4.6 Machine marking</td>
<td>The machine shall be marked with the builder’s name, trademark, or other identification symbol.</td>
<td></td>
</tr>
<tr>
<td>17.1.1 The electrical equipment shall be marked with the supplier’s name, trademark, or other identifying symbol and, where required, with a certification mark.</td>
<td>The subclause 4.6 heading meaning is included in the Clause 17 heading. Revise the 4.6 paragraph and move to Clause 17.</td>
<td></td>
</tr>
<tr>
<td>4.4 Markings</td>
<td>Nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.</td>
<td></td>
</tr>
<tr>
<td>17.1.2 Warning signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.</td>
<td>The subclause 4.4 heading meaning is included in the Clause 17 heading. Revise the 4.4 paragraph and move to Clause 17.</td>
<td></td>
</tr>
<tr>
<td>4.5 Warning marking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.2 Warning marking and signs</td>
<td>Revised the subclause 4.5 heading and move to Clause 17.</td>
<td></td>
</tr>
<tr>
<td>11.10 Warning mark</td>
<td>Enclosures that do not clearly show that they contain electrical devices shall be marked with a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol 5036 of IEC 417M, the whole in accordance with symbol 15 of ISO, 3864, as shown in Figure 3.</td>
<td></td>
</tr>
<tr>
<td>17.2.1 Enclosures that do not clearly show that they contain electrical devices shall be marked with a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol 60417-2-IEC-5036, the whole in accordance with sign B.3.6 of ISO 3864:</td>
<td>No change - Move subclause 11.10 third paragraph to Clause 17.</td>
<td></td>
</tr>
<tr>
<td>11.10 (third paragraph) The warning sign shall be plainly visible on the enclosure door or cover.</td>
<td>17.2.2 The warning sign shall be plainly visible on the enclosure door or cover.</td>
<td>No change - Move subclause 11.10 second paragraph to Clause 17.</td>
</tr>
<tr>
<td>11.10 (second paragraph) It is permitted to omit this warning sign on: - an enclosure equipped with a supply disconnecting device; - an operator–machine interface or control station; - a single device with its own enclosure (e.g. position sensor)</td>
<td>17.2.3 It is permitted to omit this warning sign on: - an enclosure equipped with a supply disconnecting device; - an operator–machine interface or control station; - a single device with its own enclosure (e.g. position sensor)</td>
<td>No change – Move subclause 4.5.1 to Clause 17.</td>
</tr>
<tr>
<td>4.5.1 A warning marking shall be provided adjacent to the disconnect operating handle(s) where the disconnect(s) that is interlocked with the enclosure door does not deenergize all exposed live parts when the disconnect(s) is in the &quot;open (off)&quot; position.</td>
<td>17.2.4 A warning marking shall be provided adjacent to the disconnect operating handle(s) where the disconnect(s) that is interlocked with the enclosure door does not deenergize all exposed live parts when the disconnect(s) is in the &quot;open (off)&quot; position.</td>
<td>No change – Move subclause 4.5.2</td>
</tr>
<tr>
<td>4.5.2 Where an attachment plug is used as the disconnecting means, a warning marking shall be attached to the control enclosure door or cover indicating that power shall be disconnected from the equipment before the enclosure is opened.</td>
<td>17.2.5 Where an attachment plug is used as the disconnecting means, a warning marking shall be attached to the control enclosure door or cover indicating that power shall be disconnected from the equipment before the enclosure is opened.</td>
<td>No change – Move subclause 4.5.3 to Clause 17.</td>
</tr>
<tr>
<td>4.5.3 Where the disconnecting means is remote from the control enclosure, a warning marking shall be attached to the enclosure door or cover indicating that the power shall be disconnected from the equipment before the enclosure is opened and that the enclosure is to be closed before the power is restored.</td>
<td>17.2.6 Where the disconnecting means is remote from the control enclosure, a warning marking shall be attached to the enclosure door or cover indicating that the power shall be disconnected from the equipment before the enclosure is opened and that the enclosure is to be closed before the power is restored.</td>
<td>No change – Move subclause 4.5.3 to Clause 17.</td>
</tr>
<tr>
<td>Section</td>
<td>Text</td>
<td>Notes</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>4.9 Function identification</td>
<td>Each control station device (e.g. pushbutton, indicating light, selector switch) shall be identified as to its function on or adjacent to the device.</td>
<td></td>
</tr>
<tr>
<td><strong>NOTE:</strong> Consideration shall be given to the use of IEC symbols for pushbuttons (see Annex C for examples).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.3 Function identification</td>
<td>Control devices, visual indicators, and displays used in the man-machine interface shall be clearly and durably marked with regard to their functions either on or adjacent to the unit.</td>
<td>Revise subclause 4.9 and move to Clause 17.</td>
</tr>
<tr>
<td><strong>Note 1:</strong> Such markings may be as agreed between the user and the supplier of the equipment, see Annex B for additional information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Note 2:</strong> For further information on symbols, see IEC 60417 and ISO 7000.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Note 3:</strong> Consideration should be given to the use of IEC symbols for pushbuttons (see Annex C for examples).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.7 Machine nameplate data</td>
<td>A permanent nameplate listing the machine serial number, supply voltage, phase frequency, full-load current, ampere rating of the largest motor or load, short-circuit interrupting capacity of the machine, overcurrent protective device where furnished as part of the equipment, and the electrical diagram number(s) or the number of the index to the electrical diagrams (bill of material) shall be attached to the control equipment enclosure or machine where plainly visible after installation. Where more than one incoming supply circuit is to be provided, the nameplate shall state the above information for each circuit.</td>
<td></td>
</tr>
<tr>
<td><strong>Exception:</strong> Where only a single motor or motor controller is used, the motor nameplate shall be permitted to serve as the electrical equipment nameplate where it is plainly visible.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.4 Machine nameplate data</td>
<td>The full-load current shown on the nameplate shall not be less than the full-load current specified on the nameplate. Where more than one incoming supply circuit is to be provided, the nameplate shall state the above information for each circuit.</td>
<td>No change – Move subclause 4.7 to Clause 17.</td>
</tr>
<tr>
<td><strong>17.4.1</strong> Control equipment (e.g. controlgear assemblies) shall be legibly and durably marked in a way that it is plainly visible after the equipment is installed. Wherever possible, a nameplate giving the following information shall be attached to the enclosure: – name or trademark of supplier; – certification mark, when required; – serial number, where applicable; – rated voltage, number of phases and frequency (if a.c.), and full-load current for each supply – ampere rating of the largest motor; – short-circuit interrupting capacity of the machine disconnecting means where provided as part of the equipment; – the electrical diagram number(s) or the number of the index to the electrical drawings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>17.4.2</strong> The full-load current shown on the nameplate shall not be less than the full-load currents for all motors and other equipment that can be in operation at the same time under normal conditions of use. Where unusual loads or duty cycles, require oversized conductors, the required capacity shall be included in the full-load current specified on the nameplate.</td>
<td></td>
<td>No change – Move subclause 4.7.2 to Clause 17.</td>
</tr>
<tr>
<td><strong>17.4.3</strong> Where more than one incoming supply circuit is to be provided, the nameplate shall state the above information for each circuit.</td>
<td></td>
<td>No change – Move the last sentence of subclause 4.7.1 to Clause 17.</td>
</tr>
<tr>
<td><strong>17.4.4</strong> Where only a single motor or motor controller is used, the motor nameplate shall be permitted to serve as the electrical equipment nameplate where it is plainly visible.</td>
<td></td>
<td>Change subclause 17.4.4 exception to a paragraph and move to Clause 17.</td>
</tr>
<tr>
<td><strong>17.4.5</strong> Where overcurrent protection is provided in accordance with 8.2, the machine shall be marked &quot;overcurrent protection provided at machine supply terminals.&quot; A separate nameplate shall be permitted to be used for this purpose.</td>
<td></td>
<td>No change – Move subclause 4.7.3 to Clause 17.</td>
</tr>
</tbody>
</table>
### Exception No. 1: Where the size or location of the devices makes individual identification impractical, group identification shall be used.

**Figure XX** – Warning sign on enclosures

- The warning sign shall be plainly visible on the enclosure door or cover.

- It **shall** be permitted to omit this warning sign on:
  - an enclosure equipped with a supply disconnecting device;
  - an operator–machine interface or control station;
  - a single device with its own enclosure (e.g. position sensor)

17.2.4 A warning marking **safety sign** shall be provided adjacent to the disconnect operating handle(s) where the disconnect(s) that is/are interlocked with the enclosure door does not deenergize all exposed live parts when the disconnect(s) is in the "open (off)" position.

17.2.5 Where an attachment plug is used as the disconnecting means, a **warning marking safety sign** shall be attached to the control enclosure door or cover indicating that power shall be disconnected from the equipment before the enclosure is opened.

---

**COMMITTEE ACTION:** Accept in Principle.

Revise to read as follows:

17 Marking, and warning safety signs and reference designations

17.1 General

17.1.1 The electrical equipment shall be marked with the supplier’s name, trademark, or other identifying symbol and/or where required, with a certification mark.

17.1.2 Warning: Safety signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.

17.2 Warning marking and signs

17.2.1 Enclosures that do not clearly show that they contain electrical devices shall be marked with a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol 60947-2:IEC-5036, the whole in accordance with sign B.3.6 of ISO 3864:

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.8.1</td>
<td>Where equipment is removed from its original enclosure or is so placed that the manufacturer's identification plate is not easily read, an additional identification plate shall be attached to the machine or enclosure.</td>
</tr>
<tr>
<td>4.8.2</td>
<td>Where a motor nameplate or connection diagram plate is not visible, additional identification shall be provided where it can be easily read.</td>
</tr>
<tr>
<td>4.8.3</td>
<td>Nameplates, identification plates, or warning markings shall not be removed from the equipment.</td>
</tr>
<tr>
<td>4.8.4</td>
<td>All control panel devices and components shall be plainly identified with the same designation as shown on the diagram(s). This identification shall be adjacent to (not on) the device or component. Exception No. 1: Where the size or location of the devices makes individual identification impractical, group identification shall be used. Exception No. 2: This section need not apply to machines on which the equipment consists only of a single motor, motor controller, pushbutton station(s), and worklight(s).</td>
</tr>
<tr>
<td>4.8.5</td>
<td>All devices external to the control panel(s) shall be identified by a nameplate with the same designation as shown on the diagram(s) and mounted adjacent to (not on) the device. Exception: Devices covered by 4.9.</td>
</tr>
<tr>
<td>4.8.6</td>
<td>Terminations on multi-conductor plugs and receptacles shall be plainly marked. The markings on the plug/receptacle and on drawings shall correspond.</td>
</tr>
<tr>
<td>4.8.7</td>
<td>Where group protection as provided for in 8.5.4 is used, information specifying the short circuit protective device for each group protected motor branch circuit shall be included with the equipment.</td>
</tr>
<tr>
<td>4.8.8</td>
<td>Where equipment is removed from its original enclosure or is so placed that the manufacturer's identification plate is not easily read, an additional identification plate shall be attached to the machine or enclosure.</td>
</tr>
<tr>
<td>4.8.9</td>
<td>Where a motor nameplate or connection diagram plate is not visible, additional identification shall be provided where it can be easily read.</td>
</tr>
<tr>
<td>4.8.10</td>
<td>Nameplates, identification plates, or warning markings shall not be removed from the equipment.</td>
</tr>
<tr>
<td>4.8.11</td>
<td>All control panel devices and components shall be plainly identified with the same designation as shown on the diagram(s). This identification shall be adjacent to (not on) the device or component. Exception No. 1: Where the size or location of the devices makes individual identification impractical, group identification shall be used. Exception No. 2: This section need not apply to machines on which the equipment consists only of a single motor, motor controller, pushbutton station(s), and worklight(s).</td>
</tr>
<tr>
<td>4.8.12</td>
<td>All devices external to the control panel(s) shall be identified by a nameplate with the same designation as shown on the diagram(s) and mounted adjacent to (not on) the device. Exception: Devices covered by 17.3.</td>
</tr>
<tr>
<td>4.8.13</td>
<td>Terminations on multi-conductor plugs and receptacles shall be plainly marked. The markings on the plug/receptacle and on drawings shall correspond.</td>
</tr>
<tr>
<td>4.8.14</td>
<td>Where group protection as provided for in 7.2.10 is used, information specifying the short circuit protective device for each group protected motor branch circuit shall be included with the equipment.</td>
</tr>
</tbody>
</table>
17.5.4 Where the disconnecting means is remote from the control enclosure, a warning marking safety sign shall be attached to the enclosure door or cover indicating that the power shall be disconnected from the equipment before the enclosure is opened and that the enclosure shall not be closed before the power is restored.

17.3 Function identification

Control devices, visual indicators, and displays used in the man-machine interface shall be clearly and durably marked with regard to their functions either on or adjacent to the unit.

Note 1: Such markings may be as agreed between the user and the supplier of the equipment, see Annex B for additional information.

Note 2: For further information on symbols, see IEC 60417 and ISO 7000.

Note 3: Consideration should be given to the use of IEC symbols for pushbuttons (see Annex C, for example).

<<insert The existing Annex C header and the symbols c.3, c.4, c.5 and c.6 from Annex C of NFPA 79-1997 here>>

17.4 Machine nameplate data

17.4.1 Control equipment (e.g., controlgear assemblies) shall be legibly and durably marked in a way that it is plainly visible after the equipment is installed. A nameplate giving the following information shall be attached to the enclosure:

- name or trademark of supplier;
- certification mark, when required;
- serial number, where applicable;
- rated voltage, number of phases and frequency (if a.c.), and full-load current for each supply;
- ampere rating of the largest motor or load;
- short-circuit interrupting capacity of the machine disconnecting means where provided as part of the equipment;
- the maximum ampere rating of the short-circuit and ground-fault protective device, where provided;
- the electrical diagram number(s) or the number of the index to the electrical drawings.

17.4.2 The full-load current shown on the nameplate shall not be less than the full-load currents for all motors and other equipment that can be in operation at the same time under normal conditions of use. Where unusual loads or duty cycles require oversized conductors, the required capacity shall be included in the full-load current specified on the nameplate.

17.4.3 Where more than one incoming supply circuit is to be provided, the nameplate shall state the above information for each circuit.

17.4.4 Where only a single motor or motor controller is used, the motor nameplate shall be permitted to serve as the electrical equipment nameplate where it is plainly visible.

17.4.5 Where overcurrent protection is provided in accordance with 7.2.3, the machine shall be marked “overcurrent protection provided at machine supply terminals.” A separate nameplate shall be permitted to be used for this purpose.

17.5 Equipment marking and identification

17.5.1 Where equipment is removed from its original enclosure or is so placed that the manufacturer’s identification plate is not easily read, an additional identification plate shall be attached to the machine or enclosure.

17.5.2 Where a motor nameplate or connection diagram plate is not visible, additional identification shall be provided where it can be easily read.

17.5.3 Nameplates, identification plates, or warning marking safety sign shall not be removed from the equipment.

17.5.4 All control panel devices and components shall be plainly identified with the same designation as shown on the diagram(s). This identification shall be adjacent to (not on) the device or component.

Exception No. 1: Where the size or location of the devices makes individual identification impractical, group identification shall be used.

Exception No. 2: This section shall not be required to apply to machines on which the equipment consists only of a single motor, motor controller, pushbutton station(s), and worklight(s).

17.5.5 All devices external to the control panel(s) shall be identified by a nameplate with the same designation as shown on the diagram(s) and mounted adjacent to (not on) the device.

Exception: Devices covered by 17.3

17.5.6 Terminations on multicore plugs and receptacles shall be plainly marked. The markings on the plug/receptacles and on drawings shall correspond.

17.5.7 Where group protection as provided for in 7.2.10 is used, information specifying the short circuit protective device for each group protected motor branch circuit shall be included with the equipment.

COMMITTEE STATEMENT: The following changes are made to the proposed text:

1) Title was changed because the reference to “reference designations” does not exist in Clause 17.
2) Change text throughout to comply with the NFPA Manual of style.
3) Change the term “warning sign” to “safety sign” throughout the clause for clarity.
4) In 17.2.6, editorially change “is to” to “shall” to comply with the NFPA Manual of Style.
5) Note 3 was revised to place the reatin the NFPA 79-1997, Annex C symbols and place them here, in the body of Note 3.
6) In 17.4.1 Delete the parenthetical expression (e.g., controlgear assemblies) for consistency within the document and because the term “controlgear assemblies” was deleted from Clause 3 and Clause 12.
7) In 17.4.1, delete the second bullet - “certification mark where required” because of document consistency and this list is not exclusive.
8) The removal of the fifth bullet of 17.4.1 is because the short-circuit current rating of the machine is not necessarily the same as the short-circuit current rating of the supply disconnecting means.
9) A new bullet was added to 17.4.1 to correlate with the NEC section, 670-3(a), first paragraph.
10) Replace the phrase “short-circuit interrupting capacity” with “short-circuit current rating” because the revised term is technically correct and matches the product standards.
11) In 17.2.3 Replace “is” with “shall” to conform with the NFPA Manual of Style.
12) In 17.3, Note 3, add symbols c.3 through c.6 to follow existing text including the introductory header because the committee believes it is worthwhile material. Remove the parenthetical reference for style.
13) In 17.5.3, change “warning marking” to “safety sign” for clarity and document consistency.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 28

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1

EXPLANATION OF NEGATIVE:

FAUST: I am in agreement with most of the committee action. The following comments are directed at 17.4.1, specifically the interrupting capacity data shown on a nameplate. The interrupting capacity of a piece of equipment is a necessary parameter in determining the amount of fault current that can be safely tolerated by a piece of equipment. In a properly coordinated electrical distribution scheme, the available fault current is limited to a “safe level” by the facility that feeds the equipment. The “safe level” should be identified on the machine nameplate. This should be a requirement of the equipment provider since they are responsible for the construction of the equipment. The “safe level” IS NOT the AIC value of the main circuit breaker. I can build any type of system and add a main circuit breaker with a 250,000 AIC breaker upstream of the system even though it may only be able to withstand a fault current of 15,000 AIC. Therefore the AIC value on the nameplate should be the withstand capability of the equipment. NFPA 79 should direct equipment manufacturers to a “safe requirement”.

1497
These concepts are applicable to a single motor unit as well as a large complicated piece of equipment. If a fault cannot be mitigated by the equipment design then the design is unsafe. The nameplate should require all of the necessary information to allow a determination on the appropriate electrical service requirements.

The following bullet should be required on the nameplate:

- short-circuit interrupting capacity of the machine

**COMMENTS ON AFFIRMATIVE:**

SAUNDERS: Do not agree with the committee action to delete the fifth bullet of 17.4.1.

The existing NEC requirement in Article 670-3(a) requires;

(a) Permanent Nameplate. A permanent nameplate that lists supply voltage, phase, frequency, full-load current, the maximum ampere rating of the short-circuit and ground-fault protective device, ampere rating of largest motor or load, short-circuit interrupting capacity of the machine overcurrent-protective device, if furnished.

The text in NFPA 79-1997 and as proposed in the original proposal for Clause 17 would require "short circuit interrupting capacity of the machine disconnecting means where provided as part of the equipment".

The Committee action to change the test to "short circuit current rating" should be accepted and the bullet should remain in the list.

This information applied on the machine nameplate is a better step in ensuring the coordination with supply system short circuit available currents and the capability of the "machine mounted" disconnect device then no label at all. This label does not address the concern of the "short circuit capability" of all the internal machine power and control components which must be addressed as part of the equipment design, selection, testing and evaluation, that is required for the system. This problem is not addressed by the elimination of the nameplate requirement.

**WITHROW:** COMMITTEE STATEMENT: 8) The removal of the fifth bullet of 17.4.1 is because the short-circuit current rating of the machine is not necessarily the same as the short-circuit current rating of the supply disconnecting means.

10) Replace the phrase "short circuit interrupting capacity" with "short-circuit current rating" because the revised term is technically correct and matches the product standards.

**REFERENCE:**

1. NFPA 79-2002 17.4.1 (proposed sixth bullet deleted by item 8): A nameplate giving the following information shall be attached to the enclosure:

- short-circuit interrupting capacity of the machine disconnecting means where provided as part of the equipment.

2. The source of subclause 17.4.1 sixth bullet is IEC 60947-1 and replaces NFPA 79-1997 subclause 4.7.1.

3. NFPA 79-1997 subclause 4.7.1 reads "short-circuit interrupting capacity of the machine overcurrent protective device where furnished as part of the equipment."

4. NFPA 79-1997 Article 670-3 (a) reads "short-circuit interrupting capacity of the machine overcurrent protective device, if furnished."

5. NFPA 70-2002 draft of Article 670-3 (a) reads "short-circuit interrupting rating of the machine overcurrent-protective device, if furnished."

**COMMENTS:** Item 8: NFPA 70 Article 670-3 (a) states that the nameplate short-circuit interrupting rating is the machine overcurrent protective device and not the short-circuit interrupting rating of system. Therefore, this bullet was correct and should not have been removed. When NFPA 70 Article 670-3 (a) is revised to define the short-circuit interrupting rating as the system, the NFPA 79 Committee should revise this subclause accordingly. Until the Code is revised NFPA 70 should follow the Code requirement for this bullet.

While it is true that "the short-circuit current rating of the machine is not necessarily the same as the short-circuit current rating of the supply disconnecting means", the intent of NFPA 79-1997 and the Code is that the nameplate shall show the short-circuit interrupting rating of the machine overcurrent protective device (disconnecting means), if furnished. When the machine user requires specific information on the short-circuit interrupting rating of the machine system, the request should be made in Annex B. A separate nameplate with the short-circuit interrupting rating of the machine system can be attached to the enclosure.

Item 10: The Committee revised the above 17.4.1 bullet requirement before it was deleted in item 8. The Committee replaced the phrase "short-circuit interrupting capacity" with "short-circuit current rating" because the revised term is technically correct and matches the product standards.

**REFERENCE:**

79-19 - (Clause 4 [Clause 18]): Accept in Principle

**SUBMITTER:** Gary J. Locke, Lockheed Martin Systems Integration

**RECOMMENDATION:** This proposal is to revise NFPA 79-1997 Clause 4 "Diagrams, instructions and nameplates" (through 4.3.4 only) and issue as new Clause 18 "Technical Documentation" as follows:

18. Technical documentation

18.1 General

18.1.1 The information necessary for installation, operation, and maintenance of the electrical equipment of a machine shall be supplied in the form of drawings, diagrams, charts, tables, and instructions as appropriate.

**The information provided may vary with the complexity of the electrical equipment. For very simple equipment, the relevant information may be compiled in one document, provided this document shows all the details of the electrical equipment and enables the connections to the supply network to be made.**

18.1.2 The machinery supplier shall ensure that the technical documentation specified in this clause is provided with each machine.

18.1.3 Technical documentation shall be permitted to be supplied in an agreed upon format.

18.2 Information to be provided

The following information shall be provided with the electrical equipment:

a) Clear, comprehensive description of the equipment, installation and mounting, and the connection to the electrical supply(ies).

b) Electrical supply(ies) requirements.

c) Information on the physical environment (e.g. lighting, vibration, noise levels, atmospheric contaminants) where appropriate.

d) Overview (block) diagram(s) where appropriate.

e) Schematic diagram(s).

f) Information (where appropriate) on:

1. Programming
2. Sequence of operation(s)
3. Frequency of inspection
4. Frequency and method of functional testing
5. Guidance on the adjustment, maintenance, and repair, particularly of the protective devices and circuits, and
6. Interconnection diagram
7. Panel layouts
8. Instruction and service manuals.
g) A description (including interconnection diagrams) of the safeguards interacting functions, and interlocking of guards with potentially hazardous motions, particularly with interacting installations.

h) A description of the safeguarding means and methods provided where the primary safeguards are suspended (e.g. manual programming, program verification).

i) Information for Safety Lockout Procedure (where appropriate).

j) Explanation of unique terms.

k) Parts list and recommended spare parts list.

l) Maintenance instructions and adjustment procedures.

m) The following shall be furnished for reference only where appropriate:
   - Lubrication diagram
   - Pneumatic diagram
   - Hydraulic diagram
   - Miscellaneous system diagrams (e.g., coolant, refrigerant).

18.3 Requirements applicable to all documentation

18.3.1 The documents shall be prepared in accordance with the requirements of 18.4 through 18.10.

18.3.2 For referencing of the different documents, the supplier shall select one of the following methods:
   - each of the documents shall carry as a cross-reference the document numbers of all other documents belonging to the electrical equipment; or
   - all documents shall be listed with document numbers and titles in a drawing or document list.

The first method shall be used only where the documentation consists of four or less documents

18.4 Basic information

The technical documentation shall contain, as a minimum, information on the following:
   - normal operating conditions of the electrical equipment including the expected conditions of the electrical supply, and where appropriate, the physical environment;
   - handling, transportation and storage;
   - inappropriate use(s) of the equipment.

That information may be presented as a separate document or as part of the installation or operation documentation.

NOTE: The documentation should also contain, where appropriate, information regarding load currents, peak starting currents and permitted voltage drops. That information should be contained in either the system or circuit diagram(s).

18.5 Installation diagram

18.5.1 The installation diagram shall provide all information necessary for the preliminary work of setting up the machine.

NOTE: In complex cases, it may be necessary to refer to the assembly drawings for details.

18.5.2 The specified position, type, and cross-sectional areas of the supply cables to be installed on site shall be clearly indicated.

18.5.3 The data necessary for choosing the type, characteristics, rated currents, and setting of the overcurrent protective device(s) for the supply conductors to the electrical equipment of the machine shall be stated (see 7.2.2).

18.5.4 Where necessary, the size, purpose, and location of any raceways (ducts) in the foundation that are to be provided by the user shall be detailed (see annex B).

18.5.5 The size, type, and purpose of raceways (ducts), cable trays, or cable supports between the machine and the associated equipment that are to be provided by the user shall be detailed (see annex B).

18.5.6 Where necessary, the diagram shall indicate where space is required for the removal or servicing of the electrical equipment.

NOTE: Examples of installation diagrams can be found in IEC 61082-4.

18.5.7 In addition, where it is appropriate an interconnection diagram or table shall be provided. That diagram or table shall give full information about all external connections. Where the electrical equipment is intended to be operated from more than one source of electrical supply, the interconnection diagram or table shall indicate the modifications or interconnections required for the use of each supply.

NOTE: Examples of interconnection diagrams/tables can be found in IEC 61082-3.

18.6 Block (system) diagrams and function diagrams

Where it is necessary to facilitate the understanding of the principles of operation, a system diagram shall be provided. A block diagram symbolically represents the electrical equipment together with its functional interrelationships without necessarily showing all of the interconnections.

NOTE 1: Examples of block diagrams can be found in IEC 61082-1 Section 2. Further rules and examples can be found in Section 3 of IEC 61082-2.

NOTE 2: Function diagrams may be used as either part of, or in addition to, the block diagram.

NOTE 3: Examples of function diagrams can be found in Section 4 of IEC 61082-1 and in section 4 of IEC 61082-2.

18.7 Circuit diagrams

18.7.1 Diagrams, including machine schematics, of the electrical system shall be provided and shall show the electrical circuits on the machine and its associated electrical equipment. Any electrical symbols shall be in accordance with IEEE 315. Any electrical symbols not shown in IEEE 315 standards shall be separately shown and described on the diagrams. The symbols and identification of components and devices shall be consistent throughout all documents and on the machine.

Exception: Wiring schematics shall not be required for commercially available or field replaceable components.

18.7.2 Pertinent information such as motor horsepower, frame size, and speed shall be listed adjacent to its symbol.

NOTE: Examples of circuit diagrams can be found in IEC 61082-1 and in section 5 of IEC 61082-2.

18.7.3 Where appropriate, a diagram showing the terminals for interface connections shall be provided. That diagram may be used in conjunction with the circuit diagram(s) for simplification. The diagram should contain a reference to the detailed circuit diagram of each unit shown.

Switch symbols shall be shown on the electromechanical diagrams with all supplies turned off (e.g. electricity, air, water, lubricant) and with the machine and its electrical equipment in the normal starting condition.

18.7.4 Conductors shall be identified in accordance with 14.2.

18.7.5 Circuits shall be shown in such a way as to facilitate the understanding of their function as well as maintenance and fault location. Characteristics relating to the function of the control devices and components which are not evident from their symbols...
representation shall be included on the diagrams adjacent to the symbol or referenced to a note.

18.7.6 Control circuit devices shall be shown between vertical lines that represent control power wiring. The left vertical line shall be the control circuit, and the right line shall be the operating coils common, except where permitted by Clause 9 design requirements. Control devices shall be shown on horizontal lines (rungs) between the vertical lines. Parallel circuits shall be shown on separate horizontal lines directly adjacent to (above or below) the original circuit.

18.7.7 An interconnection diagram shall be provided on large systems having a number of separate enclosures or control stations. It shall provide full information about the external connections of all of the electrical equipment on the machine.

18.7.8 Interlock wiring diagrams shall include devices, functions, and conductors in the circuit where used.

18.7.9 Plug/receptacle pin identification shall be shown on the diagram(s).

18.8 Operating manual

18.8.1 The technical documentation shall contain an operating manual detailing proper procedures for set-up and use of the equipment. Particular attention should be given to the safety measures provided and to the improper methods of operation that are anticipated.

18.8.2 Where the operation of the equipment can be programmed, detailed information on methods of programming, equipment required, program verification, and additional safety procedures (where required) shall be provided.

18.9 Maintenance manual

18.9.1 The technical documentation shall contain a maintenance manual detailing proper procedures for adjustment, servicing and preventive inspection, and repair.

NOTE: Recommendations on maintenance/service records should be part of that manual.

18.9.2 Where methods for the verification of proper operation are provided (e.g. software testing programs), the use of those methods shall be detailed.

18.10 Parts list

18.10.1 The parts list shall comprise, as a minimum, information necessary for ordering spare or replacement parts (e.g. components, devices, software, test equipment, technical documentation) required for preventive or corrective maintenance including those that are recommended to be carried in stock by the user of the equipment.

18.10.2 The parts list shall show for each item:
- the reference designation used in the documentation
- its type designation
- the supplier and alternative sources where available
- its general characteristics where appropriate
- the quantity of items with the same reference designation

SUBSTANTIATION:

Historical Background

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization - Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC-60204-1.

Importance of Issue - Harmonization

Today’s industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization - Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause X with IEC 60204-1 Clause 18. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber Clause X of NFPA-79-1997 to correspond with IEC 60204-1. The task group proposes the following changes to further improve useability:

18 Technical documentation


Substantiation: In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this Clause heading was brought over intact from 60204-1. This new Clause 18 parallels the old Clause 4.

18.1 General

Proposal: Add section. Add text as shown. Number section 18.1.

Substantiation: In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over virtually intact from 60204-1. Minor text alterations were effected so as to add clarity, and create consistency with the rest of this document.

18.1.1 Proposal: Add section. Add text as shown. Number section 18.1.1

Substantiation: In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over virtually intact from 60204-1. The new text serves the same function as the first sentence of NFPA-79 4.2.1.

18.1.2 Proposal: Reword first sentence of NFPA 79-1997, 4.2.1 as shown. Number section 18.1.2

Substantiation: In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over intact from 60204-1. The new text serves the same function as the first sentence of NFPA-79-1997.

18.1.3 Proposal: Add section. Add text as shown. Number section 18.1.3

Substantiation: This section was added to permit electronic format only if it is agreed upon.

18.2 Information to be provided

Proposal: Add section. Add text as shown. Number section 18.2.

18.2a) Proposal: Add text as shown and number as 18.2a)

18.2b) Proposal: Add text as shown. Number section 18.2b)

18.2c) Proposal: Add text as shown. Number section 18.2c)

18.2d) Proposal: Add text as shown. Number section 18.2d)

18.2e) Proposal: Add text as shown. Number section 18.2e)
18.2f) Proposal: Add text as shown. Number section as 18.2f).

18.2f)1 Proposal: Reformat elements of NFPA 79-1997, 4.3.3 as shown and renumber as 18.2f)1.

18.2f)2 Proposal: Reformat elements of NFPA 79-1997, 4.3.3 as shown and renumber as 18.2f)2.

18.2f)3 Proposal: Reformat elements of NFPA 79-1997, 4.3.5 a shown and renumber as 18.2f)3.

18.2f)4 Proposal: Reformat elements of NFPA 79-1997, 4.3.5 a shown and renumber as 18.2f)4.

18.2f)5 Proposal: Reformat elements of NFPA 79-1997, 4.3.5 a shown and renumber as 18.2f)5.

18.2f)6 Proposal: Move NFPA 79-1997, 4.1.1 sixth dash as shown and number as 18.2f)6.

18.2f)7 Proposal: Move NFPA 79-1997, 4.1.1 fifth dash as shown and number as 18.2f)7.

18.2f)8 Proposal: Move NFPA 79-1997, 4.1.1 ninth dash as shown and number as 18.2f)8.

18.2g) Proposal: Reword NFPA 79-1997, 4.2.7 and 4.2.8 as shown and renumber as 18.2g).

18.2h) Proposal: Add text as shown. Number section as 18.2h).

18.2i) Proposal: Move NFPA 79-1997, 4.1.1 tenth dash as shown and number as 18.2i).

18.2j) Proposal: Reformat elements of NFPA 79-1997, 4.3.1 as shown and renumber as 18.2j).

18.2k) Proposal: Reformat elements of NFPA 79-1997, 4.3.1 as shown and renumber as 18.2k).

18.2l) Proposal: Reformat elements of NFPA 79-1997, 4.3.1 as shown and renumber as 18.2l).

18.2m) Proposal: Move NFPA 79-1997, 4.1.2 as shown and number as 18.2m).

Substantiation (applicable to all of 18.2): These provisions provide comprehensive requirements that are currently stated in NFPA79-1997, Clause 4 and provide information necessary for the proper site preparation, installation, operation and maintenance.

18.3 Requirements applicable to all documentation Proposal: Add section. Add text as shown. Number section 18.3.

18.3.1 Proposal: Add section. Add text as shown. Number section 18.3.1

18.3.2 Proposal: Add section. Add text as shown. Number section 18.3.2

Substantiation (applicable to all of 18.3): Inclusion of this requirement serves to facilitate enhancements to safety relative to installations and maintenance and repair operations by providing pertinent information that might otherwise be omitted or neglected.

18.4 Basic information Proposal: Add section. Add text as shown. Number section 18.4.

Substantiation: In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over intact from 60204-1 Clause 18.4. This text was included expressly for the purpose of harmonization, and is comparable to existing text found in NFPA 79 Clause 4.3.1.

18.5 Installation diagram Proposal: Add section. Add text as shown. Number section 18.5.

18.5.1 Proposal: Add section. Add text as shown. Number section 18.5.1.

18.5.2 Proposal: Add section. Add text as shown. Number section 18.5.2.

18.5.3 Proposal: Add section. Add text as shown. Number section 18.5.3.

18.5.4 Proposal: Add section. Add text as shown. Number section 18.5.4.

18.5.5 Proposal: Add section. Add text as shown. Number section 18.5.5.

18.5.6 Proposal: Add section. Add text as shown. Number section 18.5.6.

18.5.7 Proposal: Add section. Add text as shown. Number section 18.5.7

Substantiation (applicable to all of 18.5): In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over intact from 60204-1 Clause 18.2.e). This text was included expressly for the purpose of harmonization, and is comparable to existing text found in NFPA 79 Clause 4.3.2.

18.6 Block (system) diagrams and function diagrams Proposal: Add section. Add text as shown. Number section 18.6.

Substantiation: In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over intact from 60204-1 Clause 18.6. Minor text alterations were effected so as to add clarity, and create consistency with the rest of this document. This text was included expressly for the purpose of harmonization, and is comparable to existing text found in NFPA 79 Clause 4.3.3.

18.7 Circuit diagrams Proposal: Add section. Add text as shown. Number section 18.7.

18.7.1 Proposal: Move NFPA 79-1997, 4.2.1 first paragraph as shown. Number section 18.7.1. Add text as shown.

18.7.2 Proposal: Move NFPA 79-1997, 4.2.1 second paragraph as shown. Number section 18.7.2.

18.7.3 Proposal: Reword NFPA 79-1997, 4.2.4 as shown. Number section 18.7.3.

18.7.4 Proposal: Reword NFPA 79-1997, 4.2.5 as shown. Number section 18.7.4.

18.7.5 Proposal: Reword elements of NFPA 79-1997, 4.2.6 as shown. Number section 18.7.5.

18.7.6 Proposal: Move elements of NFPA 79-1997, 4.2.6 as shown. Number section 18.7.6.

18.7.7 Proposal: Move NFPA 79-1997, 4.2.7 as shown. Number section 18.7.7.

18.7.8 Proposal: Move NFPA 79-1997, 4.2.8 as shown. Number section 18.7.8.
18.7.9 Proposal: Move NFPA 79-1997, 4.2.9 as shown. Number section 18.7.9

Substantiation (applicable to all of 18.7): This clause is primarily the existing text found in NFPA 79 Clause 4.2 with a new introductory sentence. The exception is necessary to permit manufacturers protect their intellectual property rights.


18.8.2 Proposal: Add section. Add text as shown. Number section 18.8.2.

Substantiation (applicable to all of 18.8): In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over from 60204-1 Clause 18. This text was included expressly for the purpose of harmonization, and although not a verbatim rendition - it is substantially comparable to the existing text found in NFPA 79 Clause 4.3.3.


18.9.1 Proposal: Add section. Add text as shown. Number section 18.9.1.

18.9.2 Proposal: Add section. Add text as shown. Number section 18.9.2.

Substantiation (applicable to all of 18.9): In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over from 60204-1 Clause 18. Minor text alterations were effected so as to add clarity, and create consistency with the rest of this document. This text was included expressly for the purpose of harmonization, and although less comprehensive in nature - is substantially comparable to existing text found in NFPA 79 Clause 4.3.5.

18.10 Parts list Proposal: Add section. Add text as shown. Number section 18.10.

18.10.1 Proposal: Add section. Add text as shown. Number section 18.10.1.

18.10.2 Proposal: Add section. Add text as shown. Number section 18.10.2.

Substantiation (applicable to all of 18.10): In order to facilitate the harmonization of IEC 60204-1 and NFPA 79, this text was brought over intact from 60204-1 Clause 18. Minor text alterations were effected so as to add clarity, and create consistency with the rest of this document. This text was included expressly for the purpose of harmonization, and although far more detailed in nature - is comparable to existing text found in NFPA 79 Clause 4.3.4.

CLAUSE NUMBERS: NFPA 79-1997 CROSS REF. TO PROPOSED NFPA 79-2002

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause 4</td>
<td>Clause 18</td>
</tr>
<tr>
<td>Heading (or topic)</td>
<td>Heading (or topic)</td>
</tr>
<tr>
<td>4.1 General</td>
<td>18.1 General</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.1.1 (The information necessary...)</td>
</tr>
<tr>
<td>4.2 Diagrams, instructions, and nameplates</td>
<td>18.1.2 (Technical documentation)</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.1.3 (Technical documentation)</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2 Information to be provided</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2a) (Clear, comprehensive...)</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2b) (Electrical supply(ies)...</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2c) (Information on the...)</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2d) (Overview (block)...</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2e) (Schematic diagram(s)...</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2f) (Information...)</td>
</tr>
<tr>
<td>4.3.3 Information referring to parts</td>
<td>18.2f)1 (Programming)</td>
</tr>
<tr>
<td>4.3.4 (Maintenance and...)</td>
<td>18.2f)2 (Sequence of operation(s))</td>
</tr>
<tr>
<td>4.3.5 (Maintenance and...)</td>
<td>18.2f)3 (Frequency of inspection)</td>
</tr>
<tr>
<td>4.3.6 (Maintenance and...)</td>
<td>18.2f)4 (Frequency and method...)</td>
</tr>
<tr>
<td>4.3.7 (Maintenance and...)</td>
<td>18.2f)5 (Guidance on the...)</td>
</tr>
<tr>
<td>4.1.1 (The following...)</td>
<td>18.2f)6 (Interconnection diagram)</td>
</tr>
<tr>
<td>4.1.2 (The following...)</td>
<td>18.2f)7 (Panel layouts)</td>
</tr>
<tr>
<td>4.1.3 (The following...)</td>
<td>18.2f)8 (Instruction and...)</td>
</tr>
<tr>
<td>4.1.4 (The following...)</td>
<td>18.2g) (A description...)</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.2h) (A description...)</td>
</tr>
<tr>
<td>4.1.5 (The following...)</td>
<td>18.2i) (Information for...)</td>
</tr>
<tr>
<td>4.3.1 Information referring to...</td>
<td>18.2j) (Explanation of...)</td>
</tr>
<tr>
<td>4.3.1 (Information referring...)</td>
<td>18.2k) (Parts list...)</td>
</tr>
<tr>
<td>4.3.2 Information referring to...</td>
<td>18.2l) (Maintenance...)</td>
</tr>
<tr>
<td>4.1.2 (The following...)</td>
<td>18.2m) (The following...)</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.3 Requirements applicable to all documentation</td>
</tr>
<tr>
<td>4.2 Diagrams</td>
<td>18.3.1 (The documents shall...)</td>
</tr>
<tr>
<td>(not in NFPA 79-1997)</td>
<td>18.3.2 (For referencing of...)</td>
</tr>
<tr>
<td>4.3.3 Information referring to...</td>
<td>18.3.3 Basic information</td>
</tr>
<tr>
<td>4.3.2 (The installation drawing(s)...</td>
<td>18.3.4 Installation diagram</td>
</tr>
<tr>
<td>4.3.1 (The installation drawing(s)...</td>
<td>18.3.5 (The installation diagram)</td>
</tr>
<tr>
<td>4.3.2 (The installation drawing(s)...</td>
<td>18.3.6 (The specified position...)</td>
</tr>
<tr>
<td>4.3.1 (The installation drawing(s)...</td>
<td>18.3.7 (The data necessary...)</td>
</tr>
<tr>
<td>4.3.2 (The installation drawing(s)...</td>
<td>18.3.8 (Where necessary...)</td>
</tr>
<tr>
<td>4.3.2 (The installation drawing(s)...</td>
<td>18.3.9 (The size, type, and purpose...)</td>
</tr>
<tr>
<td>4.3.2 (The installation drawing(s)...</td>
<td>18.3.10 (Where necessary...)</td>
</tr>
<tr>
<td>4.3.2 (The installation drawing(s)...</td>
<td>18.3.11 (In addition...)</td>
</tr>
<tr>
<td>4.3.3 (The description of...)</td>
<td>18.3.12 Block (system) diagrams and function diagrams</td>
</tr>
</tbody>
</table>

1502
18 Technical documentation

18.1 General

The information necessary for installation, operation, and maintenance of the electrical equipment of a machine shall be supplied in the form of drawings, diagrams, charts, tables, and instructions as appropriate. The information provided may vary with the complexity of the electrical equipment. For very simple equipment, the relevant information may be contained in one document, provided this document shows all the devices of the electrical equipment and enables the connections to the supply network to be made.

18.1.2 The machinery supplier shall ensure that the technical documentation specified in this clause is provided with each machine.

18.1.3 Technical documentation shall be permitted to be supplied in an agreed upon format.

18.2 Information to be provided

The following information shall be provided with the electrical equipment:

- a) Clear, comprehensive description of the equipment, installation and mounting, and the connection to the electrical supply(ies).
- b) Electrical supply circuit(s) requirements.
- c) Information on the physical environment (e.g. lighting, vibration, noise levels, atmospheric contaminants) where appropriate.
- d) Overview (block) diagram(s) where appropriate.
- e) Schematic diagram(s).
- f) Information (where appropriate) on:
  - g) Programming
  - h) Sequence of operation(s)
  - i) Frequency of inspection
  - j) Frequency and method of functional testing
  - k) Guidance on the adjustment, maintenance, and repair, particularly of the protective devices and circuits and
  - l) Interconnection diagram
  - m) Reference information (where appropriate) on:
    - 1. Lubrication diagram
    - 2. Pneumatic diagram
    - 3. Hydraulic diagram
    - 4. Miscellaneous system diagrams (e.g., coolant, refrigerant).
- l) Parts list
- m) Instruction and service manuals.
- n) Physical environment (e.g. lighting, vibration, noise levels, atmospheric contaminants).
- o) A description (including interconnection diagrams) of the safeguards, interacting functions, and interlocking of guards with potentially hazardous motions, particularly with interacting installations.
- p) A description of the safeguarding means and methods provided where the primary safeguards are suspended or overridden (e.g. manual programming, program verification).
- q) Information for Safety Lockout Procedure (where appropriate).
- r) Explanation of unique terms.
- s) Parts list and recommended spare parts list.
- t) Maintenance instructions and adjustment procedures.

18.3 Requirements applicable to all documentation

18.3.1 The documents shall be prepared in accordance with the requirements of 18.4 through 18.10.

18.3.2 For referencing of the different documents, the supplier shall select one of the following methods:

- a) each of the documents shall carry as a cross-reference the document numbers of all other documents belonging to the electrical equipment; or
- b) all documents shall be listed with document numbers and titles in a drawing or document list.

The first method shall be used only where the documentation consists of four or less documents.
18.3.3 Where appropriate, a table of contents shall appear prominently on the first sheet and shall refer to all major sections of the electrical drawings.

NOTE: This was added to correct an inadvertent omission from NFPA 79-1997, 4.1.3.>>

18.4 Basic information

The technical documentation shall contain, as a minimum, information on the following:
- normal operating conditions of the electrical equipment including the expected conditions of the electrical supply, and where appropriate, the physical environment;
- handling, transportation and storage;
- inappropriate use(s) of the equipment.

That information, The technical documentation, shall be permitted to be presented as a separate document or as part of the installation or operation documentation.

NOTE: The technical documentation should also contain, where appropriate, information regarding load currents, peak starting currents and permitted voltage drops. That information should be contained in either the system or circuit diagram(s).

18.5 Installation diagram

18.5.1 The installation diagram shall provide all information necessary for the preliminary work of setting up the machine.

NOTE: In complex cases, it may be necessary to refer to the assembly drawings for details.

18.5.2 The specified position, type, and cross-sectional area of the supply cables of the electrical supply, to be installed on site shall be clearly indicated.

18.5.3 The data necessary for choosing the type, characteristics, rated currents, and setting of the overcurrent protective device(s) for the supply circuit conductors to the electrical equipment of the machine shall be stated.

Note: For further information regarding supply circuit conductors, see 7.2.2.

18.5.4 Where necessary, the size, purpose, and location of any raceways (ducts) in the foundation that are to be provided by the user shall be detailed.

Note: For recommendations concerning supplier agreements, see annex B.

18.5.5 The size, type, and purpose of raceways (ducts), cable trays, or cable supports between the machine and the associated equipment that are to be provided by the user shall be detailed.

Note: For recommendations concerning supplier agreements, see annex B.

18.5.6 Where necessary, the diagram shall indicate where space is required for the removal or servicing of the electrical equipment.

NOTE: Examples of installation diagrams can be found in IEC 61082-4.

18.5.7 In addition, where it is appropriate an interconnection diagram or table shall be provided. That diagram or table shall give full information about all external connections. Where the electrical equipment is intended to be operated from more than one source of electrical supply, the interconnection diagram or table shall indicate the modifications or interconnections required for the use of each supply.

NOTE: Examples of interconnection diagrams/tables can be found in IEC 61082-3.

18.6 Block (system) diagrams and function diagrams

Where it is necessary to facilitate the understanding of the principles of operation, a system diagram shall be provided. A block diagram symbolically represents the electrical equipment together with its functional interrelationships without necessarily showing all of the interconnections.

NOTE 1: Examples of block diagrams can be found in IEC 61082-1 Section 2. Further rules and examples can be found in Section 3 of IEC 61082-2.

NOTE 2: Function diagrams may be used as either part of, or in addition to, the block diagram.

NOTE 3: Examples of function diagrams can be found in Section 4 of IEC 61082-1 and in section 4 of IEC 61082-2.

18.7 Circuit diagrams

18.7.1 Diagrams, including machine schematics, of the electrical system shall be provided and shall show the electrical circuits on the machine and its associated electrical equipment. Any electrical equipment is intended to be operated from more than one source of electrical supply, the interconnection diagram or table shall be provided. That diagram or table shall be clearly indicated.

Note: For recommendations concerning supplier agreements, see annex B.

18.7.2 Pertinent information such as motor horsepower, frame size, and speed shall be listed adjacent to its symbol.

NOTE: Examples of circuit diagrams can be found in IEC 61082-1 and in section 5 of IEC 61082-2.

18.7.3 Where appropriate, a diagram showing the terminals for interface connections shall be provided. That diagram may be used in conjunction with the circuit diagram(s) for simplification. The diagram should contain a reference to the detailed circuit diagram of each unit shown.

Switch symbols shall be shown on the electromechanical diagrams with all supplies turned off (e.g. electricity, air, water, lubricant) and with the machine and its electrical equipment in the normal starting condition and at 20 degrees C (68 degrees F) ambient.

Control settings shall be shown on the drawing diagram.~

Note: The diagram showing the terminals for interface connections may be used in conjunction with the circuit diagram(s) for simplification. The diagram should contain a reference to the detailed circuit diagram of each unit shown.

18.7.4 Conductors shall be identified in logical order, in accordance with 14.2.

18.7.5 Circuit characteristics

18.7.5.1 Circuits shall be shown in such a way as to facilitate the understanding of their function as well as maintenance and fault location. Characteristics, relating to the function of the normal devices and components which are not evident from their symbolic representation shall be included on the diagrams adjacent to the symbol or referenced to a note.

18.7.5.2 A cross-referencing scheme shall be used in conjunction with each relay, output device, limit switch, and pressure switch so that any contact associated with the device can be readily located on the diagrams.

18.7.6 Control circuit devices shall be shown between vertical lines that represent control power wiring. The left vertical line shall be the control circuits common and the right line shall be the operating coils common, except where permitted by Clause 9 design requirements. Control devices shall be shown on horizontal lines (rungs) between the vertical lines. Parallel circuits shall be shown on separate horizontal lines directly adjacent to (above or below) the original circuit.

18.7.7 An interconnection diagram shall be provided on large systems having a number of separate enclosures or control stations. It shall provide full information about the external connections of all of the electrical equipment on the machine.
18.7.8 Interlock wiring diagrams shall include devices, functions, and conductors in the circuit where used.

18.7.9 Plug/receptacle pin identification shall be shown on the diagram(s).

18.8 Operating manual

18.8.1 The technical documentation shall contain an operating manual detailing proper procedures for set-up and use of the equipment. Particular attention should be given to the safety measures provided and to the improper methods of operation that are anticipated.

18.8.2 Where the operation of the equipment can be programmed, detailed information on methods of programming, equipment required, program verification, and additional safety procedures (where required) shall be provided.

18.9 Maintenance manual

18.9.1 The technical documentation shall contain a maintenance manual detailing proper procedures for adjustment, servicing and preventive inspection, and repair.

NOTE: Recommendations on maintenance/service records should be part of that manual. Troubleshooting information and suggestions for locating and replacing faulty components, suggested preventative maintenance schedules, and related data should be included.

18.9.2 Where methods for the verification of proper operation are provided (e.g. software testing programs), the use of those methods shall be detailed.

18.10 Parts list

18.10.1 The parts list shall comprise, as a minimum, information necessary for ordering spare or replacement parts (e.g. components, devices, software, test equipment, technical documentation) required for preventive or corrective maintenance including those that are recommended to be carried in stock by the user of the equipment.

18.10.2 The parts list shall show for each item:
- the reference designation used in the documentation
- its general characteristics where appropriate.
- the quantity of items with the same reference designation

COMMITTEE STATEMENT: 1) 18.2 was editorially revise and reorganized for clarity and document consistancy.
2) 18.3.3 was added to correct an inadvertent omission from including the requirement stated in NFPA 79-1997, 4.1.3.
3) 18.4, 18.5.2, through 18.5.5, 18.7.1, and 18.7.3 were revised to comply with the NFPA Manual of style and for clarity.
4) 18.7.3 was revised to incorporate an inadvertent omission from NFPA 79-1997, 4.2.2.
5) 18.7.5 was revised to correct an inadvertent omission from NFPA 79-1997, 4.2.2.
6) 18.9.1, Note, was revised to correct an inadvertent omission from NFPA 79-1997, 4.3.5, 3rd dash.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-20 - (4.2.1 [18.7.1]): Accept
SUBMITTER: Paul R. Warndorf, McLean, VA
RECOMMENDATION: Add to the rewrite of 1997 NFPA 79, Clause 4.2.1, that is the new Clause 18.7.1.
Add the Note from NFPA 79, Clause 4.2.1 stating, "See Annex D for examples of electrical diagrams" to the new Clause 18.7.1.
SUBSTANTIATION: The proposed revision maintains the electrical drawings and reference to Annex D. The Note must have been inadvertently left out since there is no substantiation for its removal.
COMMITTEE ACTION: Accept.
COMMITTEE STATEMENT: The committee understands that this proposal modifies the Action on Proposal 79-19 (Log #53), [Clause 18].
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-21 - (4.2.3 [18.7.3]): Accept
SUBMITTER: Paul R. Warndorf, McLean, VA
RECOMMENDATION: Add to the rewrite of 1997 NFPA 79, Clause 4.2.5, that is the new Clause 18.7.5.
Add the Note from NFPA 79, Clause 4.2.3, stating, "See Annex E for examples of devices and component designations" to the new Clause 18.7.5.
SUBSTANTIATION: The proposed revision maintains the device and component designations reference to Annex E. The Note must have been inadvertently left out since there is no substantiation for its removal.
COMMITTEE ACTION: Accept.
COMMITTEE STATEMENT: The committee understands that this proposal modifies the Action on Proposal 79-19 (Log #53), [Clause 18].
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-22 - (4.3.6(New) [18.2(h))]: Accept in Principle
SUBMITTER: John B. Dean, Rep. The Association for Manufacturing Technology
RECOMMENDATION: Modify in rewrite of Clause 4, that is new Clause 18 in 18.2, item h.
Place the word "suspended" in parenthesis and before it add the word "overridden." The sentence would read: "...are overridden (suspended)."

SUBSTANTIATION: This proposed revision will provide clarification by adding the word customarily used in the U.S., while retaining, in parenthesis, the word more frequently used in Europe.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-19 (Log #53), subclause 18.2(h), which meets the intent of the submitter.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-23 - (4.7.2 (New) [17.4.1.1]): Reject
TCC NOTE: The TCC directs the committee to consider the comments expressed in the voting. This action will be considered by the committee as a public comment.
SUBMITTER: Wayne L. Withrow, Cincinnati Incorporated
RECOMMENDATION: Add the new proposed NFPA 79-2002 subclause 17.4.1.1 after the bullets in subclause 17.4.1.
17.4.1.1 The value for the nameplate short-circuit interrupting capacity shall be either:
- the short-circuit interrupting capacity as specified on a circuit breaker, or
- the short-circuit interrupting capacity specified on a fused disconnect switch or accompanying literature. This value shall be the no greater than the maximum specified by a nationally recognized testing laboratory for the disconnect switch and fuse combination.
This chapter describes the general requirements and conditions for the operation of the electrical equipment of the machine.

Note: A sample inquiry form is provided in Annex B for use in facilitating an agreement between the supplier and the user. (end of note)

The risks associated with the hazards relevant to the electrical equipment shall be assessed as part of the overall requirements for risk assessment of the machine. This will determine the acceptable level of risk and necessary protective measures for persons who can be exposed to these hazards, while still maintaining an acceptable level of performance of the machine and its equipment.

Note: Hazards can include, but are not limited to, the following:
- failures or faults in the electrical equipment resulting in the possibility of electrical shock or electrical fire;
- failures or faults in control circuits (or components and devices associated with these circuits) resulting in malfunctioning of the machine;
- disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine;
- loss of continuity of circuits which depend upon sliding or rolling contacts, resulting in a failure of a safety function;
- electrical disturbances (e.g., electromagnet, electrostatic or radio interference) either from outside the electrical equipment or internally generated;
- stored energy (either electrical or mechanical);
- audible noise at levels that cause health problems to persons.

Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user.

Design and development should be the first consideration in the reduction of risks. Where this is not possible, safeguarding should be considered. Safeguarding includes the use of safeguards, awareness means, and safe working procedures. (end of note)

4.2 Electrical components and devices

Electrical components and devices shall be installed and used assuming the operating conditions of ambient temperature, altitude, humidity, and supply voltage outlined in this chapter, and within their design ratings, taking into account any de-rating stipulated by the component or device manufacturer.

4.3 Electrical supply

4.3.1 General

The electrical equipment shall be designed to operate correctly with the conditions of the supply:
- as specified in 4.3.2, 4.3.3, or
- as otherwise specified by the user, or
- as specified by the supplier

Note: See Annex B.

4.3.2 A_{Lc2} supplies

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Steady state voltage: 0.9 ... 1.1 of nominal voltage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>0.99 ... 1.01 of nominal frequency continuously; 0.98 ... 1.02 short time.</td>
</tr>
</tbody>
</table>

Note: The short time value may be specified by the user (see Annex B).

Harmonics

Harmonic distortion not to exceed 10% of the total r.m.s. voltage between live conductors for the sum of the 2nd through 5th harmonic. An additional 2% of the total r.m.s. voltage between
live conductors for the sum of the 6th through 30th harmonic is permissible.

**Voltage unbalance**
Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in 3-phase supplies exceeds 2% of the positive sequence component.

**Voltage Impulses**
Not to exceed 1.5 ms in duration with a rise/fall time between 500 ns and 500 ms and a peak value of not more than 220% of the rated r.m.s. supply voltage value.

**Voltage interruption**
Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle. There shall be more than 1 s between successive interruptions.

**Voltage dips**
Voltage dips shall not exceed 20% of the peak voltage of the supply for more than 1 cycle. There shall be more than 1 s between successive dips.

### 4.3.3 DC supplies

**From batteries:**

| Voltage          | 0.85 ... 1.15 of nominal voltage × 0.7 ... 1.2 of nominal voltage in the case of battery-operated vehicles. |

**From converting equipment:**

| Voltage interruption | not exceeding 5 ms. |

### 4.4 Physical environment and operating conditions

#### 4.4.1 General

The electrical equipment shall be suitable for use in the physical environment and operating conditions specified in 4.4.2 to 4.4.8. When the physical environment or the operating conditions are outside those specified, an agreement may be needed between the supplier and the user (see annex B).

#### 4.4.2 Electromagnetic compatibility (EMC)

**Note:**
The electrical interference generated by the equipment itself should not exceed levels specified in the relevant equipment standards and others dealing with electromagnetic compatibility (EMC) levels. The levels allowed should be determined for the specific application.

- Generated interference signals can be kept to a minimum by:
- suppression at the source by using capacitors, inductors, diodes, Zener diodes, varistors, or active devices, or a combination of these; or,
- screening of the equipment in a bonded electrically conductive enclosure to provide segregation from other equipment.

Undesirable effects of electrostatic discharge, radiated electromagnetic energy, and supply conductor ( mains borne) interference should be avoided (e.g., use of appropriate filters and time delays, choice of certain power levels, suitable wiring types and practices).

The effects of interference on equipment can be reduced by:

- reference potential circuit or common connections: each common connection treated as a single circuit and connected to one of several central reference points which are connected to ground (wired to earth) by insulated conductors of large cross-sectional area;
- frame connections: in each piece of equipment all frame connections are to be taken to a common point with a conductor of large cross-sectional area (e.g., braided conductors, foil strips having a width much greater than the thickness) used between slides and enclosures; the connections to the frame to be as short as possible;
- transmission of signals: electrostatic screens electromagnetic shields, twisted conductors, and orientation (i.e., crossing cable runs at as near to 90 degrees as practicable) as necessary to ensure that the low level signal wiring is not affected by interference from control or power cables, or running the connections parallel to the ground plane as necessary;
- separation of equipment: separating and/or shielding sensitive equipment (e.g., units working with pulse and/or at low signal levels) from switching equipment (e.g., electromagnetic relays, thyristors); separation of low level signal wiring from control and power cables.

- European standards EN 50081, Electromagnetic compatibility – Generic emission standard, and EN 50082, Electromagnetic compatibility – Generic immunity standard, give general EMC emission and immunity limits, or product standards (e.g. IEC 60439-1) that may supercede the generic EMC requirements that give more specific EMC requirements.

### 4.4.3 Ambient temperature

Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The requirement for all electrical equipment is correct operation between air temperatures of +5°C and +40°C (41 degrees to 104 degrees F). For very hot environments (e.g., hot climates, steel mills, paper mills) and for cold environments, extra requirements may be necessary (see annex B).

#### 4.4.4 Relative Humidity

The electrical equipment shall be capable of operating within a relative humidity range of 20-95 percent (noncondensing). For extremely dry or moist environments, extra requirements may be necessary to prevent static discharge (see annex B).

Harmful effects of relative humidity outside the permitted range shall be avoided by proper design of the equipment or, when necessary, by proper additional measures (e.g., built-in heaters, air conditioners, humidifiers).

#### 4.4.5 Altitude

Electrical equipment shall be capable of operating correctly at altitudes up to 1000 m (3300 ft) above mean sea level (see annex B).

#### 4.4.6 Contaminants

Electrical equipment shall be adequately protected against the ingress of solid bodies and liquids (see 12.3).

Equipment shall be suitable for the environment where contaminants (e.g., dust, acids, corrosive gases, salt) are present.

**Note:** See Annex B.

#### 4.4.7 Non-ionizing radiation

**Note:** Where equipment is subject to radiation (e.g., microwave, ultraviolet, lasers, X-rays), additional measures should be taken to avoid malfunctioning and accelerated deterioration of the insulation.

#### 4.4.8 Vibration, shock, and bump

---

**end of note>>**
Undesirable effects of vibration, shock, and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by the use of antivibration mountings.

### 4.5 Transportation and storage

The electrical equipment shall be designed to withstand storage and transportation temperatures within the range of –25 to 55°C (–13 to +131°F) and up to 65°C (149°F) for short periods not exceeding 24 hr. Suitable means shall be provided to prevent damage from excessive moisture, vibration, stress, and mechanical shock during shipment.

#### 4.6 Provisions for handling

Heavy and bulky electrical equipment that has to be removed from the machine for transport, or that is independent of the machine, shall be provided with suitable means for handling by cranes or similar equipment.

### 4.7 Installation and operating conditions

The electrical equipment shall be installed and operated in accordance with the manufacturer’s instructions. Any conditions that are outside the operating conditions specified in Clause 4 shall be permitted where acceptable to both the manufacturer and user.

**SUBSTANTIATION:** This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

4.1 General. The added text introduces the concept of risk assessment for the design and evaluation of machinery and equipment. This assessment will determine the acceptable level of risk and necessary protective measures for persons who can be exposed to these hazards, while still maintaining an acceptable level of performance of the machine and its equipment.

4.2 Electrical components and devices

4.3 Electrical supply.

4.3.1 General. Add the “General” paragraph to provide and introduction to the expanded section

4.3.2 A.C. Supplies. Added text provides and introduction to the revised Supply Voltage clauses for clarity and ease of use. Values in the table reflect existing NFPA 79 requirements

4.3.3 D.C. Supplies.

4.4 Physical environment and operating conditions.

4.4.1 General considerations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 General operating conditions</strong></td>
<td><strong>Clause 4 – General operating conditions</strong></td>
<td><strong>Action:</strong> The Numbering for the paragraphs will be changed to follow the new table of contents utilizing the basic outline of IEC 60204-1 and the SAE HS1738 document</td>
</tr>
<tr>
<td><strong>5.1 General</strong></td>
<td><strong>4.1 General considerations</strong></td>
<td><strong>Action:</strong> Use existing NFPA 79 Paragraph and add proposed text from IEC 204 / SAE HS 1738 document</td>
</tr>
<tr>
<td>This chapter describes the general requirements and conditions for the operation of the electrical equipment of the machine.</td>
<td></td>
<td>Note added to include reference to Annex B information</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The risks associated with the hazards relevant to the electrical equipment shall be assessed as part of the overall requirements for risk assessment of the machine. This will determine the acceptable level of risk and necessary protective measures for persons who can be exposed to these hazards, while still maintaining an acceptable level of performance of the machine and its equipment.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
A sample inquiry form is provided in Annex B for use in facilitating an agreement between the supplier and the user.

**end of note>>**
### NFPA 79: 2002 (Proposed) Substantiation/Comments

<table>
<thead>
<tr>
<th>Substantiation/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: Hazards can include, but are not limited to, the following:</td>
</tr>
<tr>
<td>- failures or faults in the electrical equipment resulting in the possibility of electrical shock or electrical fire;</td>
</tr>
<tr>
<td>- failures or faults in control circuits (or components and devices associated with these circuits) resulting in malfunctioning of the machine;</td>
</tr>
<tr>
<td>- disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine;</td>
</tr>
<tr>
<td>- loss of continuity of circuits which depend upon sliding or rolling contacts, resulting in a failure of a safety function;</td>
</tr>
<tr>
<td>- electrical disturbances (e.g. electromagnetic, electrostatic or radio interference) either from outside the electrical equipment or internally generated;</td>
</tr>
<tr>
<td>- stored energy (either electrical or mechanical);</td>
</tr>
<tr>
<td>- audible noise at levels that cause health problems to persons.</td>
</tr>
<tr>
<td>Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user.</td>
</tr>
<tr>
<td>Design and development should be the first consideration in the reduction of risks. Where this is not possible, safeguarding should be considered. Safeguarding includes the use of safeguards, awareness means, and safe working procedures.</td>
</tr>
</tbody>
</table>

### 5.2 Electrical components and devices

Electrical components and devices shall be used or installed assuming the operating conditions of ambient temperature, altitude, humidity, and supply voltage outlined in this chapter, and within their design ratings, taking into account any de-rating stipulated by the component or device manufacturer.

### 4.2 Electrical components and devices

Electrical components and devices shall be installed and used assuming the operating conditions of ambient temperature, altitude, humidity, and supply voltage outlined in this chapter, and within their design ratings, taking into account any de-rating stipulated by the component or device manufacturer.
### 5.7 Electrical supply

The electrical equipment shall be designed to operate correctly under full load as well as no load with the conditions of the nominal supply as specified below unless otherwise specified by the user.

### 4.3 Electrical supply

#### 4.3.1 General

The electrical equipment shall be designed to operate correctly with the conditions of the supply:

- as specified in 4.3.2, 4.3.3, or
- as otherwise specified by the user, or
- as specified by the supplier

Note: See Annex B.

#### 5.7.1 AC supplies

- **Steady state voltage**
  - Voltage: 0.9 ... 1.1 of nominal voltage
  - Frequency: 0.99 ... 1.01 of nominal frequency continuously
  - 0.98 ... 1.02 short time

  Note: The short time value may be specified by the user.

- **Harmonics**
  - Harmonic distortion not to exceed 10% of the total rms voltage between live conductors for the sum of the 2nd through 5th harmonic.
  - An additional 2% of the total rms voltage between live conductors for the sum of the 6th through 30th harmonic is permissible.

- **Voltage unbalance (in 3-phase supplies)**
  - Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in 3-phase supplies exceeds 2% of the positive sequence component.

- **Voltage impulses**
  - Not to exceed 1.5 ms in duration with a rise/fall time between 500 ns and 500 ms and a peak value of not more than 200% of the rated rms supply voltage value.

- **Voltage interruption**
  - Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle. There shall be more than 1 sec between successive interruptions.

- **Voltage dips**
  - Voltage dips shall not exceed 20% of the peak voltage of the supply for more than 1 cycle. There shall be more than 1 sec between successive dips.

#### 4.3.2 AC supplies

- **Voltage**
  - Steady state voltage: 0.9 ... 1.1 of nominal voltage

- **Frequency**
  - 0.99 ... 1.01 of nominal frequency continuously
  - 0.98 ... 1.02 short time

  NOTE—The short time value may be specified by the user (see annex B).

- **Harmonics**
  - Harmonic distortion not to exceed 10% of the total r.m.s. voltage between live conductors for the sum of the 2nd through 5th harmonic.
  - An additional 2% of the total r.m.s. voltage between live conductors for the sum of the 6th through 30th harmonic is permissible.

- **Voltage unbalance**
  - Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in 3-phase supplies exceeds 2% of the positive sequence component.

- **Voltage Impulses**
  - Not to exceed 1.5 ms in duration with a rise/fall time between 500 ns and 500 ms and a peak value of not more than 200% of the rated r.m.s. supply voltage value.

- **Voltage interruption**
  - Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle. There shall be more than 1 sec between successive interruptions.

- **Voltage dips**
  - Voltage dips shall not exceed 20% of the peak voltage of the supply for more than 1 cycle. There shall be more than 1 sec between successive dips.
### 5.7.2 DC supplies

From batteries:

**Voltage**
- 0.85 ... 1.15 of nominal voltage;
- 0.7 ... 1.2 of nominal voltage in the case of battery-operated vehicles.

**Voltage interruption**
- Not exceeding 5 ms

From converting equipment:

**Voltage**
- 0.9 ... 1.1 of nominal voltage

**Voltage interruption**
- Not exceeding 20 ms. There shall be more than 1 sec between successive interruptions.

**Ripple (peak-to-peak)**
- Does not exceed 0.05 of nominal voltage.

### 4.3.3 DC supplies

From batteries:

**Voltage**
- 0.85 ... 1.15 of nominal voltage
- 0.7 ... 1.2 of nominal voltage in the case of battery-operated vehicles.

**Voltage interruption**
- Not exceeding 5 ms

From converting equipment:

**Voltage**
- 0.9 ... 1.1 of nominal voltage

**Voltage interruption**
- Not exceeding 20 ms. There shall be more than 1 sec between successive interruptions.

**Ripple (peak-to-peak)**
- Does not exceed 0.15 of nominal voltage.

### 4.4 Physical environment and operating conditions

**Action: Add new Paragraph**

#### 4.4.1 General

The electrical equipment shall be suitable for use in the physical environment and operating conditions specified in 4.4.2 to 4.4.8. When the physical environment or the operating conditions are outside those specified, an agreement may be needed between the supplier and the user (see annex B).

#### 4.4.2 Electromagnetic compatibility (EMC)

**Note:**

The electrical interference's generated by the equipment itself should not exceed levels specified in the relevant equipment standards and others dealing with electromagnetic compatibility (EMC) levels. The levels allowed should be determined for the specific application.

Generated interference signals can be kept to a minimum by:

- suppression at the source by using capacitors, inductors, diodes, Zener diodes, varistors, or active devices, or a combination of these; or,
- screening of the equipment in a bonded electrically conductive enclosure to provide segregation from other equipment.

Undesirable effects of electrostatic discharge, radiated electromagnetic energy, and supply conductor (mains borne) interference should be avoided (e.g., use of appropriate filters and time delays, choice of certain power levels, suitable wiring types and practices).

---

**Action: Revise NFPA Text from Annex F.1 and add to document as a note – maintaining nonmandatory text**
The effects of interference on equipment can be reduced by:
- reference potential circuit or common connections: each common connection treated as a single circuit and connected to one of several central reference points which are connected to ground (wired to earth) by insulated conductors of large cross-sectional area;
- frame connections: in each piece of equipment all frame connections are to be taken to a common point with a conductor of large cross-sectional area (e.g., braided conductors, foil strips having a width much greater than the thickness) used between slides and enclosures; the connections to the frame to be as short as possible;
- transmission of signals: electrostatic screens, electromagnetic shields, twisted conductors, and orientation (i.e., crossing cable runs at as near to 90 degrees as practicable) as necessary to ensure that the low level signal wiring is not affected by interference from control or power cables, or running the connections parallel to the ground plane as necessary;
- separation of equipment: separating and/or shielding sensitive equipment (e.g., units working with pulses and/or at low signal levels) from switching equipment (e.g., electromagnetic relays, thyristors); separation of low level signal wiring from control and power cables.
- European standards EN 50081, Electromagnetic compatibility – Generic emission standard, and EN 50082, Electromagnetic compatibility – Generic immunity standard, give general EMC emission and immunity limits, or product standards (e.g. IEC 60439-1) that may supercede the generic EMC requirements. 

<table>
<thead>
<tr>
<th>5.3 Ambient operating temperature</th>
<th>4.4.3 Ambient operating temperature</th>
<th>Replace existing text with revised text</th>
</tr>
</thead>
<tbody>
<tr>
<td>The electrical equipment shall be capable of operating in an ambient temperature range of 5 to 40°C (41 to 104°F) under no load to full load conditions.</td>
<td>Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The requirement for all electrical equipment is correct operation between air temperatures of +5°C and +40°C (41 degrees to 104 degrees F). For very hot environments (e.g. hot climates, steel mills, paper mills) and for cold environments, extra requirements may be necessary (see annex B).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.5 Relative humidity</th>
<th>4.4.4 Relative Humidity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The electrical equipment shall be capable of operating within a relative humidity range of 20-95 percent (noncondensing).</td>
<td>The electrical equipment shall be capable of operating within a relative humidity range of 20-95 percent (noncondensing). For extremely dry or moist environments, extra requirements may be necessary to prevent static discharge (see annex B).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.4 Altitude</th>
<th>4.4.5 Altitude</th>
<th>Editorial revision – add reference to annex B</th>
</tr>
</thead>
<tbody>
<tr>
<td>The electrical equipment shall be suitable for operating correctly at altitudes up to 3300 ft (1000 m) above sea level.</td>
<td>Electrical equipment shall be capable of operating correctly at altitudes up to 1 000 m (3300 ft) above mean sea level (see annex B).</td>
<td></td>
</tr>
</tbody>
</table>
4.6 Contaminants

Electrical equipment shall be adequately protected against the ingress of solid bodies and liquids (see 12.3). Equipment shall be suitable for the environment where contaminants (e.g., dust, acids, corrosive gases, salt) are present.

Note: See Annex B.

4.7 Non-ionizing radiation

Note: Where equipment is subject to radiation (e.g., microwave, ultraviolet, lasers, X-rays), additional measures should be taken to avoid malfunctioning and accelerated deterioration of the insulation. <<end of note>>

4.8 Vibration, shock, and bump

Undesirable effects of vibration, shock, and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by the use of antivibration mountings.

5.6 Transportation and storage

The electrical equipment shall be designed to withstand storage and transportation temperatures within the range of -25 to 55°C (-13 to 131°F) and up to 65°C (149°F) for short periods not exceeding 24 hr. Suitable means shall be provided to prevent damage from excessive moisture, vibration, stress, and mechanical shock during shipment.

4.5 Transportation and storage

The electrical equipment shall be designed to withstand storage and transportation temperatures within the range of -25 to 55°C (-13 to 131°F) and up to 65°C (149°F) for short periods not exceeding 24 hr. Suitable means shall be provided to prevent damage from excessive moisture, vibration, stress, and mechanical shock during shipment.

4.6 Provisions for handling.

Heavy and bulky electrical equipment that has to be removed from the machine for transport, or that is independent of the machine, shall be provided with suitable means for handling by cranes or similar equipment.

5.8 Installation and operating conditions

The electrical equipment shall be installed and operated in accordance with the manufacturer’s instructions. Any conditions that are outside the operating conditions specified in Clause 5 shall be permitted where acceptable to both the manufacturer and user.

4.7 Installation and operating conditions

The electrical equipment shall be installed and operated in accordance with the manufacturer’s instructions. Any conditions that are outside the operating conditions specified in Clause 4 shall be permitted where acceptable to both the manufacturer and user.

Editorial Revision

Test remains the same

COMMITTEE ACTION: Accept in Principle.

Revise to read as follows:

4 General Operating Conditions

4.1 General considerations

This chapter describes the general requirements and conditions for the operation of the electrical equipment of the machine. Note: A sample inquiry form is provided in Annex B for use in facilitating an agreement between the supplier and the user. <<end of note>>

The risks associated with the hazards relevant to the electrical equipment shall be assessed as part of the overall requirements for risk assessment of the machine. This will determine the acceptable level of risk and necessary protective measures for persons who can be exposed to these hazards, while still maintaining an acceptable level of performance of the machine and its equipment.

Note: Hazards can include, but are not limited to, the following:

- failures or faults in the electrical equipment resulting in the possibility of electrical shock or electrical fire;
- failures or faults in control circuits (or components and devices associated with these circuits) resulting in malfunctioning of the machine;
- disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine;
- loss of continuity of circuits which depend upon sliding or rolling contacts, resulting in a failure of a safety function;
- electrical disturbances (e.g., electromagnetic, electrostatic or radio interference) either from outside the electrical equipment or internally generated;
- stored energy (either electrical or mechanical);
- audible noise at levels that cause health problems to persons.

Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user.

Design and development should be the first consideration in the reduction of risks. Where this is not possible, safeguarding should be considered. Safeguarding includes the use of safeguards, awareness means, and safe working procedures. <<end of note>>
4.2 Electrical components and devices. Electrical components and devices shall be installed and used assuming the operating conditions of ambient temperature, altitude, humidity, and supply voltage outlined in this chapter, and within their design ratings, taking into account any de-rating stipulated by the component or device manufacturer.

4.4 Electrical supply

4.4.1 General

The electrical equipment shall be designed to operate correctly with the conditions of the supply:

- as specified in 4.3.2, 4.3.3, or
- as otherwise specified by the user, or
- as specified by the supplier.

Note: See Annex B.

4.4.2 A.C. supplies

Voltage Steady state voltage; 0.9 ... 1.1 of nominal voltage.

Frequency 0.99 ... 1.01 of nominal frequency continuously; 0.98 ... 1.02 short time.

NOTE—The short time value may be specified by the user (see annex B).

Harmonics Harmonic distortion not to exceed 10% of the total r.m.s. voltage between live conductors for the sum of the 2nd through 5th harmonic. An additional 2% of the total r.m.s. voltage between live conductors for the sum of the 6th through 30th harmonic is permissible.

Voltage unbalance (in 3-phase supplies).

Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in 3-phase supplies exceed 2% of the positive sequence component.

Voltage impulses Not to exceed 1.5 milliseconds in duration with a rise/fall time between 500 nanoseconds and 500 microseconds and a peak value of not more than 200% of the rated r.m.s. supply voltage value.

Voltage interruption Supply interrupted or at zero voltage for not more than 5 ms at any random time in the supply cycle. There shall be more than 1 s between successive interruptions.

Voltage dips Voltage dips shall not exceed 20% of the peak voltage of the supply for more than 1 cycle. There shall be more than 1 s between successive dips.

4.4.3 D.C. supplies

From batteries:

Voltage 0.85 ... 1.15 of nominal voltage; 0.7 ... 1.2 of nominal voltage in the case of battery-operated vehicles.

Voltage interruption not exceeding 5 ms.

From converting equipment:

Voltage 0.9 ... 1.1 of nominal voltage.

Voltage interruption not exceeding 20 ms. There shall be more than 1 s between successive interruptions.

Ripple (peak-to-peak) does not exceed 0.05 of nominal voltage.

4.4 Physical environment and operating conditions

4.4.1 General. The electrical equipment shall be suitable for use in the physical environment and operating conditions specified in 4.4.2 to 4.4.6 and 4.4.8. The electrical equipment shall be suitable for use in the physical environment and operating conditions specified in 4.4.3 to 4.4.6 and 4.4.8. When the physical environment or the operating conditions are outside those specified, an agreement may be needed between the supplier and the user (see annex B).

4.4.2 Electromagnetic compatibility (EMC)

NOTE—The interference generated by the equipment itself should not exceed levels specified in the relevant equipment standards and others dealing with electromagnetic compatibility (EMC) levels. The levels allowed should be determined for the specific application.

Generated interference signals can be kept to a minimum by:

- suppression at the source by using capacitors, inductors, diodes, Zener diodes, varistors, or active devices, or a combination of these; or,
- screening of the equipment in a bonded electrically conductive enclosure to provide segregation from other equipment.

Undesirable effects of electrostatic discharge, radiated electromagnetic energy, and supply conductor (main borne) interference should be avoided (e.g., use of appropriate filters and time delays, choice of certain power levels, suitable wiring types and practices).

The effects of interference on equipment can be reduced by:

- reference potential circuit or common connections: each common connection treated as a single circuit and connected to one of several central reference points which are connected to ground (wired to earth) by insulated conductors of large cross-sectional area;
- frame connections: in each piece of equipment all frame connections are to be taken to a common point with a conductor of cross-sectional area (e.g., braided conductors, foil strips having a width much greater than the thickness) used between shields and enclosures; the connections to the frame to be as short as possible;
- transmission of signals: electrostatic screens, electromagnetic shields, twisted conductors, and orientation (i.e., crossing cable runs at as near to 90 degrees as practicable) as necessary to ensure that the low level signal wiring is not affected by interference from control or power cables, or running the connections parallel to the ground plane as necessary;
- separation of equipment: separating and/or shielding sensitive equipment (e.g., units working with pulses and/or at low signal levels) from switching equipment (e.g., electromagnetic relays, thyristors); separation of low level signal wiring from control and power cables.

- European standards EN 50081, Electromagnetic compatibility – Generic emission standard; EN 50082, Electromagnetic compatibility – Generic immunity standard, give general EMC emission and immunity limits, or product standards (e.g., IEC 60439-1) that may supercede the generic EMC requirements. that give more specific EMC requirements. <end of note>

4.4.3 Ambient operating temperature. Electrical equipment shall be capable of operating correctly in the intended ambient air temperature.

Ambient operating temperature. The requirement for all electrical equipment is correct operation between air temperatures of +5°C and +40°C (41 degrees to 104 degrees F). For very hot environments (e.g., hot climates, steel mills, paper mills) and for cold environments, extra requirements may be necessary.

Note: See annex B.

4.4.4 Relative Humidity. The electrical equipment shall be capable of operating within a relative humidity range of 20-95 percent (noncondensing). For extremely dry or moist environments, extra requirements may be necessary to prevent static discharge (see annex B).

Harmful effects of relative humidity outside the permitted range shall be avoided by proper design of the equipment or, where necessary, by proper additional measures (e.g., built-in heaters, air conditioners, humidifiers).

4.4.5 Altitude. Electrical equipment shall be capable of operating correctly at altitudes up to 1 000 m (3500 ft) above mean sea level.

Note: See annex B.
4.4.6 Contaminants. Electrical equipment shall be adequately protected against the ingress of solid bodies and liquids (see 12.3).

Equipment shall be suitable for the environment where contaminants (e.g., dust, acids, corrosive gases, salt) are present.

Note: See Annex B.

4.4.7 Non-ionizing radiation

Note: Where equipment is subject to radiation (e.g., microwave, ultraviolet, lasers, X-rays), additional measures should be taken to avoid malfunctioning and accelerated deterioration of the insulation.

4.4.8 Vibration, shock, and bump. Undesirable effects of vibration, shock, and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by the use of antivibration mountings.

4.5 Transportation and storage. The electrical equipment shall be designed to withstand storage and transportation temperatures within the range of -25 to 55°C (-13 to +131°F) and up to 65°C (149°F) for short periods not exceeding 24 hr. Suitable means shall be provided to prevent damage from excessive moisture, vibration, stress, and mechanical shock during shipment.

4.6 Provisions for handling. Heavy and bulky electrical equipment that has to be removed from the machine for transport, or that is independent of the machine, shall be provided with suitable means for handling by cranes or similar equipment.

4.7 Installation and operating conditions. The electrical equipment shall be installed and operated in accordance with the manufacturer's instructions. Any conditions that are outside the operating conditions specified in Clause 4 shall be permitted where acceptable to both the manufacturer and user.

COMMITTEE STATEMENT: 1) The second sentence of the second paragraph in 4.1 was deleted because it conflicted with the NFPA Manual of Style, Section 2.2.3.2. In addition this provision would introduce concepts not presently in the NFPA 79 document.

2) Editorial corrections were made to conform with the NFPA Manual of Style, for clarity, editorial consistency, and to correct revised cross references.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE: BLOODGOOD: As noted at the ROP meeting, the 2nd paragraph together with the note are also found in the Foreword as non mandatory language. This addition to the Foreword was made at a previous committee with the intent of deleting it from the new clause 4. There is no information provided to the user of the standard as to how the risk assessment is to be conducted nor how risk reduction is to be conducted.

DOBROWSKY: There are some requirements, which have been incorporated into various chapters of this standard, that apply to all or multiple portions of a machine. These requirements, such as working space, which is presently proposed for Chapter 12, “bridge” issues covered by more than one chapter. I believe these types of requirements are more appropriately placed in Chapter 4, which would then apply in general to the entire machine.

79-25 - (Clause 6 [Clause 6]): Accept in Principle

SUBMITTER: John Freudenberg, Teradyne

RECOMMENDATION: Revise wording as follows:

6 Protection from Electric Shock.

6.1 General. The electrical equipment shall provide protection of persons from electrical shock both in normal operation and during fault conditions.

6.2 Protection from electric shock during normal operation

6.2.1 Live parts operating at 50 volts rms ac or 60 volts dc or more shall be guarded against accidental contact by an enclosure or shall be encased in listed insulation (e.g., flexible cords or flexible cables).

6.2.1.1 Protection by Insulation of Live Parts. Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal operating conditions.

Paints, varnishes, lacquers, and similar products are inadequate for protection against electric shock under normal operating conditions.

6.2.2 Protection by Enclosures.

6.2.2.1 Direct Contact from outside an enclosure. Live parts shall be located inside enclosures such that there cannot be any direct contact to live parts from the outside of an enclosure when using the test finger. The determination of the suitability of an enclosure as protection from electrical shock shall be determined by using a test finger as described in figure XX. The test finger is applied without appreciable force, in every opening in the enclosure after removal of all parts of the enclosure that can be removed without the use of a tool.

(Figure shown on following page)

6.2.3 Enclosure Interlocking

Enclosure interlocking as described in this subclause shall be provided.

6.2.3.1 Each disconnecting means shall be mechanically or electrically interlocked, or both, with the control enclosure doors. Interlocking shall be reactivated automatically when panel doors are closed.

Exception No. 1: A disconnecting means used only for maintenance lighting circuits within control enclosures shall not be required to be interlocked with the control enclosure. The marking requirements of XXX shall apply.

Exception No. 2: Where an attachment plug is used as the disconnecting means in accordance with XXX

Exception No. 3: A disconnecting means used for power supply circuits within control enclosures to memory elements and their support logic requiring power at all times to maintain the storage of information shall not be required to be interlocked with the control enclosure doors. The marking requirements of XXX shall apply.

Exception No. 4: Where a remotely mounted disconnecting means is permitted as per XXX Exception No. 2, (machines with a motor(s) totaling 2hp or less) interlocking shall not be required provided that a tool is required to open the enclosure door and a label is attached to the control enclosure warning of dangerous voltage inside and advising disconnection of the power before opening.

Where the disconnecting means is not interlocked with the enclosure door in accordance with 6.2.2.1, per Exceptions 1, 2, 3 and 4, the enclosure shall comply with 6.2.2.6.

6.2.3.2 Interlocking shall be provided to prevent closing of the disconnecting means while the enclosure door is open, unless an interlock is operated by deliberate action.

6.2.3.3 All doors on multiple-door enclosures shall be interlocked simultaneously with the door that is interlocked with the main disconnecting means.

6.2.3.4 Where there are two or more sources of power to the equipment or where there are two or more independent disconnecting means, power wiring from each disconnecting means shall be run in separate conduit and shall not terminate in or pass through common junction boxes.
Dimensions in millimeters

Tolerances on dimensions without specific tolerance:
- on angles: ±10°
- on linear dimensions:
  - up to 25 mm: ±0.05 mm
  - over 25 mm: ±0.2 mm

Material of finger: heat-treated steel, etc.

Both joints of this finger may be bent through an angle of (90° ±10°) but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a (90° ±10°) bending angle.

Figure XX - Jointed test finger
6.2.3.5 Any door(s) that permits access to live parts operating at
50 volts rms or 60 volts dc or more shall be so interlocked that the
door(s) cannot be opened unless all power is disconnected.

Exception No. 1: External interlocking circuits operating at less
than 150 volts shall not be required to be disconnected provided
that the circuit conductors are identified with a yellow-colored
insulation as described in XXX and a warning marking is attached
to the door in accordance with XXX.

Exception No. 2: It shall be permitted to provide means for
qualified persons to gain access without removing power. The
interlocking shall be reactivated automatically when the door(s) is
closed.

Exception No. 3: Where an attachment plug is used as the
disconnecting means and a warning marking is attached to the
door in accordance with XXX.

Exception No. 4: Where the motor(s) on the machine totals two
horsepower or less, an external, noninterlocked disconnecting
means shall be permitted provided that the disconnecting means is
in sight from and readily accessible, the control enclosure door or
cover is marked with a warning indicating that the power shall be
removed by the disconnecting means before the enclosure is
opened, and further provided that a tool is required to open the
enclosure.

6.2.3.6 Protection from Direct Contact inside an Enclosure.

Requirements in this subclause are addressing equipment where a
qualified (skilled) person, using appropriate work practices, needs
to enter an enclosure not meeting the requirements of 6.2.2.1
while the equipment is energized.

Note: The design objective is to minimize operations where a
qualified (skilled) person must enter the enclosure while the
equipment is energized.

All enclosures relied on to prevent contact with live parts operating
at 50 volts rms ac or 60 volts dc or more shall comply with at least
one of the following conditions:

a) the use of a key or tool is required for opening an enclosure.

b) disconnection of live parts inside the enclosure before the
enclosure door is opened.

c) for opening an enclosure without the use of a key or a tool and
without disconnection of live parts shall be possible only when all
live parts inside are separately enclosed or guarded such that there
cannot be any direct contact to live parts with the test finger.

6.3 Protection by the use of PELV (protective extra low voltage)

6.3.1 General Requirements. The use of PELV (protective extra-
low voltage) is to protect persons against electric shock from
indirect contact and limited area direct contact.

PELV circuits shall satisfy all of the following conditions:

a) the nominal voltage shall not exceed:
   - 50 V a.c. r.m.s. or 60 V ripple-free d.c., when the equipment is
   normally used in dry locations and when large area contact of live
   parts with the human body is not expected; or
   - 6 V a.c. r.m.s. or 15 V ripple-free d.c. in all other cases;

NOTE – Ripple-free is conventionally defined for a sinusoidal
ripple voltage as a ripple content of not more than 10 % r.m.s.

b) one side of the circuit or one point of the source of the supply
of that circuit shall be connected to the equipment grounding
(protection bonding) circuit;

live parts of PELV circuits shall be electrically separated from other
live circuits. Electrical separation shall be not less than that
required between the primary and secondary circuits of a safety
isolating transformer.

Note: For additional information on isolating transformers, refer
to IEC 60742 and IEC 61558-1.

c) conductors of each PELV circuit shall be physically separated
from those of any other circuit. When this requirement is
impracticable, the insulation provisions of XXX shall apply.

d) Attachment plugs and receptacles (plugs and socket
combinations) for a PELV circuit shall conform to the following:
   1) Attachment plugs (plugs) shall not be able to enter receptacles
      (socket-outlets) of other voltage systems;
   2) receptacles (socket-outlets) shall not admit plugs of other
      voltage systems.

Where such circuits are used as control circuits, they shall also
fulfill the relevant requirements of Clause X

6.3.2 Sources for PELV. The source for PELV shall be one of the
following:
   - a safety isolating transformer;
   - a source of current providing a degree of safety equivalent to that
     of the safety isolating transformer (e.g. a motor generator with
     winding providing equivalent isolation);
   - an electrochemical source (e.g. a battery) or another source
     independent of a higher voltage circuit (e.g. a diesel-driven
generator);
   - an identified electronic power supply conforming to the
     appropriate standards specifying measures to be taken to ensure
     that, even in the case of an internal fault, the voltage at the
     outgoing terminals cannot exceed the values specified in 6.X.X.

6.4 Protection Against Residual Voltages.

6.4.1 Live parts having a residual voltage greater than 60 volts after
the supply has been disconnected shall be reduced to 60 volts or
less within 5 seconds after disconnection of the supply voltage.

Exception 1: Exempted from this requirement are components
having a stored charge of 60 micro-coulombs or less.

Exception 2: Where such a provision would interfere with the
proper functioning of the equipment, a durable warning notice
drawing attention to the hazard and stating the delay required
before the enclosure may be entered shall be displayed at an easily
visible location on or immediately adjacent to the enclosure
containing the capacitance.

6.4.2 In the case of plugs or similar devices, the withdrawal of
which results in the exposure of conductors (e.g. pins), the
discharge time shall not exceed 1 second.

Exception 1: Exempted from this requirement are components
having a stored charge of 60 micro-coulombs or less.

Exception 2: Exempted from this requirement are conductor
bars, or slip-ring assemblies which comply with X.XX.

SUBSTANTIATION:

Historical Background

In March of 1998, the NFPA 79 committee prepared a statement of
work. The major elements of the statement of work are:

Harmonization - Purpose

As the users and the manufacturers of industrial machines move
toward a global manufacturing community, the need for a
harmonized standard affecting industrial machinery becomes an
economic necessity. Generally, large users and manufacturers find
regulations burdensome. However, multiple regulations as well as
conflicting regulations are an economic disincentive to global
expansion. In order to ease the burden of differing regulation, and
at the same time maintain the high standard of electrical machine
safety, the NFPA 79 committee has expressed their desire, through
a ballot vote, to harmonize NFPA 79 with IEC-60204-1.

Importance of Issue - Harmonization

Today's industrial machines are very complex and expensive. As
manufacturing lines become modular and transportable, industrial
machines originally produced for a foreign market may quickly be
transported to the domestic market. The reverse is also true.

Differing electrical standards add a large cost to multinational
manufacturers as they build and sometimes move manufacturing
facilities.

Harmonization - Objective

This work is necessary to accomplish the goal of allowing industry
to economically build one industrial machine capable of passing a
detailed electrical safety inspection using either IEC 60204-1 or
NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards
Council reviewed the statement of work in July of 1998. The TCC
The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where in concert with the NEC and its related codes and standards.

Result:
The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.
The Task Group compared NFPA-79-1997, Clause 6 with IEC 60204-1 Clause 6. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.
The Task Group proposes to remove Clause 6 of NFPA 79-1997 to correspond with IEC 60204-1. The task group proposes the following changes to further improve usability.

Revise NFPA79:1997 clause 6 title

Replace “Safeguarding of personnel” with “Protection from electric shock”.

The proposed wording is intended to narrowly focus the scope of clause 6 on “Protection from electric shock”. This new title is consistent with all existing NFPA79:1997 clause 6 subclauses except 6.3 which was deleted.

Revise NFPA79:1997 clause 6.1 text.

Safeguarding and service have other meanings. Change “safeguarding” to “protection” and change “service” to “operation” consistent with the original intent of NFPA79:1997 and proposed revised title.

Revise NFPA79:1997 clause 6.2 title...

Safeguarding and service have other meanings. Change “safeguarding” to “protection” and change “service” to “operation” consistent with the original intent of NFPA79:1997 and proposed revised title.

Revise NFPA79:1997 clause 6.2.1 text.

Insert “operating at 50 volts rms ac or 60 volts dc or more” to separate hazardous live parts and live parts, otherwise parts at signal level and other live parts at potentials below 50 volts would have to be protected the same as hazardous live parts at primary voltages and other voltages 50 volts or more.

Insert a new 6.2.1.1 text.

This proposed new wording provides more specific requirements in support of original NFPA79:1997 clause 6.2.1 general requirement for “insulation that can only be removed by destruction”.

Insert a new 6.2.2 title

Insert a new 6.2.2.1 title and new text.

The UL test finger provides a simple consistent approach for inspecting all kinds of regular and irregular openings. The UL test finger also addresses the appropriate recess for a live part behind the opening where a test finger can be partially inserted. The test finger is commonly used throughout USA and IEC standards for household, computer, office, and other electrical equipment standards including some industrial standards such as UL508.

Insert new Figure XX illustrating the dimensions of the test finger.

Resnumber NFPA79:1997 7.9.1 to 6.2.3.1 in the new committee draft of NFPA79:2002

No changes to NFPA79:1997 7.9.1 text.

Resnumber NFPA79:1997 7.9.2 to 6.2.3.2 in the new committee draft of NFPA79:2002

Delete “To prevent closing of the disconnecting means while the door is in the initial latch position or until the door hardware is fully engaged.” This requirement does not reduce the probability of shock and was considered overly restrictive and impractical.

Resnumber NFPA79:1997 7.9.5 to 6.2.3.5 in the new committee draft of NFPA79:2002

No changes to NFPA79:1997 7.9.3 text.

Resnumber NFPA79:1997 7.9.4 to 6.2.3.4 in the new committee draft of NFPA79:2002

No changes to NFPA79:1997 7.9.4 text.

Resnumber NFPA79:1997 11.8 to 6.2.3.5 in the new committee draft of NFPA79:2002

No changes to NFPA79:1997 11.8 text. However, 11.8 applied only to control enclosures in the original NFPA79:1997 clause 11 and it now applies to all enclosures in the proposed clause 6.

Insert new clause 6.2.3.6 in the committee draft of NFPA79:2002

There are 4 exceptions to NFPA79:1997 7.9.1 (now proposed 6.2.3.1) and 4 exceptions to NFPA79:1997 11.8 (now proposed 6.2.3.5) that need a minimum requirement for protection against electric shock.

The new 6.2.3.6 in the committee draft of NFPA79:2002 will address minimum requirements for all other conditions NOT excepted or not specifically included in the original NFPA79:1997 text.

The NFPA79:1997 clause 6.3 text for PELV was extracted from IEC204. The proposed text in new committee draft of NFPA79:2002 clause 6.3 was extracted from IEC60204:1997. The primary justification for this changes are to maintain consistency between IEC60204 & NFPA79 on the conditions to satisfy PELV.

Summary:

- added ripple-free for dc voltages
- added max wet location voltages in item a deleted text in item b deleted text in item c revised text in item d revised text in item e revised text in item f revised text in item g

Item b in the original NFPA79:1997 text was deleted because the limitation of maximum current to 1 A ac or 0.2 A dc (30 VA) in case of failure (short circuit) has absolutely no relationship with the maximum currents through the human body that can cause shock or burn injury. The limitation of maximum current for PELV is overly restrictive compared to limited power circuits and Class 2 circuits such that very few, if any, low voltage & low energy circuits satisfy PELV with this limitation of maximum current.

Insert new 6.3.2 from IEC60204 titled “Sources for PELV”

Revise NFPA:1997 6.4 text and renumber as 6.4.1.

A voltage that reduces to 60 volts or less in 5 seconds would also meet 50 volts or less in 1 minute.

By harmonizing the level between NFPA79 and IEC60204 suppliers users, evaluators and inspectors can perform one analysis or one capacitor discharge test that is accepted worldwide.

Add new Exception 1 where stored energy from small capacitors not considered significant to electric shock (ex thousands of tiny printed wiring board mounted capacitors.)

Add new Exception 2 where stored energy hazard cannot be eliminated by design and warning is appropriate.

Insert new clause 6.4.2 in committee draft of NFPA79:2002

NFPA 79:1997 does not address discharge at the pins of the plug for cord-connected machines. The person is likely to be touching the bare pins of the plug immediately after disconnection from the receptacle and “X” capacitors connected from phase to phase can be discharged across the person’s fingers.

Delete NFPA79: 1997 clause 6.5 including the text of clause of 6.5.1 & 6.5.2

Safeguarding against other hazards (presumably other than electrical shock ) does not fit in clause 6 and possibly does not fit within the scope of the electrical standard for machines. If mechanical hazards are to be addressed in NFPA79 it would warrant a dedicated clause to address mechanical hazards properly.
NFPA 79 — May 2002 ROP

Cross Reference between NFPA 79-1997 and proposed text

<table>
<thead>
<tr>
<th>Clause</th>
<th>Heading</th>
<th>Clause</th>
<th>Heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Safeguarding of personnel</td>
<td>6</td>
<td>Protection from Electric Shock</td>
</tr>
<tr>
<td>6.1</td>
<td>General</td>
<td>6.1</td>
<td>General</td>
</tr>
<tr>
<td>6.2</td>
<td>Safeguarding against electric shock in normal service</td>
<td>6.2</td>
<td>Protection from electric shock during normal operation</td>
</tr>
<tr>
<td>6.2.1</td>
<td>new</td>
<td>6.2.1</td>
<td>Protection by Insulation of Live Parts</td>
</tr>
<tr>
<td>6.2.2</td>
<td>new</td>
<td>6.2.2</td>
<td>Protection by Enclosures</td>
</tr>
<tr>
<td>6.2.3</td>
<td>new</td>
<td>Figure XX</td>
<td>Test finger</td>
</tr>
<tr>
<td>7.9.1</td>
<td>Interlocking</td>
<td>6.2.3</td>
<td>Enclosure Interlocking</td>
</tr>
<tr>
<td>7.9.2</td>
<td>6.2.3.1</td>
<td>6.2.3.1</td>
<td></td>
</tr>
<tr>
<td>7.9.3</td>
<td>6.2.3.2</td>
<td>6.2.3.2</td>
<td></td>
</tr>
<tr>
<td>7.9.4</td>
<td>6.2.3.3</td>
<td>6.2.3.3</td>
<td></td>
</tr>
<tr>
<td>6.4</td>
<td>Safeguarding against electrical shock from residual voltages</td>
<td>6.4</td>
<td>Protection Against Residual Voltages</td>
</tr>
<tr>
<td>new</td>
<td>6.2.3.5</td>
<td>6.2.3.5</td>
<td></td>
</tr>
<tr>
<td>6.2.1</td>
<td>Protection by Insulation of Live Parts</td>
<td>6.3</td>
<td>Protection by the use of PELV (protective extra low voltage)</td>
</tr>
<tr>
<td>6.2.2</td>
<td>new</td>
<td>6.3.1</td>
<td>General requirements</td>
</tr>
<tr>
<td>6.2.3</td>
<td>new</td>
<td>6.3.2</td>
<td>Sources for PELV</td>
</tr>
<tr>
<td>6.3</td>
<td>new</td>
<td>6.4</td>
<td>Protection Against Residual Voltages</td>
</tr>
<tr>
<td>6.5</td>
<td>Safeguarding against other hazards</td>
<td>deleted</td>
<td></td>
</tr>
<tr>
<td>6.5.2</td>
<td>deleted</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

COMMITTEE ACTION: Accept in Principle.
Revise text to read as follows:

6 Protection from Electric Shock

6.1 General. The electrical equipment shall provide protection of persons from electrical shock both in normal operation and during fault conditions.

6.2 Protection from electric shock during normal operation. Live parts operating at 50 volts rms ac or 60 volts dc or more shall be guarded against accidental contact by an enclosure or shall be encased in listed insulation, a listed multiconductor cable or flexible cord, e.g. flexible cord or flexible cable.

6.2.1 Protection by Insulation of Live Parts. Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal operating conditions.

Paints, varnishes, lacquers, and similar products are inadequate for protection against electric shock under normal operating conditions.

6.2.2 Protection by Enclosures

6.2.2.1 Direct Contact from outside an enclosure. Live parts shall be located inside enclosures such that there cannot be any direct contact to live parts from the outside of an enclosure when using the test finger. The determination of the suitability of an enclosure as protection from electrical shock shall be determined by using a test finger as described in figure XX. The test finger is shall be applied, without appreciable force, in every opening in the enclosure after removal of all parts of the enclosure that can be removed without the use of a tool.

(Figure shown on following page)
Figure XX - Jointed test finger.

Dimensions in millimeters

Tolerances on dimensions without specific tolerance:
- on angles: 0° ± 10°
- on linear dimensions:
  up to 25 mm: 0° ± 0.05 mm
  over 25 mm: ± 0.2 mm

Material of finger: heat-treated steel, etc.

Both joints of this finger may be bent through an angle of (90° ± 10°) but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a (90° ± 10°) bending angle.
6.2.3.1 Each disconnecting means mounted within or adjacent to a control enclosure that contains live parts operating at 50 volts rms or 60 volts dc or more shall be mechanically or electrically interlocked, or both, with the control enclosure doors so that none of the doors can be opened unless the power is disconnected. Interlocking shall be reactivated automatically when all the doors are closed.

Exception No. 1: A disconnecting means used only for maintenance lighting circuits within control enclosures shall not be required to be interlocked with the control enclosure. A safety sign shall be provided which meets the requirements of 17.2.5.

Exception No. 2: A disconnecting means used for power supply circuits within control enclosures to memory elements and their support logic requiring power at all times to maintain the storage of information shall not be required to be interlocked with the control enclosure doors. A safety sign shall be provided which meets the requirements of 17.2.5.

6.2.3.1.1 Means shall be permitted to be provided for qualified persons, using appropriate work practices, to gain access without removing power. The interlocking means shall:

a) utilize a device or tool as specified by the manufacturer of the interlock to allow qualified persons to defeat the interlock, and

b) be reactivated automatically when the door(s) is closed, and

c) prevent closing of the disconnecting means while the enclosure door is open, unless an interlock is operated by deliberate action.

6.2.3.2 Where a qualified (skilled) person, using appropriate work practices, need to enter an enclosure not having a disconnect, one of the following conditions shall be met:

a) the use of a key or tool is required for opening the enclosure, or

b) an enclosure door shall be permitted to be opened without the use of a key or a tool and without disconnection of live parts only when all live parts inside are separately enclosed or guarded such that there cannot be any direct contact with live parts by a test finger.

6.2.3.4 Where there are two or more sources of power to the equipment or where there are two or more independent disconnecting means, power wiring from each disconnecting means shall be run in separate raceway and shall not terminate in or pass through common junction boxes.

6.2.3.5 Any door(s) that permits access to live parts operating at 50 volts rms or 60 volts dc or more shall be so interlocked that the door(s) cannot be opened unless all power is disconnected.

Exception No. 1: External interlocking circuits operating at less than 500 volts shall not be required to be disconnected provided that the circuit conductors are identified with a yellow or orange-colored insulation as described in 149.4.1 and a warning marking is attached to the door in accordance with 17.2.4.

Exception No. 2: It shall be permitted to provide means for qualified persons to gain access without removing power. The interlocking shall be reactivated automatically when the door(s) is closed.

Exception No. 3: Where an attachment plug is used as the disconnecting means and a warning marking is attached to the door in accordance with 17.2.5.

Exception No. 4: Where the motor(s) on the machine totals two horsepower or less, an external, noninterlocked disconnecting means shall be permitted provided that the disconnecting means is sight from and readily accessible, the control enclosure door or cover, is marked with a warning indicating that the power shall be removed before the disconnecting means before the enclosure is opened, and further provided that a tool is required to open the enclosure.

6.2.3.6 Protection from Direct Contact inside an Enclosure

Requirements in this subclause are addressing equipment where a qualified (skilled) person, using appropriate work practices, need to enter an enclosure not meeting the requirements of 6.2.3.1 while the equipment is energized.

Note: The design objective is to minimize operations where a qualified (skilled) person must enter the enclosure while the equipment is energized.

All enclosures relied on to prevent contact with live parts operating at 50 volt rms or 60 volt dc or more shall comply with one of the following conditions:

a) the use of a key or tool is required for opening an enclosure.  
b) disconnection of live parts inside the enclosure before the enclosure door is opened.

c) for opening an enclosure without the use of a key or a tool and without disconnection of live parts shall be possible only when all live parts inside are separately enclosed or guarded such that there cannot be any direct contact to live parts by a test finger.  
<<D fisher Friday action>>

6.3 Protection by the use of PELV (protective extra-low voltage)

6.3.1 General requirements

The use of PELV (protective extra-low voltage) is to protect persons against electric shock from indirect contact and limited area direct contact.

Where such circuits are used as control circuits, they shall also fulfill the relevant requirements of Clause 5.

PELV circuits shall satisfy all of the following conditions:

a) the nominal voltage shall not exceed:
   – 30 V a.c. r.m.s. or 60 V ripple-free d.c. when the equipment is normally used in dry locations and when large area contact of live parts with the human body is not expected; or
   – 6 V a.c. r.m.s. or 15 V ripple-free d.c. in all other cases;

NOTE – Ripple-free is conventionally defined for a sinusoidal ripple voltage as a ripple content of not more than 10% r.m.s.

b) one side of the circuit or one point of the source of the supply of that circuit shall be connected to the equipment grounding (protective bonding) circuit;

c) live parts of PELV circuits shall be electrically separated from other live circuits. Electrical separation shall be not less than that required between the primary and secondary circuits of a safety isolating transformer.

Note: For additional information on isolating transformers, refer to IEC 60742 and IEC 61558-1.

c) conductors of each PELV circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation provisions of 14.11.3 shall apply;

d) Attachment plugs and receptacles (plugs and socket combinations) for a PELV circuit shall conform to the following:
   1) Attachment plugs (plugs) shall not be able to enter receptacles (socket-outlets) of other voltage systems;
   2) receptacles (socket-outlets) shall not admit plugs of other voltage systems.

Where such circuits are used as control circuits, they shall also fulfill the relevant requirements of Clause 5.

6.3.2 Sources for PELV. The source for PELV shall be one of the following:

a) a safety isolating transformer;

b) a source of current providing a degree of safety equivalent to that of the safety isolating transformer (e.g. a motor generator with winding providing equivalent isolation);

c) an electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. a diesel-driven generator);
6.4 Protection Against Residual Voltages

6.4.1 Live parts having a residual voltage greater than 60 volts after the supply has been disconnected shall be reduced to 60 volts or less within 5 seconds after disconnection of the supply voltage.

Exception 1 Exempted from this requirement are components having a stored charge of 60 micro-coulombs or less.

Exception 2 Where such a provision would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be entered shall be displayed at an easily visible location on or immediately adjacent to the enclosure containing the capacitance.

6.4.2 In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (e.g. pins), the discharge time shall not exceed 1 second.

Exception 1 Exempted from this requirement are components having a stored charge of 60 micro-coulombs or less.

Exception 2 Exempted from this requirement are conductors which are protected against direct contact

Exception 3 removable collectors on collector wires, conductor bars, or slipping assemblies which comply with X.X.X are permitted. [deleted for correlation]

COMMITTEE STATEMENT: All cross references were updated to reflect current locations. In addition the following items further explain the changes made to the initial proposal:

1) In 6.2, the phrase listed insulation was changed to a listed multiconductor cable or flexible cord for clarity. The e.g. statement was removed because it no longer added clarity.
2) The word "is" 6.2.2.1 was changed to "shall be" to comply with the NFPA Manual of Style.
3) Section 6.2.3 was completely reorganized to assist in clarity and useability.
4) In 6.2.3.4 the term conduit was changed to raceway to be less restrictive and reflect current practice.
5) 6.3.1(d)(2), last sentence, was moved to 6.3.1, General because it is more appropriate at that location.
6) 6.4.2. Exception No. 3 was deleted for correlation with action taken on Clause 13.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE: ANDERSON: The chapter material hierarchical arrangement and resultant numbering system shown in the proposal is still not clear [or consistent]. After reading the chapter with the committee's statement and consulting the MOS, I believe the chapter organization would be as outlined below. The numbers are only proposed to illustrate the chapter, section and subsection subject order for the titles. The numbered but untitled paragraphs and subparagraphs are not shown.

6 Protection from Electric Shock

6.1 General

6.2 Protection from electric shock during normal operation

6.2.1 Protection by Insulation of Live Parts

6.2.2 Protection by Enclosures

6.2.3 Enclosure interlocking

6.3 Protection by the use of PELV (protective extra low voltage)

6.3.1 General requirements

6.3.2 Sources for PELV

6.4 Protection against residual voltages

BLOODGOOD: I would be in favor of modifying this proposal based on the proposal submitted by John Dean (seq #79-27) (Log #79).

DOBROWSKY: (1) I am close to casting a negative vote on this proposal.

(2) 6.2.2.1 The test finger and its related information belong in an annex. Much of the language is informational and contains terms such as "must" and "may" which are not permitted. Many machines are built using listed enclosures and using a test finger is not necessary.

(3) 6.2.3 The interlocking requirements belong in either Chapter 5 or Chapter 12 or the relevant portions in both. The requirements need to be revised to describe features instead of being written as work practices.

(4) 6.3 This should be revised or deleted. Most of the provisions are informational and do not describe where PELV circuits are to be used.

(5) 6.4 The exceptions need to be revised to improve clarity.

FREUDENBERG: Annex or note related to Clause 6 and Clause 11

Protection from electric shock and energy hazards for electronic computer and test equipment

The product standards applicable to listed electronic computer and test equipment permit personnel to touch live outputs from and energized live parts within the following circuits provided no energy (burn) hazard exists based on the following safety principles for protection against electric shock. These safety principles including associated definitions and requirements are not incorporated in the text of NFPA79:

- bare live parts of SELV circuits (low voltage circuits),
- bare live parts supplied by power supplies with SELV outputs,
- bare live parts supplied by limited current circuits (for hazardous voltage circuits exceeding 60Vdc with limited currents),
- bare live parts supplied by TTN circuits under the conditions specified for circuits powered by the telecommunication network.

Note: SELV circuit requirements are not equivalent to PELV circuit requirements.

Protection from electrical energy (burn) hazards for electronic computer and test equipment

There shall be no energy hazard in operator access areas.

Compliance is checked by means of the test finger figure in a straight position applied without appreciable force. It shall not be possible to bridge with this test finger two bare parts, one of which may be an earthed conductive part, between which a hazardous energy level exists.

Protection from electric shock and energy hazards for Information Technology Equipment (ITE)

Protection from electric shock and energy hazards for electronic computer equipment within the scope of Information Technology Equipment (ITE) are typically listed to UL1950 in the USA. UL1950 is also harmonized with EN60950 in Europe and harmonized with the national versions of IEC60950 in 45 other countries so computers certified by qualified labs in other countries have been evaluated to the same requirements for protection from electric shock and energy hazards in UL1950.

Protection from electric shock and energy hazards for Electronic Test and Measurement Equipment

Protection from electric shock and energy hazards for electronic test equipment within the scope of Electronic Test and Measurement Equipment are typically listed to UL3111 in the USA. UL3111 is also harmonized with EN61010-1 in Europe and harmonized with the national versions of IEC61010-1 in 45 other countries so test equipment certified by qualified labs in other countries have been evaluated to the same requirements for protection from electric shock and energy hazards in UL3111.

Classification of Information Technology Equipment (ITE) and Test Equipment for protection from electric shock

Grounded equipment or circuits relying on basic insulation between primary and earth ground (Class I), or

Ungrounded equipment or circuits relying on the equivalent to double insulation (Class II), or
Grounded or Ungrounded equipment or circuits powered by a low voltage supply circuit with SELV outputs (Class III)

NOTE Equipment containing ELV circuits or parts at hazardous voltage is Class I or Class II. There are no requirements in this standard for protection against electric shock for Class III equipment.

Protection from electrical energy (burn) hazards for electronic computer and test equipment

Live parts of terminals and associated interconnecting secondary wiring supplied by power limited sources will by definition meet the energy limits of Class 2 per article XX of the NEC NFPA 70.

Note: Class II per UL1950 is not the same as Class 2 per the NEC. Power Limited Circuits complying with UL1950 also satisfy Class 2 per the NEC. To avoid confusion between Class II and Class 2, these circuits are referred to as power limited circuits.

Limited power circuits

A mains-operated limited power source, or a battery-operated limited power source that is recharged from the mains while supplying the load, shall incorporate an isolating transformer.

A limited power source shall comply with one of the following:

- the output is inherently limited in compliance with table 8;
- an impedance limits the output in compliance with table 8. If a Positive Temperature Coefficient device is used, it shall pass the tests specified in IEC 730-1, clauses 15 and 17, and IEC 730-1, amendment 3, clauses J15 and J17;
- an overcurrent protective device is used and the output is limited in compliance with table 9;
- a regulating network limits the output in compliance with table 8, both under normal operating conditions and after any single fault in the regulating network (open circuit or short-circuit);
- a regulating network limits the output in compliance with table 8 under normal operating conditions and an overcurrent protective device limits the output in compliance with table 9 after any single fault in the regulating network (open-circuit or short-circuit).

Where an overcurrent protective device is used, it shall be a fuse or a non-adjustable non-autoreset electromechanical device.

Insert Table 8 and Table 9 from proposal #79-31, log# 158

Definitions from UL1950 and UL3111

The definitions for circuits & circuit characteristics, classes of equipment, and types of insulation are necessary for a basic understanding of the overview in this Annex. For further details on all of above, see UL1950 and UL3111.

1.2.4 Classes of equipment - Protection against electric shock

1.2.4.1 CLASS I EQUIPMENT

Equipment where protection against electric shock is achieved by:

- a using basic insulation, and also
- b providing a means of connecting to the protective earthing conductor in the building wiring those conductive parts that are otherwise capable of assuming hazardous voltages if the basic insulation fails.

NOTE 1 Class I equipment may have parts with double insulation or reinforced insulation, or parts operating in SELV circuits.

NOTE 2 For equipment intended for use with a power supply cord, this provision includes a protective earthing conductor as part of the cord.

1.2.4.2 CLASS II EQUIPMENT

Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no reliance on either protective earthing or installation conditions.

NOTE 1 This definition for Class II equipment differs from the term Class II equipment as used in IEC 536.

NOTE 2 Class II equipment may be of one of the following types:

- equipment having a durable and substantially continuous electrical enclosure of insulating material which envelops all conductive parts, with the exception of small parts, such as nameplates, screws and rivets, which are isolated from parts at hazardous voltage by insulation at least equivalent to reinforced insulation; such equipment is called insulation-encased class II equipment.
- equipment having a substantially continuous metallic electrical enclosure, in which double or reinforced insulation is used throughout; such equipment is called metal-encased class II equipment.

1.2.4.3 CLASS III EQUIPMENT

Equipment in which protection against electric shock relies upon supply from SELV circuits and in which hazardous voltages are not generated.

1.2.8 Circuits and circuit characteristics

1.2.8.1 PRIMARY CIRCUIT

An internal circuit which is directly connected to the external supply mains or other equivalent source (such as a motor-generator set) which supplies the electric power. It includes the primary windings of transformers, motors, other loading devices and the means of connection to the supply mains.

1.2.8.2 SECONDARY CIRCUIT

A circuit which has no direct connection to primary power and derives its power from a transformer, converter or equivalent isolation device, or from a battery.

1.2.8.3 HAZARDOUS VOLTAGE

A voltage exceeding 42.4 V peak, or 60 V d.c., existing in a circuit which does not meet the requirements for either a limited current circuit, or a TNV circuit.

1.2.8.4 ELV CIRCUIT

A secondary circuit with voltages between any two conductors of the ELV circuit, and between any one such conductor and earth, not exceeding 42.4 V peak, or 60 V d.c., under normal operating conditions, which is separated from hazardous voltage by at least basic insulation, and which neither meets all the requirements for an SELV circuit nor meets all of the requirements for a limited current circuit.

1.2.8.5 SELV CIRCUIT

A secondary circuit which is so designed and protected that under normal and single fault conditions the voltages do not exceed a safe value.

NOTE 1 The limiting value of voltage under normal operating and single fault conditions are specified in 2.3. See also annex V and table V.1.

NOTE 2 This definition of an SELV circuit differs from the term SELV as used in IEC 364.

1.2.8.6 LIMITED CURRENT CIRCUIT

A circuit which is so designed and protected that under both normal conditions and a likely fault condition the current which can be drawn is not hazardous.

NOTE The limiting values are specified in 2.4.

1.2.8.7 HAZARDOUS ENERGY LEVEL

A stored energy level of 20 J or more, or an available continuous power level of 240 VA or more at a potential of 2 V or more.

1.2.8.8 TELECOMMUNICATION NETWORK VOLTAGE (TNV) CIRCUIT

A circuit in the equipment to which the accessible area of contact is limited and that is so designed and protected that under normal operating and single fault conditions, the voltages do not exceed specified limiting values.
A TNV circuit is considered to be a secondary circuit in the meaning of this standard.

NOTE The specified limiting values of voltages under normal operating and single fault conditions are in 6.2.1.1. See also annex V. Requirements regarding accessibility for TNV circuits are in 6.2.2.

TNV circuits are classified as TNV-1, TNV-2 and TNV-3 circuits as defined in 1.2.8.9, 1.2.8.10, and 1.2.8.11 and as shown in table V.1.

1.2.8.9 TNV-1 CIRCUIT

A TNV circuit: whose normal operating voltages do not exceed the limits for an SELV circuit under normal operating conditions.

on which overvoltages from telecommunication networks are possible.

1.2.8.10 TNV-2 CIRCUIT

A TNV circuit: whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions.

which is not subject to overvoltages from telecommunication networks.

1.2.8.11 TNV-3 CIRCUIT

A TNV circuit: whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions.

on which overvoltages from telecommunication networks are possible.

1.2.9 Types of Insulation

1.2.9.1 OPERATIONAL INSULATION

Insulation needed for the correct operation of the equipment. NOTE Operational insulation by definition does not protect against electric shock. It may however serve to minimize exposure to ignition and fire.

1.2.9.2 BASIC INSULATION

Insulation to provide basic protection against electric shock.

1.2.9.3 SUPPLEMENTARY INSULATION

Independent insulation applied in addition to basic insulation in order to ensure protection against electric shock in the event of a failure of the basic insulation.

1.2.9.4 DOUBLE INSULATION

Insulation comprising both basic insulation and supplementary insulation.

1.2.9.5 REINFORCED INSULATION

A single insulation system which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard. NOTE The term "insulation system" does not imply that the insulation has to be in one homogeneous piece. It may comprise several layers which cannot be tested as supplementary or basic insulation.

1.2.9.6 WORKING VOLTAGE

The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use. NOTE See 2.2.7.

(See figure on following page)

SAUNDERS: The revision of the definition of live parts from "Electrical conductors, buses, terminals, or components that are uninsulated or exposed and a shock hazard exists" to "Energized conductive components" alters the requirement found in 6.2 significantly. Previously, only live parts that are uninsulated or exposed and a shock hazard exists, would be required to be guarded against accidental contact by an enclosure. By revising the definition of live parts, clause 6.2 now requires all energized conductive components to be guarded against accidental contact by the use of an enclosure. No substantiation has been submitted to indicate that this previous requirement should be changed. During the committee meeting, it was recognized that there might be sections where the change in definition may alter the requirements and that these issues should be addressed during the comment stage. Recommendation:

Revise 6.2 to read "Live parts operating at 50 volts rms ac or 60 volts dc or more that are uninsulated or exposed and a shock hazard exists shall be guarded against accidental contact by an enclosure or shall be a listed multicorder cable or flexible cord".

Revise 6.2.2.1 to read "Live parts that are uninsulated or exposed and a shock hazard exists shall be located inside enclosures such that there cannot be any direct contact to the parts...".

Revise 6.2.5.1 to read "...that contains live parts operating at 50 volts rms ac or 60 volts dc or more that are uninsulated or exposed and a shock hazard exists shall be mechanically or electrically interlocked..."

Revise 6.2.5.2 to read "...that with live parts that are uninsulated or exposed and a shock hazard exists by a test finger...".

79-17 - (6.1.6.1): The proposed text in Section 6.1 does not read as follows:

6.1 General. Electrical equipment shall provide protection of persons from electrical shock hazards during both normal operation and during fault conditions.

SUBSTANTIATION: Recent studies have expanded the list of electrical hazards to also include arcflash. Numerous IEEE papers and testing have been published relating to designing systems to reduce the hazardous effects of arcflash. This will also align with the existing requirements in NFPA 70 1999 National Electrical Code Section 110-3(a)(6).

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The committee does not desire to expand the requirements of Clause 6 to include other "electrical" hazards.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 28 VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 22 NEGATIVE: 6

NOT RETURNED: 1 Norman EXPLANATION OF NEGATIVE:

DOBROWSKY: This proposal should be accepted. Section 1.6 describes this standard as providing "detailed information..." that will promote safety to life and property..." Enclosing live parts accomplishes more than just protection from electric shock.

FREUDENBERG: Adding "burn / energy" to shock to the title of clause 6 would require new requirements limiting available energy inside and outside the enclosure. This should be done. Inside the enclosure any live part exceeding 2 volts where the available current exceeds 240 VA (example a live part at 5 volts dc with an available current of more than 250 amperes) when inadvertently shorted to another live part or ground by a chain, ring, watch, screwdriver or other conductive object may cause a burn hazard from hot or molten metal. Certainly any output terminal or wiring method exiting the enclosure should be limited to NEC Class 2. Also see comments on proposal # 79-31, log# 158.

GARVEY: Electrical energy hazards other than shock should be addressed by Clause 6. Testimony presented to the panel clearly indicates that listed equipment is not intended to be switched on or off with the door open. The proposed text in Clause 6 permits operating the disconnect through the deliberate action of defeating the supply disconnect interlock. Clause 6 should address the consequences of such action.

Committee 7 does cover overcurrent protection. Clause 7 rules are intended to protect the building and occupants from the potential fire hazard improperly protected equipment presents. The test proposed by Mr. Lottmann belongs in Clause 6.
Figure 5A - Examples of application of insulation
NFPA 79 — May 2002 ROP — Copyright 2001, NFPA

79-27 - (6.2.1) [6.2.2]: Reject
SUBMITTER: John B. Deam, Rep. The Association for Manufacturing Technology
RECOMMENDATION: Modify in the rewrite of 1997 NFPA 79 Clause 6, that is new Clause 6 in 6.2.2 as proposed below.

Delete the first sentence in the proposed clause 6.2.2 and use instead the wording of the current edition of NFPA 79 clause 6.2.1, but with the references to Clause 11 and Clause 12 of the NFPA 79-6.2.1 deleted.

Change the second and third sentences in the proposed new rewritten Clause 6.2.2 to the form of a Note. Simultaneously change the word "shall" in the first sentence of the newly proposed Note to "could."

SUBSTANTIATION: The requirement for the use of a "test finger" to establish the sufficiency of clearances internal to enclosures is mandated in neither the current NFPA 79, nor in the current IEC 60947-1. In the other hand the use of such a device could be one of a number of ways to test this condition. Hence this current proposal to provide such information in note form.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The committee agrees with the substantiation provided in Proposal 79-25 (Log #86) which states the following:

The UL test finger provides a simple consistent approach for inspecting all kinds of regular and irregular openings. The UL test finger also addresses the appropriate recess for a live part behind the opening where a test finger can be partially inserted. The test finger is commonly used throughout USA and IEC standards for household, computer, office, and other electrical equipment standards including some industrial standards such as UL508.

In addition, the submitter has failed to provide alternative recognized methods for compliance with this clause.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 21
NEGATIVE: 4
NOT RETURNED: 1 Norman
EXPLANATION OF NEGATIVE: BLOODGOOD: See my Comment on Affirmative for Proposal 79-25 (Log # 68).
DOBROWSKY: The proposal should be accepted or accepted in principle. The use of a test finger is not necessary in many situations and its provisions should be located in an annex. No evidence of a problem has been demonstrated with the existing NFPA 79 or IEC 60204-1 requirements. See also my Comment on Proposal 79-25 (Log #08).
MONETTHE: I agree with the Explanation of Negative Vote of Mr. Dobrowsky.
PADGET: I agree with Mr. Dobrowsky’s Explanation of Negative Vote.

COMMENT ON AFFIRMATIVE: FREUDENBERG: Compliance may be determined by inspection, or where appropriate, use of the test finger. The size and shape of the test finger is described in exact detail such that the determination need not be made without actually owning or applying the test finger.

SUBSTANTIATION: The proposal reduces the potential of shock hazard. Equipment users (SAE HS 1758), NRTLs (UL 508), AHJ (Calf. OSHA) now require some form of back of hand and fingersafe construction.

COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The recommended text is written in a manner more suited for a procedure or work practice. Nonmandatory language is not permitted in the body of the standard. Disconnects are not tested for, nor are they intended for, operation with the door in the open position.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE: DOBROWSKY: Service personnel should not be subjected to inadvertent contact or unexpected contact with live parts while performing typical service operations; specific touchproof or back of hand requirements do not take into account typical service operations and the need to access specific areas inside the enclosure for servicing. It is also unrealistic to assume power will always be disconnected for service and maintenance operations where live adjustments and measurements must be made, however touchproof & back of hand access limitations are too restrictive inside the enclosure in some cases and not safe enough in other cases where the live parts are located immediately adjacent to other parts that must be adjusted while the equipment is energized.

SANDERS: This material is more suitable for NFPA 70B "Recommended Practices for Electrical Maintenance". The submitter is urged to re-submit this information to that Technical Committee for consideration.

79-29 - (16.x): Reject
RECOMMENDATION: Add text to read as follows:

X.1 Voltage and current measuring circuit terminals which generate or accept voltages above 50V ac rms or 60Vdc are permitted provided both of the following conditions are met:
- the measuring circuit has sufficiently high impedance at the interface to safely generate or accept the rated maximum working voltage or current;
- the measuring circuit terminals are marked with the rated maximum working voltage or current as applicable adjacent to the terminals.

Exception 1: Measuring input circuit terminals (connectors) which are dedicated only for connection to specific terminals of other equipment need not be marked.

Exception 2: If there is insufficient space for markings adjacent to the measuring circuit terminals (as in multi-input equipment), it is permissible for the rated maximum working voltage or current information to be located in the operating manual.

Exception 3: Measuring circuit terminals provided by listed test and measurement equipment.

SUBSTANTIATION: Measuring circuit terminals of NFPA 79 needs to cease including measuring circuits in the scope and in the annex or technically address the significant differences between "high impedance" measuring circuits and "low impedance" power circuits.

Volimeters commonly accept voltages up to 1000V or more. Insulation resistance (megohm) meters commonly generate 500Vdc voltages for measuring purposes.

Ground continuity testers commonly use a current injection method of 10 amps, 25 amps, or 1000Vdc. Dielectric withstand (hypot) testers commonly generated up to 5000V ac or 5000V dc.

Obviously these types of measuring terminals have been used for decades and can be designed safely even though NFPA 79 does not address these types of terminals are currently unsafe according to the letter of NFPA 79.

Additional concepts of current limited terminals and power limited terminals are intended for this proposal establishes standards for test and measurement equipment if the 79 Technical Committee wants to add more detail. For now the above is a good introduction.

COMMITTEE ACTION: Reject.

79-28 - (6.2.4) (New) [6.2.4]: Reject
SUBMITTER: Gordon T. Davis, Moeller Electric Corp.
RECOMMENDATION: Add new text:
6.2.4 The use of a key or a tool is necessary for access by a skilled and instructed person to carry out the operation for which it may not be appropriate to disconnect the equipment. The supply disconnecting means may be operated as needed while the door is operation with the door in the open position.

Examples of such operations are: replacement of fuse elements; disconnecting means may be operated as needed while the device is inside the enclosure in some cases and not safe enough in other cases where the live parts are located immediately adjacent to other parts that must be adjusted while the equipment is energized.

- the measuring circuit has sufficiently high impedance at the interface to safely generate or accept the rated maximum working voltage or current;
- the measuring circuit terminals are marked with the rated maximum working voltage or current as applicable adjacent to the terminals.

Exception 1: Measuring input circuit terminals (connectors) which are dedicated only for connection to specific terminals of other equipment need not be marked.

Exception 2: If there is insufficient space for markings adjacent to the measuring circuit terminals (as in multi-input equipment), it is permissible for the rated maximum working voltage or current information to be located in the operating manual.

Exception 3: Measuring circuit terminals provided by listed test and measurement equipment.

SUBSTANTIATION: Measuring circuit terminals of NFPA 79 needs to cease including measuring circuits in the scope and in the annex or technically address the significant differences between "high impedance" measuring circuits and "low impedance" power circuits.

Volimeters commonly accept voltages up to 1000V or more. Insulation resistance (megohm) meters commonly generate 500Vdc voltages for measuring purposes.

Ground continuity testers commonly use a current injection method of 10 amps, 25 amps, or 1000Vdc. Dielectric withstand (hypot) testers commonly generated up to 5000V ac or 5000V dc.

Obviously these types of measuring terminals have been used for decades and can be designed safely even though NFPA 79 does not address these types of terminals are currently unsafe according to the letter of NFPA 79.

Additional concepts of current limited terminals and power limited terminals are intended for this proposal establishes standards for test and measurement equipment if the 79 Technical Committee wants to add more detail. For now the above is a good introduction.

COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The current requirements of NFPA 79 do not prohibit this practice provided that safety is assured by compliance with 6.2.2.1. It is not the intent of this committee that these parts should be exposed live parts.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 2
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:
FREUDENBERG: NFPA 79 does not currently address measuring terminals inside or outside the equipment enclosure. When measuring circuits are measuring voltage or current at the terminals, there is likely to be an alternate connection to an source of AC or DC power. The probes, leads, terminals and circuits used for measuring are protected by the very impedance of the measuring circuits.

COMMITTEE STATEMENT:
The committee is unaware of provisions in Clause 6 that provide for the use of "limited current circuits" as a protective technique from energy hazard.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 25

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 23
NEGATIVE: 1 Norman
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: A fine print note explaining how protection against shock by limited current circuits are used in UL1950 would be very extremely helpful. See attachment submitted for proposal # 79-25, log # 68.

(Add text to read as follows: X.0 Limited power terminals
A limited power terminal shall comply with one of the following:
- output is inherently limited in compliance with Table 8;
- an impedance limits the output in compliance with Table 8;
- a regulating network limits the output in compliance with Table 8, both under normal operating conditions and after any single fault in the regulating network (open circuit or short circuit);
- a regulating network limits the output in compliance with Table 8, both under normal operating conditions and after any single fault in the regulating network (open circuit or short circuit);
Table 8 Limits for inherently limited power sources
Table 9 Limits for power sources not inherently limited (overcurrent protective device required)

Table 8 Limits for inherently limited power sources

<table>
<thead>
<tr>
<th>Output Voltage (Uoc)</th>
<th>Output current (Ioc)</th>
<th>VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 20</td>
<td>up to 20</td>
<td>up to 8.0</td>
</tr>
<tr>
<td>over 20 up to 30</td>
<td>over 20 up to 30</td>
<td>up to 8.0</td>
</tr>
<tr>
<td>- over 30 up to 60</td>
<td>over 30 up to 60</td>
<td>up to 150/Uoc</td>
</tr>
</tbody>
</table>

Conditions applicable to table 8
1. Uoc: Output voltage measured with the equipment connected to the supply at rated input voltage and with all load circuits disconnected. Voltages are for sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and d.c., with ripple greater than 10% peak, the peak voltage shall not exceed 42.4 V.
2. Ioc: Maximum output current after 60 s of operation with any non-capacitive load, including short circuit.
3. VA: Maximum output VA with any load. Initial transients lasting less than 100 ms are ignored.

Table 9 Limits for power sources not inherently limited (overcurrent protective device required)

<table>
<thead>
<tr>
<th>Output Voltage (Uoc)</th>
<th>Output current (Ioc)</th>
<th>VA</th>
<th>Rated current value of overcurrent protective device</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 20</td>
<td>up to 20</td>
<td>A</td>
<td>up to 50</td>
</tr>
<tr>
<td>over 20 up to 30</td>
<td>over 20 up to 30</td>
<td>Up to 1000/Uoc</td>
<td>up to 250</td>
</tr>
<tr>
<td>over 30 up to 60</td>
<td>over 30 up to 60</td>
<td>up to 100</td>
<td></td>
</tr>
</tbody>
</table>

Conditions applicable to table 9
1. Uoc: Output voltage measured with the equipment connected to the supply at rated input voltage and with all load circuits disconnected. Voltages are for sinusoidal a.c. and ripple free d.c. For non-sinusoidal a.c. and d.c., with ripple greater than 10% peak, the peak voltage shall not exceed 42.4 V.
2. Ioc: Maximum output current after 60 s of operation with any non-capacitive load, including short circuit and with any overcurrent protective devices bypassed.
3. VA: Maximum output VA with any load and with overcurrent protective devices bypassed. Initial transients lasting less than 100 ms are ignored.
4. The rated current values of overcurrent protective devices are based on fuses and circuit breakers that break the circuit within 120 s with a current equal to 210 percent of the rated current value specified in the
The installation.

SAME TIME and qualified persons who are authorized will service

WHERE CONDITIONS of maintenance and supervision ensure that

ASSOCIATED SWITCHGEAR, PANELBOARDS, or MOTOR CONTROL CENTERS

ACROSS THE AISLE from each other or across from a grounded

PERMITTED between control cabinets or compartments located

EXCEPTION 1 – Condition 1 working clearance depth shall be permitted where all of the following conditions are met:

1 – the control cabinet or compartment is operating at not over 150 volts line-to-line or line-to-ground

2 – the conditions of maintenance and supervision ensure that only qualified persons will service the installation

3 – the door(s) of the control cabinet or compartment open at least 90 degrees or are removable.

EXCEPTION 2 – By special permission working space clearance depth less than 2 1/2 ft (762 mm) shall be permitted where all of the following conditions are met:

1 – the control cabinet or compartment is operating at not over 150 volts line-to-line or line-to-ground

2 – the conditions of maintenance and supervision ensure that only qualified persons will service the installation

3 – the control cabinet and compartment requires a tool to open

4 – where only diagnostic troubleshooting and testing on live parts is involved

5 – the door(s) of the control cabinet and compartment open at least 90 degrees or are removable.

EXCEPTION 3 – Condition 2 working clearance depth shall be permitted where all of the following conditions are met:

1 – the control cabinet or compartment is operating at greater than 150 volts line-to-line or line-to-ground

2 – the conditions of maintenance and supervision ensure that only qualified persons will service the installation

3 – the control cabinet and compartment open at least 90 degrees or are removable.

EXCEPTION 4 – Condition 1 working clearance depth shall be permitted where control cabinets or compartments are located across the aisle from each other, or across from a grounded surface, and all associated control cabinet or compartment devices and equipment operating at greater than 150 volts line-to-line or line-to-ground.

4 – where only diagnostic troubleshooting and testing on live parts is involved

5 – the door(s) of the control cabinet or compartment open at least 90 degrees or are removable.

Table 4.4.9.1.1 Working Space Depth

<table>
<thead>
<tr>
<th>Nominal Voltage to Ground</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-150</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>151-600</td>
<td>3</td>
<td>3 1/2</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes:

1. For SI units, 1 ft = 0.3048 m.
2. Where the conditions are as follows:

   Condition 1 – Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not over 300 volts to ground shall not be considered live parts.

   Condition 2 – Exposed live parts on one side and a grounded surface on the other side. Concrete, brick, or tile walls shall be considered as grounded.

   Condition 3 – Exposed live parts on both sides of the working space (not guarded as provided in Condition 1) with the operator between.

   Exception 1 – Working space shall not be required in back or sides of control cabinets or compartments, where there are no renewable or adjustable parts on the back or sides and where all connections are accessible from locations other than the back or sides. Where rear access is required to work on de-energized parts on the back of enclosed control cabinet and compartment, a minimum working space of 2 1/2 ft. (762 mm) horizontally shall be provided.

   Exception 2 – By special permission working space clearance depth 2 1/2 ft (762 mm) or less shall be permitted where all uninsulated parts are at a voltage no greater than 50 volts rms ac, or 60 volts dc.

   Exception 3 – Condition 2 working clearance depth shall be permitted between control cabinets or compartments located across the aisle from each other or across from non-machinery associated switchgear, panelboards, or motor control centers where conditions of maintenance and supervision ensure that written procedures have been adopted to prohibit the affected equipment doors on both sides of the aisle from being open at the same time and qualified persons who are authorized will service the installation.
application of Article 110-26. The baseline text of this proposal comes from Article 110-26, and Article 670-5, with additions and revision intended to facilitate this stated purpose.

Substantiation for 4.4.9 Spaces About Control Cabinets and Compartments

The baseline of this text is from NFPA 70 Article 110-26(a) and NFPA 70 Article 110-26. Sentence positioning and structure, as well as minor text alterations, are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for 4.4.9.1 Working Space Depth

This text is from NFPA Article 110-26(a). The positioning of this sentence is appropriate in this location as relative to its position in Article 110-26(a)2 because the opening of a control cabinet or compartment door requires working space in three planes (i.e. depth, width and height), not one (i.e. width). The text is better served when more appropriately placed and readily found.

The sentence brought over from Article 110-26(a)2 was truncated because an element of the sentence (i.e. "in all cases...") is meaningless, and serves no purpose relative to the control cabinets and compartments of industrial machinery.

Substantiation for 4.4.9.1.1

This text is from NFPA 70 Article 110-26(a).1. The table reference is renumbered to create consistency with the rest of this document.

Substantiation for Table 4.4.9.1.1 Working Space Depth

This table is from NFPA 70 Table 110-26(a). The table is renumbered to create consistency with the rest of this document.

Substantiation for notes to Table 4.4.9.1.1

Note 1: This heading and text is from NFPA 70 Table 110-26(a) Notes 1 without alteration.

Note 2: This heading and text is from NFPA 70 Table 110-26(a) Notes 2 without alteration.

Substantiation for Condition 1

This text is from NFPA 70 Article 110-26(a) Notes Condition 1. The first sentence was truncated because an element of the sentence (i.e. ".by suitable wood or other...") appears to serve no current practices relative to the control cabinets and compartments of industrial machinery.

Substantiation for Condition 2:

This heading and text is from NFPA 70 Article 110-26(a) Notes Condition 2 without alteration.

Substantiation for Condition 3:

This heading and text is from NFPA 70 Article 110-26(a) Notes Condition 3 without alteration.

Substantiation for Exception 1:

This exception is from NFPA 70 Article 110-26(a) Exception 1. Minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for Exception 2:

This exception is from NFPA 70 Article 110-26(a) Exception 2. Minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

The identified AC voltage level is altered to maintain consistency with the rest of this document.

A specific depth of 2 1/2 ft or less is identified for control cabinets and compartments containing non-hazardous voltages. The 2 1/2 baseline depth is comparable to the permisssible depth established in Article 110 Article 670-5 for the higher voltage levels and specified conditions identified. Based on the logic of comparable adequacy the 2 1/2 ft depth is specified here to reduce the ambiguity in Article 110-26 Exception 2 where no specific depth is identified.

Substantiation for Exception 3:

This exception is from NFPA 70 Article 110-26(a) Exception 3, with the intent of the text extensively modified. In its original form Article 110-26(a) Exception 3 deals with Condition 2 working space acceptable under the specified circumstances of Article 110-26(a) Exception 3, can be replicated in many industrial establishments. This exception would allow working space clearance depth relief of 6 in. in those establishments, while maintaining a comparable level of safety prescribed in Article 110-26(a) Exception 3.

Again, minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for Exception 4:

This exception is new text that seeks to establish IP20 (i.e. "finger safe") or greater protected or rated devices and equipment as an effective means of enhancing work place safety. As a precursor to this discussion several definitions must be established.

Per NFPA 70 Article 100 Definitions:

Exposed. Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts that are not suitably guarded, isolated, or insulated.

"Live Parts. Electric conductors, buses, terminals, or components that are uninsulated or exposed and a shock hazard exists.

Per International Electro-technical Commission (IEC) Publication 529 Degrees of Protection by Enclosures:

"IP20. Protection against touch with the finger and medium-sized foreign bodies greater than 12 mm in diameter with no protection against water." ("IP" stands for "ingress protection". The first digit of an IP rating indicates the degree of protection relative to contact with a foreign body. The second digit indicates the degree of protection relative to water. All IP ratings with a value greater than 20 are more restrictive against contact with a foreign body and offer greater protection against water.)

Per the stated definitions devices and equipment protected or rated IP20 or greater do not constitute "exposed" "live parts". Equipment protected or rated IP20 or greater satisfy UL 508 Industrial Control Equipment, and IEC 529 "finger safe" criteria. Equipment protected or rated IP20 or greater are "suitably guarded" in NFPA 70, and cannot be "inadvertently touched." As such the same degree of workspace clearance depth for totally exposed terminals and bus bars is not necessary for devices and equipment protected or rated IP20 or greater.

Equivalent safety is achieved by technology that is not currently addressed by NFPA 70 generally, nor covered by Articles 110-26 and 670-5 specifically.

If a control cabinet or compartment for industrial machinery contains only equipment protected or rated IP20 or greater it would not contain any "exposed" "live parts". With no "exposed" "live parts" NFPA 70 Table 110-26(a) is inapplicable. How then would working space clearance depth be ascertained? The minimum working space clearance depth identified in Table 110-26(a) is 3 ft – therefore, as a baseline requirement, it would appear that 3 ft would be appropriate. Further more, Table 110-26(a) Condition 1 (i.e. 3 ft working space clearance depth) can provide guidance – reference; "...exposed live parts on both sides effectively guarded by suitable wood or other insulating materials." Although not "exposed" "live parts", the devices and equipment protected or rated IP20 or greater, by design, are "effectively guarded" with "insulating materials". As such Condition 1 provides further indication that 3 ft would constitute an appropriate working space clearance depth.

Substantiation for Exception 5:

This exception is from NFPA 70 Article 670-5. Format and minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for Exception 6:

This exception is from NFPA 70 Article 670-5 and Article 670-5 Exception. Format and minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for 4.4.9.1.2:

This text is from NFPA 70 Article 110-26(a) Exception 2. Minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for 4.4.9.1.3:

This text is from NFPA 70 Article 110-26(a) Exception 2. Minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for 4.4.9.10 Access:

This text is from NFPA 70 Article 110-26(c). Minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.

Substantiation for 4.4.10.1:

This text is from NFPA Article 110-26(b). Minor text alterations are effected to enhance clarity of purpose relative to the control cabinets and compartments of industrial machinery, and to create consistency with the rest of this document.
COMMITTEE ACTION: Accept in Principle.
1) Delete from Proposal 79-84 (Log #54) [Clause 12] Sections 12.5, 12.5.1 and 12.5.2. Retain 12.5.3 from Proposal 79-84 (Log #54).
2) Insert the proposed text from this proposal into a new 12.5 and before 12.5.3 to read as follows:

12.5.1.1 Working Space. The working space shall permit at least 90 degree opening of control cabinet and compartment doors or hinged panels. The depth of the working space in the direction of access to live parts shall not be less than indicated in Table XX. Distances shall be measured from the control cabinet or compartment front or opening.

### Table XX Working Space Depth

<table>
<thead>
<tr>
<th>Nominal Voltage to Ground</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-150</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>151-600</td>
<td>3</td>
<td>3 1/2</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes:
1. For SI units, 1 ft = 0.3048 m.
2. Where the conditions are as follows:
   - Condition 1 — Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not over 300 volts to ground shall not be considered live parts.
   - Condition 2 — Exposed live parts on one side and a grounded surface on the other side. Concrete, brick, or tile walls shall be considered as grounded.
   - Condition 3 — Exposed live parts on both sides of the working space (not guarded as provided in Condition 1) with the operator between.

Exception 1 — Working space shall not be required in back or sides of control cabinets or compartments where there are no renewable or adjustable parts on the back or sides and where all connections are accessible from locations other than the back or sides. Where rear access is required to work on de-energized parts on the back of enclosed control cabinet and compartment, a minimum working space of 2 1/2 ft (762 mm) horizontally shall be provided.

Exception 2 — By special permission working space clearance depth less than 2 1/2 ft (762 mm) shall be permitted where all of the following conditions are met:
1. the control cabinet or compartment is operating at not over 150 volts line-to-line or line-to-ground
2. the conditions of maintenance and supervision ensure that only qualified persons will service the installation
3. the door(s) of the control cabinet or compartment open at least 90 degrees or are removable.

Exception 6 — By special permission working space clearance depth less than 2 1/2 ft (762 mm) shall be permitted where all of the following conditions are met:
1. the control cabinet or compartment is operating at not over 150 volts line-to-line or line-to-ground
2. the conditions of maintenance and supervision ensure that only qualified persons will service the installation
3. the door(s) of the control cabinet or compartment open at least 90 degrees or are removable.
4. where only diagnostic troubleshooting and testing on live parts is involved
5. the door(s) of the control cabinet and compartment open at least 90 degrees or are removable.

COMMITTEE STATEMENT: The committee agrees with the substantiation submitted for this proposal. However, the text proposed is better suited for Clause 12 “Control equipment: location, mounting, and enclosures” then Clause 44 “General operating conditions”. The committee understands that the action on this proposal modifies Proposal 79-84 (Log #54) [Clause 12].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 23
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 23
NEGATIVE: 2

EXPLANATION OF NEGATIVE: DOBROWSKY: (1) I agree that access and working space should be addressed in this standard but believe the requirements belong in Chapter 4 because they apply to more than control equipment. See also my comment on Proposal 79-24 (Log #60). (2) 4.4.9.1.1 Exception No. 4. The issue of using “IP ratings” needs to be addressed but I am concerned about having different requirements than the NEC. Electrical shock is only one of the hazards that needs to be considered. These types of components are used on industrial machinery but they are also becoming common on building systems associated with premises wiring. I don’t see a reason for having different requirements. Possibly a joint task group comprised of members of NEC CMP-1 and NFPA 79 could be formed to address this issue.

GARVEY: Proposed Exception No. 3 is significantly different from the NEC. The NEC Exception applies only to existing installations. Pertaining to Condition 2 working clearance of 42 inches with written procedures may be appropriate in a replacement situation. It does not affect the same level of protection for the worker as the minimum 48 inches required by Condition 5 with over 150 volts to ground present.

Proposed Exception No. 6 is unenforceable. It does not provide any minimum workspace depth. Proposed Exception No. 5 gives installers a reduced clearance to 30-inches with similar restrictions. Proposed Exception No. 5 should be the bottom line.

Proposed Exception No. 4 is new. It should be accepted. The IP20 level of protection is very restrictive and does provide an additional safeguard for the worker.

79-33 - (Clause 7 [Clause 51]): Accept in Principle

SUBMITTER: David S. Fisher, Rockwell Automation/Rep. NEMA

RECOMMENDATION: Revise text as follows:
5 Incoming supply conductor terminations and devices for disconnecting and removal of power
5.1 Incoming supply conductor terminations
5.1.1 Where practicable, the electrical equipment of a machine shall be connected to a single power supply. Where it is
necessary to use another supply for certain parts of the equipment
(e.g. electronic circuits, electromagnetic clutches), that supply
shall, as far as is practicable, be derived from devices (e.g.
transformers, converters) forming part of the electrical equipment
of the machine.

5.1.2 Unless an attachment plug is provided with
the machine for the connection to the supply (see 5.3.2 item f), the
supply conductors shall be contained in their own separate
conduit or raceway and shall be terminated at the supply
disconnecting means.

5.1.3 Connections to guarded terminal blocks or other
devices ahead of the disconnecting means for excepted circuits
according to 5.3.5 shall be permitted. Terminals for more than
one conductor shall be so identified.

5.1.4 Where a grounded conductor is used it shall be clearly
indicated in the technical documentation of the machine, such as
in the installation diagram and in the circuit diagram. A separate
insulated terminal shall be provided for the grounded conductor
(see question 14 in annex B).

5.1.5 All terminals for the incoming supply connection shall
be legible marked.

5.2 Grounding terminal.

A grounding terminal shall be provided for each incoming supply
circuit (see 8.2.1.2 for requirements).

5.3 Supply disconnecting (isolating) means

5.3.1 General

5.3.1.1 A supply disconnecting means shall be provided:
– for each incoming supply circuit to a machine;
– for the supply to a feeder system using collector wires,
collector bars, slip-ring assemblies, flexible cable systems
(reeled, festooned), to a machine or a number of
machines; and
– for each on-board power source (e.g. generator)

5.3.1.1.1 Each disconnecting means required by 5.3.1.1 shall be
legibly marked to indicate its purpose. Where a machine is
supplied by more than one source of supply, a marking shall be
installed at each supply disconnect location denoting all other
disconnects that supply a source of power to the machine.

5.3.1.2 The supply disconnecting means shall disconnect
(isolate) the electrical equipment of the machine, including all
control circuits, from the supply when required (e.g. for work on
the machine, including the electrical equipment). Circuits that
are not required to be disconnected by the supply disconnecting
means shall comply with 5.3.5.

5.3.1.3 The supply disconnecting means shall be mounted
within the control enclosure or immediately adjacent thereto.
Where the disconnecting means is mounted external to the control
enclosure, a tool is required to open the control enclosure door
and a label shall be attached to that door warning of dangerous
circuit (see 8.2.1.2 for requirements).

5.3.1.4 Wire bending space shall be provided for the supply
disconnecting means in accordance with NFPA 70, Section
450.10(b) and accidental contact with the line side live parts shall
be inhibited. The supply conductors to the disconnecting means
shall be separated from other internal conductors by either:
a) mounting the disconnect as near as practicable to the
top of the enclosure while dedicating sufficient space
between the top of the enclosure and the disconnect for
the supply conductors; or
b) mounting the disconnect other than at the top of the
enclosure and guarding its line side live parts against
accidental contact, and by separating the supply
collectors from other internal conductors by the use of
a barrier.

5.3.1.5 There shall be no exposed live parts with the
disconnecting means in the open (off) position except those
associated with the circuits described in 5.3.5.

5.3.1.6 Where two or more disconnecting means are provided
within the control enclosure for multiple supply circuits, they shall
be grouped in one location. Protective Interlocks for their correct
operation shall be provided where a hazardous condition or
damage to the machine or to the work in progress can occur.

5.3.2 Type

The supply disconnecting device shall be one of the following
types:

a) a listed motor-circuit switch (switch disconnector) rated
in horsepower;
b) a listed molded case circuit breaker;
c) a listed molded case switch;
d) an instantaneous trip circuit breaker that is part of a
listed combination motor controller;
e) a listed self-protected combination controller limited to
single motor applications;
f) an attachment plug and receptacle (plug/socket
combination) for cord connection to motor load
totaling 2 hp or less.

5.3.3 Requirements

5.3.3.1 Where the supply disconnecting device is one of the
types listed in 5.3.2 items a-e it shall fulfill all of the following
requirements:
– isolate the electrical equipment from the supply and
have one OFF (isolated) and one ON position only.
Circuit-breakers are permitted to have a reset (tripped)
position between OFF and ON;
– have an external operating means (e.g. handle)

Exception: Power operated switchgear need not be operable
from outside the enclosure where there are other means to open
it.
– be provided with a permanent means permitting it to be
locked only in the open (OFF) (isolated) position (e.g.
by padlocks). When so locked, remote as well as local
locking shall be prevented;
– disconnect all ungrounded conductors of its power
supply circuit simultaneously;
– be rated for the application as follows:
   a) The ampere rating shall be at least 115 percent o
the sum of the full-load currents required for al
equipment that may be in operation at the sam
time under normal conditions of use;
   b) Where rated in horsepower, the horsepower rating
shall be at least equal to which is defined by
ANSI/NFPA 70, Table 430–151B for a locked roto
motor which can be started simultaneously and
non-motor loads that can be operated at that time
   c) The voltage rating shall be at least equal to the
nominal supply voltage.

5.3.3.2 Where the supply disconnecting device is one of the
types listed in 5.3.2 items a-e, the available fault current at the
point of the supply to the machine shall not be greater than the
short-circuit rating of the disconnecting device.

5.3.3.3 When the supply disconnecting device is an
attachment plug and receptacle (plug/socket combination), it
shall fulfill the following requirements:
– have a load-break rating or be interlocked with a
switching device that is load-break rated, to interrupt the
(locked rotor current) stalled current of the largest motor together with the sum of the normal running currents of the remaining motors and non-motor loads that can be operating at that time;

- be of such a type and be so installed as to prevent unintended contact with live parts at any time even during insertion or removal of the connected components;

- have a first make, last break grounding (earthing) contact;

- where rated at more than 20 A have a retaining means to prevent unintended or accidental disconnection.

5.3.3.4 In addition, a switching device on the machine shall be provided for switching the machine on and off.

5.4 Operating Handle

5.4.1 The center of the grip of the operating handle of the disconnecting means, when in its highest position, shall be not more than 6 ft 7 in. (2.0 m) above the floor. A permanent operating platform, readily accessible by means of a permanent stair or ladder, shall be considered as the floor for the purpose of this requirement.

5.4.2 An operating handle of the disconnecting means shall:

- be readily accessible with doors in the open or closed position;

- be engaged with the operating mechanism of the disconnecting means at all times;

- maintain the environmental rating of the enclosure.

5.5 Excepted circuits

5.5.1 The following circuits are not required to be disconnected by the main supply disconnecting means:

- lighting circuits for lighting needed during maintenance or repair;

- Attachment plugs and receptacles (plug and socket outlets) for the exclusive connection of repair or maintenance tools and equipment (e.g. hand drills, test equipment);

- undervoltage protection circuits that are only used for automatic tripping in the event of supply failure;

- circuits supplying equipment that are required to remain energized for satisfactory operation (e.g. temperature controlled measuring devices, product (work in progress) heaters, program storage devices).

5.5.2 A source of supply for excepted circuits shall comply with all of the following conditions:

- be a separate primary disconnecting means, isolating transformer, and secondary overcurrent protection furnished in an enclosure and mounted within the control enclosure, adjacent to the main disconnecting means;

- have line side (of the supply disconnect) supply connections internal to the control enclosure that are separate from and do not share a raceway with other conductors, and that are encased in rigid or flexible conduit if longer than 18 inches.

5.5.3 The control interlocking circuits shall be capable of being disconnected at the control panel from which they are sourced.

5.5.4 Where circuits are not disconnected by the main supply disconnecting means:

- a permanent warning label(s) shall be appropriately placed in proximity adjacent to the main supply disconnecting device(s) indicating that it does not de-energize all exposed live parts when it is in the open (off) (isolated) position;

- a corresponding statement shall be included in the maintenance manual;

- a permanent warning label shall be placed in proximity to each excepted circuit or the excepted circuit shall be separated from other circuits or shall be identified by color (see 14.2.4).

5.4 Devices for switching off for prevention of unexpected start-up

5.4.1 Means for removal of power for prevention of unexpected start-up

5.4.1 Means for removal of power shall be provided when prevention of unexpected start-up is required (e.g. during maintenance where the unexpected start-up of a machine can create a hazard). Such means shall be:

- appropriate for the intended use;

- conveniently located;

- readily identifiable, and

- provided with permanent means for locking in the “Off” position only, except as allowed in 5.6.

5.4.2 Removal of power can be accomplished by the use of the supply disconnecting device(s) in accordance with 5.3.2, or other means (e.g. a contactor switched off by a control circuit).

5.4.3 Where such other means are used, a single failure of any of its components shall not result in an inadvertent or unexpected start-up, and shall prevent reinitiation of the machine until the system is reset or the fault is corrected.

5.4.4 Such other means shall be employed only for situations that include:

- routine exchange of parts, fixtures and tools requiring no significant dismantling of the machine;

- work on the electrical equipment where all of the following conditions exist:
  - there is no hazard arising from electric shock (see clause 6) and burn;
  - the switching off means cannot be negated by the work;
  - the work is of a minor nature (e.g. replacement of plug-in devices without disturbing existing wiring).
Harmonization – Objective

Differing electrical standards add a large cost to multinational transport to the domestic market. The reverse is also true. Machines originally produced for a foreign market may quickly be unsalable. As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. The burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Harmonization – Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Harmonization – Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Harmonization – Purpose

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

1. Devices for disconnecting electrical equipment

5.5.1 Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be carried out without a risk from electric shock or burn.

5.5.2 The supply disconnecting device (see 5.3) shall be permitted to fulfill this requirement where there is no need for isolating individual portions of the electrical circuit.

5.5.3 However, where it is expected that it will be necessary to work on the electrical equipment of separately operable parts of a machine, a disconnecting means shall be permitted for the electrical equipment of each such part of the machine requiring separate isolation.

5.5.4 The following devices shall be permitted to fulfill this isolating function:

- Devices described in 5.3.2;
- A manual motor controller suitable for motor disconnecting and complying with UL 508 where located on the load side of the last short circuit protective device (in the branch), and
- A redundantly monitored, remotely operated contactor isolating system incorporating control lockout provisions, and listed for isolation purposes.

5.5.5 Such devices shall be:

- Readily accessible;
- Within sight of the part of the machine requiring isolation;
- Readily identifiable, and
- For other than attachment plugs, provided with permanent means for locking in the "off" position only.

Historical Background

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization – Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Importance of Issue – Harmonization

Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization – Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Harmonization – Purpose

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

1. Devices for disconnecting electrical equipment

5.5.1 Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be carried out without a risk from electric shock or burn.

5.5.2 The supply disconnecting device (see 5.3) shall be permitted to fulfill this requirement where there is no need for isolating individual portions of the electrical circuit.

5.5.3 However, where it is expected that it will be necessary to work on the electrical equipment of separately operable parts of a machine, a disconnecting means shall be permitted for the electrical equipment of each such part of the machine requiring separate isolation.

5.5.4 The following devices shall be permitted to fulfill this isolating function:

- Devices described in 5.3.2;
- A manual motor controller suitable for motor disconnecting and complying with UL 508 where located on the load side of the last short circuit protective device (in the branch), and
- A redundantly monitored, remotely operated contactor isolating system incorporating control lockout provisions, and listed for isolation purposes.

5.5.5 Such devices shall be:

- Readily accessible;
- Within sight of the part of the machine requiring isolation;
- Readily identifiable, and
- For other than attachment plugs, provided with permanent means for locking in the "off" position only.

To be placed in an annex:

FPN to 5.1.1: For large complex machinery comprising a number of widely-spaced machines working together in a coordinated manner, there may be a need for more than one incoming supply depending upon the site supply arrangements (see 5.3.1).

SUBSTANTIATION: This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

Historical Background

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization – Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Importance of Issue – Harmonization

Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization – Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause 7 with IEC 60204-1 Clause 5. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber NFPA 79-1997 Clause 7 to correspond with IEC 60204-1 Clause 5. The task group proposes the following changes to further improve usability.

SUBSTANTIATION FOR NFPA 79 1997 CLAUSE 7 REVISIONS

5.1 Incoming supply conductor terminations

Recommendation: Revise the NFPA 79 – 1997 Clause 7 title “Supply circuit disconnecting means” to harmonize with the IEC Clause 5 heading.

Substantiation: The new heading better reflects the breadth of this revised Clause 5.

5.1.1 Recommendation: Add new subclause paragraph.

Substantiation: This added material is appropriate for the installation of larger machines where there could be options as to the use of multiple of incoming supplies.

5.1.2 Recommendation: Add new subclause paragraph essentially incorporating the requirements of 7.6 of NFPA 79 – 1997.

Substantiation: The new text contains the original provisions along with the additional provision that disallows the installation of line and load conductors in the same conduit or raceway. This provision is intended to provide protection for maintenance personal who may come in contact with conductors that may remain energized with the disconnect in OFF position due to insulation failure.

5.1.3 Recommendation: Revise the NFPA 79 – 1997 Clause 7 title “Supply circuit disconnecting means” to harmonize with the IEC Clause 5 heading.

Substantiation: The new heading better reflects the breadth of this revised Clause 5.

5.1.4 Recommendation: Add new subclause paragraph.

Substantiation: This subclause explicitly allows for the tapping off of the line side of the main disconnect for supplying circuits that cannot be disconnected when it is opened.
5.1.5 Recommendation: Add new subclause paragraph.

Substantiation: This subclause requires the marking of the incoming supply connections.

5.2 Grounding terminal

Recommendation: Add this new subclause paragraph and the associated requirement.

Substantiation: This text anticipates the possibility of multiple incoming supplies and the necessity of keeping the respective equipment grounding conductors separate in order to provide the appropriate ground fault paths.

5.3 Supply disconnecting (isolating) means

Recommendation: Add this new subclause heading.

Substantiation: This heading is very similar to the Clause 7 heading in NFPA 79 - 1997 except that this title includes the parenthetical term “isolating” which denotes an implicit function in listed disconnects in the US but helps to align with IEC text.

5.3.1 General

Recommendation: Add this new subclause heading.

5.3.1.1 Recommendation: Add this new subclause paragraph which hierarchically covers the requirements of 7.1 of NFPA 79 - 1997.

Substantiation: This subclause elaborates on the types of supply/source for which disconnects are required. The second bullet has been added to recognize the specialty applications involving overhead cranes, gantries and such equipment. The third bullet was added to clarify that if the source of power to the machine is generated on board, then a supply disconnecting means shall be provided.

5.3.3.1 Recommendation: Add this new subclause paragraph which captures the requirements of 7.5 in NFPA 79 – 1997 and some of the requirements of 7.5 and 7.10 of NFPA 79 – 1997.

Substantiation: This subclause essentially embodies the referenced requirements NFPA 79 – 1997 either in whole or in part.

5.3.1.3 and 5.3.1.4

Recommendation: Add these new subclause paragraphs which capture the requirements of 7.8.1 of NFPA 79 – 1997.

Substantiation: These subclauses embody the original requirements of 7.8.1 in NFPA 79 - 1997 but in a different organizational structure. Existing Exception No. 1 has been deleted from subclause 7.8.1 of existing NFPA 79-1997 because the requirement is covered by the new requirement of subclause 5.3.1.4.

5.3.1.5 Recommendation: Add this new subclause paragraph which captures the requirements of 7.7 of NFPA 79 – 1997.

Substantiation: This subclause embodies the original requirements of 7.7 in NFPA 79 - 1997 but in a different organizational structure.

5.3.1.6 Recommendation: Add this new subclause paragraph which captures the requirements of 7.8.2 of NFPA 79 - 1997 and provides additional requirements regarding protective interlocks.

Substantiation: This subclause embodies the original requirements of 7.8.2 in NFPA 79 - 1997 but in a different organizational structure. In addition it requires that protective interlocks be used where a hazardous condition or damage to the machine could occur if all supply disconnects were closed at the same time.

5.3.2 Recommendation: Add this subclause heading which is identical to 7.2 of NFPA 79 - 1997 and the associated requirements herein embody those of 7.21 and 7.2.2 of NFPA 79 - 1997.

Substantiation: This subclause enlarges the list of the permitted types of devices to align with the National Electric Code. Item “e” has been added to the list of permissible supply disconnecting means with an additional restriction limiting it to single motors. This is because these devices are in of themselves limited to a single motor machine application.

5.3.3 Requirements

Recommendation: Add this new subclause heading.

Substantiation: This heading organizationally collects all of the requirements associated with the types of disconnecting devices permitted in 5.3.2.

5.3.3.3 Recommendation: Add this new subclause paragraph which embodies all of the requirements of 7.3 and 7.4 and adds the following:

Substantiation: The language for the short-circuit rating of the disconnecting device is revised such that the provider of the machine alone.

5.3.3.4 Recommendation: Add this subclause paragraph which embodies the requirements for the use of an attachment plug for disconnecting purposes, 7.11 of NFPA 79 – 1997, with the exception of the 2nd, 3rd and 5th listed items of 7.11.

Substantiation: This subclause appropriately covers the requirements stated but does not cover the following requirements excepted from 7.11:

- The supply voltage shall not exceed 150 to ground.
- DC shall not be used.
- The attachment plug shall be single voltage rated.

These requirements were not included because they were considered to be unnecessarily restrictive.

Recommendation: Add this subclause paragraph which requires the provision of a switching device on the machine to switch the machine on and off where its disconnecting means is an attachment plug.

Substantiation: This subclause requires a means to readily turn the machine on and off which is practically not possible with a remote attachment plug used as a disconnecting means.
5.3.4 Operating handle

Recommendation: Add this subclause heading which is identical to the heading of 7.10 of NFPA 79 – 1997.

5.3.4.1 Recommendation: Add this subclause paragraph which is identical to the requirements of 7.10.2 of NFPA 79 – 1997.

5.3.4.2 Recommendation: Add this subclause paragraph which broadens the requirements of 7.10 of NFPA 79 - 1997.

Substantiation: The first two requirements of this subclause both ultimately mandate that the handle of the disconnecting device be in control of the disconnecting device at all times regardless of the position of the door. In practical terms, this means that having the handle of a rotary operated disconnecting device mounted to the door, such that it separates from the rest of the disconnect mechanism when the door is opened, does not meet the requirements of this subclause. The intent here is to provide immediate operability of the disconnecting device and to have the provision for locking the disconnecting device in the off position, independent of the door position. These requirements align with those of SAES H - 1738:2001. The additional requirement stipulates that the handle of the disconnecting device not compromise the environmental rating of the enclosure.

5.3.5 Excepted circuits

Recommendation: Add this subclause heading covering the requirements for those circuits that need not be disconnected by the supply disconnect.

5.3.5.1 Recommendation: Add this subclause paragraph listing those circuits that are not required to be disconnected by the supply disconnecting means.

Substantiation: This subclause consolidates the two types of circuits referenced in 7.9.1 of NFPA 79 - 1997 with two other types of circuits which can be exempted from disconnection by the supply disconnecting means.

5.3.5.2 Recommendation: Add this subclause paragraph providing requirements for the source of supply for those circuits excepted in 5.3.5.1 in this proposed revision.

Substantiation: This subclause specifies requirements essentially identical to those specified in 14.3.2 f) of NFPA 79 - 1997 for the supply for those circuits excepted from the requirement to be disconnected by the supply disconnecting means. It further specifies requirements for the connections between the “transformer-disconnect” supply and the line side of the main supply disconnect.

5.3.5.3 Recommendation: Add this subclause paragraph regarding the disconnection of interlocking control circuits which are excluded from the requirement to be disconnected by the supply disconnect by 7.5 (Exception) of NFPA 79 – 1997.

Substantiation: Subclause 7.5 of NFPA 79 - 1997 makes these circuits “excluded” but does not define any means by which they are to be disconnected. This subclause requires that the interlocking control circuit be disconnected by either the supply disconnect or the “transformer-disconnect” (as provided in 5.3.5.2) in the sourcing panel.

5.3.5.4 Recommendation: Add this subclause paragraph regarding requirements, other than those relating to disconnection, for the “excepted circuits”.

Substantiation: This subclause includes requirements for the warning as stipulated in the “Exception” of 7.5 of NFPA 79 – 1997. In addition it includes documentation requirements and requirements for separation, labeling or identifying the excepted circuits by color. The color requirements of the proposed 14.2.4 reserve the colors YELLOW or ORANGE for all conductors that remain energized after the main disconnect is opened (i.e. all excepted circuits).

5.4 Means for removal of power for prevention of unexpected start-up

Recommendation: Add this new subclause heading and its associated subclause paragraphs.

Substantiation: This subclause provides requirements for the use of means other than the disconnecting devices permitted for use as a supply disconnecting means. It provides reliability requirements for the “other means” and, in addition, limits the kinds of work or activity permitted on the machine where such other means are used.

5.5 Devices for disconnecting electrical equipment

Recommendation: Add this new subclause heading and its associated subclause paragraphs.

Substantiation: This subclause stipulates the types of disconnecting devices that are permitted to be employed where it is necessary to separately isolate individual parts of the machine electrical equipment for work on these parts while the remaining parts of the electrical equipment can be energized. In addition, application requirements are specified for these additional disconnecting means.

NFPA 79-1997, 7.9.2, second bullet:

This subclause bullet has been deleted because there is no exclusive requirement for vault-type hardware either in NFPA 79-1997 or in the new proposals, therefore, there can be no requirement for an interlock function that requires a complimentary function (initial latch) inherent to traditional vault-type hardware.

NFPA 79-1997, 7.11, second, third and fifth bullet:

These subclause bullets have been deleted because suitably identified devices having voltage ratings greater than 150 volts are available. The requirement for a single voltage rated device is overly restrictive. Additionally, a load break rating is now required for these devices according to this proposal in subclause 5.3.3.3.

NFPA 79-1997, 7.9.4:

This subclause has been deleted because the requirement for separate conduits and separation of supply circuits is not applicable to load side machinery wiring any longer. The requirement currently appeared in NFPA 79-1997, 7.9.4 which covers interlocking provisions and is not applicable to incoming supply conductor requirements. Additionally, 14.1.3, Conductors of Different circuits, contains installation requirements for conductors of different circuits which may occupy the same raceway (ducts).
COMMITTEE ACTION: Accept in Principle.

5 Incoming supply conductor terminations and devices for disconnecting and removal of power

5.1 Incoming supply conductor terminations

5.1.1 Where practicable, the electrical equipment of a machine shall be connected to a single power supply circuit. Where it is necessary to use another supply circuit, for certain parts of the equipment (e.g., electronic circuits, electromagnetic clutches), that supply circuit shall, as far as is practicable, be derived from devices (e.g., transformers, converters) forming part of the electrical equipment of the machine.

5.1.2 Unless an attachment plug is provided with the machine for the connection to the supply (see 5.3.2 item f), the supply conductors shall be contained in their own separate conduit or raceway and shall be terminated at the supply disconnecting means.

5.1.3 Connections to guarded terminal blocks or other devices ahead of the disconnecting means shall be permitted for excepted circuits according to 5.3.5 shall be permitted. Terminals for more than one conductor shall be so identified.

5.1.4 Where a grounded conductor is used it shall be clearly indicated in the technical documentation of the machine, such as in the installation diagram and in the circuit diagram. A separate
insulated terminal shall be provided for the grounded conductor (see question 14 in annex B).

5.1.5 All terminals for the incoming supply circuit connection shall be legibly marked.

5.2 Grounding terminal.

A grounding terminal shall be provided for each incoming supply circuit.

Note: For additional information on the grounding terminal, see 8.2.1.2 (for requirements).

5.3 Supply circuit disconnecting (isolating) means

5.3.1 General

5.3.1.1 A supply circuit disconnecting means shall be provided:
- for each incoming supply circuit to a machine;
- for the supply circuit to a feeder system using collector wires, collector bars, slip-ring assemblies, flexible cable systems (reeled, festooned), to a machine or a number of machines; and
- for each on-board power source (e.g. generator).

5.3.1.1.1 Each disconnecting means required by 5.3.1.1 shall be legibly marked to indicate its purpose. Where a machine is supplied by more than one source of supply circuit, a marking shall be installed at each supply circuit disconnect location denoting the location of all other supply circuit disconnects, that supply a source of power to the machine.

5.3.1.2 The supply circuit disconnecting means shall disconnect (isolate) the electrical equipment of the machine, including all control circuits, from the supply circuit when required (e.g. for work on the machine, including the electrical equipment). Circuits that are not required to be disconnected by the supply circuit disconnecting means shall comply with 5.3.5.

5.3.1.3 The supply circuit disconnecting means other than attachment plugs and receptacles shall be mounted within the control enclosure or immediately adjacent thereto.

Exception: Externally mounted supply circuit disconnecting means, whether interlocked or not interlocked with the control enclosure, supplying machines totaling 2 HP or less shall be permitted to be mounted up to 20 feet away from the enclosure providing that the disconnecting means is in sight from, and readily accessible to the operator.

Supply circuit disconnecting means mounted within or adjacent to the control enclosure shall be interlocked with the control enclosure in accordance with 5.2.3. Where the supply circuit disconnecting means is not adjacent to the control enclosure, or where the supply disconnecting means is an attachment plug and receptacle, a tool is required to open the control enclosure door and a label shall be attached to that door warning of dangerous voltage inside and advising disconnection of the power before opening.

5.3.1.4 Wire bending space shall be provided for the supply circuit disconnecting means in accordance with NFPA 70, Section 430.10(b) and accidental Space shall be determined by maximum wire size of incoming lines or by maximum capacity of line lugs on the disconnecting means. Accidental contact with the line side live parts shall be inhibited. The supply circuit conductors to the disconnecting means shall be separated from other internal conductors by either:

(a) mounting the disconnect as near as practicable to the top of the enclosure while dedicating sufficient space between the top of the enclosure and the disconnect for the supply circuit conductors; or
(b) mounting the disconnect other than at the top of the enclosure and guarding its line side live parts against accidental contact, and by separating the supply circuit conductors from other internal conductors by the use of a barrier.

5.3.1.5 There shall be no exposed live parts with the disconnecting means in the open (off) position except those associated with the circuits described in 5.3.5.

5.3.1.6 Where two or more disconnecting means are provided within the control enclosure for multiple supply circuits, they shall be grouped in one location. Protective Interlocks for their correct operation shall be provided where a hazardous condition or damage to the machine or to the work in progress can occur.

5.3.2 Type

The supply circuit disconnecting device shall be one of the following types:

a) a listed motor-circuit switch (switch disconnecter) rated in horsepower;
b) a listed molded case circuit breaker;
c) a listed molded case switch;
d) an instantaneous trip circuit breaker that is part of a listed combination motor controller;
e) a listed self-protected combination controller limited to single motor applications;
f) an attachment plug and receptacle (plug/socket combination) for cord connection to motor loads totaling 2 hp or less.

5.3.3 Requirements

5.3.3.1 Where the supply circuit disconnecting device is one of the types listed in 5.3.2 items a-e it shall fulfill all of the following requirements:

- isolate the electrical equipment from the supply circuit and have one OFF (isolated) and one ON position only. Circuit-breakers are permitted to have a reset (tripped) position between OFF and ON;
- have an external operating means (e.g. handle)

Exception: Power operated switchgear need not be operable from outside the enclosure where there are other means to open it.

- be provided with a permanent means permitting it to be locked only in the open (OFF) (isolated) position (e.g. by padlocks) independent of the door position. When so locked, remote as well as local closing shall be prevented;
- disconnect all ungrounded conductors of its power supply circuit simultaneously;
- be rated for the application as follows:
  a) The ampere rating shall be at least 115 percent of the sum of the full-load currents required for all equipment that may be in operation at the same time under normal conditions of use;
  b) Where rated in horsepower, the horsepower rating shall be at least equal to which is defined by ANSI/NFPA 70, Table 430–151B for a locked rotor equivalent equal to the largest sum resulting from the locked-rotor currents of any combination of motors which can be started simultaneously and the full load currents of the remaining motor and non-motor loads that can be operated at that time;
  c) The voltage rating shall be at least equal to the nominal supply circuit voltage.
- be operable by qualified persons, independent of the door position without the use of accessory tools or devices.

5.3.3.2 Where the supply circuit disconnecting device is one of the types listed in 5.3.2 items a-e the available fault current at the point of the supply to the machine shall not be greater than the short-circuit current rating of the disconnecting device.

5.3.3.3 When the supply circuit disconnecting device is an attachment plug and receptacle (plug/socket combination), it shall fulfill all of the following requirements:

- have a load-break rating or be interlocked with a switching device that is load-break rated, to interrupt the (locked rotor current) stalled current of the largest motor together with the sum of the normal running currents of the
remaining motors and non-motor loads that can be operating at that time;
- be of such a type and be so installed as to prevent unintended contact with live parts at any time even during insertion or removal of the connectors;
- have a first make, last break grounding (earthing) contact;
- where rated at more than 20 A have a retaining means to prevent unintended or accidental disconnection;
- be located within sight from the operator station and readily accessible.

5.3.3.4 In addition, a switching device on the machine shall be provided for switching the machine on and off.

5.3.4 Operating Handle

5.3.4.1 The center of the grip of the operating handle of the disconnecting means, when in its highest position, shall be not more than 6 ft 7 in. (2.0 m) above the floor. A permanent operating platform, readily accessible by means of a permanent stair or ladder, shall be considered as the floor for the purpose of this requirement.

5.3.4.2 An operating handle of the disconnecting means shall:
- be readily accessible with doors in the open or closed position;
- be engaged with the operating mechanism of the disconnecting means at all times;
- maintain the environmental rating of the enclosure.
not be restricted by the enclosure door when the door is in the open position.

5.3.5 Excepted circuits

5.3.5.1 The following circuits are not to be required to be disconnected by the main supply circuit disconnecting means:
- lighting circuits for lighting needed during maintenance or repair;
- Attachment plugs and receptacles (plug and socket outlets) for the exclusive connection of repair or maintenance tools and equipment (e.g. hand drills, test equipment);
- undervoltage protection circuits that are only used for automatic tripping in the event of supply failure;
- circuits supplying equipment that are required to remain energized for satisfactory operation (e.g. temperature controlled measuring devices, product (work in progress) heaters, program storage devices).

5.3.5.2 A source of supply. Supply circuits for excepted circuits shall comply with all of the following conditions:
- be a separate primary disconnecting means, isolating transformer, and secondary overcurrent protection furnished in an enclosure and mounted within the control enclosure, adjacent to the main disconnecting means;
- have line side (of the supply circuit disconnect) supply circuit connections internal to the control enclosure that are separate from and do not share a raceway with other conductors, and that are encased in rigid or flexible conduit if longer than 18 inches.

5.3.5.3 The control interlocking circuits shall be capable of being disconnected at the control panel from which they are sourced.

5.3.5.4 Where circuits are not disconnected by the supply circuit disconnecting means:
- a permanent warning label(s) shall be placed adjacent to the supply circuit disconnecting means indicating that it does not de-energize all exposed live parts when it is in the open (off) (isolated) position;
- a corresponding statement shall be included in the maintenance manual;
- a permanent warning label shall be placed in proximity to each excepted circuit or the excepted circuit shall be separated from other circuits or shall be identified by color

Note. For additional information on identification by color for other conductors, see 14.2.1.

5.4 Means for removal of power for prevention of unexpected start-up

5.4.1 Means for removal of power shall be provided when prevention of unexpected start-up is required (e.g. during maintenance where the unexpected start-up of a machine can create a hazard). Such means shall be:
- appropriate for the intended use;
- conveniently located;
- readily identifiable, and
- provided with permanent means for locking in the “Off” position only.

5.4.2 Removal of power can be accomplished by the use of the supply circuit disconnecting means, additional devices conforming to 5.3.2, or other means (e.g. a contactor switched off by a control circuit).

5.4.3 Where such other means are used, a single failure of any of its components shall not result in an inadvertent or unexpected start-up.

5.4.4 Such other means shall be employed only for situations that include:
- routine exchange of parts, fixtures and tools requiring no significant dismantling of the machine;
- work on the electrical equipment where all of the following conditions exist:
  • there is no hazard arising from electric shock (see clause 6 and burn);
  • the switching off means cannot be negated by the work;
  • the work is of a minor nature (e.g. replacement of plug-in devices without disturbing existing wiring).

5.5 Devices for disconnecting electrical equipment

5.5.1 Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be carried out performed without a risk from electric shock or burn.

5.5.2 The supply circuit disconnecting device (see 5.3) shall be permitted to fulfill this requirement where there is no need for isolating individual portions of the electrical circuit.

5.5.3 However, where it is expected that it will be necessary to work on the electrical equipment of separately operable parts of a machine, a disconnecting means shall be permitted for the electrical equipment of each such part of the machine requiring separate isolation.

5.5.4 The following devices shall be permitted to fulfill this isolating function:
- devices described in 5.3.2;
- a manual motor controller suitable for motor disconnecting and complying with UL 508 where located on the load side of the last short circuit protective device (in the branch), and
- a redundantly monitored, remotely operated contactor isolating system incorporating control lockout provisions, and listed for isolation purposes.

5.5.5 Such devices shall be:
- readily accessible;
- within sight of the part of the machine requiring isolation;
- readily identifiable, and
- for other than attachment plugs, provided with permanent means for locking in the “Off” position only.

To be placed in an annex:

FPN to 5.1.1: For large complex machinery comprising a number of widely-spaced machines working together in a coordinated manner, there may be a need for more than
one stating: 1. Add the word "circuit" after the word "supply" throughout Clause 5 where appropriate to clarify that the term "supply" actually means "circuit supply.
2. Remove 5.1.2 where it is outside the scope of the document.
3. Move phrase "shall be permitted" to follow "disconnecting means" to improve clarity.
4. Editorially revise the first sentence of 5.1.3 to be consistent with previous change to 5.1.2
5. Revised note following 5.2 to be more user friendly.
6. The editorial revision to 5.3.1.3 adds clarity to the requirement.
7. Reverse first sentence of 5.3.1.4 to two sentence for clarity.
8. Add a new bullet to 5.3.3.3 to include text inadvertently omitted text from NFPA 79-1997, sub clause 7.11.
9. Revise "are not required" to "shall not be required" in 5.3.5.1 to comply with the NFPA Manual of Style.
10. In 5.3.5.4 and elsewhere make the note into complete sentences to comply with the NFPA Manual of Style.
11. Change "carry out" to "performed" in 5.5.1.
12. NFPA 79-1997, 7.8.1, last sentence "Space shall be determined by maximum wire size of incoming lines or by maximum capacity of line lugs on the disconnecting means" was added to 5.3.1.4 because it was an inadvertent omission.
15. In 5.5.3, delete the first instance of the phrase "--the electrical equipment of "..." This will clarify the intent of the section.
14. Add a new bullet to 5.3.4.2 to clarify that access to the operating handle should not be impeded by the enclosure door.

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**

**AFFIRMATIVE:** 24

**NEGATIVE:** 1

**NOT RETURNED:** 1 Norman

**EXPLANATION OF NEGATIVE:**

**DEFELICE:** The wording of the fourth bullet item of 5.3.5.1 "Excepted circuits" (see committee action) is vague and can easily be misinterpreted to allow many or even all of the electrical circuits of a machine to remain energized when the main supply circuit disconnecting means is open. The result is that the risk of injury when troubleshooting is greatly increased.

In its present form, the fourth bullet item can lead to unsafe working conditions for maintenance personnel and enforcement difficulties for the authority having jurisdiction. This item should be deleted or modified.

**COMMENT ON AFFIRMATIVE:**

**ANDERSON:** In the committee statement Point # 2 "Remove 5.1.2 since it is outside the scope of the document" I believe the committee has inadvertently over looked the situation in which the supply conductors are routed though the control enclosure to the incoming supply circuit conductor terminations, rather than directly in the top of the enclosure directly to the disconnecting devices terminations. If the incoming supply cable is not isolated in a separate conduit or raceway then it would become a power circuit within the control cabinet that may remain energized when the cabinet's main disconnecting means is in the off position. The incoming supply circuit is not included as an excepted circuit [5.3.5].

**DOBROWSKY:** 5.3.2 An exception should be added as follows:

"Exception: Listed attachment plugs shall be permitted to be used in accordance with their ratings."

Another option is to revise (f) as follows:

"(f) A listed attachment plug receptacle (plug/socket combination) for enclosures containing motor loads totaling 2hp or less.

Reason: Listed products are readily available that exceed 2hp ratings and should be permitted to be used according to their ratings.

**FISHER:** Through the door disconnect handles are presently applied in many applications. NEMA feels that the committee has added requirements in the last bullet item 5.3.3.1 (- be operable, by qualified persons, independent of the door position without the use of accessory tools or devices) that were not substantiated in the proposal.

**MONTEITH:** Clause 5.3.4.2 - It is confusing and leave open interpretation to the type of disconnects that can be used. Proposal 79-30 (Log #122) suggests a clarification that could be worded to state: a secondary handle attached to the shaft of the disconnect device shall be permitted that can be operated when the door is in the open position provided it can be locked in the OFF (open) position when the door is open.

**PADGETT:** Clause 5.3.4.2 It is confusing and leaves open interpretation to the type of disconnects that can be used.

After adding the new bullet, the subclause reads as follows:

5.3.4.2 An operating handle of the disconnecting means shall:

- be readily accessible with doors in the open or closed position;
- maintain the environmental rating of the enclosure;
- not be restricted by the enclosure door when the door is in the open position.

**WITHEROW:** COMMITTEE STATEMENT: 14) Add a new bullet to 5.3.4.2 to clarify that access to the operating handle should not be impeded by the enclosure door.

After adding the new bullet, the subclause reads as follows:

5.3.4.2 An operating handle of the disconnecting means shall:

- be readily accessible with doors in the open or closed position;
- maintain the environmental rating of the enclosure;
- not be restricted by the enclosure door when the door is in the open position.

**COMMENT:** The third bullet is the Committee proposal and appears to be included in the first bullet. Clarify the intent of the third bullet.

**97-34 - (7.2.1(b) [5.3.2]): Accept**

**SUBMITTER:** Todd Lottmann, Washington, MO

**RECOMMENDATION:** Revise text as follows:

"b) A listed rated, branch circuit rated, molded case circuit breaker."

**SUBSTANTIATION:** The added words will clarify for the public the use of UL489 branch rated circuitbreakers versus UL1077 supplementary protectors (circuit breakers). UL489 Circuit Breakers are tested and rated for branch circuit switching and cannot be used for this purpose. UL1077 Supplementary protectors are not tested and rated for branch circuit switching and cannot be used for this purpose. The devices are very similar in physical appearance, thus leaving an opening for possible misapplication.

The additional words will clarify, for the public, the proper device to select.

**COMMITTEE ACTION:** Accept

**COMMENT ON AFFIRMATIVE:**

**ANDERSON:** The attempt in using the "branch circuit rated" requirement to clarify that supplementary protection devices are not to be considered for use in a supply circuit, disconnecting applications. The proposed modification is to add the term "branch circuit rated", however this "rated" requirement is not directly defined. Defined terminology needs to be found and applied, e.g. "suitable for branch circuit over current protection".
practical to mount them in one location as required in this subclause. Also, the two circuit breaker disconnects are not intended to be interlocked.

COMMITTEE ACTION: Accept.

COMMITTEE STATEMENT: The committee understands that this proposal modifies the Action on Proposal 79-35 (Log #59), in subclause 5.3.1.6. The committee understands that the remainder of 5.3.1.6 remains unchanged.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

FREUDENBERG: The phrase "where practicable" is necessary in this case.

79-36 - (7.9.5 (New) [6.2.3]): Accept in Principle in Part

SUBMITTER: Gordon T. Davis, Moeller Electric Corp.

RECOMMENDATION: Add new text to read as follows:

"A device or tool as specified by the manufacturer of the interlock may permit skilled persons to defeat the interlock provided that - it is possible at all times while the interlock is defeated to open the disconnecting means and - on closing the door the interlock is automatically restored. The operation of the disconnecting means shall only be performed using tools or devices provided or specified by the manufacturer of the disconnecting means. For operators that remain with the door when the door is open, a disconnecting means shall have a secondary operator provided or specified by the manufacturer."

SUBSTANTIATION: This proposal is based on the wording found in IEC 60294-1. It sets a standard for the disconnecting means in panels in which work must be performed with the panel door open and the disconnecting means energized. It indicates that when the panel door is open, the disconnecting means must be operable and able to deenergize the assembly. Locking the disconnecting means in the energized position with the door open would be prohibited. It emphasizes that only skilled personnel should work on any live equipment.

The proposal specifically prohibits the unsafe practice of using tools unspecified by the manufacturer with the disconnecting means.

The proposal allows for presently available designs of disconnecting means and it gives the user a choice of devices based on risk assessment per ANSI B11.

COMMITTEE ACTION: Accept in Principle in Part.

COMMITTEE STATEMENT: See Committee Action and Statement on Proposal 79-25 (Log #68) [Clause 6] in 6.2.3.2. The committee believes that this text meets the intent of the submitter in part and in principle.

The word "may" was changed to shall be permitted to follow the NFPA Manual of Style. The term Qualified persons is a defined term from Clause 3. The committee rejected the remainder of the proposed text because the language is more appropriate for a work practice standard. The committee understands that all action from this proposal is already incorporated in Proposal 79-25 (Log #68) [Clause 6].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman


NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

FREUDENBERG: The phrase "where practicable" is necessary in this case.

79-38 - (7.9.5 Note (New) [5.3]): Reject

SUBMITTER: Gordon T. Davis, Moeller Electric Corp.

RECOMMENDATION: Add new Fine Print Note to read as follows:

"OSHA requires that each installation have suitable existent safety procedures for any work performed with panel door open."

SUBSTANTIATION: Because of the dangers of work with the panel door open there is a need for users to be reminded of OSHA requirements. There is also a need for the authority having jurisdiction to ascertain the existence of the safety procedures.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: OSHA regulations do not necessarily apply to all locations where industrial machines are used. Users should refer to NFPA 70E for the correct applications of work practices.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

FREUDENBERG: If this submitter referenced OSHA rather then NFPA 70E maybe a fine print note saying "See NFPA 70E for additional information on work practices".

79-39 - (7.10.1 [3.3.4.2]): Accept in Principle

SUBMITTER: Richard Graham, Bridgeport Machines Limited/Rep. CECIMO (European Committee for Co-operation of the Machine Tool Industries

RECOMMENDATION: Add the same wording as proposed by the committee in the new 5.3.4.2 and add the following:

Note - The disconnect may have more than one operating handle. The main one that is fixed to the door and a secondary one that is attached to the shaft of the disconnect device that can be operated when the door is open in the open position.

SUBSTANTIATION: The secondary handle will indicate the position of the contacts of the disconnect. The proposal will allow manufacturers to develop a solution to the revised clause without major changes to the enclosure and disconnect switch that the proposal would demand if it remains unaltered.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-41 (Log #31) and 79-33 (Log #59).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24

NEGATIVE: 2

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

KIHR: See my Explanation of Negative on Proposal 79-41 (Log #31). This proposal (79-39) was Accepted in Principle based upon the Committee Action on 79-41. I am essentially voting against the acceptance of Proposal 79-41.

COMMITTEE STATEMENT: See my Comment on Negative for Proposal 79-33 (Log #59).

PADGETT: See my Comment on Negative for Proposal 79-33 (Log #39).

79-40 - (7.10.1 [3.3.4.2]): Accept in Principle

SUBMITTER: Glen Kampa, Hoffman

RECOMMENDATION: Revise text to read as follows:
7.10.1 The operating handle of the disconnecting means shall be readily accessible and in control of the disconnect at all times, regardless of enclosure door being in the open position.

**SUBSTANTIATION:** The concern is the ability to control the disconnect switch to the open position (off) from the operating handle while the door is in the open position. Furthermore, to prevent the door hinge from being located on the same side of the enclosure as the operator handle creating a barrier between the enclosure opening and the switch while the door is opened. The added text addresses these concerns.

**COMMITTEE ACTION:** Accept in Principle.

**COMMITTEE STATEMENT:** See the Committee Action and Statement on Proposal 79-41 (Log #31) and 79-33 (Log #59).

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**
- **AFFIRMATIVE:** 24
- **NEGATIVE:** 1
- **NOT RETURNED:** 1 Norman

**EXPLANATION OF NEGATIVE:**
KIHHR: See my Explanation of Negative on Proposal 79-41 (Log #31). This proposal (79-40) was Accepted in Principle based upon the Committee Action on 79-41. I am essentially voting against the acceptance of Proposal 79-41.

---

79-41 - (7.10.1 Exception [5.3.4.2]): Accept in Principle

**SUBMITTER:** Todd Lottmann, Washington, MO

**RECOMMENDATION:** Add the following Exception to the bottom of proposed Section 5.3.4.2:

Exception: A disconnect with a handle mounted on the panel door shall be considered to meet these requirements provided it complies with all the following:
- an additional internal operating handle is supplied which remains in contact with the switch operating mechanism at all times;
- the internal operating handle is lockable in the open (OFF) position

**SUBSTANTIATION:** This added exception will allow the use of rotary disconnects with through the door handles only under the conditions stated in the exception. With this setup all the requirements are met in the proposed section 5.3.4.2 as follows:
- With the door closed the external (door mounted handle) will be accessible and with the door open the internal handle will be accessible;
- With the door closed the external (door mounted handle) will be in control of the operating mechanism of the switch and with the door open the internal handle will be in control of the operating mechanism;
- The environmental rating can be maintained with the external handle
- In addition the requirements of proposed NFPA 79-2002 subclause 6.2.3.2 can be met;
- With the lockable handle being locked out a deliberate action will be required to operate the disconnect;
- The switch is not operable until the door is fully closed. The shaft has to be inserted a certain distance into the door mounted handle before the switch is operable and this will only be achieved when the door is fully closed.

**COMMITTEE ACTION:** Accept in Principle.

1. Delete the second listed item of 5.3.4.2.
2. Add another listed item to 5.3.3.1 with text as follows: "be operable, by qualified persons, independent of the door position without the use of accessory tools or devices".
3. Add the following text to the end of the first sentence of the third listed item of 5.3.3.1: "independent of the door position".

**COMMITTEE STATEMENT:** The action of this proposal has already been incorporated into Proposal 79-33 (Log #59) and this action meets the intent of the submitter.

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**
- **AFFIRMATIVE:** 24
- **NEGATIVE:** 1
- **NOT RETURNED:** 1 Norman

**EXPLANATION OF NEGATIVE:**
KIHHR: I vote against the Accept in Principle of this proposal for the following reasons:
1. I am strongly opposed to the removal of the second listed item of 5.3.4.2, which states that "an operating handle of the disconnecting means shall - be engaged with the operating mechanism of the disconnecting means at all times".

2. Of particular concern is the use of rotary, through the door type disconnects. The use of these types of disconnects results in the possibility of a serious, possibly even fatal, accident. The possible situation is one in which a service technician locks out the machine and begins to perform work. Another technician, opens the control enclosure door, thus removing the first technicians lock from the operating mechanism of the disconnect. The machine could now potentially be restarted without the knowledge of the first technician, who assumes that the machine is still locked out.

3. The solution which was presented in the original proposal to alleviate this problem was to require a "additional internal operating handle which remains in contact with the switch operating mechanism at all times". This solution was not included as part of the Accept in Principle.

4. Therefore, the original substantiation for proposal 79-41 which states "with the door closed the external (door mounted handle) will be accessible and with the door open the internal handle will be accessible" is no longer applicable. Without the inclusion of a requirement for this second handle, the substantiation given for this proposal, no longer supports its acceptance.

---

79-42 - (7.10.1 [5.3.4.2]): Accept in Principle

**SUBMITTER:** Richard Graham, Bridgeport Machines Limited/Rep. CECIMO (European Committee for Co-operation of the Machine Tool Industries

**RECOMMENDATION:** Retain current text.

**SUBSTANTIATION:** The proposal of the NFPA 79 committee in the new 5.3.4.2 will result in many manufacturers having to redesign the electrical enclosure interlocking aspect of the machine at considerable cost. The new clause will reduce drastically the amount of rotary through the door disconnect devices that could be used and that would still satisfy the proposed clause. The rotary through the door devices can be considered state of the art considering the amount of manufacturers using them as could be seen at recent trade fairs in the USA and Europe. These devices and their associated implementation have an excellent track record. Forcing manufacturers to source either a different rotary or a new flange mount disconnect will add to the cost of every machine tool. I have never witnessed any supporting data to rule the current practice unsafe.

**COMMITTEE ACTION:** Accept in Principle.

**COMMITTEE STATEMENT:** See the Committee Action and Statement on Proposal 79-41 (Log #31) and 79-33 (Log #59).

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**
- **AFFIRMATIVE:** 24
- **NEGATIVE:** 1
- **NOT RETURNED:** 1 Norman

**EXPLANATION OF NEGATIVE:**
KIHHR: See my Explanation of Negative on Proposal 79-41 (Log #31). This proposal (79-42) was Accepted in Principle based upon the Committee Action on 79-41. I am essentially voting against the acceptance of Proposal 79-41.

---

79-43 - (7.10.1 [5.3.4.2]): Accept in Principle

**SUBMITTER:** John B. Deam, Rep. The Association for Manufacturing Technology

**RECOMMENDATION:** Delete from the rewrite of 1997 NFPA 79 that is Clause 5, sub clause 5.3.4.2, the second bullet that reads "be engaged with the...

**SUBSTANTIATION:** There is no requirement for the provision of the proposed second bullet in the current edition (1997) of NFPA 79, or in the current edition (2000) of the International Standard 60204-1 entitled Safety of Machinery - Electrical Equipment of Machines. Nor does there appear to be credible evidence that this provision would improve the safety of the industrial machinery.

**COMMITTEE ACTION:** Accept in Principle.

**COMMITTEE STATEMENT:** See Committee Action and Statement on Proposal 79-41 (Log #31) and 79-33 (Log #59).

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**
- **AFFIRMATIVE:** 24
- **NEGATIVE:** 1
- **NOT RETURNED:** 1 Norman
EXPLANATION OF NEGATIVE:
KIIHR: See my Explanation of Negative on Proposal 79-41 (Log #31). This proposal (79-43) was Accepted in Principle based upon the Committee Action on 79-41. I am essentially voting against the acceptance of Proposal 79-41.

7.2 Overcurrent protection

7.2.1 General
Overcurrent protection shall be provided where the current in a machine circuit can exceed either the rating of any component or the current carrying capacity of the conductors, whichever is the lesser value. The ratings or settings to be used are detailed in 7.2.10.

7.2.2 Supply conductors
Unless otherwise specified by the user, the supplier of the electrical equipment shall not be responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment.

The supplier of the electrical equipment shall state on the installation diagram the data necessary for selecting this overcurrent protective device (see 7.2.10 and 18.5).

NOTE—the size and overcurrent protection of the supply conductors to a machine are covered by NFPA 70, Article 670.

7.2.3 Power circuits (feeder & branch circuits)
Devices for detection and interruption of overcurrent, selected in accordance with NFPA 70 Article 450-Part A.

7.2.4 Control circuits
A control circuit tapped from the load side of the branch-circuit short-circuit and ground-fault protective device(s) and functioning to control the load(s) connected to that branch circuit shall be protected against overcurrent in accordance with this subtitle. Such a tapped control circuit shall not be considered to be a branch circuit and shall be permitted to be protected by either a supplementary or branch-circuit overcurrent protective device(s).

7.2.4.1 Conductor protection
7.2.4.1.1 Conductors larger than AWG No. 14 shall be protected against overcurrent in accordance with their ampacities. See Table 310-16 of NFPA 70 for conductor ampacities.

7.2.4.1.2 Conductors sizes of AWG 18, 16, and 14 shall be considered as protected by an overcurrent device(s) of not more than 20 amperes rating.

7.2.4.1.3 Conductors that do not extend beyond the control cabinet enclosure shall be considered protected by the load branch-circuit short-circuit and ground-fault protective device(s) where the rating of the protective device(s) is not more than 400 percent of the ampacity of the control circuit conductor for conductors AWG No. 14 and larger, or not more than 25 amperes for AWG No. 18 and 40 amperes for AWG No. 16.

7.2.4.1.4 Conductors of AWG No. 14 and larger that extend beyond the enclosure shall be considered protected by the load branch-circuit short-circuit and ground-fault protective device(s) where the rating of the protective device(s) is not more than 300 percent of the ampacity of the control circuit conductors.

7.2.4.1.5 Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary shall be considered protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with 7.2.7 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary voltage ratio. Transformer secondary conductors (other than 2-wire) are not considered to be protected by the primary overcurrent protection.

7.2.4.1.6 Conductors of control circuits shall be considered protected by the motor branch-circuit short-circuit and ground-fault protective device(s) where the opening of the control circuit would create a hazard as, for example, the control circuit of a magnetic chucky and the like.

7.2.5 Receptacle outlets and their associated conductors
Overcurrent protection shall be provided for the circuits feeding general-purpose receptacle outlets intended primarily for supplying power to maintenance equipment.

Overcurrent protective devices shall be provided in the ungrounded phase conductors of each circuit feeding receptacle outlets. Overcurrent protection for these socket outlets shall not exceed 15 amperes.

7.2.6 Lighting circuits
Overcurrent protection for lighting branch circuits shall not exceed 15 amperes.

7.2.7 Transformers
Transformers for Motor Control Circuits shall be protected in accordance with NFPA 70 Article 450-Part F; Transformers for other than Motor Control Circuits shall be protected in accordance with NFPA 70 Article 450-Part A.

7.2.8 Location of overcurrent protective devices
An overcurrent protective device shall be located at the point where the conductor to be protected is connected to the supply except

(a) Overcurrent protection at the supply shall not be required if all of the following conditions are met:

- the current carrying capacity of the conductor is at least equal to that required for the load;
- each connecting conductor to the overcurrent protective device is no longer than 3 m (9.9 ft.) and
- the conductor is suitably protected from physical damage;
- the conductor does not extend beyond the control panel enclosure;
- the conductor terminates in a splitter block, single-circuit breaker or set of fuses.

(b) Overcurrent protection at the supply shall not be required if all of the following conditions are met:

- the conductor has an ampacity of at least one-third (1/3) that of the conductor from which it is supplied;
- the conductor is suitably protected from physical damage;
- the conductor is not over 25 ft. (7.62 m) long and the conductor terminates in a single circuit breaker or set of fuses.

7.2.9 Overcurrent protective devices
The short-circuit interrupting rating shall be at least equal to the available fault current at the point of application. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (e.g., from motors, from power factor correction capacitors), these shall be taken into consideration.

Class H fuses, and devices that will accept Class H fuses, shall not be used.

7.2.10 Rating and setting of overcurrent protective devices
7.2.10.1 Each motor controller and its associated wiring shall be protected as an individual branch circuit by a short-circuit protective device (SCPD) as specified by the controller manufacturer. The maximum rating of the designated SCPD shall be as shown in Table 1. Exception: Table 1 shall not apply to Design E motor circuits. The provisions of NFPA 70 shall be observed for Design E motor circuits.

7.2.10.2 Several motors each not exceeding 1 horsepower in rating shall be permitted on a nominal 120-volt branch circuit protected at not over 20 amperes or a branch circuit of 600 volts, nominal, or less, protected at not over 15 amperes, where all of the following conditions are met:

a. The full-load rating of each motor does not exceed 6 amperes.

b. The rating of the branch-circuit short-circuit and ground-fault protective device marked on any of the controllers is not exceeded.

c. Individual overload protection conforms to 7.3.

Table 1 Fuse and circuit breaker selection: motor, motor branch circuit, and motor controller

<table>
<thead>
<tr>
<th>Maximum setting or rating</th>
<th>Percentage of Full-Load Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse class with time delay²</td>
<td>Type² of Application</td>
</tr>
<tr>
<td>AC-2</td>
<td>AC-3</td>
</tr>
<tr>
<td>150</td>
<td>175</td>
</tr>
<tr>
<td>RK-5</td>
<td>J</td>
</tr>
<tr>
<td>150</td>
<td>175</td>
</tr>
<tr>
<td>Instantaneous trip C/B³</td>
<td>800</td>
</tr>
<tr>
<td>Inverse trip C/B³</td>
<td>150</td>
</tr>
</tbody>
</table>

NOTES (to Table 1):
1. Where the values determined by Table 1 do not correspond to the standard sizes or ratings, the next higher standard size, rating, or possible setting shall be permitted.

2) Types:
- AC-2: Slip-ring motors starting, switching off, or all light-starting duty motors.
- AC-3: Squirrel-cage motors; starting, switching off while running, occasional inching, jogging, or plugging but not to exceed 5 operations per minute or 10 operations per 10 minutes. All wye-delta and two-step auto-transformer starting, or all medium starting duty motors.
- AC-4: Squirrel-cage motors; starting, plugging, inching, jogging, or all heavy starting duty motors.

3) Where the rating of a time delay fuse (other than CC type) specified by the table is not sufficient for the starting of the motor, it shall be permitted to be increased but shall in no case exceed 225 percent. The rating of a time-delay Class CC fuse shall be permitted to be increased but shall in no case exceed 400 percent of the full-load current.

4) Class RK-5 fuses shall be used only with NEMA rated motor controllers. Exception: Motor controllers listed for use with RK5 fuses.

5) Magnetic only circuit breakers are limited to single motor applications. These instantaneous trip circuit breakers shall only be used if they are adjustable, if part of a combination controller having motor-running and also short-circuit and ground-fault protection in each conductor, and if the combination is especially identified for use, and it is installed per any instructions included in its listing or labeling. Circuit breakers with adjustable trip settings shall be set at the controller manufacturer's recommendation, but not greater than 1300 percent of the motor full-load current.

6) Where the rating of an inverse time circuit breaker specified in the table is not sufficient for the starting current of the motor, it shall be permitted to be increased but in no case exceed:

a. 400 percent for full-load currents of 100 amperes or less or

b. 300 percent for full-load currents greater than 100 amperes.

NOTE: EEC 947-4 defines the terms Type 1 and Type 2 coordinated protection as follows:
- Type 1 Protection: Under short-circuit conditions the contactor or starter may not be suitable for further use without repair or replacement.
- Type 2 Protection: Under short-circuit conditions the contactor or starter shall be suitable for further use.

The maximum allowable values in Table 1 do not guarantee Type 2 protection. Type 2 protection is recommended for use in applications where enhanced performance and reliability are required.

7.2.10.3 Where the branch-circuit and short-circuit and ground-fault protective device is selected not to exceed that allowed by 7.2.10.1 for the motor of the smallest rating, two or more motors or one or more motors and other load(s), with each motor having individual overload protection, shall be permitted to be connected to a branch circuit where it can be determined that the branch-circuit short-circuit and ground-fault protective device will not open under the most severe normal conditions of service that might be encountered.

7.2.10.4 Two or more motors and their control equipment shall be permitted to be connected to a single branch-circuit where short-circuit and ground-fault protection is provided by a single inverse-time circuit breaker or a single set of fuses, provided both of the following conditions are met:

a) Each motor controller and overload device is listed (see ANSI/NFPA 70, Article 100, Listed) for group installation with specified short-circuit current ratings.

NOTE: The short-circuit current rating includes:
1) The class and rating of the short-circuit protective device.
2) The maximum nominal application voltage.
3) The maximum available fault current.

b) The rating or setting of the overcurrent device does not exceed the values in Table 2 for the smallest conductor in the circuit.

Table 2 – Relationship between conductor size and maximum rating or setting of short-circuit protective device for power circuits

<table>
<thead>
<tr>
<th>Conductor size (AWG)</th>
<th>Max. rating Non-time delay fuse or inverse time circuit breaker in Amperes</th>
<th>Time delay or dual element fuse in Amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>12</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>150</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>250</td>
<td>125</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>350</td>
<td>175</td>
</tr>
<tr>
<td>1</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>0</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>2/0</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>5/0</td>
<td>700</td>
<td>350</td>
</tr>
<tr>
<td>4/0</td>
<td>800</td>
<td>400</td>
</tr>
</tbody>
</table>

7.2.11 Resistance heating branch circuit overcurrent protection
If the branch circuit supplies a single nonmotor-operated load rated at 16.7 amperes or more, the overcurrent device rating shall not exceed 150 percent of the load rating.

Equipment employing resistance-type heating elements rated at more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

EXCEPTION—A single sheath-type heating element requiring more than 48 amperes shall be protected at not more than 125 percent of the load where the element is integral with and enclosed within the machine housing.

The supplementary overcurrent protective devices shall be: (1) installed within or on the machinery or provided as a separate
assembly; and (2) accessible but need not be readily accessible; and (3) suitable for branch-circuit protection.

The main conductors supplying these overcurrent protective devices shall be considered branch-circuit conductors.

7.3 Overload protection of motors

7.3.1 Overload Protection Requirements

Overload devices shall be provided to protect each motor, motor controller, and branch-circuit conductor against excessive heating due to motor overloads or failure to start.

Motor overload protection shall be provided as follows:

11. Motors in accordance with NFPA 70, National Electrical Code, Article 430, Part C.
12. Adjustable speed drives (electronic drives) in accordance with NFPA 70, National Electrical Code, Article 430.2.

7.3.2 Resetting

Resetting of the overload device shall not restart the motor.

Exception: Where there is only a single motor of two horsepower or less on the machine, an overload reset operator mounted on the motor shall be permitted to restart the motor provided that the distance between the overload reset operator and the machine start pushbutton operator is 12 in. (300 mm) or less, and a suitable warning label is attached on or adjacent to the overload reset operator.

7.3.3 Number of overloads

The minimum number and location of running overcurrent units shall be determined from Table 3.

<table>
<thead>
<tr>
<th>Kind of motor</th>
<th>Supply systems</th>
<th>Number and location of overcurrent units (such as trip coils, relays, or thermal cutouts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-phase, ac or dc</td>
<td>2-wire, 1-phase ac or dc ungrounded</td>
<td>1 in either conductor</td>
</tr>
<tr>
<td>1-phase, ac or dc</td>
<td>2-wire, 1-phase ac or dc, one conductor grounded</td>
<td>1 in ungrounded conductor</td>
</tr>
<tr>
<td>1-phase, ac or dc</td>
<td>3-wire, 1-phase ac or dc, grounded neutral</td>
<td>1 in either ungrounded conductor</td>
</tr>
<tr>
<td>3-phase, ac</td>
<td>Any 3-phase</td>
<td>3, one in each phase</td>
</tr>
</tbody>
</table>

* Exception: Unless protected by other approved means.

NOTE: For 2-phase power supply systems see ANSI NFPA 70, Section 430–37.

Sort-time rated motors or high-reversing duty motors that cannot be adequately protected by external overload devices shall be protected by a thermal device mounted in the motor and sensitive to the temperature of the motor, or to both motor temperature and current.

Motors that are an integral part of a refrigeration compressor of the hermetic or semihermetic type shall be protected per the compressor manufacturer’s recommendations.

7.4 Abnormal temperature protection

Resistance heating or other circuits that are capable of attaining or causing abnormal temperatures and therefore can cause a hazardous condition shall be provided with suitable detection to initiate an appropriate control response. An example could be a resistance-heating circuit that is short-time rated or which loses its cooling medium.

2.2 Protection against supply interruption or voltage reduction and subsequent restoration

7.5.2 Undervoltage Protection

Where the operation of the machine can allow for an interruption or a reduction of the voltage for a short time period, delayed undervoltage protection shall be permitted to be provided. The operation of the undervoltage device shall not impair the operation of any stopping control of the machine.

7.5.3 Restarting

Upon restoration of the voltage or upon switching on the incoming supply, automatic or unintentional restarting of the machine shall be prevented when such a restart can cause a hazardous condition.

Where only a part of the machine or of the group of machines working together in a coordinated manner is affected by the voltage reduction or supply interruption, the undervoltage protection shall initiate appropriate control responses to ensure co-ordination.

7.6 Motor overspeed protection

Unless the inherent characteristics of the motor or the controller, or both, are such as to limit the speed adequately, drive systems motors shall include protection against motor overspeed.

Overspeed protection means include, but are not necessarily limited to, the following:

1. A mechanical overspeed device incorporated in the drive to remove armature voltage on motor overspeed.
2. An electrical overspeed detector that will remove armature voltage on motor overspeed.
3. Field loss detection to remove armature voltage upon the loss of field current.
4. Voltage-limiting speed-regulated drives that operate with constant full field. In this case, protection is obtained individually for the loss of field or tachometer feedback; however, protection against simultaneous loss of field and tachometer is not provided.

Equipment overspeed protection: Where the safe operating speed of the equipment is less than that of the drive motor, means shall be provided to limit the speed of the equipment.

7.7 This section left intentionally blank

7.8 Phase sequence protection

Where a phase loss or an incorrect phase sequence of the supply voltage can cause a hazardous condition or damage to the machine, protection shall be provided.

NOTE—Conditions of use which may lead to an incorrect phase sequence include:

- a machine transferred from one supply to another;
- a mobile machine with a facility for connection to an external power supply

7.9 Protection against overvoltages due to lightning and to switching surges

7.9.1 Protective devices shall be permitted to be provided to protect against the effects of overvoltages due to lightning or to switching surges.

7.9.2 Where provided, devices for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the supply disconnecting device.

7.9.3 Where provided, devices for the suppression of overvoltages due to switching surges shall be connected across the terminals of all equipment requiring such protection.

7.10 Power factor correction capacitors

7.10.1 Where capacitors are installed for motor power factor correction on circuits of 600 volts, nominal, and under, overcurrent protection for the conductors shall be provided. See 7.2.1 and 7.2.10.

Each capacitor cell or capacitor bank shall be protected against rupture of the individual cells. Protection included as part of the capacitor assembly shall be permitted.
Clause 7.10.2 Discharge of Stored Energy

**Capacitors shall be provided with a means of discharging stored energy.**

(a) Time of Discharge. The residual voltage of a capacitor shall be reduced to 50 volts, nominal, or less, within 1 minute after the capacitor is disconnected from the source of supply.

(b) Means of Discharge. The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used.

**Clause 7.10.2 is a copy of the text in NFPA 70 Section 460-6 and should be shown as “extracted text”**

**SUBSTANTIATION:**

**Substantiation for Clause 7 – NFPA79-2002**

**Historical Background.**

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

- **Harmonization - Purpose**
- As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC-60204-1.

- **Importance of Issue - Harmonization**
- Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

- **Harmonization - Objective**
- This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 609204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

“The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60924, where feasible and where in concert with the NEC and its related codes and standards.”

**Result**

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause 8 with IEC 609204-1 Clause 7. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber Clause 8 of NFPA 79-1997 to correspond with IEC 609204-1. The task group proposes the following changes to further improve usability.

These new reference numbers are used as the base in this substantiation for understanding the concept and substantiated changes.

**Clause 7**

**Recommendation:** Revise the general heading of NFPA79-1997 clause 8 from “Protection” to “Protection of Equipment”.

**Substantiation:** The change is an editorial change for harmonization.

Clause 7.1 General

**Recommendation:** A new sub-clause was created to provide a bulleted list of the general topics addressed in Clause 7.

**Substantiation:** Editorialy added a list clarifying content for the users of the standard.

Clause 7.2 Overcurrent protection

**Recommendation:** Create a general header for grouping of overcurrent protection requirements

**Substantiation:** Editorial reorganization for user clarity.

Clause 7.2.1 General

**Recommendation:** Add a new sub-clause outlining the general requirements for location and ratings of overcurrent devices.

**Substantiation:** Although this is a new sub-clause the requirement were implied in many section of NFPA79-1997 and is considered editorial. The new statement is in agreement with the requirement in NFPA70-1999.

Clause 7.2.2 Supply conductors

**Recommendation:** Restate clause 8.2 of NFPA 79-1997 without reference to figures.

**Substantiation:** This clause editorially restates the requirements in NFPA79-1997 clause 8.2 without references to figures without change to the requirements.

Clause 7.2.3 Power circuits

**Recommendation:** Restate clause 8.3 of NFPA 79-1997 without reference to figures. A reference to the subclause outlining the selection of overcurrent devices (7.2.10) has been added.

**Substantiation:** This clause editorially restates the requirements in NFPA79-1997 clause 8.3 without references to figures. A reference to the subclause outlining the selection of overcurrent devices (7.2.10) making the remaining subclauses in NFPA79-1997 clause 8.3 unnecessary.

Clause 7.2.4 Control circuits

**Recommendation:** Utilize information currently shown as clause 8.9.1 in NFPA79-1997.

**Substantiation:** Renumbered to conform to the new format.

Clause 7.2.4.1 Conductor Protection

**Recommendation:** Utilize information currently shown as clause 8.9.2 in NFPA79-1997.

**Substantiation:** Renumbered to conform to the new format.

Clause 7.2.4.1.1

**Recommendation:** Utilize the information currently shown as 8.9.2.1 in NFPA79-1997 with the exception that the reference to Table 11 has been replace with a reference to Table 310-16 in the NEC.

**Substantiation:** The modifications to the text were made to avoid duplication plus avoid discrepancies in case of change with the paper document. Table 11 has also been deleted from the new document since it is no longer referenced in the text.

Clause 7.2.4.1.2

**Recommendation:** Utilize information currently in 8.9.2.2 of NFPA79-1997.

**Substantiation:** Renumbered to conform to the new format.

Clause 7.2.4.1.3

**Recommendation:** Utilize the information currently in 8.9.2.2 Exception No. 1 of NFPA79-1997 with the exception that the information has been converted to positive text rather than an exception.

**Substantiation:** Renumbered to conform to the new format plus revise to positive test to comply with the style manual.

Clause 7.2.4.1.4

**Recommendation:** Utilize the information currently in 8.9.2.2 Exception No. 2 of NFPA79-1997 with the exception that the information has been converted to positive text rather than an exception.
Clause 7.2.10.3 Recommendation: Utilize the information currently in 8.5.3 of NFPA79-1997
Substantiation: Renumbered to conform to the new format

Clause 7.2.10.4 Recommendation: Utilize the information currently in 8.5.4 of NFPA79-1997 plus Table 2 of NFPA79-1997.
Substantiation: Renumbered to conform to the new format

Clause 7.2.11 Resistance heating branch circuit overcurrent protection
Recommendation: The heading of current 8.8 in NFPA79-1997 was expanded to clarify the requirements in this subclause were overcurrent protection requirements. Additionally the requirement currently in 8.8.1, 8.8.2, 8.8.3, and 8.8.4 of NFPA79-1997 are combined into a single clause.
Substantiation. Renumber to conform to the new format plus editorial changes.

Clause 7.3 Overload protection of motors
Recommendation: The title of current 8.6 of NFPA79-1997 was expanded to clarify the intent is overcurrent protection.
Substantiation: Added words for user clarity

Clause 7.3.1 Overload protection requirements
Recommendation: Utilize the information currently in 8.6.1 and 8.15 of NFPA79-1997
Substantiation: Renumbered to conform to the new format

Clause 7.3.2 Resetting
Recommendation: Utilize the information currently in 8.6.2 of NFPA 79-1997
Substantiation: Renumbered to conform to the new format

Clause 7.3.3 Recommendation: Utilize the information currently in 8.6.3 of NFPA79-1997 plus the associated Table 3 in NFPA79-1997.
Substantiation: Renumbered to conform to the new format

Clause 7.4 Abnormal temperature protection
Recommendation: Add new text for abnormal temperatures.
Substantiation: To recognize the hazards associated with unprotected heat sources, requirements have been added requiring those elements and circuits to be protected.

Clause 7.5 Protection against supply interruption or voltage reduction and subsequent restoration
Recommendation: In order to recognize and give requirements for additional supply interruption hazards, the title of clause 8.14 in NFPA79-1997 is to be expanded to include supply interruptions in addition to voltage reductions.
Substantiation: The title is modified for user clarity.

Clause 7.5.1 Recommendation: Add a general statement to clarify the requirements in this clause.
Substantiation: The text is added for user clarity in explanation of the clause contents.

Substantiation: The clause has been editorially modified to harmonize with international and global requirements. The protection requirements are the same.

Clause 7.5.3 Restarting
Substantiation: The clause has been editorially modified to harmonize with international and global requirements. The protection requirements are the same.

Substantiation: The title is modified for user clarity.

Clause 7.5.1 Recommendation: Add a general statement to clarify the requirements in this clause.
Substantiation: The text is added for user clarity in explanation of the clause contents.

Substantiation: The clause has been editorially modified to harmonize with international and global requirements. The protection requirements are the same.

Clause 7.5.3 Restarting
Substantiation: The clause has been editorially modified to harmonize with international and global requirements. The protection requirements are the same.
Clause 7.6 Motor overspeed protection
Recommendation: Utilize the requirements in subclause 8.16 and 8.17 of NFPA79-1997 but combine into a single clause.

Substantiation: Renumbered to conform to the new format. Changes are editorial only.

Clause 7.8 Phase sequence protection
Recommendation: Add new text concerning phase sequence protection.

Substantiation: It is recognized there are personnel and equipment hazards associated with improper phase sequence with some electrical operations. This subclause is added to provide requirements to protect against such hazards.

Clause 7.9 Protection against overvoltages due to lightning and to switching surges.
Recommendation: Add this clause and its subclauses of 7.9.1, 7.9.2 and 7.9.3

Substantiation: These requirements are non-mandatory but where overvoltage protection is utilized requirements are added to indicate the location of proper connections.

Improper connection of these device may lead to the desired protection being negated. To protect against this hazard these requirements were added.

Clause 7.10 Power factor correction capacitors
Recommendation: Add this clause and its subclauses of 7.10.1 and 7.10.2.

Substantiation: These requirements are non-mandatory but where power factor correction capacitors are utilized requirements for proper connection are necessary.
Capacitors without proper overcurrent protection and a means to discharge stored energy may constitute a fire or shock hazard. Requirements are added for proper connection.

Recommendation: Delete existing figures 1 and 2 shown in Clause 8 of NFPA 79-1997.
Substantiation: Due to the re-organization of the material in this clause Figures 1 and 2 in Clause 8 of NFPA79-1997 are no longer necessary and have been omitted from the new text.

### CLAUSE NUMBERS: NFPA 79-1997 VERSUS PROPOSED NFPA 79-2002

<table>
<thead>
<tr>
<th>NFPA 79-1997</th>
<th>Proposed NFPA 79-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause</td>
<td>Heading</td>
</tr>
<tr>
<td>8</td>
<td>Protection</td>
</tr>
<tr>
<td>8.1</td>
<td>Machine Circuits</td>
</tr>
<tr>
<td>8.1.1</td>
<td></td>
</tr>
<tr>
<td>8.1.2</td>
<td></td>
</tr>
<tr>
<td>Figure 1</td>
<td>One line representation of electrical system power distribution</td>
</tr>
<tr>
<td>Figure 2</td>
<td>One line representation of electrical system power protection</td>
</tr>
<tr>
<td>8.2</td>
<td>Supply conductors and machine overcurrent protection</td>
</tr>
<tr>
<td>8.3</td>
<td>Branch circuit overcurrent protection</td>
</tr>
<tr>
<td>8.3.1</td>
<td></td>
</tr>
<tr>
<td>8.3.3</td>
<td></td>
</tr>
</tbody>
</table>
8.4 Location of protective devices 7.2.8
8.5 Motor branch circuits
8.5.1

Table 1  Fuse and circuit breaker selection: motor, motor branch circuit, and motor controller

8.5.2  7.2.10.2
8.5.3  7.2.10.3
8.5.4  7.2.10.4

Table 2  Relationship between conductor size and maximum rating or short-circuit protective device for power circuits

8.6 Motor overload 7.3 Overload protection of motors
8.6.1  7.3.1 Overload Protection Requirements
8.6.2  7.3.2 Resetting
8.6.3  7.3.3 Number of overloads

Table 3  Running overcurrent units

8.6.4
8.7 Motor overload, special duty 7.3
8.7.1  7.3
8.7.2  7.3

8.8 Resistance heating branch circuits 7.2.11
8.8.1  7.2.11
8.8.2  7.2.11
8.8.3  7.2.11
8.8.4  7.2.11

8.9 Control circuit conductors 7.2.4
8.9.1 General 7.2.4
8.9.2 Conductor protection 7.2.4.1 Conductor Protection
8.9.2.1  7.2.4.1.1
8.9.2.2  7.2.4.1.2
8.9.2.2 Exc No 1  7.2.4.1.3
8.9.2.2 Exc No 2  7.2.4.1.4
8.9.2.2 Exc No 3  7.2.4.1.5
8.9.2.2 Exc No 4  7.2.4.1.6

8.10 Lighting branch circuits 7.2.6
8.11 Power transformer 7.2.7
8.11.1 Primary 7.2.7
8.11.2 Primary and secondary 7.2.7
8.12 Control circuit transformer 7.2.7
8.12.1 7.2.7
Table 4 Control transformer overcurrent protection 7.2.7
Table 5 Control transformer overcurrent protection 7.2.7
8.12.2 7.2.4, 7.2.7
8.12.3 7.2.7
8.12.4 7.2.7
8.13 Common overcurrent device 7.7?
8.14 Undervoltage protection 7.5 Protection against supply interruption voltage reduction and subsequent restoration.
8.14.1 7.5.2 Undervoltage Protection
8.14.2 7.5.3 Restarting
8.14.3 7.5 –
8.15 Adjustable-speed drive system 7.3 Overload protection of motors
8.16 Motor overspeed protection 7.6
8.17 Equipment overspeed protection 7.6

COMMITTEE ACTION: Accept in Principle.
Revise text as follows:

7.1 General. This clause details the measures to be taken to protect equipment against the effects of:
- overcurrent arising from a short circuit;
- overload currents;
- ground faults;
- overvoltages due to lightning and switching surges; abnormal temperatures;
- loss of or reduction in the supply voltage;
- overspeed of machines/machine elements;
- incorrect phase sequence

7.2 Overcurrent protection

7.2.1 General. Overcurrent protection shall be provided where the current in a machine circuit can exceed either the rating of any component or the current carrying capacity of the conductors, whichever is the lesser value. The ratings or settings to be used are detailed in 7.2.10.

Note: Figures 1 and 2 show typical circuits acceptable for the protection of current-carrying and current-consuming electrical machine components. Protective interlocks are not shown. (see Table 310-16 of NFPA70 for conductor ampacities)

7.2.2 Supply conductors
Unless otherwise specified by the user, the supplier of the electrical equipment shall not be responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment.

The supplier of the electrical equipment shall state on the installation diagram the data necessary for selecting the overcurrent protective device. (see 7.2.10 and 18.5)

NOTE—The size and overcurrent protection of the supply conductors to a machine are covered by NFPA 70, Article 670.

7.2.3 Power circuits (feeder & branch circuits)

Devices for detection and interruption of overcurrent, selected in accordance with 7.2.10, shall be applied to each ungrounded phase conductor. Conductors shall be protected against overcurrent in accordance with their ampacities as specified in Appendix A.

7.2.4 Control circuits. A control circuit tapped from the load side of the branch-circuit short-circuit and ground-fault protective device(s) and functioning to control the load(s) connected to that branch circuit shall be protected against overcurrent in accordance with this subclause. Such a tapped control circuit shall not be considered to be a branch circuit and shall be permitted to be protected by either a supplementary or branch-circuit overcurrent protective device(s).

7.2.4.1 Conductor protection

7.2.4.1.1 Conductors larger than AWG No. 14, other than flexible cords and fixture wires, shall be protected against overcurrent in accordance with their ampacities as specified in 13.5, unless otherwise permitted in 7.2.4.1.2 through 7.2.4.1.6. See Table 310-16 of NFPA70 for conductor ampacities.

7.2.4.1.2 Conductors sizes of AWG 18, 16, and 14 shall be considered as protected by an overcurrent device(s) of not more than 20 amperes rating.

7.2.4.1.3 Conductors that do not extend beyond the control cabinet enclosure shall be considered protected by the load branch-circuit short-circuit and ground-fault protective device(s) where the rating of the protective device(s) is not more than 400 percent of the ampacity of the control circuit conductor for conductors AWG No. 14 and larger, or not more than 25 amperes for AWG No. 18 and 40 amperes for AWG No. 16.

7.2.4.1.4 Conductors of AWG No. 14 and larger that extend beyond the enclosure shall be considered protected by the load branch-circuit short-circuit and ground-fault protective device(s) where the rating of the protective device(s) is not more than 300 percent of the ampacity of the control circuit conductors.

7.2.4.1.5 Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary shall be considered protected by overcurrent protection provided on the
7.2.4.1.6 Conductors of control circuits shall be considered protected by the motor branch-circuit short-circuit and ground-fault protective device(s) where the opening of the control circuit would create a hazard as, for example, the control circuit of a magnetic chuck and the like.

7.2.5 Receptacle (socket) outlets and their associated conductors. Overcurrent protection shall be provided for the circuits feeding general purpose receptacle (socket) outlets intended primarily for supplying power to maintenance equipment.

Overcurrent protective devices shall be provided in the ungrounded phase conductors of each circuit feeding receptacle (socket) outlets. Overcurrent protection for these receptacle (socket) outlets shall not exceed 15 amps.

7.2.6 Lighting circuits. Overcurrent protection for lighting branch circuits shall not exceed 15 amperes.

7.2.7 Transformers. Transformers for Motor Control Circuits shall be protected in accordance with NFPA70 Article 430-Part F; Transformers for other than Motor Control Circuits shall be protected in accordance with NFPA70 Article 450-Part A.

7.2.8 Location of overcurrent protective devices. An overcurrent protective device shall be located at the point where the conductor to be protected is connected to the supply except:

(a) Overcurrent protection at the supply shall not be required if all of the following conditions are met:
   - the current carrying capacity of the conductor is at least equal to that required for the load;
   - each connecting conductor to the overcurrent protective devices is no longer than 5 m (9.9 ft.) and the conductor is suitably protected from physical damage;
   - the conductor does not extend beyond the control panel enclosure;
   - the conductor terminates in a split-plex block, single branch circuit rated circuit breaker or set of fuses.

(b) Overcurrent protection at the supply shall not be required if all of the following conditions are met:
   - the conductor has an ampacity of at least one-third (1/3) that of the conductor from which it is supplied;
   - the conductor is suitably protected from physical damage;
   - the conductor is not over 25 ft. (7.62 m) long and the conductor terminates in a single circuit breaker or set of fuses.

7.2.9 Overcurrent protective devices. The short-circuit interrupting rating shall be at least equal to the available fault current at the point of application. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (e.g. from motors, from power factor correction capacitors), these shall be taken into consideration. Class II fuses, and devices that will accept Class II fuses, shall not be used.

7.2.10 Rating and setting of overcurrent protective devices

7.2.10.1 Each motor controller and its associated wiring shall be protected as an individual branch circuit by a short-circuit protective device (SCPD) as specified by the controller manufacturer. The maximum rating of the designated SCPD shall be as shown in Table 1. Exception: Table 1 shall not apply to Design E motor circuits. The provisions of NFPA 70 shall be observed for Design E motor circuits.

7.2.10.2 Several motors each not exceeding 1 horsepower in rating shall be permitted on a nominal 120-volt branch circuit protected at not over

primary (supply) side of the transformer, provided this protection is in accordance with 7.2.7 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary voltage ratio. Transformer secondary conductors (other than 2-wire) are not considered to be protected by the primary overcurrent protection.

20 amperes or a branch circuit of 600 volts, nominal, or less, protectat not over 15 amperes, where all of the following conditions are met:

a. The full-load rating of each motor does not exceed 6 amperes.

b. The rating of the branch-circuit short-circuit and ground fault protective device marked on any of the controllers is not exceeded.

c. Individual overload protection conforms to 7.3.

Table 1

<table>
<thead>
<tr>
<th>Maximum setting or rating (Fuse and circuit breaker)</th>
<th>Percentage of Full-Load Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse class with time delay</td>
<td>Type 1 of Application</td>
</tr>
<tr>
<td>AC-2</td>
<td>150</td>
</tr>
<tr>
<td>AC-3</td>
<td>150</td>
</tr>
<tr>
<td>AC-4</td>
<td>150</td>
</tr>
<tr>
<td>CC</td>
<td>150</td>
</tr>
<tr>
<td>Instantaneous trip C/B</td>
<td>800</td>
</tr>
<tr>
<td>Inverse trip C/B</td>
<td>150</td>
</tr>
</tbody>
</table>

NOTES (to Table 1):
2. Where the values determined by Table 1 do not correspond to the standard sizes or ratings, the next higher standard size, rating, or possible setting shall be permitted.

2) Types:
  - AC-2: Slip-ring motors starting, switching off, or all light-starting duty motors.
  - AC-3: Squirrel-cage motors; starting, switching off while running, occasional inching, jogging, or plugging but not to exceed 5 operations per minute or 10 operations per 10 minutes. All wye-delta and two-step auto-transformer starting, or all medium starting duty motors.
  - AC-4: Squirrel-cage motors; starting, plugging, inching, jogging, or all heavy starting duty motors.

3) Where the rating of a time delay fuse (other than CC type) specified by the table is not sufficient for the starting of the motor, it shall be permitted to be increased but shall in no case be permitted to exceed 225 percent. The rating of a time-delay Class CC fuse shall be permitted to be increased but shall in no case exceed 400 percent of the full-load current.

4) Class RK-5 fuses shall be used only with NEMA rated motor controllers. Exception: Motor controllers listed for use with RK5 fuses.

5) Magnetic only circuit breakers are limited to single motor applications. These instantaneous trip circuit breakers shall only be used if they are adjustable, if part of a combination controller having motor-running and also short-circuit and ground-fault protection in each conductor, and if the combination is especially identified for use, and it is installed per any instructions included in its listing or labeling. Circuit breakers with adjustable trip settings shall be set at the controller manufacturer's recommendation, but not greater than 1300 percent of the motor full-load current.

6) Where the rating of an inverse time circuit breaker specified in the table is not sufficient for the starting current of the motor it shall be permitted to be increased but in no case exceed:
   - a. 400 percent for full-load currents of 100 amperes or less or
   - b. 300 percent for full-load currents greater than 100 amperes.

NOTE: IEC 947-4 defines the terms Type 1 and Type 2 coordinated protection as follows:

- Type 1 Protection: Under short-circuit conditions the contactor or starter may not be suitable for further use without repair or replacement.
- Type 2 Protection: Under short-circuit conditions the contactor or starter shall be suitable for further use.

The maximum allowable values in Table 1 do not guarantee Type 2 protection. Type 2 protection is recommended for use in
7.2.10.3 Where the branch-circuit and short-circuit and ground-fault protective device is selected not to exceed that allowed by 7.2.10.1 for the motor of the smallest rating, two or more motors or one or more motors and other load(s), with each motor having individual overload protection, shall be permitted to be connected to a branch circuit where it can be determined that the branch-circuit short-circuit and ground-fault protective device will not open under the most severe normal conditions of service that might be encountered.

7.2.10.4 Two or more motors and their control equipment shall be permitted to be connected to a single branch-circuit where short-circuit and ground-fault protection is provided by a single inverse-time circuit breaker or a single set of fuses, provided both of the following conditions are met:

a) Each motor controller and overload device is listed (see ANSI/NFPA 70, Article 100, Listed) for group installation with specified short-circuit current ratings.

NOTE: The short-circuit current rating includes:

1) The class and rating of the short-circuit protective device.
2) The maximum nominal application voltage.
3) The maximum available fault current.

b) The rating or setting of the overcurrent device does not exceed the values in Table 2 for the smallest conductor in the circuit.

Table 2 – Relationship between conductor size and maximum rating or setting of short-circuit protective device for power circuits

<table>
<thead>
<tr>
<th>Conductor size (AWG)</th>
<th>Max. rating</th>
<th>Non-time delay fuse or inverse time circuit breaker in Ampères</th>
<th>Time delay or dual element fuse in Ampères</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>60</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>12</td>
<td>80</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>50</td>
<td>125</td>
</tr>
<tr>
<td>8</td>
<td>150</td>
<td>80</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>250</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>350</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>400</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>500</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>2/0</td>
<td>600</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>3/0</td>
<td>700</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>4/0</td>
<td>800</td>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>

7.2.11 Resistance heating branch circuit overcurrent protection. If the branch circuit supplies a single nonmotor-operated load rated at 16.7 amperes or more, the overcurrent device rating shall not exceed 150 percent of the load rating.

Equipment employing resistance-type heating elements rated at more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

EXCEPTION—A single sheath-type heating element requiring more than 48 amperes shall be protected at not more than 125 percent of the load where the element is integral with and enclosed within the machine housing.

The supplementary overcurrent protective devices shall be: (1) installed within or on the machinery or provided as a separate assembly; and (2) accessible but need not be readily accessible; and (3) suitable for branch-circuit protection.

The main conductors supplying these overcurrent protective devices shall be considered branch-circuit conductors.

7.2.12 Programmable electronic system power supply input overcurrent protection

Programmable electronic system power supply inputs shall be protected by overcurrent protective devices either externally or internally. The overcurrent protection size or rating shall be in accordance with the manufacturer’s instructions.

7.2.13 Control devices. Pushbuttons, selector switches, sensors and limit switches shall in no case be connected to a circuit rated larger than 10 amperes.

<<sensors was added to include additional pilot devices>>

7.2.14 Common overcurrent device. The use of the same overcurrent device to provide the protection called for in 7.2.4, 7.2.6, and 7.2.7 shall be permitted.

7.3 Overload protection of motors

7.3.1 Overload Protection Requirements. Overload devices shall be provided to protect each motor, motor controller, and branch-circuit conductor against excessive heating due to motor overloads or failure to start.

Motor overload protection shall be provided as follows:

(a) Motors in accordance with NFPA 70, National Electrical Code, Article 430, Part C.

(b) Adjustable speed drives (electronic drives) in accordance with NFPA 70, National Electrical Code, Article 430-2.

7.3.2 Resetting. Resetting of the overload device shall not restart the motor.

Exception: Where there is only a single motor of two horsepower or less on the machine, an overload reset operator mounted on the motor shall be permitted to restart the motor provided that the distance between the overload reset operator and the machine start pushbutton operator is 12 in. (300 mm) or less, and a suitable warning label is attached on or adjacent to the overload reset operator.

7.3.3 Number of overloads. The minimum number and location of running overcurrent units shall be determined from Table 3.

Table 3 – Running overcurrent units

<table>
<thead>
<tr>
<th>z</th>
<th>Supply systems</th>
<th>Number and location of overcurrent units (such as trip coils, relays, or thermal cutouts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–phase, ac or dc</td>
<td>2–wire, 1–phase ac or dc ungrounded</td>
<td>1 in either conductor</td>
</tr>
<tr>
<td>1–phase, ac or dc</td>
<td>2–wire, 1–phase ac or dc grounded</td>
<td>1 in ungrounded conductor</td>
</tr>
<tr>
<td>1–phase, ac or dc</td>
<td>3–wire, 1–phase ac or dc, grounded neutral</td>
<td>1 in either ungrounded conductor</td>
</tr>
<tr>
<td>3–phase, ac</td>
<td>Any 3–phase</td>
<td>* 3, one in each phase</td>
</tr>
</tbody>
</table>

* Exception: Unless protected by other approved means.

NOTE: For 2–phase power supply systems see ANSI NFPA 70, Section 430-37.

Short-time rated motors or high-reversing duty motors that cannot be adequately protected by external overload devices shall be protected by a thermal device mounted in the motor and sensitive to the temperature of the motor, or to both motor temperature and current.

Motors that are an integral part of a refrigeration compressor of the hermetic or semihermetic type shall be protected per the compressor manufacturer’s recommendations.

7.4 Abnormal temperature protection. Resistance heating or other circuits that are capable of attaining or causing abnormal temperatures and therefore can cause a hazardous condition shall be provided with suitable detection to initiate an appropriate control response. An example could be a resistance-heating circuit that is short-time rated or which loses its cooling medium.

2.3 Protection against supply interruption or voltage reduction and subsequent restoration
7.5.1 General. Where a supply interruption or a voltage reduction can cause a hazardous condition, damage to the machine, or to the work in progress, undervoltage protection shall be provided (e.g. to switch off the machine) at a predetermined voltage level.

7.5.2 Undervoltage Protection. Where the operation of the machine can allow for an interruption or a reduction of the voltage for a short time period, delayed undervoltage protection shall be permitted to be provided. The operation of the undervoltage device shall not impair the operation of any stopping control of the machine.

7.5.3 Restarting. Upon restoration of the voltage or upon switching on the incoming supply, automatic or unintentional restarting of the machine shall be prevented when such a restart can cause a hazardous condition.

Where only a part of the machine or of the group of machines working together in a coordinated manner is affected by the voltage reduction or supply interruption, the undervoltage protection shall initiate appropriate control responses to ensure co-ordination.

7.6 Motor Overspeed Protection

7.6.1 Motor overspeed protection. Unless the inherent characteristics of the motor or the controller, or both, are such as to limit the speed adequately, drive systems motors shall include protection against motor overspeed.

Note: Overspeed protection means include, but are not necessarily limited to, the following:
1. A mechanical overspeed device incorporated in the drive to remove armature voltage upon motor overspeed.
2. An electrical overspeed detector that will remove armature voltage upon motor overspeed.
3. Field loss detection to remove armature voltage upon the loss of field current.
4. Voltage-limiting speed-regulated drives that operate with constant full field. In this case, protection is obtained individually for loss of field or tachometer feedback; however, protection against simultaneous loss of field and tachometer is not provided.

7.6.2 Equipment Overspeed Protection. Where the safe operating speed of the equipment is less than that of the drive motor, means shall be provided to limit the speed of the equipment.

7.7 This section left intentionally blank

7.8 Phase sequence protection. Where a phase loss or an incorrect phase sequence of the supply voltage can cause a hazardous condition or damage to the machine, protection shall be provided.

Note—Conditions of use which may lead to an incorrect phase sequence include:
- A machine transferred from one supply to another;
- A mobile machine with a facility for connection to an external power supply

7.9 Protection against overvoltages due to lightning and to switching surges

7.9.1 Protective devices shall be permitted to be provided to protect against the effects of overvoltages due to lightning or to switching surges.

7.9.2 Where provided, devices for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the supply disconnecting device.

7.9.3 Where provided, devices for the suppression of overvoltages due to switching surges shall be connected across the terminals of all equipment requiring such protection.

7.10 Power factor correction capacitors

7.10.1 Where capacitors are installed for motor power factor correction on circuits of 600 volts, nominal, and under, overcurrent protection for the conductors shall be provided. See 7.2.1 and 7.2.10.

Each capacitor cell or capacitor bank shall be protected against rupture of the individual cells. Protection included as a part of the capacitor assembly shall be permitted.

7.10.2 (extracted text) Discharge of Stored Energy. Capacitors shall be provided with a means of discharging stored energy.

(a) Time of Discharge. The residual voltage of a capacitor shall be reduced to 50 volts, nominal, or less, within 1 minute after the capacitor is disconnected from the source of supply.

(b) Means of Discharge. The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank upon removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used. <end of extract text>

<<Clause 7.10.2 is a copy of the text in NFPA 70 Section 460-6 and should be shown as “extracted text”>>

COMMITTEE STATEMENT: 1) In 7.2.1, insert Figure 1 and Figure 2 from NFPA 79-1997. The committee does not agree that the reorganization of Clause 7 requires the deletion of Figures 1 and 2. The committee desires that staff update the column 2 references in both figures to reflect the new numbering of the proposed document.

2) In 7.2.3, make a correction to delete the cross reference and then add a new sentence to clarify the intent of the committee.

5) Editorially correct 7.2.4.1, 7.2.5, 7.6, and 7.10.2(b) to add clarity, have consistency with Chapter 5, and follow the manual of style.

4) This was the correction of an inadvertent omission to include NFPA 79-1997, 8.3.1. as the new 7.2.12.

5) This was the correction of an inadvertent omission to include NFPA 79-1997, 8.3.3. as the new 7.2.13.

6) This corrects an inadvertent omission to include NFPA 79-1997, 8.13, but the committee editorially corrects the requirement for clarity in 7.2.14.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 2

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

DEFELICE: We believe that the rating of the overcurrent device permitted by 7.2.4.1.2 for protection of a AWG 18 copper conductor is unacceptable. While we acknowledge that the results of laboratory testing has shown that AWG 18 wire can be protected by a 20 amp overcurrent device, our field experience indicates quite the opposite. Insulations typically found on AWG 18 wire vary greatly, and in our experience many have proven to be inadequate to withstand the current levels over the duration required to clear some faults. We believe that 15 amps in an acceptable value.

Similarly, the allowable levels for conductor protection found in 7.2.4.1.3 for AWG 18 wire (25 amps) are excessive. Field experience indicates that a maximum value of 15 amps does provide adequate protection of the conductor.

COMMENT ON AFFIRMATIVE:

DOBROWSKY: The following should be added to Section 7.2.9: Applications. A circuit breaker with a straight voltage rating, such as 240V or 480V, shall be permitted to be applied in a circuit in which the nominal voltage between any two conductors does not exceed the circuit breaker’s voltage rating. A two-pole circuit breaker shall not be used for protecting a 3-phase, corner-grounded delta circuit unless the circuit breaker is marked for 3-phase.

DEFELICE: Proper application of molded case circuit breakers on 3-phase systems, other than solidly grounded wye, particularly on corner grounded delta systems, considers the circuit breakers’ individual pole interrupting capability.

Reason: To provide requirements for equipment used on industrial machinery. The present text does not address the proper selection relative to voltage ratings. This requirement was taken from the NEC 240.85. Possibly changing the term “circuit breaker” to “equipment” or “overcurrent devices” would allow this requirement to apply to other products.
COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

SAUNDERS: I do not agree with the action to eliminate the acronym (PES). It is in the existing text in NFPA 79 and the definition of the term is in this section and refers to a term that is commonly used in industry.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-44 (Log #45) since it meets the intent of the submitter.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

SAUNDERS: I do not agree with the action to eliminate the acronym (PES). It is in the existing text in NFPA 79 and the definition of the term is in this section and refers to a term that is commonly used in industry.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-44 (Log #45) since it meets the intent of the submitter.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

SAUNDERS: I do not agree with the action to eliminate the acronym (PES). It is in the existing text in NFPA 79 and the definition of the term is in this section and refers to a term that is commonly used in industry.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-44 (Log #45) since it meets the intent of the submitter.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The committee understands that the action of this proposal modifies the Action on Proposal 79-44 (Log #45) [Clause 7].
Also the way the current text is written, it would allow the connection of wire without any overcurrent protection. The current wording could allow wire to be installed that would not be protected against short circuits or overloads. See the example given below.

Whenever the cable fed directly from the line-side overcurrent protective device is sized smaller than the device, it is considered a tap. If that tap conductor ends in a splitter block, smaller conductors will be connected on the load side of the splitter block. Those are therefore taps, too. That means that we are tapping a tap, which is never allowed.

The added words “branch circuit rated” will clarify for the public the use of UL489 branch rated circuit breakers versus UL1077 supplementary protectors (circuit breakers). UL489 Circuit Breakers are tested and rated for branch circuit protection and can be used for this purpose. UL1077 Supplementary protectors are not tested and rated for branch circuit protection and cannot be used for this purpose. The devices are very similar in physical appearance, thus leaving an opening for possible misapplication. The additional words will clarify, for the public, the proper device to select.

COMMITTEE ACTION: Accept.

COMMITTEE STATEMENT: This action from this proposal has been incorporated into Proposal 79-44 (Log #45), in 7.2.8(a), bullet 5.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:
GARVEY: The submitter is correct. The text proposed by Mr. Lottmann does not prohibit the use of splitter blocks. It clarifies that a single tap from the splitter block is consistent with industry practice and should be allowed by the Code. By requiring the tap terminate in a branch-circuit circuit breaker or branch-circuit rated fuses, multiple taps from the splitter block are prohibited.

COMMENT ON AFFIRMATIVE:
ANDERSON: The attempt in using the “branch circuit rated” requirement is to clarify that supplementary protection devices are not to be considered for use in a supply circuit, disconnecting applications. The proposed modification is to add the term “branch circuit rated”, however this “rated” requirement is not directly defined. Defined terminology needs to be found and applied, e.g. “suitable for branch circuit over current protection”.

DOBROWSKY: The phrase “branch circuit rated” should also be inserted before “set of fuses”.

Reason: The proposal wording can be interpreted as requiring branch circuit rated circuit breakers but allowing fuses that are not branch circuit rated.
79-51 - (8.4.1(New) [7.2.2]): Reject

**SUBMITTER:** Richard H. Geister, SCR Electric

**RECOMMENDATION:** Add new text to read as follows:

"Propose that (Control) Panel Wiring, for line supply side of fuse blocks, wire be installed if mounted horizontal at top of fuse block. Load wire at bottom of fuse block. If fuse block is mounted horizontal line supply to left. Load wire to right-side of fuse blocks."

**SUBSTANTIATION:** I have myself seen and done pulled fuse for a motor (safety from electrical shock) think that the bottom or right side of the fuse block is dead. Only to find that it is not and the live side is connected to the bottom or right of the fuse block. Knowing that in all cases one should check for voltage before working on any system.

**COMMITTEE ACTION:** Reject.

**COMMITTEE STATEMENT:** There is no evidence that this change will improve the safety of machines. Good work practices, such as checking for voltage before working in equipment is the appropriate safe method.

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**

**AFFIRMATIVE:** 22

**NEGATIVE:** 3

**NOT RETURNED:** 1 Norman

---

**EXPLANATION OF NEGATIVE:**

**DOBROWSKY:** The proposal should be accepted in principle and revised as follows:

"The top terminal of cartridge type fusesholders shall be connected to the line(supply) conductors where fusesholders are mounted so that the fuses are in a vertical position. Exception: Fuseholders that are marked to indicate the line and load side shall be permitted to have supply connections at the bottom."

**Reason:** Providing a convention will inherently reduce the risk of injury and improve consistency. If this is not feasible the marking should not be a major inconvenience.

**GARVEY:** The panel should accept the principal of the submitter’s argument. Fusesholders enclosures should be mounted in a vertical position. This requirement is found in NEC 240-33. When an electrician removes a cartridge fuse, the motion of the arm and the body is away from the fuseholder and out of the enclosure. Mount the fuseholder horizontally and the motion is towards or into the enclosure. This is a safety hazard. Accepted practice is to supply the top of the overcurrent device. Listed products such as panelboards, motor control centers, and industrial control panels utilize this construction. NFPA 79 should not permit deviations from this practice.

**PADGET:** I agree with Mr. Dobrowsky’s Explanation of Negative Vote.

**COMMENT ON AFFIRMATIVE:**

**ANDERSON:** Good work practices, such as checking for voltage before working in equipment is the appropriate safe method. However having equipment laid out in a consistent pattern is easier to service. Where as a fuse block’s function doesn’t depend on establishing a load and a line side some devices such as circuit breakers and fused switches with an interrupt rating generally do. If looking at plugged case circuit breakers [not those used in panel boards], and use the generally agreed man-machine interface actuating principles of up and to the right is the closed or “on” position, then the line side terminals would be at either the top or the right side and the load terminals would be down or to the left. [Which is a different arrangement that was proposed in the rejected proposal #13.]

NFPA 79 1997 edition in 7.8.1 implies a top location for the incoming feed or line side but stop short of directly suggesting or requiring the top to be the feeder circuit location. Based on missed expectations of the feed verses the load connection locations on equipment supplied by various machine manufacturers, I would suggest that some direct preference or, requirement for the location of the line and load terminals on circuit interrupting devices including disconnect switches, fuses and circuit breakers be included by the committee in the NFPA79 2002 edition.

---

**R 300 300 300**

**T 300 300 300**

**CC 300 300 300**

**T 300 300 300**

Also revise note 3 to read as follows:

3) Where the rating of a time delay fuse (other than CC type) specified by the table is not sufficient for the starting of the motor, it shall be permitted to be increased but shall in no case be permitted to exceed 225 percent. The rating of a time-delay Class CC fuse and non time delay Class CC, I, or T shall be permitted to be increased but shall in no case exceed 400 percent of the full-load current.

**SUBSTANTIATION:** The addition of these fuse types will align with the requirements currently existing in the National Electrical Code® Article 430.

**COMMITTEE ACTION:** Accept.

**COMMITTEE STATEMENT:** The committee understands that this proposal modifies the Action on Proposal 79-44 (Log #45).

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**

**AFFIRMATIVE:** 25

**NOT RETURNED:** 1 Norman

---

**RECOMMENDATION:**

**ANDERSON:** Good work practices, such as checking for voltage before working in equipment is the appropriate safe method. However having equipment laid out in a consistent pattern is easier to service. Where as a fuse block’s function doesn’t depend on establishing a load and a line side some devices such as circuit breakers and fused switches with an interrupt rating generally do. If looking at plugged case circuit breakers [not those used in panel boards], and use the generally agreed man-machine interface actuating principles of up and to the right is the closed or “on” position, then the line side terminals would be at either the top or the right side and the load terminals would be down or to the left. [Which is a different arrangement that was proposed in the rejected proposal #13.]

NFPA 79 1997 edition in 7.8.1 implies a top location for the incoming feed or line side but stop short of directly suggesting or requiring the top to be the feeder circuit location. Based on missed expectations of the feed verses the load connection locations on equipment supplied by various machine manufacturers, I would suggest that some direct preference or, requirement for the location of the line and load terminals on circuit interrupting devices including disconnect switches, fuses and circuit breakers be included by the committee in the NFPA79 2002 edition.

**PADGET:** I agree with Mr. Dobrowsky’s Explanation of Negative Vote.

**COMMENT ON AFFIRMATIVE:**

**ANDERSON:** Good work practices, such as checking for voltage before working in equipment is the appropriate safe method. However having equipment laid out in a consistent pattern is easier to service. Where as a fuse block’s function doesn’t depend on establishing a load and a line side some devices such as circuit breakers and fused switches with an interrupt rating generally do. If looking at plugged case circuit breakers [not those used in panel boards], and use the generally agreed man-machine interface actuating principles of up and to the right is the closed or “on” position, then the line side terminals would be at either the top or the right side and the load terminals would be down or to the left. [Which is a different arrangement that was proposed in the rejected proposal #13.]

NFPA 79 1997 edition in 7.8.1 implies a top location for the incoming feed or line side but stop short of directly suggesting or requiring the top to be the feeder circuit location. Based on missed expectations of the feed verses the load connection locations on equipment supplied by various machine manufacturers, I would suggest that some direct preference or, requirement for the location of the line and load terminals on circuit interrupting devices including disconnect switches, fuses and circuit breakers be included by the committee in the NFPA79 2002 edition.

**SUBMITTER:** Todd Lottmann, Washington, MO

**RECOMMENDATION:** Revise Table 1 by adding the following rows to the table and add another title in column 1 to what is shown below.
79-56 - (8.6.4 [7.3.1]): Reject
SUBMITTER: John J. Kowal, Webster, NY

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: Drive protection is not specifically covered in Part C of Article 430, of the 1999 NEC. Drive manufacturers should be consulted for proper selection of overcurrent protection.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-57 - (8.8 (New) [7.2]): Reject
SUBMITTER: John J. Kowal, Webster, NY

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The committee is not convinced that 150 percent is the hold-in current rating. It is preferable that Table 11 of the new NFPA 79 replaces 1997 NFPA 79, Clause 8.6.4.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-58 - (Z.8.8 (New) [7.2]): Reject
SUBMITTER: Steven D. Taplin, G.W. Lisk Co. Inc.

RECOMMENDATION: Add text to read as follows:
"AC Solenoids: are electromechanical devices which produce work, such as motors, which exhibit the same current draw features. A solenoid has inrush and hold amps which directly relates to a motor with its start and run amp values.

SUBSTANTIATION: AC solenoids when not allowed to shift produce a condition as a motor when in a "locked rotor" mode. If a solenoid is not fuse directly (150 percent hold amp value) it could exceed the thermal withstand rating of the magnet wire. This will lead to overheating leading to burn out failure.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-57 (Log #48). The submitter has not provided for specific direction for placement of the text according to the Regulations Governing Committee Projects, Section 43-3.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-59 - (8.9 [7.2.4]): Reject
SUBMITTER: Heinrich Moedden, German Machine Tool Builders Association (VDW)

RECOMMENDATION: Add text as follows:
"Switch-off in case of short to ground after 0.5 sec at the latest."

SUBSTANTIATION: Current NFPA definitions do not sufficiently protect against short to ground.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The time current characteristics of overcurrent protective devices are included in the product standards and product evaluations. The placement of the proposed text is not clear. The change is not properly substantiated. The practices in both NFPA 79 and NFPA 70 do protect against shorts to ground.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-60 - (8.9.2.1 [7.2.4.1.1]): Accept in Principle
SUBMITTER: John J. Kowal, Webster, NY

RECOMMENDATION: Modify rewritten clause 7.2.4.1.1 to 1997 NFPA 79 Clause 8.9.2.1.

For the second sentence of proposed clause 7.2.4.1 use the second sentence of current NFPA 79 clause 8.9.2.1.

SUBSTANTIATION: It is preferable that Table 11 of the new rewritten NFPA 79 (which was derived from NEC Table 310-16) be used since it is in the standard and to avoid references to other standards that may not be readily available.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-44 (Log #45) (Clause 7).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-61 - (8.12.3 [7.2.7]): Reject
SUBMITTER: Steven Duritt, Empire Abrasive Equipment Co.

RECOMMENDATION: Revise as follows:
"8.12.3 Where multiple overcurrent protective devices are used to protect individual branch circuits, and the sum of the current ratings of the overload protective devices which are connected to simultaneously energized loads exceeds the current allowed in Table 310-16.

SUBSTANTIATION: I utilize 500 VA through 5 KVA industrial control transformers and apply 8.11.1 for primary overcurrent protection. Due to coordination of the branch circuits connected to the secondary, the current total is not exceeded. Since the energized branch circuit loads at any instant do not exceed the
values in Table 5, there should be no need for an additional "single overload protective device."

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: Primary protection of a transformer (even if sized such that secondary transformer protection is not needed) does not necessarily protect conductors on the secondary side of a transformer.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

9.1  Control circuits and control functions

9.1.1  Control circuit supply

9.1.1.1  Control transformers shall be used for supplying the control circuits. Control circuits shall not be derived from autotransformers.

9.1.1.2  Where dc control circuits are connected to the equipment grounding (protective bonding) circuit (see 8.2.1); they shall be supplied from a separate winding of the ac control circuit transformer or by another control circuit transformer or a listed dc power supply.

9.1.1.3  Transformers shall not be required if the supply voltage does not exceed 120 volts ac and the available short circuit current does not exceed 1,000 amps RMS.

9.1.1.4  The source of supply for all control circuits shall be taken from the load side of the main disconnecting means.

EXCEPTION—Power supply to memory elements and their support logic requiring power at all times to maintain the storage of information shall be permitted to be taken from the line side of the main disconnecting means or other power source.

9.1.1.5  The marking requirements of subclause 17.2.4, Warning signs, shall apply.

9.1.2  Control circuit voltages

9.1.2.1  AC control circuit voltages

The nominal voltage shall not exceed 120 volts AC single phase.

EXCEPTION 1: Other voltages shall be permitted, where necessary, for the operation of electronic, precision, static, or devices used in the control circuit.

EXCEPTION 2: Any electromechanical magnetic device having an inrush current exceeding 20 amperes at 120 volts shall be permitted to be energized at line voltage through contactor or relay contacts. The contactor or relay contacts shall break both sides of the line voltage circuit to the magnetic device. The relay coil shall be connected to the control circuit.

9.1.2.2  DC control circuit voltages

Direct-current (dc) control voltage shall be 250 volts or less.

9.1.3  Protection

Control circuits shall be provided with overcurrent protection in accordance with Clause 7.

9.1.4  Connection of control circuit devices

9.1.4.1  All operating coils of electromechanical magnetic devices and indicator lamps (or transformer primary windings for indicator lamps) shall be directly connected to the same side of the control circuit. All control circuit contacts shall be connected between the coil and the other side of the control circuit.

Exception No. 1: Overload relay contacts where the wiring to these contacts does not extend beyond the control enclosure.

Exception No. 2: Contacts of multi-pole control circuit switching devices that simultaneously open both sides of the control circuit.

Exception No. 3: Ground test switching device contacts in ungrounded control circuits.

Exception No. 4: Solenoid test switching device contacts in ungrounded circuits.

Exception No. 5: Coils or contacts used in electronic control circuits where the wiring to these coils or contacts does not extend beyond the control enclosure.

EXCEPTION 1: Other voltages shall be permitted, where necessary, for presses having ground detection circuits and overcurrent protection in each conductor.

9.1.4.2  Contacts shall not be connected in parallel to increase ampacity.

9.2  Control functions

9.2.1  Start functions

Start functions shall operate by energizing the relevant circuit.

9.2.2  Stop functions

There are three categories of stops as follows:

(a) Category 0: stopping by immediate removal of power to the machine actuators (i.e., an uncontrolled stop - see 3.113).

(b) Category 1: a controlled stop (see 3.24) with power to the machine actuators available to achieve the stop and then removal of power when the stop is achieved.

(b) Category 2: a controlled stop with power left available to the machine actuators.

NOTE—With the exception of emergency stop (see 9.2.5.4), and depending upon the risk assessment, removal of power may be accomplished by the use of either electromechanical or solid-state components.

9.2.3  Operating modes

9.2.3.1  Each machine shall be permitted to have one or more operating modes (e.g., automatic, manual, normal and bypass) determined by the type of machine and its application.

9.2.3.2  When hazardous conditions result from mode selection, such selection shall be prevented from occurring (e.g., key operated switch, access code). Mode selection by itself shall not initiate machine operation. A separate action by the operator shall be required.

9.2.3.3  Safeguarding means shall remain effective for all operating modes. (See 9.2.4 for suspension of safeguards under special conditions).

9.2.3.4  Indication of the selected operating mode shall be provided (e.g., position of mode selector, provision of indicating light, visual display indication).

9.2.4  Overriding of safeguards

Where it is necessary to temporarily override one or more safeguards a mode selection device or means capable of being secured (e.g., locked) in the desired mode shall be provided to prevent automatic operation. In addition, one or more of the following measures should be provided:

(1) Initiation of motion by a hold-to-run or other control device

(2) A portable controls station (e.g., pendant) with an emergency stop device, and where appropriate, an enabling device. Where a portable station is used, motion shall only be initiated from that station.

(3) Limiting the speed or the power of motion

(4) Limiting the range of motion
9.2.5 Operation

9.2.5.1 General

9.2.5.1.1 The necessary interlocks (see 9.3) shall be provided for safe operation.

9.2.5.1.2 Measures shall be taken to prevent movement of the machine in an unintended manner after any stopping of the machine (e.g., locked-off condition, power supply fault, battery replacement, lost signal condition with cable-less control).

9.2.5.2 Start

9.2.5.2.1 The start of an operation shall be possible only where all of the safeguards are in place and functional except for conditions as described in 9.2.4.

9.2.5.2.2 On those machines where safeguards cannot be applied for certain operations, manual control of such operations shall be by hold-to-run controls, together with enabling devices.

9.2.5.2.3 Interlocks shall be provided to ensure correct sequential starting.

9.2.5.2.4 On machines requiring the use of more than one control station to initiate a start:
   (a) Each control station shall have a separate manually actuated start control device.
   (b) All required conditions for machine operation shall be met.
   (c) All start control devices shall be in the released (off) position before a start operation is permitted.
   (d) All start control devices shall be actuated concurrently (see 3.6).

9.2.5.3 Stop

9.2.5.3.1 Each machine shall be equipped with a category 0 stop.

9.2.5.3.2 Category 0, category 1 and/or category 2 stops shall be provided where indicated by an analysis of the risk assessment and the functional requirements of the machine (see 4.1). Category 0 and category 1 stops shall be operational regardless of operating modes (see 9.2.3) and category 0 shall take priority. Stop functions shall override related start functions (see 9.2.5.2).

9.2.5.3.3 Where required, provisions to connect protective devices and interlocks shall be provided. Where applicable, the stop function shall signal the logic of the control system that such a condition exists. The reset of the stop function shall not initiate any hazardous conditions.

9.2.5.4 Emergency operations (emergency stop, emergency switching off)

9.2.5.4.1 General

This standard specifies the requirements for the emergency stop and emergency switching off functions, each of which are, in this standard, initiated by a single human action. Emergency switching off is an emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electrical shock or another risk of electrical origin is involved. For other safety related stop functions see 11.3.4.

9.2.5.4.2 Emergency stop

9.2.5.4.2.1 In addition to the requirements for stop (see 9.2.5.3), the emergency stop has the following requirements:
   (a) It shall override all other functions and operations in all modes.
   (b) Power to the machine actuators which causes a hazardous condition(s) shall be removed as quickly as possible without creating other hazards (e.g., by the provision of mechanical means of stopping requiring no external power, by reverse current braking for a category 1 stop).
   (c) Reset of an emergency stop circuit shall not initiate a restart.

9.2.5.4.2.2 Where required provisions to connect additional emergency stop devices shall be provided (see 10.7 for the requirements of emergency stop devices).

9.2.5.4.3.3 The emergency stop shall function as either a category 0 or a category 1 stop (see 9.2.2). The choice of the category of the emergency stop shall be determined by the risk assessment of the machine.

9.2.5.4.4 Where a category 0 stop is used for the emergency stop function, it shall have hardwired electromechanical components.

Exception: An electronic logic system that complies with 11.3.3 shall be permitted. The final removal of power shall be accomplished by means of electromechanical components.

9.2.5.4.2.5 Where a category 0 or a category 1 stops is used for the emergency stop function, final removal of power to the machine actuators shall be ensured and shall be by means of electromechanical components.

9.2.5.4.3 Emergency switching off

9.2.5.4.3.1 Emergency switching off shall be permitted where:
   (1) Protection against direct contact (e.g. with collector wires, collector bars, slip-ring assemblies, control-gear in electrical operating areas) is achieved only by placing out of reach or by obstacles (see 6.2.5) or;
   (2) There is the possibility of other hazards or damage caused by electricity.

9.2.5.4.3.2 Emergency switching off is accomplished by disconnecting the incoming supply of the machine affecting a category 0 stop. When the machine cannot tolerate the category 0 stop, it shall be necessary to provide other protection, for example against direct contact so that emergency switching off is not necessary.

9.2.5.5 Hold-to-run controls

9.2.5.5.1 Hold-to-run controls [e.g., jog, inch functions] shall require continuous actuation of the control device(s) to achieve operation.

9.2.5.5.2 JOG or INCH functions shall operate only in the MANUAL mode. MANUAL reverse shall be considered a JOG function.

9.2.5.6 Two-hand control

All two-hand controls shall have the following features:
   (a) The provision of two control devices requiring the permitted actuation by both hands;
   (b) It shall be necessary to actuate the control devices within a certain time limit of each other (see annex B).
   (c) Where the time limit of less than or equal to 0.5 seconds is exceeded, both control devices shall be released before operation is initiated;
   (d) The control devices shall require continuous actuation during the hazardous conditions;
   (e) Machine operation shall cease upon the release of either control device when hazardous conditions are still present and;
   (f) Require of the release of both control-devices, before the machine operation is reinitiated.

9.2.5.7 Enabling device

9.2.5.7.1 An enabling device is an additional manually operated control device used in conjunction with a start control and which, when continuously actuated, allows a machine to function.

9.2.5.7.2 When an enabling device is provided as a part of a system, it shall be designed to allow motion when actuated in one position only. In any other position motion shall be stopped.

9.2.5.7.3 Enabling device shall have the following features:
   (1) Be connected to a category 0 or a category 1 stop (see 9.2.2)
   (2) Be designed to ergonomic principles
   (3) For two-position types:
      a. Position 1: off-function of the switch (actuator is not operated)
      b. Position 2: enabling function (actuator is operated)
NOTE the initiation of potentially hazardous motions, in the following
equipped with cable-less control shall have a means of
9.2.7.3.2 function.

stop function initiated on the machine results in an emergency stop
marked or labeled as an emergency stop device, even though the
machine or of all the motions that causes a hazardous condition.
clearly identifiable means to initiate the stop function of the
predetermined zones or locations.

9.2.7.1 Cable-less control functions

9.2.7.1.1 Means shall be provided to remove or disconnect the
power supply of the operator control station.
9.2.7.1.2 Means (e.g. key operated switch access code) shall be
provided, as necessary, to prevent unauthorized use of the operator
control station.

9.2.7.1.3 Each operator control station shall carry an unambiguous
indication of which machine(s) are intended to be controlled by
that operator control station.

9.2.7.2 Control limitation

9.2.7.2.1 Measures shall be taken to ensure that control commands:

(1) Affect only the intended machine
(2) Affect only the intended functions

9.2.7.2.2 Measures shall be taken to prevent the machine from
responding to signals other than those from the intended operator
control station(s).

9.2.7.2.3 Means shall be provided so that the machine shall only be
controlled from operator control stations in one or more
predetermined zones or locations.

9.2.7.3 Stop

9.2.7.3.1 Operator control stations shall include a separate and
clearly identifiable means to initiate the stop function of the
machine or of all the motions that causes a hazardous condition.
The actuating means to initiate this stop function shall not be
marked or labeled as an emergency stop device, even though the
stop function initiated on the machine results in an emergency stop
function.

9.2.7.3.2 A machine having safety-critical functions and which are
equipped with cable-less control shall have a means of
automatically initiating the stopping of the machine and preventing
the initiation of potentially hazardous motions, in the following
situations:
(a) When a stop signal is received.
(b) When a fault is detected in the system.
(c) When a valid signal has not been detected within a specified
period of time (see annex B).
NOTE—A valid signal also includes the signal that confirms
communication is established and maintained.

9.2.7.4 Serial data communication

In a machine where the control of safety critical functions relies on
serial data transfer, correct communications shall be ensured by
using an error detection method that is able to cope with up to
three error bits in any command sequence. The safety capability of
the serial data communication system shall be certified by a
nationally recognized testing laboratory to have the same degree of
safety capability as hardware based components installed in
accordance with this standard [NFPA 79].

NOTE—One way to determine applicable error detection methods
is to refer to IEC 60870-5-1: 1990, “Telecontrol equipment and
systems. Part 5:Transmission protocols - Section One: Transmission frame formats”.

9.2.7.5 Use of more than one operator control station
Where a machine has more than one operator control station,
measures shall be taken to ensure that only one control station
shall be enabled at a given time. Indication of which operator
control station is in control of the machine shall be provided at
locations where necessary for the safety requirements of the
machine.

Exception: A stop command from any one of the control stations shall be
effective where necessary for the safety requirements of the machine.

9.2.7.6 Battery-powered operator control stations
A variation in the battery voltage shall not cause a hazardous
condition. If one or more potentially hazardous motions are
controlled using a battery-powered operator control station, a clear
indication shall be given to warn the operator when a variation in
battery voltage exceeds specified limits. Under those circumstances, the operator control station shall remain functional
long enough to put the machine into a non-hazardous condition.

9.3 Protective interlocks

9.3.1 Re-Closing or resetting of an interlocking safeguard
The re-closing or resetting of an interlocking safeguard shall not
initiate machine motion or operation where that results in a
hazardous condition.

9.3.2 Overtravel limits
Where a machine overtravels a hazardous condition, a position
sensor or limit switch shall be provided to initiate control
action.

9.3.3 Operation of auxiliary functions

9.3.3.1 Appropriate devices (e.g. pressure sensors) shall check the
correct operation of the auxiliary functions.

9.3.3.2 Where the non-operation of a motor or device for an
auxiliary function (e.g. lubrication, coolant, swarf removal) causes
a hazardous condition, cause damage to the machine, or to the
work in progress, interlocking shall be provided.

9.3.4 Interlocks between different operations and for contrary
motions

9.3.4.1 All contactors, relays, and other control devices which
control elements of the machine that cause a hazardous condition
when actuated at the same time (e.g. those which initiate contrary
motion), shall be interlocked against incorrect operation.

9.3.4.2 Reversing contactors (i.e. those controlling the direction of
a motor) shall be interlocked in such a way that in normal service
no short circuit shall occur when switching. This shall include
both mechanical and electrical interlocking.

9.3.4.3 Where for safety or for continuous operation, certain
functions on the machine are required to be interrelated,
coordination shall be ensured by interlocks. For a group of
machines working together in a coordinated manner and having
more than one controller, provision shall be made to coordinate
the operations of the controllers as necessary.

9.3.4.4 Where a failure of a mechanical brake actuator results in the
brake being applied when the associated machine actuator is
energized and a hazardous situation results, interlocks shall be
provided to switch off the machine actuator.
9.3.5 Reverse current braking

9.3.5.1 Where reverse current braking is used on motor, effective measures shall be taken to prevent the motor starting in the opposite direction at the end of braking where this reversal will cause a hazardous condition or damage to the machine or to the work in progress. For this purpose, the use of a device operating exclusively as a function of time shall not be allowed.

9.3.5.2 Control circuits shall be arranged so that rotation of a motor shaft, manually or otherwise, shall not result in a hazardous condition.

9.4 Control functions in the event of failure

9.4.1 General requirements

Where failures or disturbances in the electrical equipment cause a hazardous condition or damage to the machine or the work in progress, measures shall be taken to minimize the probability of the occurrence of such failures or disturbances. The required measures and the extent to which they are implemented, either individually or in combination, depend on the safety requirements associated with the respective application (see 4.1).

Note 1 Measures to reduce these risks include but are not limited to:

(1) Protective devices on the machine (e.g. interlock guards, trip devices)
(2) Protective interlocking of the electrical circuit
(3) Use of proven circuit techniques and components (see 9.4.2.1)
(4) Provisions of partial or complete redundancy (see 9.4.2.2) or diversity (see 9.4.2.3)
(5) Provision for functional tests (see 9.4.2.4)

In general, only single failures are to be regarded. In the event of higher levels of risk, it may be necessary to ensure that more than one failure cannot result in a hazardous condition.

Note 2 Measures to minimize risk in the event of failure

Note 2.1 Use of proven circuit techniques and components

These measures include but are not limited to:

(1) Bonding of control circuits for operational purposes (see 9.4.3.1)
(2) One terminal of the control device (i.e. the operating coil) connected to the bonded conductor and all switching elements (e.g. contacts) connected to the non-earthed (grounded) side of the control supply (see 9.1.4)
(3) Stopping by de-energizing (see 9.2.2)
(4) Switching of all live conductors to the device being controlled (see 9.3.3.1)
(5) Use of switching devices having positive opening operation (see IEC 947-5-1)
(6) Circuit design to reduce the possibility of failures causing undesirable operations

Note 2.2 Provisions for redundancy

By providing partial or complete redundancy it is possible to minimize the probability that one single failure in the electrical circuit can result in a hazardous condition. Redundancy can be effective in normal operation (i.e. on-line redundancy) or designed as special circuits that take over the protective function (i.e. off-line redundancy) only where the operating function fails.

Where off-line redundancy that is not active during normal operation is used, suitable measures shall be taken to ensure that these control circuits are available when required.

Note 2.3 Use of diversity

The use of control circuits having different principles of operation or differing types of devices may reduce the probability of faults and failures giving rise to hazards. Examples include:

(1) The combination of normally open and normally closed contacts operated by interlocking guards
(2) The use of different types of control circuit components in the circuit (3) The combination of electromechanical and electronic circuits in redundant configurations
(4) The combination of electrical and non-electrical systems (e.g. mechanical, hydraulic, pneumatic) may perform the redundant function and provide the diversity.

Note 2.4 Functional tests

Functional tests shall be permitted to be carried out automatically, by the control system, or manually by inspection or tests at start-up and at predetermined intervals, or a combination as appropriate (see also 18.2 and 19.7).

9.4.2 Protection against unintended operation due to ground (earth) faults and voltage interruptions

9.4.2.1 Ground (earth) faults

Ground (earth) faults on any control circuit shall not cause unintentional starting, potentially hazardous motions, or prevent stopping of the machine. Grounded control circuits shall be in accordance with 8.2 and 8.3. Ungrounded control circuits shall be provided with an insulation-monitoring device that either indicates a ground (earth) fault or interrupts the circuit automatically after a ground (earth) fault.

9.4.2.2 Voltage interruptions

9.4.2.2.1 The requirements detailed in 7.5 shall apply.

9.4.2.2.2 Where a memory is used, its functioning in the event of power failure shall be ensured (e.g. by using a non-volatile memory) where such loss of memory can result in a hazardous condition.

SUBSTANTIATION:

Historical Background.

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization - Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulations, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Importance of Issue - Harmonization

Today’s industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization - Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

“The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards.”

Result

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.
The Task Group for Clause 9 consisted of Bill Anderson, Dave Fisher, Dick Bromstad and Thomas Pilz. The Task Group compared NFPA-79-1997, Clause 9 with IEC 60204-1 Clause 9. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber Clause 9 of NFPA 79-1997 to correspond with IEC 60204-1. The task group proposes the following changes to further improve usability.

**Substantiation for NFPA 79-2002 Chapter 9 Control circuits and control functions**

9

**Recommendation:** Replace NFPA 79 1997 Editions Clause “9 Control circuits” with “Chapter 9 Control circuits and control functions”

**Substantiation:** Represents the material in Chapter 9 that includes both circuits and functions. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.1

**Recommendation:** Relocate NFPA 79 1997 Edition 9 title “Control circuits” to 9.1

**Substantiation:** Chapter 9 is divided into 4 sections 1 Control circuits, 2 Control functions, 3 Protective interlocks, and 4 Control functions in the event of failure. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.1.1

**Recommendation:** Add title “Control circuit supply”

**Substantiation:** Section 9.1 is divided into 4 subsections 1 Control circuit supply, 2 Control circuit voltages, 3 Protection, and 4 Connection of control circuit devices. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.1.1.1

**Recommendation:** NFPA 79 1997 Edition 9.2.1 supply isolation requirement is moved to this paragraph and voltage limitation to paragraph 9.1.2.1

**Substantiation:** The word “control” was added to the original IEC text to clarify the type and application of the transformer. Note this is also a proposed change to IEC. In order to ensure derived circuits are isolated, auto-transformers are not permitted. Editorial changes to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.1.1.2

**Recommendation:** Add new text to reflect current technology

**Substantiation:** Added requirements that reflect current North American practices.

9.1.1.3

**Recommendation:** Add new text to reflect current technology

**Substantiation:** The requirements thus far, recognize that control circuits generally consist of equipment that has little or no fault withstand rating. The usual control transformer is generally specified to establish a lower control voltage and to limit the available fault current. This paragraph establishes when a control transformer may not be required based on an acceptable voltage and reduced available fault being present.

9.1.1.4

**Recommendation:** Relocate NFPA 79 1997 Edition, 9.1 “Source of control power” paragraph and exception to 9.1.1.4 and exception with marking requirement contained in 9.1.1.5


9.1.1.5

**Recommendation:** Add marking requirements from NFPA 79 1997 Edition 4.5.1


9.1.2

**Recommendation:** Relocate NFPA 79 1997 Edition, 9.2 “Control circuit voltages” to 9.1.2

**Substantiation:** Section 9.1 is divided into 4 subsections 1 Control circuit supply, 2 Control circuit voltages, 3 Protection, and 4 Connection of control circuit devices. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.1.2.1

**Recommendation:** NFPA 79 1997 Edition 9.2.1, voltage limitation, and exceptions 1 and 3 are moved to this paragraph and exceptions 1 and 2: and, supply isolation requirement from NFPA 79 1997 Edition 9.2.1, to paragraph 9.1.1.1


9.1.2.2

**Recommendation:** NFPA 79 1997 Edition, 9.2.2 moved to this paragraph, exception is deleted

**Substantiation:** Revised NFPA 79-1997, 9.2.2 requirement by removing the exception. The proposer is unaware of any need for de control voltage to exceed 250 volt in machine control circuits

9.1.3

**Recommendation:** Add title “Protection” and paragraph point to chapter 7 “Protection of equipment”

**Substantiation:** Section 9.1 is divided into 4 subsections 1 Control circuit supply, 2 Control circuit voltages, 3 Protection, and 4 Connection of control circuit devices. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.1.4

**Recommendation:** Relocate NFPA 79 1997 Edition 9.4 title “Connection of control circuit devices” to 9.1.4

**Substantiation:** Section 9.1 is divided into 4 subsections 1 Control circuit supply, 2 Control circuit voltages, 3 Protection, and 4 Connection of control circuit devices. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.1.4.1

**Recommendation:** Relocate NFPA 79 1997 Edition 9.4.1 and exceptions to 9.1.4.1


9.1.4.2

**Recommendation:** Relocate NFPA 79 1997 Edition 9.4.2 to 9.1.4.2


9.2

**Recommendation:** Relocate NFPA 79 1997 Edition 9.5 title “Control functions” to 9.2

9.2.5.3

Recommendation: Relocate NFPA 79 1997 Edition, 9.6.1 2nd paragraph moved to 9.2.5.3

9.2.5.3.1

Recommendation: Relocate requirement from NFPA 79-1997, 9.5.2 last paragraph 1st sentence to 9.2.5.3.1

Substantiation: This requirement currently appears in NFPA 79-1997, 9.5.2 last paragraph. It has been separated out to add clarity and to align with the IEC 60204-1 structure; also to reflect consistency in stop circuit, function and operation requirement

9.2.5.3.2

Recommendation: Relocate requirements and edit text from NFPA 79-1997 Edition, 9.5.2 last paragraph to 9.2.5.3.2

Substantiation: This requirement currently appears in NFPA 79-1997, 9.5.2 last paragraph. It has been separated out to add clarity and to align with the IEC 60204-1 structure.

9.2.5.3.3

Recommendation: Relocate NFPA 79 1997 Edition, 9.6.2 2nd paragraph to 9.2.5.3.3


9.2.5.4

Recommendation: Add title “Emergency operations (emergency stop, emergency switching off)”

Substantiation: Subsection 9.2.5 is divided into 7 sub-subsections 1 General, 2 Start, 3 Stop, 4 Emergency operations, 5 Hold to run controls, 6 Two-hand control, and 7 Enabling device. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.2.5.4.1

Recommendation: Add title “General” and text

Substantiation: Sub-subsection 9.2.5.4 is divided into 3 (sub) sub-subsections 1 General, 2 Emergency stop, and 3 Emergency switching off. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. This (sub)(sub)subsection, “General”, is used to consolidate information that applies to all parts of the sub-subsection 9.2.5.4 into one area for clarity.

9.2.5.4.2

Recommendation: Relocate NFPA 79 1997 Edition, 9.6.3 title “Emergency stop” to 9.2.5.4.2


9.2.5.4.2.1

Recommendation: Relocate NFPA 79 1997 Edition, 9.6.3 1st paragraph requirement moved to 9.2.5.4.2.1


9.2.5.4.2.2

Recommendation: Relocate NFPA 79 1997 Edition, 9.6.3 2nd paragraph requirement moved to 9.2.5.4.2.2


9.2.5.4.2.3

Recommendation: Relocate NFPA 79 1997 Edition, 9.6.3 3rd paragraph requirement moved to 9.2.5.4.2.3 with editorial clarification


9.2.5.4.2.4


9.2.5.4.2.5

Recommendation: Relocate NFPA 79 1997 Edition, 9.6.3, 5th paragraph requirement moved to 9.2.5.4.2.5


9.2.5.4.3

Recommendation: Add modified IEC text to clarify how Emergency switch off is a practice recognized and used throughout a number of machinery sectors. This additional paragraph includes provisions for the implementation of this practice. Some industries have implemented this practice to permit an emergency response for non-motion hazards. Clause three has been revised to include a definition of emergency switching off.

9.2.5.4.3.1

Recommendation: Add modified IEC text to permit Emergency switch off

Substantiation: The proposer understands that emergency switching off is a practice recognized and used throughout a number of machinery sectors. This additional paragraph includes examples of how and to do the implementation of this practice. Some industries have implemented this practice to permit an emergency response for non-motion hazards. Clause three has been revised to include a definition of emergency switching off.

9.2.5.4.3.2

Recommendation: Add modified IEC text to clarify how Emergency switch off can be accomplished and when Emergency switch off is not necessary

Substantiation: The proposer understands that emergency switching off is a practice recognized and used throughout a number of machinery sectors. This additional paragraph includes examples of when and how to do the implementation of this practice. Some industries have implemented this practice to permit an emergency response for non-motion hazards. Clause three has been revised to include a definition of emergency switching off.

9.2.5.5


Substantiation: Subsection 9.2.5 is divided into 7 sub-subsections 1 General, 2 Start, 3 Stop, 4 Emergency operations, 5 Hold to run controls, 6 Two-hand control, and 7 Enabling device. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.
Recommendation: Relocate NFPA 79 1997 Edition, 9.7.1 requirement to 9.2.5.5.1 text edited for clarity


9.2.5.5.2

Recommendation: Relocate NFPA 79 1997 Edition, 9.7.2 requirement to 9.2.5.5.2 text edited for clarity


9.2.5.6

Recommendation: Relocate NFPA79 1997 Edition 9.14, title “Two-hand control circuits” and modified text to 9.2.5.6

Substantiation: Subsection 9.2.5, is divided into 7 sub-subsections 1 Start functions, 2 Stop functions, 3 Operating modes, 4 Overriding of safeguards, 5 Operation, 6 Two-hand control, and 7 Enabling device. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

The requirement of two hand control have been modified by deleting permission to utilize Type 1 and 2 control because the circuitry is conventionally not suitable for applications that require anti-tie-down features, Text has been changed to combine the requirements for Types 1, 2 and 3 into one provision and thus eliminate the type designations.

9.2.5.7

Recommendation: Add title "Enabling device"

Substantiation: Subsection 9.2.5 is divided into 7 sub-subsections 1 Start functions, 2 Stop functions, 3 Operating modes, 4 Overriding of safeguards, 5 Operation, 6 Two-hand control, and 7 Enabling device. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

New text added for Proposed NFPA 79-2002 9.2.5.7 "enabling device", because it provides additional methods for personnel protection than the present NFPA 79-1997 provides

9.2.5.7.1

Recommendation: Add definition and description of an enabling device

Substantiation: The proposer understands that use of an enabling device is a practice recognized and used throughout a number of machinery sectors. This additional subclause includes a description of such device

9.2.5.7.2

Recommendation: Add restriction for safe operation of an enabling device representing current practice

Substantiation: The proposer understands that use of an enabling device is a practice recognized and used throughout a number of machinery sectors.

9.2.5.7.3

Recommendation: Add the design features of an enabling device representing current practice

Substantiation: The proposer understands that use of an enabling device is a practice recognized and used throughout a number of machinery sectors.

9.2.5.7.4

Recommendation: Add restriction for safe operation of an enabling device representing current practice

Substantiation: The proposer understands that use of an enabling device is a practice recognized and used throughout a number of machinery sectors.

9.2.5.7.5

Recommendation: Add restriction for safe operation of an enabling device representing current practice

Substantiation: The proposer understands that use of an enabling device is a practice recognized and used throughout a number of machinery sectors. This “enabling device” is a type of additional held switch that is connected in series with the usual momentary “start” push button. This enabling (similar to an “arming” switch?) device prevents the casual/unintentional starting of the machine. An enabling device is not required for all systems. When one is provided, the guidelines shown must be followed. No conflict exists with NFPA79

9.2.6

Recommendation: Add title “Combined start and stop controls” and text

Substantiation: Section 9.2 is divided into 7 subsections 1 Start functions, 2 Stop functions, 3 Operating modes, 4 Overriding of safeguards, 5 Operation, 6 Combined start and stop controls, and 7 Cable-less control functions. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

New text added for Proposed NFPA 79-2002 9.2.6 “Combined start and stop controls” was added because it prevents use of “push-push”, alternate action a push button as the primary start device.

9.2.7

Recommendation: Add title “Cable-less control functions”

Substantiation: Section 9.2 is divided into 7 subsections 1 Start functions, 2 Stop functions, 3 Operating modes, 4 Overriding of safeguards, 5 Operation, 6 Combined start and stop controls, and 7 Cable-less control functions. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

New subsection from IEC 60204-1 1997 Edition 9.2.7 for Proposed NFPA 79-2002 9.2.7 “Cable-less control functions” was added with minor clarifying editorial changes to provided requirements that recognize the current practice for cable-less control applications. Radio-modem controls are used on a regular basis for control over a long distance, such as for decentralized sewage pumping stations.

9.2.7.1

9.2.7.1.1 through 9.2.7.1.3

Recommendation: Add title “General” and IEC 60204-1 1997 Edition 9.2.7.1 text

Substantiation: Subsection 9.2.7 is divided into 6 sub-subsections 1 General, 2 Control limitation, 3 Stop, 4 Serial data communication, 5 Use of more than one operator control station, 6 Battery-powered operator controls. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

This sub-subsection, “General”, is used to consolidate information that applies to all the parts of the Subsection 9.2.7 into one area for clarity

9.2.7.2

9.2.7.2.1 through 9.2.7.2.3

Recommendation: Add title “Control limitation” and IEC 60204-1 1997 Edition 9.2.7.2 text

Substantiation: Subsection 9.2.7 is divided into 6 sub-subsections 1 General, 2 Control limitation, 3 Stop, 4 Serial data communication, 5 Use of more than one operator control station, 6 Battery-powered operator controls. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

This sub-subsection, “Control limitations”, is used to consolidate information about unique functional requirements that present themselves in cable-less controls [when used] verses the hard wired portion of a machine’s control systems
9.2.7.3
9.2.7.3.1 through 9.2.7.3.2

Recommendation: Add title "Stop" and IEC 60204-1 1997 Edition 9.2.7.3 text

Substantiation: Section 9.2.7 is divided into 6 sub-sections 1 General, 2 Control limitation, 3 Stop, 4 Serial data communication, 5 Use of more than one operator control station, 6 Battery-powered operator controls. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. This sub-section, "Stop", is used to consolidate information about unique requirements for the stop function that present themselves in cable-less controls (when used) versus the hard wired portion of a machine’s control systems

9.2.7.4

Recommendation: Add title "Serial data communication" and IEC 60204-1 1997 Edition 9.2.7.4 text with minor clarifying editorial changes and note

Substantiation: Subsection 9.2.7 is divided into 6 sub-sections 1 General, 2 Control limitation, 3 Stop, 4 Serial data communication, 5 Use of more than one operator control station, 6 Battery-powered operator controls. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. This sub-section paragraph, "Serial data communication", is used present the requirements for serial data links and the special capabilities required when used in machines for safety critical control applications. This control situation is relatively new but seen in some current machine applications.

9.2.7.5

Recommendation: Add title "Use of more than one operator control station" and IEC 60204-1 1997 Edition 9.2.7.5 text and exception with minor clarifying editorial changes

Substantiation: Subsection 9.2.7 is divided into 6 sub-sections 1 General, 2 Control limitation, 3 Stop, 4 Serial data communication, 5 Use of more than one operator control station, 6 Battery-powered operator controls. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. This sub-section paragraph, "Use of more than one operator control station", presents the requirements for the situation where multiple operator control stations may exist. This control situation is relatively new but seen in some current machine applications.

9.2.7.6

Recommendation: Add title "Battery powered operator control stations" and IEC 60204-1 1997 Edition 9.2.7.6 text

Substantiation: Subsection 9.2.7 is divided into 6 sub-sections 1 General, 2 Control limitation, 3 Stop, 4 Serial data communication, 5 Use of more than one operator control station, 6 Battery-powered operator controls. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. This sub-section paragraph, "Battery powered operator control stations", presents the requirements when portable operator control stations may exist. This control situation is in some current machine applications in warehouses and material handling situations.

9.3

Recommendation: Add title "Protective interlocks"

Substantiation: Chapter 9 is divided into 4 sections 1 Control circuits, 2 Control functions, 3 Protective interlocks, and 4 Control functions in the event of failure. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. Guarding and interlocking application requirement are generally found in other equipment standards and legal requirements [e.g. ANSI B11 series and OSHA regulations such as CFR 29 Chapter XVII 1910.217 “Technical power presses”]. The text in this part of Chapter 9 to proposed NFPA 79-2002 Edition is added to support the execution of the needed guarding and interlocking function requirements from those standards and regulations.

9.3.1

Recommendation: Add title "Re-closing or resetting of an interlocking safeguard" and IEC 60204-1 1997 Edition 9.3.1 text

Substantiation: Section 9.3 is divided into 5 subsections 1 Re-closing of resetting of an interlocking safeguard, 2 Over-travel limits, 3 Operation of auxiliary functions, 4 Interlocks between different operations and for contrary motions, 5 Reverse current braking. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. New text added for Proposed NFPA 79-2002 9.3.1 "Re-closing or resetting of an interlocking safeguard" was added because provides requirements for application of safeguards interlock when they are used.

9.3.2

Recommendation: Add title "Over-travel limits" and IEC 60204-1 1997 Edition 9.3.2 text

Substantiation: Section 9.3 is divided into 5 subsections 1 Re-closing of resetting of an interlocking safeguard, 2 Over-travel limits, 3 Operation of auxiliary functions, 4 Interlocks between different operations and for contrary motions, 5 Reverse current braking. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. New text added for Proposed NFPA 79-2002 9.3.2 "Over travel limits" was added because provides requirements for application of over travel limits when they are used.

9.3.3 9.3.3.1


9.3.3.2


Substantiation: Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. New text, was added for Proposed NFPA 79-2002 9.3.3.2 provides requirements of interlocking where the failure of a motor can cause hazardous condition or damage to the machine.

9.3.4

9.3.4.1 through 9.3.4.4


9.3.5

9.3.5.1 and 9.3.5.2

Recommendation: Add IEC 60204-1 1997 Edition 9.3.5 title, "Reverse current braking", and text

New text added for Proposed NFPA 79-2002 9.3.5 “Reverse current braking” was added because provides requirements reflecting present practices.

9.4

Recommendation: Add title “Control functions in the event of failure” to 9.4

Substantiation: Chapter 9 is divided into 4 sections 1 Control circuits, 2 Control functions, 3 Protective interlocks, and 4 Control functions in the event of failure. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

New text added for Proposed NFPA 79-2002 9.4 “Control functions in the event of failure” was added because provides requirements for application when the failure of control circuit must not result in maloperation of the machine.

9.4.1

Recommendation: Add title, “General requirements” and text with minor clarifying editorial changes from IEC 60204-1 1997 Edition 9.4.1 1st paragraph. Text with minor clarifying editorial changes from IEC 60204-1 1997 Edition 9.4.1, 2nd paragraph and all of 9.4.2 “Measures to minimize risk in the event of failure” will be moved to a note.

Substantiation: Section 9.4 is divided into 2 subsections 1 General requirements, 2 Protection against unintended operation due to ground (earth) faults and voltage interruptions. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

This sub-subsection, “General requirements”, is used to consolidate information that applies to all the parts of the Section 9.4 into one area for clarity.

The text with minor clarifying editorial changes from IEC 60204-1 1997 Edition 9.4.1, 2nd paragraph and all of 9.4.2 “Measures to minimize risk in the event of failure” is considered valuable guidance to be considered in control system design, though not enforceable, should be retained in a note form.

9.4.2

Recommendation: Add title, “Protection against unintended operation due to ground (earth) faults and voltage interruptions” from IEC 60204-1 1997 Edition 9.4.3 with added USA words ground for “earthed”

Substantiation: Section 9.4 is divided into 2 subsections 1 General requirements, 2 Protection against unintended operation due to ground (earth) faults and voltage interruptions. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

9.4.2.1

Recommendation: Add title, “Ground (earth) faults” with minor clarifying editorial changes from IEC 60204-1 1997 Edition 9.4.3.1, and relocate NFPA 79 1997 Edition 9.3.4 sentence with additional text. Relocate NFPA 79 1997 Edition 9.3.4 1st sentence to §3 Control circuits “Control circuits shall be permitted to be grounded or ungrounded.”


The added text is to clarify the coordination of control circuit ground (earth) requirements with additional requirements within this standard and provide additional requirements specific to grounded and ungrounded control circuits.
<table>
<thead>
<tr>
<th>Clause</th>
<th>Heading</th>
<th>Section/Paragraph</th>
<th>Heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Control circuits</td>
<td>9.1</td>
<td>Control circuits</td>
</tr>
<tr>
<td>9.1</td>
<td>Source of control power</td>
<td>9.1.1.4</td>
<td>Exception</td>
</tr>
<tr>
<td>9.2</td>
<td>Control circuit voltages</td>
<td>9.1.2</td>
<td>Control circuit voltages</td>
</tr>
<tr>
<td>9.2.1</td>
<td>AC control circuit voltages</td>
<td>9.1.2.1</td>
<td>Exception No.1</td>
</tr>
<tr>
<td></td>
<td>Exception No.1: moved</td>
<td>9.1.2.1</td>
<td>Exception No.2</td>
</tr>
<tr>
<td></td>
<td>Exception No.2:</td>
<td>9.1.2.2</td>
<td>DC control circuit voltages</td>
</tr>
<tr>
<td>9.2.2</td>
<td>Exception</td>
<td>9.1.2.2</td>
<td>Exception</td>
</tr>
<tr>
<td>9.3</td>
<td>Grounding of control circuits elsewhere provisions elsewhere see 8.3 &amp; 9.4.2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.4</td>
<td>Connection of control devices</td>
<td>9.1.4</td>
<td>Connection of control devices</td>
</tr>
<tr>
<td>9.4.1</td>
<td>Exception No.1:</td>
<td>9.1.4.1</td>
<td>Exception No.1</td>
</tr>
<tr>
<td></td>
<td>Exception No.2:</td>
<td>9.1.4.1</td>
<td>Exception No.2</td>
</tr>
<tr>
<td></td>
<td>Exception No.3:</td>
<td>9.1.4.1</td>
<td>Exception No.3</td>
</tr>
<tr>
<td></td>
<td>Exception No.4:</td>
<td>9.1.4.1</td>
<td>Exception No.4</td>
</tr>
<tr>
<td></td>
<td>Exception No.5:</td>
<td>9.1.4.1</td>
<td>Exception No.5</td>
</tr>
<tr>
<td></td>
<td>Exception No.6:</td>
<td>9.1.4.1</td>
<td>Exception No.6</td>
</tr>
<tr>
<td>9.4.2</td>
<td>Exception</td>
<td>9.1.4.2</td>
<td>Exception</td>
</tr>
<tr>
<td>9.5</td>
<td>Control functions</td>
<td>9.2</td>
<td>Control functions</td>
</tr>
<tr>
<td>9.5.1</td>
<td>Start functions</td>
<td>9.2.1</td>
<td>Start functions</td>
</tr>
<tr>
<td>9.5.2</td>
<td>Stop functions</td>
<td>9.2.2</td>
<td>Stop functions Note: Stop function requirement also covered in 9.2.5 “Operation” &amp; 9.2.5.3 “Stop”</td>
</tr>
<tr>
<td>9.6</td>
<td>Operation</td>
<td>9.2.5</td>
<td>Operation</td>
</tr>
<tr>
<td>9.6.1</td>
<td>Start</td>
<td>9.2.5.2</td>
<td>Start</td>
</tr>
<tr>
<td>9.6.2</td>
<td>Stop</td>
<td>9.2.5.3</td>
<td>Stop</td>
</tr>
<tr>
<td>9.6.3</td>
<td>Emergency stop</td>
<td>9.2.5.4.2</td>
<td>Emergency stop</td>
</tr>
<tr>
<td>9.7</td>
<td>Hold to run circuits</td>
<td>9.2.5.5</td>
<td>Hold-to-run controls</td>
</tr>
<tr>
<td>9.7.1</td>
<td></td>
<td>9.2.5.5</td>
<td>Operation of auxiliary functions</td>
</tr>
<tr>
<td>9.7.2</td>
<td></td>
<td>9.2.5.5.1</td>
<td>Operation of auxiliary functions</td>
</tr>
<tr>
<td>9.8</td>
<td>Operating modes</td>
<td>9.2.3</td>
<td>Operating modes</td>
</tr>
<tr>
<td>9.8.1</td>
<td></td>
<td>9.2.3.1</td>
<td>Operation of auxiliary functions</td>
</tr>
<tr>
<td>9.8.2</td>
<td></td>
<td>9.2.3.2</td>
<td>Operation of auxiliary functions</td>
</tr>
<tr>
<td>9.8.3</td>
<td></td>
<td>9.2.3.3</td>
<td>Operation of auxiliary functions</td>
</tr>
<tr>
<td>9.9</td>
<td>Feed interlocked with spindle drive</td>
<td>9.3.1</td>
<td>Operation of auxiliary functions</td>
</tr>
<tr>
<td>9.10</td>
<td>Machinery door interlocking</td>
<td>9.3.4.2</td>
<td>Not carried forward not in NFPA79 Purpose Statement.</td>
</tr>
<tr>
<td>9.11</td>
<td>Motor contactors and starters</td>
<td>9.3.4.2</td>
<td>Two-hand control</td>
</tr>
<tr>
<td>9.12</td>
<td>Relays and solenoids</td>
<td>9.3.4.2</td>
<td>Two-hand control</td>
</tr>
<tr>
<td>9.13</td>
<td>Setup mode</td>
<td>9.3.4.2</td>
<td>Two-hand control</td>
</tr>
<tr>
<td>9.14</td>
<td>Two-hand control circuits</td>
<td>9.2.3.6</td>
<td>Two-hand control</td>
</tr>
<tr>
<td>9.15</td>
<td>Overriding of safeguards</td>
<td>9.2.4</td>
<td>Suspension of safeguards</td>
</tr>
</tbody>
</table>
Proposed new Table of content

Chapter 9 Control circuits and control functions

Section 9.1 Control Circuits
Subsection 9.1.1 Control circuit supply
Sub-subsection 9.1.2 Control circuit voltages
Sub-subsubsection 9.1.3 Protection
Sub-subsubsection 9.1.4 Connection of control circuit devices

Section 9.2 Control functions
Subsection 9.2.1 Start functions
Subsection 9.2.2 Stop functions
Subsubsection 9.2.3 Operating modes
Subsubsection 9.2.4 Overriding of safeguards
Subsubsection 9.2.5 Operation (emergency stop, emergency switch off)
Subsubsubsection 9.2.5.1 General
Subsubsubsection 9.2.5.2 Start
Subsubsubsection 9.2.5.3 Stop
Subsubsubsection 9.2.5.4 Emergency operations

Subsubsubsection 9.2.5.4.1 General
Subsubsubsection 9.2.5.4.2 Emergency Stop
Subsubsubsection 9.2.5.4.3 Emergency switch off
Subsubsection 9.2.5.5 Hold-to-run controls
Subsubsection 9.2.5.6 Two-hand control
Subsubsection 9.2.5.7 Enabling device

Subsubsection 9.2.6 Combined start and stop controls
Subsubsection 9.2.7 Cable-less control functions
Subsubsection 9.2.7.1 General
Subsubsection 9.2.7.2 Control limitation
Subsubsection 9.2.7.3 Stop
Subsubsection 9.2.7.4 Serial data communication
Subsubsection 9.2.7.5 Use of more than one operator

Subsubsection 9.2.7.6 Battery-powered operator

Subsubsection 9.3 Protective interlocks
Subsubsection 9.3.1 Re-Closing of resetting of an interlocking safeguard
Subsubsection 9.3.2 Overtravel limits
Subsubsection 9.3.3 Operation of auxiliary functions
Subsubsection 9.3.4 Interlocks between different operations and for contrary motions
Subsubsection 9.3.5 Reverse current braking

Subsubsection 9.4 Control functions in the event of failure
Subsubsection 9.4.1 General requirements
Subsubsection 9.4.2 Protection against unintended operation due to ground (earth) faults and voltage interruptions
Subsubsubsection 9.4.2.1 Ground (earth) faults
Subsubsubsection 9.4.2.2 Voltage interruptions

COMMITTEE ACTION: Accept in Principle.
Revise text to read as follows:

8.1 General. This clause provides for grounding, bonding and grounded conductor requirements.

Note: The terms protective earthing conductor, protective bonding conductor, protective conductor, neutral, and earth are used in other countries.
8.2.2 Equipment grounding (protective) conductors and bonding jumpers.

Equipment grounding (protective) conductors and bonding jumpers shall be identified in accordance with 14.2.2.

8.2.2.1 Conductors used for grounding and bonding purposes shall be copper. Stipulations on standing and flexing as outlined in this standard shall apply.

8.2.2.2 Equipment grounding conductors and bonding jumpers shall be insulated, covered, or bare and shall be protected against physical damage.

8.2.2.3 Equipment grounding conductors and bonding jumpers of the wire type shall not be smaller than shown in Table XX.

Equipment grounding conductors and bonding jumpers of the wire type shall not be smaller than shown in Table XX, but shall not be required to be larger than the circuit conductors supplying the equipment.

8.2.2.3.1 It shall be permitted to use machine members or structural parts of the electrical equipment in the equipment grounding circuit provided that the cross-sectional area of these parts is at least electrically equivalent to the minimum cross-sectional area of the copper conductor required. <this was note to table but was moved here according to Log #81>.

Table XX — Minimum Size of equipment grounding conductors and bonding jumpers

<table>
<thead>
<tr>
<th>Rating or setting of automatic overcurrent device in circuit ahead of the equipment (A)</th>
<th>Copper Conductor Size, AWG or kcmil</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>16 or 18</td>
</tr>
<tr>
<td>15</td>
<td>14, 16, or 18</td>
</tr>
<tr>
<td>20</td>
<td>14, 16, or 18</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>200</td>
<td>6</td>
</tr>
<tr>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>400</td>
<td>3</td>
</tr>
<tr>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>600</td>
<td>1</td>
</tr>
<tr>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>2/0</td>
</tr>
<tr>
<td>1200</td>
<td>2/0</td>
</tr>
<tr>
<td>1500</td>
<td>4/0</td>
</tr>
<tr>
<td>2000</td>
<td>250</td>
</tr>
<tr>
<td>2500</td>
<td>350</td>
</tr>
<tr>
<td>3000</td>
<td>500</td>
</tr>
<tr>
<td>4000</td>
<td>500</td>
</tr>
<tr>
<td>5000</td>
<td>700</td>
</tr>
<tr>
<td>6000</td>
<td>900</td>
</tr>
<tr>
<td>8000</td>
<td>1000</td>
</tr>
</tbody>
</table>

8.2.3 Continuity of the equipment grounding (protective bonding) circuit.

8.2.3.1 The continuity of the equipment grounding (protective bonding) circuit shall be ensured by effective connections through conductors or structural members.

8.2.3.2 Removing a device shall not interrupt the continuity of the equipment grounding (protective) circuit.

8.2.3.3 Bonding of equipment with bolts or other identified means shall be permitted where paint and dirt are removed from the joint surfaces or where the bonded members are effectively penetrated.

8.2.3.4 Moving machine parts, other than accessories or attachments, having metal-to-metal bearing surfaces shall be considered as bonded. Sliding parts separated by a nonconductive fluid under pressure shall not be considered as bonded.

8.2.3.5 Raceways, wireways, and cable trays shall not be used as equipment grounding or bonding conductors.

8.2.3.6 Doors or Covers.

(1) Where electrical devices are mounted on conductive doors or covers, an equipment (protective) bonding jumper shall be installed.

(2) An equipment (protective) bonding jumper shall connect the conductive door or cover to the equipment enclosure or to an equipment grounding (protective bonding) terminal within the enclosure.

8.2.3.7 Portable, pendant, and resilient-mounted equipment shall be bonded by separate conductors. Where multicore cable is used, the bonding conductor shall be included as one conductor of the cable.

8.2.3.8 Where equipment grounding conductors are subject to physical damage they shall be protected or be monitored to ensure continuity.

8.2.4 Exclusion of switching devices. The equipment grounding (protective) circuit shall not contain any switches or overcurrent protective devices. Links or plugs in the grounding circuit shall be permitted if properly labeled or interlocked with the control circuits.

8.2.7 Equipment grounding (protective) conductor connecting points.

(1) All equipment grounding (protective) conductors shall be terminated in accordance with 14.1.1. The equipment grounding (protective) conductor connecting points shall have no other function.

(2) The equipment grounding conductor connecting points, other than the equipment grounding terminal, shall be identified by a green color or by use of the symbol that appears in 8.2.1.2.1.

Note: The letters PE or the bicolor green and yellow is used in some countries.

8.3 Control circuits. Control circuits shall be permitted to be grounded or ungrounded. Where grounding is provided, that side of the circuit common to the coils shall be grounded at the control transformer if alternating current or at the power supply terminal if direct current. Where grounding is not provided, an insulation-monitoring system shall be utilized as described in 9.4.2.1.

Ungrounded control circuits shall be provided with an insulation-monitoring device that either indicates a ground (earth) fault or interrupts the circuit automatically after a ground (earth) fault.

Exception No. 1: Exposed control circuits as permitted by 6.4.6.3 shall be grounded.

Exception No. 2: Overload relay contacts shall be permitted to be connected between the coil and the grounded conductor where the conductors between such contacts and coils of magnetic devices do not extend beyond the control enclosure.

Exception No. 3: NFPA 70, Article 725, Class 2, low voltage circuits shall not require insulation monitoring.

8.5 Lighting circuits.

8.5.1 One conductor of all machine lighting and maintenance lighting circuits shall be grounded. The grounded conductor(s) shall be identified in accordance with 14.2. Identification of conductors.
8.5.2 Where the lighting circuit is supplied by a separate isolation transformer, the grounding shall occur at the transformer. Where the equipment maintenance lighting circuit is supplied directly from the plant lighting circuit, the grounding shall occur at the grounding terminal.

8.5.3 The grounded conductor, where run to a screw-shell lampholder, shall be connected to the screw-wheel.

COMMITTEE STATEMENT: Revision to the proposed text were as follows:

1) In Section 9.1.1.4, revise "main disconnecting means" to "supply disconnecting means" and add the word "circuit" after the word supply for editorial consistency.
2) In 9.2.2(a) and (b), make the editorial corrections such as change e.g. to i.e. and delete see x.xx in (a) and (b). Also, correct second (b) to a (c).
3) In 9.2.3.2, change the first word "when" to "where" and correct result.
4) In 9.2.3.3, insert the word "Note" before (see). Change the word "suspension" to "overriding."
5) In 9.2.4, change should to shall in the second sentence to Comply with the NFPA Manual of Style.
6) In 9.2.5.1.1 and 9.2.5.2.4(d), delete the parenthetical expression.
7) In 9.2.5.3.2, replace and/or with and.
8) Globally throughout Clause 9, delete all "(see x.xxxx)"
9) In 9.2.5.4.1, delete last sentence since it is unnecessary.
10) In 9.2.5.4.2.1, change the word "has" to "shall have" in the first sentence.
11) In 9.2.5.4.2.2, editorially revise the sentence to read as follows: "Where required, provisions to connect additional emergency stop devices shall be provided in accordance with Article 10.7."
12) In 9.2.5.4.2.4, insert the word "only" before the word "hardwired" since there was no substantiation to delete the word only.
13) In 9.2.5.4.3.2, change the word "is" to the word "shall be" and insert the word "circuit" after the word supply in the first sentence.
14) In 9.2.5.7.1, add "as used in this clause is defined as" for clarity and allows the verb is.
15) In 9.2.6, change "pushbutton" to "Pushbuttons" and delete the word "a". Editorial
16) In 9.2.7.3.2, change "having" to "that has" and delete the word "and" after the word "functions."
17) In 9.3.4.2, revise sentence for clarity.
18) In 9.4.2, revise title for clarity.
19) Delete 9.4.2.2 since it is already covered in 11.3.2 and 7.5.
20) In 9.4.1, Notes 2.2 and 2.4, replace the word shall with the word "may."
21) Due to an inadvertent omission, add the last sentence to 9.2.5.3.2 "Stop function shall operate by deenergizing that relevant circuit and shall override related start functions." taken from NFPA 79-1997, 9.5.2.3.
22) Due to an inadvertent omission; Insert a new second sentence in 9.2.5.5.2.2 to read as follows: "The prevention of RUN or AUTOMATIC operation during JOG or INCH shall be accomplished by an operator interface and a separate JOG or INCH selection method." taken from 1997 NFPA 79-1997, 9.7.2.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
ANDERSON: In the committee statement point # 7 " In 9.2.5.3.2, replace and/or with and and was not immediately seen as feasible without loosing the original meaning and failing that attempt the and/or to was to remain. I look for this to be a point of clarification at the ROC meeting.

In the committee statement point # 9 "In 9.2.5.4.1, delete last sentence since it is unnecessary", I would argue that the last sentence should remain as it is pointing to another place in the standard where control functions, "additional safety related stops", are described. Chapter 9 title is Control circuits and control functions, Chapter 11 title is Electronic equipment, it may not be obvious from the index that Chapter 11 also contains additional safety related stop control functions. Since one of Chapter 9's main topics is "control functions", and additional direct treatment of the main topic is outside the chapter, for good reason, reference to the additional location is preferable to that of repeating the remotely located material.

9.2.5.4.1 General
This standard specifies the requirements for the emergency stop and emergency switching off functions, each of which is, in this standard, initiated by a single human action. Emergency switching off is an emergency operation intended to switch off the supply of electrical energy to a part of an installation where a risk of electric shock or another risk of electrical origin is involved. For other safety related stop functions see 11.3.4.

In the committee statement point #14 "In 9.2.5.7.1, add 'as used in this clause is defined for clarity and uses the verb is." The corrected 9.2.5.7.1 should actually include additional commas and italicizing [see my comment to proposal 138] and read:

9.2.5.7.1 An enabling device, as used in this chapter, is defined as an additional manually operated control device used in conjunction with a start control and which, when continuously actuated, allows a machine to function.

In the committee statement point #15 "In 9.2.6, change 'pushbutton' to Pushbuttons and delete the word "a". My notes indicate that the referral to a single pushbutton was intended and was the intent of when the requirement in 9.2.6 was operative with respect to a pushbutton. I believe the agreed text for 9.2.6 is:

9.2.6 Combined start and stop controls. A single pushbutton and other devices that alternately start and stop motion shall only be used for secondary functions where no hazardous condition arises when they are operated.

In the committee statement point #16 "In 9.2.7.3.2, change 'having' to 'than has' and delete the word 'and' after the word 'functions'." Deleting the word "and", changes the meaning of the subsection to nonsense and in fact the machine is equipped with the "cable-less control", and has the "safety-critical functions. The "function" is not a part of the group of physical things, e.g. machine, cable-less control.

From Webster's Collegiate Dictionary, 10th edition: functions (noun) "the action for which a person or thing is specially fitted or used or for which a thing exists: PURPOSE" or [intransitive verb] "to carry on a function or be in action: OPERATE"

Making sense from the committee statement by dropping the suggested "and" and adding commas and keeping noun verb agreement, 9.2.7.3.1 should read as follows:

9.2.7.3.2 A machine, that has safety-critical functions, and that is equipped with cable-less control shall have a means of automatically initiating the stopping of the machine and preventing the initiation of potentially hazardous motions, in the following situations:

(a) When a stop signal is received.
(b) When a fault is detected in the system.
(c) When a valid signal has not been detected within a specified period of time (see annex B for the agreed time specification).

Note - A valid signal also includes the signal that confirm communication is established and maintained

In the committee statement point #18 "In 9.4.2, revise title for clarity. My notes show that this proposed point was rejected. The proposal would have deleted " and voltage interruptions from the title of 9.4.2 on the basis it was covered in chapters 11 and 7. In fact the title of Chapter 11 is "Control circuits and control functions" subsection 9.4.2 deals with the control function aspect of ground (earth) faults and voltage interruptions. These particular topics are not dealt with else where in the standard.

In the committee statement point #19 "Delete 9.4.2.2 since it is already covered in 11.32 and 7.2. Again my notes show that this proposed point was rejected. The proposal would have deleted sub section 9.4.2.2 Voltage interruptions, on the basis it was covered in chapters 11 and 7. In fact the title of Chapter 9 is "Control circuits and control functions" sub subsection 9.4.2.2 deals with the control function aspect of voltage interruptions. These particular topics are not dealt with else where in the standard.

In fact the title of Chapter 9 is "Control circuits and control functions" sub subsection 9.4.2.2 deals with the control function aspect of voltage interruptions. These particular topics are not dealt with else where in the standard.

In the committee statement point #19 "Delete 9.4.2.2 since it is already covered in 11.32 and 7.2. Again my notes show that this proposed point was rejected. The proposal would have deleted sub section 9.4.2.2 Voltage interruptions, on the basis it was covered in chapters 11 and 7. In fact the title of Chapter 9 is "Control circuits and control functions" sub subsection 9.4.2.2 deals with the control function aspect of voltage interruptions. These particular topics are not dealt with else where in the standard.

In the committee statement point #19 "Delete 9.4.2.2 since it is already covered in 11.32 and 7.2. Again my notes show that this proposed point was rejected. The proposal would have deleted sub section 9.4.2.2 Voltage interruptions, on the basis it was covered in chapters 11 and 7. In fact the title of Chapter 9 is "Control circuits and control functions" sub subsection 9.4.2.2 deals with the control function aspect of voltage interruptions. These particular topics are not dealt with else where in the standard.
In the committee statement the changes from log # 147 were inadvertently not brought forward to the committee action for log 46, also please see log 132 [which is accepted in part] in which subsection 9.2.3.2 is modified to read:

9.2.3.2 Where hazardous conditions result from mode selection, such inadvertent selection shall be prevented from occurring (e.g. key operated switch, access code). Mode selection by itself shall not initiate machine operation. A separate action by the operator shall be required.

In the committee statement the changes from log # 151 were inadvertently not brought forward to the committee action for log 46, also please see log 151 [which is shown as accepted with editorial revision of "should" to "shall" in the proposed revision] [also note: the log # 151 accept does not show the committee statement # 5 for log 46, but is shown below]. Log 151 thus shows subsection 9.2.4 is modified to read:

9.2.4 Overriding of safeguards. Where it is necessary to temporarily override one or more safeguards a mode selection device or means capable of being secured (e.g. locked) in the desired mode shall be provided to prevent automatic operation. The control circuit for the suspension of a safeguard shall have the same safety requirements as the suspended safeguard itself. In addition, one or more of the following measures should be provided:

1. Initiation of motion by a hold-to-run or other control device
2. A portable controls station (e.g. pendant) with an emergency stop device, and where appropriate, an enabling device. Where a portable station is used, motion shall only be initiated from that station.
3. Limiting the speed or the power of motion
4. Limiting the range of motion

In the committee statement the changes from log # 150 and #171 and #12 were inadvertently not brought forward to the committee action for log 46, also please see log 150 and 171 and 12 [which is accepted, 12 accepted in principle] in which the exception to paragraph 9.2.5.4.2.4 is modified to read:

9.2.5.4.2.4 Where a category 0 stop is used for the emergency stop function, it shall have hardwired electromechanical components:

Exception: An electronic logic (hardware or software) system as well as the communication network of link that complies with 11.3.4 and is listed for category 0 emergency stop function shall be permitted. The final removal of power shall be accomplished by means of electromechanical components.

In the committee statement the addition from log # 116 was inadvertently not brought forward to the committee action for log 46, also please see log 1110 [which is accepted in principle] in which subsection 9.3.6 is added to read:

9.3.6 Protective interlock. Where doors are interlocked, in the interlocking devices shall be listed safety switches to prevent the operation of the equipment when the doors are open.

In the committee statement the changes from log # 163 were inadvertently not brought forward to the committee action for log 46, also please see log 163 [which is accepted] in which Note 1 of subsection 9.4.1 is modified to read:

Note 1: Measures to reduce the risks from failures or disturbances in the electrical equipment that could cause a hazardous condition or damage to the machine or to the work in progress include but are not limited to:

1. Protective devices on the machine (e.g. interlock guards, trip devices)
2. Protective interlocking of the electrical circuit
3. Use of proven circuit techniques and components (see note 2.1)
4. Provision of partial or complete redundancy (see note 2.2) or diversity (see note 2.3)
5. Provisions for functional tests (see note 2.4)

BLOOGOOD: The exception to clause 9.2.5.4.2.4 permitting an electronic logic system as an emergency stop should not be included if Proposal for 79-77 (Log #12) and 79-47 (Log #155) are defeated. In the case that those log numbers are defeated the exception in this clause should be eliminated.

FISHER: The exception to clause 9.2.5.4.2.4 permitting an electronic logic system as an emergency stop should not be included if 79-75 (Log #155) and 79-77 (Log #12) are defeated. In the case that those log numbers are defeated the exception in this clause should be eliminated.

MONTIEITH: Clause 9.3.2 This clause is vague and open to interpretation. It is recommended that a "Note" be provided that states "Note: A hazardous condition and the use of a position sensor (e.g. proximity switch, position comparator) or limit switch is determined through the overall requirements for risk assessment of the machine as stated in 4.1.2.

FADGETT: Clause 9.3.2 This clause is vague and open to interpretation. It is recommended that a "Note" be provided that states "Note: A hazardous condition and the use of a position sensor (e.g. proximity switch, position comparator) or limit switch is determined through the overall requirements for risk assessment of the machine as stated in 4.1.2.

PILZ: This comment is in support of the committee action to accept in principle the wording in clause 9.

I do want to point out that 9.2.5.4.2.1 is int he need of an additional requirement.

Proposal: Add the following wording to the committee proposal:

9.2.5.4.2.1(D) The emergency stop shall be incorporated into the Safety Circuit, where it can be directly incorporated into the power circuit.

SAUNDERS: Safety lies in the design of the control, not in the choice of the control technology. The committee acknowledges this by allowing an exception for programmable technology to be used in e-stop circuitry, thus allowing the advance of eh technology to take place. However, the committee also decided to give guidance in Chapter 11 on how this technology needs to be designed in order to be admissible. By including this new paragraph D into 9.2.5.4.2.1, which points the user of the standard to the newly introduced wording of 9.5.1 the committee would give the additional guidance on the design of the emergency stop circuit.

Like the wording of clause 11.3.4 in Chapter 11, the wording of 9.5.1 is so selected that it points the users of the standard towards control components that have been designed to be used in control circuits that need to be available at all times or in case of a failure of the control itself inform the personnel that a fault exists by either shutting down the equipment or not allowing restart after a regular shut down. The user of the standard is pointed towards a risk assessment as guidance for the design of the safety circuit. This together with the guidance given in Chapter 9.4 give the user of NFPA 79 2002 a more comprehensive tool to design a safe machine.

To underline the importance this newly suggested paragraph I have included a power point presentation that demonstrates that a hardwired design of an e-stop circuit cannot be unsafe. Only when incorporated into a safety circuit the desired protection can be achieved. Please see presentation titled En 60204 US.

SAUNDERS: The addition to 9.2.5.3.2 in the committee action that requires all stop functions to operate by "deenergizing the relevant circuit" would eliminate the use of many category 1 and 2 stops, since many of these stops achieve the stop without deenergizing the circuit.

Recommendation: Delete "shall operate by deenergizing that relevant circuit and" from the last sentence of 9.2.5.3.2.
To undermine the importance of this newly suggested paragraph, I have included a power point presentation that demonstrates that a hardwired design of an e-stop circuit can be unsafe. Only when incorporated into a safety circuit the desired protection can be achieved.

Note: Supporting Material is available for review at NFPA Headquarters.

COMMITTEE ACTION:

COMMITTEE STATEMENT:

EXPLANATION OF NEGATIVE:

AFFIRMATIVE: 21
NEGATIVE: 4
NOT RETURNED: 1 Norman

COMMITTEE ACTION:

COMMITTEE STATEMENT:

EXPLANATION OF NEGATIVE:

AFFIRMATIVE: 23
NEGATIVE: 2
NOT RETURNED: 1 Norman

COMMITTEE ACTION:

COMMITTEE STATEMENT:

EXPLANATION OF NEGATIVE:

AFFIRMATIVE: 22
NEGATIVE: 3
NOT RETURNED: 1 Norman
RECOMMENDATION: The committee understands that this proposal modifies 79-62 (Log #46) [Clause 9] by adding a new second sentence to 9.3.4.2.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: 

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79-66 - (Clause 9 [9.4.1]): Accept

SUBMITTER: John B. Deam, Rep. The Association for Manufacturing Technology

RECOMMENDATION: Modify rewrite of 1997 NFPA 79, Clause 9 that is new Clause 9 in 9.4.1, Note 2.2 and Note 2.4. In the second paragraph of Note 2.2, change the word "shall" to "should."

SUBSTANTIATION: Both changes correct for mandatory language placed in a note by deleting the words "shall" and "shall be permitted."

COMMITTEE ACTION: Accept.

COMMITTEE STATEMENT: The committee understands that this proposal modifies 79-62 (Log #46) [Clause 9].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: 

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79-65 - (9.3.1): Accept

TCG NOTE: The Technical Correlating Committee directs that the Panel clarify the Panel Action on this Proposal and correlate this action with the action on proposal 79-82 (Log #163). This action will be considered by the Panel as a Public Comment.

SUBMITTER: John B. Deam, Rep. The Association for Manufacturing Technology

RECOMMENDATION: Modify rewrite of 1997 NFPA 79, Clause 9 that is new Clause 9 in 9.4.1. Add in the first paragraph, first sentence, the word "can" between the words "equipment" and "cause." Sentence to read: 

"electrical equipment can cause a ..."

Move the second sentence of the rewrite 9.4.1. to Note 1 and make it the first sentence of the note and delete the word "required" from the sentence.

SUBSTANTIATION: The word "can" is in IEC text of 9.4.1, and must have been mistakenly not included, therefore, reinsert the word.

The second sentence of the paragraph is not mandatory, therefore, it should be a note. Moving the sentence to the first sentence of Note 1 provides a logical introduction to this note.

COMMITTEE ACTION: Accept.

COMMITTEE STATEMENT: The committee understands that this proposal modifies 79-62 (Log #46) [Clause 46].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: 

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79-68 - (9.3.1(New) [9.4.2.1]): Accept in Principle

SUBMITTER: Heinrich Moedden, German Machine Tool Builders Association (VDW)

RECOMMENDATION: Revise text as follows:

"Ground-free control circuits are permitted only with earth leakage monitor."

SUBSTANTIATION: Ground-free without earth leakage monitor is not a protection against malfunction due to short to ground.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: The proposal [Ground-free control circuits are permitted only with earth leakage monitor.], is addressed in 9.4.2.1 "Ground (earth) faults", and 8.3 "(Grounding) Control Circuits". See Committee Action on Proposal 79-62 (Log #46). The committee believes that this action meets the intent of the submitter.

79-70 - (9.2.3.2): Accept in Part

SUBMITTER: Thomas Pilz, Pilz Industrial Electronics L.P.

RECOMMENDATION: OLD

9.2.3.2 When hazardous conditions results from mode selections, such selection shall be prevented from occurring (e.g. key operated switch, access code). Mode selection by itself shall not initiate machine operation. A separate action by the operator shall be required.

NEW

9.2.3.2 Operation mode switches must have the same safety requirements as the control elements used in the most hazardous selectable operation mode of the machine, assessed in a risk assessment. When hazardous conditions results from mode selection, inadvertent selection shall be prevented from occurring (e.g. key operated switch, access code). Mode selection by itself shall not initiate machine operation. A separate action by the operator shall be required.
SUBSTANTIATION: A selection of the wrong operation mode by a system fault can lead to a hazardous condition, therefore the operation mode selection must be treated like the highest selectable hazardous mode. Therefore, a touch screen is not an acceptable device for a mode select switch. This would lead the requirement of the extensive hardwired circuit for this application ad absurdum. Change "such selection" to inadvertent, since it can be possible that the selected mode is dangerous. However, the danger in that mode cannot be avoided by the design of the machine. The operator who is aware of the hazard however can handle the danger, provided he knows that the dangerous mode is activated. Therefore, the hazard is not the danger that comes from the operation mode of the machine but from the inadvertent switch to the dangerous mode.

COMMITTEE ACTION: Accept in Part.

Revise text as follows:

9.2.5.2 Operation mode switches must have the same safety requirements as the control elements used in the most hazardous selectable operation mode of the machine, assessed in a risk assessment. Where hazardous conditions results from mode selection, inadvertent selection shall be prevented from occurring (e.g. key operated switch, access code). Mode selection by itself shall not initiate machine operation. A separate action by the operator shall be required.

COMMITTEE STATEMENT: The committee disagrees with the first three sentences of the substantiation because protection equivalent to that of a key operated switch or access code can be provided via a Man Machine Interface or a touch screen. The operation mode switches are judged to a different standard making equivalent protection difficult to determine.

The committee understands that this action is already incorporated in Proposal 79-62 (Log #46) [Clause 9].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 23
NEGATIVE: 2
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
THOMAS PILZ, Pilz Industrial Electronics L.P.

This comment is in support of the committee action to accept in principle to include a definition for safety control circuit. However, I suggest adding the following sentence to the wording suggested by the committee:

... not initiate machine operation. The mode selection switch therefore shall be incorporated into the safety circuit of the machine ...

Substantiation: The added sentence gives additional guidance towards the design of a safe machine. A selection of the wrong operation mode by a system fault can lead to a hazardous condition, therefore the operation mode selection must be treated like the highest selectable hazardous mode. This requires the incorporation of the mode selection switch into the safety circuit.

SAUNDERS: The first sentence of the revised text in the Committee action should also be deleted. If the requirements of the second and third sentences are followed, the hazardous condition indicated in the first sentence will never occur, therefore the sentence is unnecessary.

79-71 - (9.2.4.1): Accept
SUBMITTER: Thomas Pilz, Pilz Industrial Electronics L.P.

RECOMMENDATION: Old
9.2.4.1 Overriding of safeguards.
Where it is necessary to temporarily override one or more safeguards a mode selection device or means capable of being secured (e.g. locked) in the desired mode shall be provided to prevent automatic operation. In addition, one or more of the following measures should be provided:

(1) Initiation of motion by a hold-to-run or other control device
(2) A portable controls station (e.g. pendant) with an emergency stop device, and where appropriate, an enabling device. Where a portable station is used, motion shall only be initiated from that station
(3) Limiting the speed or the power of motion
(4) Limiting the range of motion.
New
9.2.4.2 Where it is necessary to temporarily override one or more safeguards a mode selection device or means capable of being secured (e.g. locked) in the desired mode shall be provided to prevent automatic operation. The control circuit for the suspension of a safeguard shall have the same safety requirements as the suspended safeguard itself. In addition, one or more of the following measures should be provided:

(1) Initiation of motion by a hold-to-run or other control device
(2) A portable controls station (e.g. pendant) with an emergency stop device, and where appropriate, an enabling device. Where a portable station is used, motion shall only be initiated from that station
(3) Limiting the speed or the power of motion
(4) Limiting the range of motion.

COMMITTEE ACTION: Accept.

I editorially revise "should" to "shall" in the proposed revision.

COMMITTEE STATEMENT: The committee understands that this proposal will modify Proposal 79-62 (Log #46) [Clause 9].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 23
NEGATIVE: 2
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:
PILZ: I agree with Mr. Bloodgood's Explanation of Negative Vote on Proposal 79-77 (Log #12).

SAUNDERS: The change to require "the same safety requirements" has been rejected in several other proposals of this same nature as "introducing a concept outside the scope of NFPA 79" (see Committee Statement for Proposal 79-64 (Log #149). The committee action to change the "should" to "shall" is acceptable to match the existing paragraph 9.15 in NFPA 79 – 1997.

COMMENT ON AFFIRMATIVE:
DEFELICE: The second sentence of the proposed language should be modified as follows:

"The control circuit for the suspension of a safeguard shall have the same safety requirements provide the same level of safety as the suspended safeguard itself." Interpretation of the "same safety requirements" is difficult; as it may be thought to require total component redundancy. We believe that the proposed change meets the submitter's intent while providing clarity to the reader.
understand that when we use words such as "integrity" or "safety" to refer to the use of electronic or programmable components. It is imperative to ensure that safety related control systems employed electronic or programmable components in critical or hazardous applications. (c) Incorporate at least one passive, self-monitored electromechanical device as back-up to ensure a line disconnect in case of a failure of the solid state components (d) Be designed such that any single safety related component or firmware failure shall (1) Prevent harm to personnel or damage to equipment. (2) Have a redundant microprocessor in conjunction with firmware to process the signals from the light beam to the actuator. However, the wording of NFPA 79 does not allow for those widely used components to be used in E-stop category 0 circuits. In addition, there are programmable safety systems on the market that have been approved by a third party in Europe to be suitable for the use in this area. Therefore, this proposal should be rejected.

COMMITTEE ACTION: Accept in Principle.

SUBMITTER: John B. Deam, Rep. The Association for Manufacturing Technology

RECOMMENDATION: Add to proposed rewrite of Clause 20, that "prevent unintended start-up of equipment upon correction of the failure." Then at the end of the line identified as "(a.2)" change the period to a comma and add the word "and".

SUBSTANTIATION: This additional requirement is needed to prevent harm to personnel or damage to equipment.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: This additional requirement is needed to prevent harm to personnel or damage to equipment.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26 VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25 NOT RETURNED: 1 Norman

EXPLANATION OF VOTE:

BLOODGOOD: See my Explanation of Negative for Proposal 79-77 (Log #12).

FISHER: There may be occasions where it is advantageous to employ electronic or programmable components in critical or safety related control circuits and it is known that there are persons capable of designing safety related control systems that employ electronic or programmable components. It is imperative to understand that when we use words such as "integrity" or "safety" within the context of a control system we are talking about system attributes. In order for the system to have a certain level of integrity there may be a need to have components with special capabilities or attributes. However, the use of components with special capabilities or attributes in a system will not assure that the system achieves the intended or required integrity. The safety related component or system integrity is not simply a function of the system design. The focus of this proposal is on the components, and not on the system, with the final requirement for the component being third party certification. There are many components certified for use as safety components by adding redundancy into the devices. The missing link is not the component with special capabilities or attributes. Rather, the missing link is an approved application standard to guide the development of safety related control systems incorporating electronic or programmable components. Such standards are not under development but will not be ready within the next year or two. UL 1998, mentioned in the substantiation, is not that application standard as noted in the following excerpts from its Preface and Scope:

"The requirements in UL 1998 are applicable when used in conjunction with an application-specific standard that contains requirements for safety-related functions implemented using software. UL 1998 does not apply to software in programmable components used in general purpose applications where the risks for the end-application cannot be identified." (Scope) "1.1 These requirements apply to non-networked embedded microprocessor-based computer equipment where the software is capable of resulting in a risk of fire, electric shock, or injury to persons. 1.4 These requirements are intended to supplement applicable product or component standards and requirements, and are not intended to serve as the whole basis for investigating the risk of fire, electric shock, or injury to persons." In short, this standard is neither a product standard nor a safety related system application standard. It is a software standard. It cannot substitute for what we described as the missing link. Without an appropriate application standard to which system compliance can be required, providing allowance in this standard for this kind of system would require provision of all the necessary requirements in this standard. This would appear to be an unrealistically ambitious task at this time. Certainly, such requirements would need to be much more comprehensive than any single failure shall... and "shall supply the same degree of safety achieved by using hardwired/hardware components". Therefore, this proposal should be rejected.

PADDLE: I agree with Mr. Fisher's Explanation of Negative Vote.

COMMITTEE STATEMENT:

The requirements in UL 1998 are applicable when used in conjunction with an application-specific standard that contains requirements for safety-related functions implemented using software. UL 1998 does not apply to software in programmable components used in general purpose applications where the risks for the end-application cannot be identified." (Scope) "1.1 These requirements apply to non-networked embedded microprocessor-based computer equipment where the software is capable of resulting in a risk of fire, electric shock, or injury to persons. 1.4 These requirements are intended to supplement applicable product or component standards and requirements, and are not intended to serve as the whole basis for investigating the risk of fire, electric shock, or injury to persons." In short, this standard is neither a product standard nor a safety related system application standard. It is a software standard. It cannot substitute for what we described as the missing link. Without an appropriate application standard to which system compliance can be required, providing allowance in this standard for this kind of system would require provision of all the necessary requirements in this standard. This would appear to be an unrealistically ambitious task at this time. Certainly, such requirements would need to be much more comprehensive than any single failure shall... and "shall supply the same degree of safety achieved by using hardwired/hardware components". Therefore, this proposal should be rejected.
SUBSTANTIATION: This additional requirement is needed since neither the current version 2000 of IEC 60204-1, nor the current version 1997 of NFPA 79 allow the use of electronic logic systems to control a category 0 emergency stop function. The use of such systems for use in the stop function of last resort is yet to be endorsed by many designers and users alike. Nor does there appear to be credible evidence that recognized third parties approve this provision for this specific purpose.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: See the Committee Action and Statement on Proposal 79-77 (Log #12)

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79-76 - (9.6.3 [9.2.5.4.2.4]): Accept in Principle

SUBMITTER: William E. Anderson, The Procter & Gamble Company

RECOMMENDATION: Revise the following paragraph (9.2.5.4.2.4 Exception)

9.2.5.4.2.4 Where a category 0 stop is used for the emergency stop function, it shall have hardwired electromechanical components. Exception: An electronic logic system that complies with 11.3.4 shall be permitted. The final removal of power shall be accomplished by means of electromechanical components.

SUBSTANTIATION: The requirement is covered in NFPA 79 proposed 2002 Edition 11.3.4 Use in Safety-related functions. The reference number was shifted in final version of Clause 11.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See Committee Action on Proposal 79-72 (Log #150)

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24

NEGATIVE: 1

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

BLOODGOOD: See my Explanation of Negative for Proposal 79-77 (Log #12).  I do not agree with Mr. Anderson’s submission.  Safety-related software and firmware-based controllers and communication networks should be capable of performing all safety-related functions, including emergency stop.  The use of hardwired electromechanical components is extremely restrictive and does not provide a sufficient degree of safety.  The economic benefits of using microprocessor redundancy and firmware-based redundant components have been widely recognized and accepted.  In addition, the extra cost of using hardwired components is never justified.

NOT RETURNED: 1 Norman

79-77 - (9.6.3, 9.x.x (New) [9.2.5.4.2.4]): Accept in Principle

SUBMITTER: Thomas Pilz, Pilz Industrial Electronics L.P.

RECOMMENDATION: Revise text as follows:

"Where a Category 0 stop is used for the emergency stop function, it shall be designed with hardwired electromechanical components. In addition, its operation shall not depend on electronic logic (hardware or software) or the transmission of commands over a communications network or link."

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: This proposal modifies the Committee Action on Proposal 79-77 (Log #12).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 22

NEGATIVE: 3

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

BLOODGOOD: Proposals 79-77 (Log #12), 79-76 (Log #25), 79-72 (Log #150), 79-73 (Log #155), 79-76 (Log #171) 1 disapprove of the Committee Action on Proposal 79-77 (Log #12) as this is an attempt to redefine Category 0. Also, there are communication standards which preclude the transmission of an Emergency Stop Command over the network (e.g. ISO 9506 – MMS). It is noted that when ‘Category 0’ was created it was done with the understanding that there are cases where programmable electronic devices and communication networks were not suitable for emergency stop no matter what precautions or design requirements were taken. In seq # 79-73 – (Log #155) what is meant by line disconnect? To me it implies that the emergency stop control is disconnected from the supply. Not normally a good idea. Also there is no provision for this in IEC 60204-1.

I support the NEMA reasoning for the rejection of these proposals. I prefer the modifications to 11.3.4 made by the Committee except that the Heading ‘Use in safety-related functions’ should be changed to ‘Use in safety functions’ (See CP4). Same for 11.3.4(c). Also there is a discrepancy between the Committee Action on Proposal 79-77 (Log #12) and 79-72 (Log #150). 79-73 (Log #155).

PADGET: I agree with Mr. Bloodgood’s Explanation of Negative Vote.

79-78 - (9.6.3.1 [9.2.5.4.2]): Reject

SUBMITTER: Gordon T. Davis, Moeller Electric Corp.

RECOMMENDATION: New 9.6.3.1 The safety related parts of an emergency stop circuit shall be so designed that a single fault in any of these parts does not lead to the loss of the safety function.

SUBSTANTIATION: A fault tolerant emergency stop circuit adds a degree of additional safety to this critical safety circuit.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The proposed requirement is normally associated with applications when the risk assessment has identified the need to have safety related parts in accordance with the requirements of EN954 category 3 or 4. This requirement for all applications is unduly restrictive and may in fact not provide additional safety.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24

NOT RETURNED: 1 Norman

1576
Hinged or sliding doors providing access to moving parts shall be interlocked to prevent the operation of the equipment when the doors are opened.

Substantiation: This requirement is essential to assure the safety of production and maintenance personnel. It still permits OEM's the option to provide "fixed" guarding, by the use of bolts or other such means, which would require the use of tools and deliberate action to remove. "Fixed" guarding would not require interlocked switches to detect door closure.

I believe that any hinged or sliding door which allows access to moving parts during equipment operation poses a safety hazard to personnel. Therefore, it becomes the responsibility of the engineering community to ensure that safeguards are in place to prevent such hazards. Furthermore, since equipment safety falls under the scope of NFPA 70, any requirements which enhance and promote personnel safety should be included in that document.

Removed the phrase "through limit switches or other means" to reflect the Committee Action on Proposal 79-79 (Log #116), stating the requirement of Listed Safety Switches when used for guard doors. The requirement does not need to be re-stated in Proposal 79-80 (Log #117).

The word "ready" and phrase "compartment containing belts, gears, or other" were removed to clarify the intent to protect against exposure to moving parts.

Removed the phrase "that may expose hazardous conditions" to clarify intent and follow definitions in Chapter 3. (Only defines hazard and hazardous situations)

Removed "closed with" opened for clarity.

Removed last sentence. This is too vague and does not mandate compliance with a specific standard. It only lists an example which would move to the back of the document as a note. Does not aid in clarifying the intent of the requirement.


---

97-79 - (9.10 [9.3,6]): Accept in Principle

SUBMITTER: Pat Hodge, Visteon Corp

RECOMMENDATION: Provided that 9.10 "Machinery door interlocking" is retained from NFPA 79 1997 edition, revise text as follows:

"Hinged or sliding doors providing ready access to compartments containing belts, gears, or other moving parts that may expose hazardous conditions shall be interlocked through limit switches or other means, which would require the use of tools and deliberate action to remove. "Fixed" guarding would not require interlocked switches to detect door closure.

I believe that any hinged or sliding door which allows access to moving parts during equipment operation poses a safety hazard to personnel. Therefore, it becomes the responsibility of the engineering community to ensure that safeguards are in place to prevent such hazards. Furthermore, since equipment safety falls under the scope of NFPA 70, any requirements which enhance and promote personnel safety should be included in that document.

Removed the phrase "through limit switches or other means" to reflect the Committee Action on Proposal 79-79 (Log #116), stating the requirement of Listed Safety Switches when used for guard doors. The requirement does not need to be re-stated in Proposal 79-80 (Log #117).

The word "ready" and phrase "compartment containing belts, gears, or other" were removed to clarify the intent to protect against exposure to moving parts.

Removed the phrase "that may expose hazardous conditions" to clarify intent and follow definitions in Chapter 3. (Only defines hazard and hazardous situations)

Removed "closed with" opened for clarity.

Removed last sentence. This is too vague and does not mandate compliance with a specific standard. It only lists an example which would move to the back of the document as a note. Does not aid in clarifying the intent of the requirement.

individually or in combination, depend on the safety requirements associated with the respective application (see 4.1).

Note 1: Measures to reduce these risks include but are not limited to:
- To read as follows:
  Note 1: Measures to reduce these risks from failures or disturbances in the electrical equipment that cause a hazardous condition or damage to the machine or the work in progress include but are not limited to:

SUBSTANTIATION: When the material was moved from the text to a note and with the fact that the new format will place the note in a remote location in the document, the connection with the pronoun "these" became completely unclear. The proposal repeats the original referred language in place of "these" in Note 1.

COMMITTEE ACTION: Accept

In Note 1 of 9.4 of Proposal 79-62 (Log #46), editorially correct the phrase "...that cause..." to "...that could cause...".

COMMITTEE STATEMENT: The committee understands that this proposal only modifies the note 1 of 9.4 in Proposal 79-62 (Log #46) [Clause 9].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79-83 - (9.16 (New) [9.4.1 (Note)]): Reject

SUBMITTER: Thomas Pilz, Pilz Industrial Electronics L.P.

RECOMMENDATION: Old

Note 2.3 Use of diversity

The use of control circuits having different principles of operation or differing types of devices may reduce the probability of faults and failures giving rise to hazards. Examples include:
- (1) The combination of normally open and normally closed contacts operated by interlocking guards, while only the normally open contact shall be operated when the safe guard is in the closed position.
- (2) The use of different types of control circuit components in the circuit.
- (3) The combination of electromechanical and electronic circuits in redundant configurations.
- (4) The combination of electrical and non-electrical systems (e.g., mechanical, hydraulic, pneumatic) may perform the redundant function and provide the diversity.

New

Note 2.3 Use of diversity

The use of control circuits having different principles of operation or differing types of devices may reduce the probability of faults and failures giving rise to hazards. Examples include:
- (1) The combination of normally open and normally closed contacts operated by interlocking guards, while only the normally open contact shall be operated when the safe guard is in the closed position.
- (2) The use of different types of control circuit components in the circuit.
- (3) The combination of electromechanical and electronic circuits in redundant configurations.
- (4) The combination of electrical and non-electrical systems (e.g., mechanical, hydraulic, pneumatic) may perform the redundant function and provide the diversity.

SUBSTANTIATION: Wording changed to reduce the possibility of misinterpretation. See EN 1088 picture.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT: Unfortunately the terms normally open and normally closed are ambiguous at best when applying to guard door-interlocking devices. The normally position for a safety guard in a guard door switch is when the guard is in the closed or safe position. In other devices the normal position is as found on the shelf (without power). The additional proposed phrase adds no additional clarity to the situation.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 23

NEGATIVE: 2

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

GARVEY: I agree with the substantiation. The added text clarifies the intent of the requirement and gives specific guidance to the designer.

PILZ: I disagree with the committee action to reject the proposal.

I suggest changing the committee action to "accept".

Substantiation: I disagree with the statement of the committee that the terms normally open and normally closed are ambiguous, it is commonly understood that devices are incorporated into circuitry schematic in the de-energized mode as found on the shelf. This is where the terms normally open and normally closed originate. To bring conformity into the circuitry drawings. Every electrician knows this when reading a circuit diagram. When incorporated into a safety gate the normally open contact is actuated when the gate is closed. This means that the normal position of the contact during the operation of the machine is in the energized state and not in the de-energized state as drawn into the drawings. In order to point this out to the user of NFPA 79, the new wording was added. To me the committee statement is substantiation for the inclusion of the wording rather than to reject it, which in turn suggests the conclusion that the added wording should be accepted.

79-84 - (Clause 11 [Clause 12]): Accept in Principle

SUBMITTER: Dick Bromstad, Commonwealth Systems

RECOMMENDATION:

12 Control equipment, location, and enclosures

12.1 General requirements

12.1.1. All control equipment shall be located and mounted so as to facilitate:
- Its accessibility and maintenance;
- Its protection against the external influences or conditions under which it is intended to operate;
- Operation and maintenance of the machine and its associated equipment.

12.1.2. For minimum construction requirements, see UL 508 & U.L. 50 for metallic and nonmetallic enclosures.

12.1.3. The depth of the enclosure or compartment including doors or covers shall not be less than the maximum depth of the enclosed equipment plus the required electrical clearances.

12.1.4. Any door(s) that permits access to live parts shall comply with 6.3.2.5.

12.2 Location and mounting

12.2.1. Accessibility and maintenance

12.2.1.1. All items of control equipment shall be placed and oriented so that they can be identified without moving them or the wiring. Where practicable, items that require checking for correct operation or that are liable to need replacement, those actions shall be possible without dismantling other equipment or parts of the machine (except opening doors or removing covers).

Terminals not associated with control equipment shall also conform to these requirements.

12.2.1.2. Exposed, nonarcing, bare, live parts within an enclosure or compartment shall have an air space of not less than 15 mm (1/2 inch) between them and the uninsulated walls of the enclosure or compartment, including conduit fittings. The air space for uninsulated covers or doors of the enclosure shall be not less than 25 mm (1 inch). Where barriers between metal enclosures or compartments and energizing parts are required, they shall be of flame-retardant, noncarbonizing insulating materials.

12.2.1.3. All control equipment shall be mounted so as to facilitate its operation and maintenance. Where a special tool is necessary to remove a device, such a tool shall be supplied.

Note: Where access is required for regular maintenance or adjustment, it is recommended that the relevant devices be located between 0.4m (15.75 inches) and 2.0m (78.75 inches) above the servicing level and be so placed that conductors and cables can be easily connected to them.

12.2.1.4. Threaded fasteners with machine threads shall be used to attach components to a sub plate and shall provide sufficient thread engagement to maintain secure mounting.

12.2.1.4.1. Steel sub plate thickness shall provide engagement of at least 2 full threads.

12.2.1.4.2. Aluminum sub plate thickness shall provide engagement of at least 3 full threads.

12.2.1.4.3. Thread cutting or thread forming screws shall be permitted if the above thread engagement requirements are met.

12.2.1.4.4. Sheet metal screws, rivets, welds, solders, or bonding materials shall not be used to mount components to a sub plate. Exception: Rivets shall be permitted to be used for attaching mounting rails and wiring channels.

12.2.1.5. Swing frames or swing out panels shall be permitted, provided the swing is more than 110 degrees. Wiring shall not inhibit swing. Panel-mounted components behind swing frames shall be accessible when open.
12.2.1.7 Where control devices are connected through plug-in arrangements, their association shall be made clear by type (shape), marking or reference designation, singly or in combination.

Note: 14.4.5 contains additional information on attachment plug and receptacle (plug/socket) combinations.

12.2.1.8. Attachment plugs and receptacles (plug/socket) combinations that are handled during normal operation shall be located and mounted as to provide unobstructed access.

12.2.1.9. Test points, where provided, shall be mounted to provide unobstructed access, plainly marked to correspond with markings on the drawings, adequately insulated, and sufficiently spaced for connection of test leads.

12.2.2 Physical separation or grouping

12.2.2.1. Machine compartments containing control equipment (built-in control) shall be completely isolated from coolant and oil reservoirs. The compartment shall be readily accessible and completely enclosed; it shall not be considered enclosed where it is open to the floor, the foundation upon which the machine rests, or other compartments of the machine that are not clean and dry.

12.2.2.2. Pipelines, tubing, or devices (e.g., solenoid valves) for handling air, gases, or liquids shall not be located in enclosures or compartments containing electrical control equipment.

Exception: Equipment for cooling electronic devices.

12.2.2.3. Control devices mounted in the same location and connected to the supply voltage, or to both supply and control voltages, shall be grouped separately from those connected only to the control voltages.

12.2.2.4. Terminals shall be separated into groups for: power circuits; associated control circuits; other control circuits, fed from external sources (e.g. for interlocking).

12.2.2.5. The groups shall be permitted to be mounted adjacently, provided that each group can be readily identified (e.g. by markings, by use of different sizes, by use of barriers, by colors).

12.2.3. Heating effects

Heat generating components (e.g. heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the component manufacturers specified limits.

12.3 Degrees of protection

12.3.1 The protection of control equipment against ingress of solid foreign objects and of liquids shall be adequate taking into account the external influences under which the machine is intended to operate (i.e. the location and the physical environmental conditions including dust, coolants, and swarf.)

NOTE: The degrees of protection against ingress of water and other liquids are covered by NEMA 250. See also Annex H.

12.3.2. Enclosures of control equipment shall provide a degree of protection of at least NEMA Type 1.

Exception No.1 Where removable collectors on collector wire or collector bar systems are used and NEMA Type 1 enclosures are not practicable, suitable protection shall be provided (e.g. elevation, guarding.)

12.4 Enclosures, doors, and openings

12.4.1. Enclosures shall be constructed and finished using materials capable of withstanding the mechanical, electrical and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service.

12.4.2. Where corrosion protection beyond normal requirements is needed, non-metallic enclosures identified for the purposes shall be permitted if they meet the requirements of UL 508.

12.4.3. Subplates having a surface area of more than 15,484 sq.cm (2400 sq. in.) shall have supports provided in addition to the panel mounting means to aid in subplate installation.

12.4.4. Enclosures and sub plates shall be free of burrs and sharp edges.

12.4.5. The exterior of the enclosure shall include a protective finish suitable for the intended environment.

12.4.6. Fasteners used to secure doors and covers shall be of the captive type. Windows provided for viewing internally mounted indicating devices should be of a material suitable to withstand mechanical stress and chemical attack (e.g. toughened glass, polycarbonate sheet of 3mm (1/8-in.) thickness).

12.4.7. Door fasteners on enclosures and compartments with door openings less than 1016 mm (40 in.) shall be designed to seal the door tightly around its perimeter with either captive fasteners or vault type hardware which latch at the top and bottom.

12.4.8. Door fasteners on enclosures and compartments with door openings 1016 mm (40 in.) tall or more shall be designed to seal the door tightly around its perimeter with either captive fasteners or vault type hardware which latch at the top, center and bottom.

12.4.9. A print pocket sized to accommodate electrical diagrams shall be attached to the inside of the door of the control enclosure or compartment. Single-door and multitdoor enclosures shall have at least one print pocket.

12.4.10. The joints or gaskets of doors, lids, covers, externally mounted accessories, interconnect panels and enclosures shall withstand the deleterious effects of liquids, vapors, or gases used on the machine. The means used to maintain the degree of protection of an enclosure on doors, lids and covers that require opening or removal for operation or maintenance shall be securely attached to either the door/covers or the enclosure and not deteriorate due to removal or replacement of the door or the cover, and so impair the degree of protection.

12.4.11. All openings in the enclosure, including those towards the floor or foundation or to other parts of the machine, shall be closed by the supplier(s) in a manner ensuring the protection specified for the equipment. Openings for cable entries shall be easily re-opened on site. A suitable opening shall be permitted in the base of enclosures within the machine so that moisture due to condensation is allowed to drain.

12.4.12. There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating or hydraulic fluids, or those into which oil, other liquids, or dust can penetrate. This requirement does not apply to electrical devices specifically designed to operate in oil (e.g. electromagnetic clutches) nor to electrical equipment in which coolants are used.

12.4.13. Where there are holes in an enclosure for mounting purposes, care shall be taken so that after mounting, the holes do not impair the required protection.

12.4.14. Equipment that, in normal or abnormal operation, can attain a surface temperature sufficient to cause a risk of fire or harmful effect to an enclosure material:

- Shall be located within an enclosure that will withstand, without risk of fire or harmful effect, such temperatures as may be generated; and
- Shall be mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see also 12.2.3); or
- Shall be otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment.

12.5 Access to control equipment

12.5.1. Working clearances: Sufficient space and access shall be provided about all electrical equipment and enclosures to permit safe operations and maintenance of such equipment. In all cases, the workspace shall permit at least 90-degree opening of the door or hinged panel.

12.5.2. Access to control equipment shall be in accordance with NFPA 70, Section 110-26 for the requirements for working space in the direction of access to live parts operating at 600 volts nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized.

Note: Additional clearance requirements are found in NFPA 70, 670-5.

12.5.3. Door in gangways and for access to electrical operating areas shall be at least 0.7m wide and 2.0m (6 ft. 7 in.) high; open outwards; have a means (e.g. panic bolts or panic bars) to allow opening from the inside without the use of a key or tool. [add English units and remove , adding decimal]

12.6 Machine-mounted control equipment
12.6.1 Control equipment (e.g. limit switches, brakes, solenoids, position sensors) shall be mounted rigidly in a reasonably dry and clean location, shall be protected from physical damage, and shall be free from the possibility of accidental operation by normal machine movements or by the operator. Such equipment shall be mounted with sufficient clearance from surrounding surfaces to make its removal and replacement easy and shall have a suitable enclosure for the termination of conduit as well as provisions for making electrical connections.

Exception No. 1: A solenoid sealed in an individual oil-filled container shall be permitted.

Exception No. 2: Pre wired devices, e.g. limit switches, proximity switches, provided with an identified (see 3.49) cable need not be equipped with provisions for termination of conduit.

12.6.2 All limit switches or position sensors shall be installed so that accidental over travel by the machine will not damage the limit switch or sensor.

12.6.3 Solenoids for operating devices shall be mounted so that liquids shall drain away from the electrical component enclosure.

**SUBSTANTIATION:**
Clause 12 Substantiation and Comments

12.0 Title covers existing NFPA 79 clauses 11 & 12. The clause title is changed from (11) Control Enclosures & Compartments & (12) Location & Mounting of Control Equipment to Control Equipment; location, mounting and enclosures. Combine the appropriate text of NFPA 79-1997 into a new combined clause.

12.1 The sub-clause title was changed from "Type" to "General Requirements." More clearly reflect the content.

12.1.1 Recommendation: Accept new text. Substantiation: The present text including the exception was too specific for general requirements. The intent is to provide guidance for minimum construction of enclosures but not mandate a listing requirement.

12.1.2 The proposed NFPA 79 text was accepted in order to provide guidance for minimum construction of enclosures but not mandate a listing requirement. This will replace 11.2 & 11.4 with 12.1.2

Reference to UL 50 is added to encompass enclosure construction details. UL 50 covers more than just industrial machine applications (e.g. junction boxes, cabinets and cutout boxes) and the applicable requirements of UL 50 are presently included in UL 508.

UL 508 covers industrial control enclosures that may be for individual components as well as a group of components within a common enclosure and provides information for enclosure sizes based upon their wall thickness.

12.1.3 Accept proposed new text and add a note to provide guidance to location of components and to facilitate maintenance. The special tool is provided to assist in the maintenance of the machine where such parts must be removed.

12.1.4 Recommendation. Add new text. Substantiation: Provide a base line standard for mounting components. Add an exception for mounting rails and wiring channels.

12.1.5 Accept proposed new text for mounting plate information for steel.

12.1.6 Accept proposed new text for mounting plate information for aluminum.

12.1.7 Accept proposed new text for thread cutting.

12.1.8 Accept proposed new text to state what is not acceptable for component mounting.

12.1.9 Accept proposed to provide information on swing frames and panels.

12.1.10 Accept new text providing information dealing with door mounted devices.

12.1.11 Accept new text providing information through plug in devices.

12.1.12 Accept proposed new text for attachments of plugs and receptacles.

12.1.13 Retained present text and renumbered.

12.2 Accept proposed new title (Physical Separation or Grouping) as more descriptive.

12.2.1.1 Accept proposed new title (Accessibility & Maintenance). Provides additional information.

12.2.1.2 Accept proposed new text because it provides more comprehensive requirements for accessibility and serviceability.

12.2.2 Move NFPA 79 12.1.2 to proposed 12.2.2 "Physical separation and grouping."

12.2.2 Accept proposed new text providing additional information on devices and terminals.

12.2.2.3 Recommendation: Add new text. Substantiation: Accept proposed new text providing information on locating of heat generating components. This is necessary because excessive heat can impact the reliability of sensitive components. Compliance with UL 508 is considered to comply with this requirement.

12.2.2.5 Accept proposed new text providing information on terminal separation.

12.2.2.6 Accept proposed new text providing additional information on devices and terminals.

12.2.3 Recommendation: Add new text. Substantiation: Accept proposed new 12.3 title (Degrees of Protection), 12.3.1 & 12.3.2 text. Providing information for environmental protection of swarf, etc.

12.2.3.1 Recommendation: Added new text that gives general requirements for control enclosures. Substantiation: These concepts are similar to the requirements of NFPA 70-1997, 11.1.2 and 12.4.

12.2.3.2 Recommendation: Added new text that sets a minimum level of acceptable environmental protection with exceptions. Substantiation: This sets the minimum level of protection for the enclosure. NFPA 79-1997 did not contain such a minimum requirement.
12.4 Added new title 12.4 (Enclosures, doors and opening), and new paragraphs 12.4.1, 12.4.2, 12.4.3, 12.4.4 & 12.4.5.

Substantiation: These requirements provide information on enclosure finishing, corrosion protection, supporting, sharp edges and exterior details. NFPA 79-1997 did not contain such a minimum requirement.

NFPA 79-1997, 11.9

Recommendation: Delete this section.

Substantiation: This requirement is too restrictive.

12.4.6 Accept proposed new text accepted to provide door, cover and window requirements.

12.4.7 & 12.4.8 Recommendation: Revise NFPA 79-1997, 11.6 by removing the requirements for hinged doors and adding specific requirements for fasteners and deleting the exception.

Substantiation: Accept proposed 12.4.7 and 12.4.8 text as more descriptive and complete. The referenced UL Standards in 12.1.2 covers the performance requirements, such as door thickness and fasteners.

12.4.9 Deleted title and absorbed text (12.4.9)

12.4.10 Deleted title and accepted proposed new text providing additional detail.

12.4.11, 12.4.12, 12.4.13 & 12.4.14 Accepted proposed new text to cover openings in and between enclosures. Additionally providing information for openings in enclosures and normal and abnormal surface temperatures.

12.5 Accept proposed new title (Access to Control Equipment), 12.5.1 & 12.5.2 text for working clearances.

12.6 Retained NFPA 79 text and numbering sequence.

Clause 12 Cross Ref.

NFPA 79 1997 NFPA 79 2002

Clauses 11 & 12 Clause 12

11 12
11.1 12.1
11.1.1 & 11.1.2 12.1.1
11.2 & 11.4 12.1.2
11.5 12.1.3
11.8 12.1.4
12 12.2
12.1 12.2.1
12.1.1 12.2.1.1
12.1.2 12.2.1
12.5.2 12.2.1.2
12.2.5, 12.2.6 & 12.3 12.2.1.3
12.2.1.4
12.2.1.4.1
12.2.1.4.2
12.2.1.4.3
12.2.1.4.4
12.2.1.5
12.2.1.6.
12.2.1.7
12.2.1.8
12.2.1.9
11.3 12.2.2

COMMITTEE ACTION: Accept in Principle.

Revise text to read as follows:

12 Control equipment: location, mounting, and enclosures

12.1 General requirements

12.1.1. All control equipment shall be located and mounted so as to facilitate:

- Its accessibility and maintenance;
- Its protection against the external influences or conditions under which it is intended to operate;
- Operation and maintenance of the machine and its associated equipment.

12.1.2. For minimum Minimum construction requirements, enclosures shall comply with UL 508 & and U.L. 50 for metallic and nonmetallic enclosures.

12.1.3. The depth of the enclosure or compartment including doors or covers shall not be less than the maximum depth of the enclosed equipment plus the required electrical clearances.

12.1.4. Any door(s) that permits access to live parts shall comply with s.3.2.5.

12.2 Location and mounting

12.2.1 Accessibility and maintenance

12.2.1.1. All items of control equipment shall be placed and oriented so that they can be identified without moving them or the wiring. Where practicable, items that require checking or adjustment for correct operation or that are liable to need
shall be of the manufacturers specified limits.

Heat generating components (e.g. heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the component markings and be so placed that conductors and cables can be easily adjusted. It is recommended that the relevant devices be located between 0.4 m (13.75 inches) and 2.0 m (78.75 inches) above the servicing level to facilitate maintenance. It is recommended that terminals be at least 0.2 m (7.88 inches) above the servicing level and be so placed that conductors and cables can be easily connected to them.

12.2.1.4 Threaded fasteners with machine threads shall be used to attach components to a sub plate and shall provide sufficient thread engagement to maintain secure mounting.

Steel sub plate thickness shall provide engagement of at least 2 full threads.

12.2.1.5.1 Aluminum sub plate thickness shall provide engagement of at least 3 full threads.

Thread cutting or thread forming screws shall be provided if the above thread engagement requirements are met.

Sheet metal screws, rivets, welds, solders, or bonding materials shall not be used to mount components to a sub plate.

12.2.1.5.4. Exception: Rivets shall be permitted to be used for attaching mounting rails and wiring channels.

Swing frames or swing out panels shall be permitted, provided the swing is more than 110 degrees. Wiring shall not inhibit swing. Panel-mounted components behind swing frames shall be accessible when open.

12.2.1.5 Where control devices are connected through plug-in arrangements, their association shall be made clear by type (shape), marking or reference designation, singly or in combination.

Note: 14.4.5 contains additional information on attachment plug and receptacle (plug/socket) combinations.

12.2.1.5.6 Attachment plugs and receptacles (plug/socket) combinations that are handled during normal operation shall be located and mounted as to provide unobstructed access.

Test points, where provided, shall be mounted to provide unobstructed access, plainly marked to correspond with markings on the drawings, adequately insulated, and sufficiently spaced for connection of test leads.

12.2.2 Physical separation or grouping

Machine compartments containing control equipment (built-in control) shall be completely isolated from coolant and oil reservoirs. The compartment shall be readily accessible and completely enclosed; it shall not be considered enclosed where it is open to the floor, the foundation upon which the machine rests, or other compartments of the machine that are not clean and dry.

12.2.2.2 Pipelines, tubing, or devices (e.g. solenoid valves) for handling air, gases, or liquids shall not be located in enclosures or compartments containing electrical control equipment.

Exception: Equipment for cooling electronic devices.

12.2.2.3 Control devices mounted on the same location within the control enclosure and connected to the supply voltage, or to both supply and control voltages, shall be grouped separately from those connected only to the control voltages.

12.2.4 Terminals shall be separated into groups for: power circuits; associated control circuits; other control circuits, fed from external sources (e.g. for interlocking).

12.2.2.5 The groups shall be permitted to be mounted adjacent, provided that each group can be readily identified (e.g. by markings, by use of different sizes, by use of barriers, by colors).

12.2.3 Heating effects. Heat generating components (e.g. heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the component markings and be so placed that conductors and cables can be easily handled.

12.3 Degrees of protection.

12.3.1 The protection of control equipment against ingress of solid foreign objects and of liquids shall be adequate taking into account the external influences under which the machine is intended to operate (i.e. the location and the physical environmental conditions) including dust, coolants, and swarf.

NOTE —The degrees of protection against ingress of water and other liquids are covered by NEMA 250. See also annex H.

12.3.2 Enclosures of control equipment shall provide a degree of protection of at least NEMA Type 1.

Exception No.1 Where removable collectors on collector wire or collector bar systems are used and NEMA Type 1 enclosures are not practicable, suitable protection shall be provided (e.g. elevation, guarding).

12.4 Enclosures, doors, and openings

12.4.1 Enclosures shall be constructed and finished using materials capable of withstanding the mechanical, electrical and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service.

12.4.2 Where corrosion protection beyond normal requirements is needed, non-metallic enclosures identified for the purposes shall be permitted if they meet the requirements of UL 508.

12.4.3 Subplates having a surface area of more than 13,484 sq cm (2400 sq in.) shall have supports provided in addition to the panel mounting means to aid in subplate installation.

12.4.4 Enclosures and sub plates shall be free of burrs and sharp edges.

12.4.5 The exterior of the enclosure shall:

(1) be of a material suitable for the intended environment, or

(2) include a protective finish suitable for the intended environment.

12.4.6 Fasteners used to secure doors and covers shall be of the captive type. Windows provided for viewing internally mounted indicating devices should be of a material suitable to withstand mechanical stress and chemical attack [e.g. toughened glass, polycarbonate sheet of 3-mm (1/8-in.) thickness].

12.4.7 Door fasteners on enclosures and compartments with door openings less than 1016 mm (40 in.) shall be designed to seal the door tightly around its perimeter with either captive fasteners or vault type hardware which fasts at the top and bottom.

12.4.8 Door fasteners on enclosures and compartments with door openings 1016 mm (40 in.) tall or more shall be designed to seal the door tightly around its perimeter with either captive fasteners or vault type hardware which fasts at the top, center and bottom.

12.4.9 A print pocket sized to accommodate electrical diagrams shall be attached to the inside of the door of the control enclosure or compartment. Single-door and multidoor enclosures shall have at least one print pocket.

12.4.10 The joints or gaskets of doors, lids, covers, externally mounted accessories, interconnect panels and enclosures shall withstand the deleterious effects of liquids, vapors, or gases used on the machine. The means used to maintain the degree of protection of an enclosure on doors, lids and covers that require opening or removal for operation or maintenance shall: be securely attached to either the door/cover or the enclosure; and not deteriorate due to removal or replacement of the door or the cover, and so impair the degree of protection.

12.4.11 All openings in the enclosure, including those towards the floor or foundation or to other parts of the machine, shall be closed by the supplier(s) in a manner ensuring the protection specifically specified for the equipment. Openings for cable entries shall be easily re-opened on site. A suitable opening shall be permitted in the base of enclosures within the machine so that moisture due to condensation is allowed to drain.

12.4.12 There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating or hydraulic fluids, or those into which oil, other liquids, or dust can penetrate. This requirement does not apply to electrical devices specifically designed to operate in oil (e.g. electromagnetic clutches) nor to electrical equipment in which coolants are used.

12.4.13 Where there are holes in an enclosure for mounting purposes, care shall be taken so that after mounting, the holes do not impair the required protection.

12.4.14 Equipment that, in normal or abnormal operation, can attain a surface temperature sufficient to cause a risk of fire or harmful effect to persons or materials shall be located within an enclosure that will withstand, without violation of the enclosure material:

- Shall be located within an enclosure that will withstand, without risk of fire or harmful effect, such temperatures as may be generated; and
- Shall be mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see also 12.2.3); or
- Shall be otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment.

12.5.1 Access to control equipment

12.5.2 Access to control equipment shall be in accordance with NFPA 70, Section 110-26 for the requirements for working space in the direction of access to live parts operating at 600 volts nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized.

Note: Additional clearance requirements are found in NFPA 70, 260.

12.5.3 Door in gangways and for access to electrical operating areas shall: be at least 0.7 m wide and 2.0 m (6 ft 7 in.) high; open outwards; have a means (e.g. panic bolts or panic bars) to allow opening from the inside without the use of a key or tool. [add English units and remove, adding decimal]

12.6 Machine-mounted control equipment

12.6.1 Control equipment (e.g. limit switches, brakes, solenoids, position sensors) shall be mounted rigidly in a reasonably dry and clean location, shall be protected from physical damage, and shall be free from the possibility of accidental operation by normal machine movements or by the operator. Such equipment shall be mounted with sufficient clearance from surrounding surfaces to make its removal and replacement easy and shall have a suitable enclosure for the termination of conduit as well as provisions for making electrical connections.

12.6.2 All limit switches or position sensors shall be installed so that accidental over travel by the machine will not damage the switch or sensor.

12.6.3 Solenoids for operating devices shall be mounted so that liquids shall drain away from the electrical component enclosure.

COMMITTEE STATEMENT:

1) Revise 12.1.2 to comply with the NFPA Manual of Style.
2) Editorially add "or adjustment" to 12.2.1.1.
3) 12.4.6 Delete "and covers". Covers is new material and is unsubstantiated. It does not agree with the definition of cover in UL 50.
4) The revision to Section 12.5 incorporates the Committee Action on Proposal 79-32 (Log #96).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25
NEGATIVE: 1

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

FREUDENBERG: Specifying the type or location of fasteners and other hardware, direction of swing of doors, etc. may inadvertently be limiting the ability of machine suppliers to freely design and build their own enclosures suitable for the intended environment.

COMMENTS ON AFFIRMATIVE:

SAUNDERS: The revision of the definition of live parts from "Electric conductors, buses, terminals, or components that are uninsulated or exposed and a shock hazard exists" to "Energized conductive components" alters the requirement found in 12.5.2 significantly. No substantiation has been submitted to indicate that this previous requirement should be changed.

During the committee meeting, it was recognized that there may be sections where the change in definition may alter the requirements and that these issues should be addressed during the comment stage.

Recommendaion: Revise 12.5.2 to read "access to live parts that are uninsulated or exposed and a shock hazard exists operating at 600 volts nominal...."

79-85 - (Clause 11 [12.2.2]): Accept in Principle

SUBMITTER: George M. Schreck, Komatsu America Industries LLC

RECOMMENDATION: Add new text to read as follows: "Any device(s) mounted on the control panel, carrying line voltage or a combination of line voltage and control voltage, shall be grouped above or to the side and segregated from devices which carry only control voltage.

Devices carrying control voltage other than 115 VAC or a combination of 115 VAC and lower control voltage, shall also be segregated from devices mentioned above. This does not apply where the line voltage is 115 VAC. In no case shall any device be mounted directly above the disconnecting means.

SUBSTANTIATION: Reduction of shock hazard when performing troubleshooting procedures under "powered" conditions. When used with "color coding" of wire conductors allow visual identification to the electrician of the voltage hazard potential.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See Committee Action and Statement on Proposal 79-84 (Log #54) (12.2.2.3 and 12.2.2.4 and 12.2.2.5). See also Committee Action on Proposal 79-53 (Log #59) (5.3.1.3).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-86 - (11.1.1) [12.1.1]): Reject

SUBMITTER: George M. Schreck, Komatsu America Industries LLC

RECOMMENDATION: Revise text as read to follow: Control enclosures and compartments shall be nonventilated with construction and sealing suitable for the intended environment constructed in conformance with the applicable sections of this standard and both of the following:

1. NEMA Type 12 (See NEMA Standard IC-1, Industrial Controls)
2. Underwriter’s Laboratories Standard UL 508, Industrial Control Equipment.

Exception: Equipment normally requiring ventilation may be housed in ventilated enclosures or compartments, provided they are located so that the equipment is capable of operating satisfactorily and without hazard.

SUBSTANTIATION: This allows enclosures to be properly “labeled or identified” by a NRTL for use in the intended industrial environment normally encountered by equipment identified by the ANSI B11 standards.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: This standard covers machines beyond the scope of the ANSI B11 series. Equipment must be selected to be suitable for the environment.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

FREUDENBERG: There is no data as to what percentage of machines are installed in each of the wide range of environments from cleanroom, to office-like, to light industrial, to heavy industrial, to extremely harsh environments including outdoor installations. The general statement “suitable for the intended environment” is appropriate because one generic standard has to fit all industries and all environments for both machines covered by ANSI B11 series and machines not covered by the ANSI B11 series.

79-87 - (11.4 [12.1.2]): Accept in Principle

SUBMITTER: Glen Kampa, Hoffman

RECOMMENDATION: Revise text as follows: 11.4 Minimum wall thickness and construction requirements. The walls of compartments shall not be less than the following: 0.25 in. (6.4 mm) for sheet metal; 1/8 in. (3.2 mm) for cast metal; or 3/32 in. (2.38 mm) for malleable iron.

The minimum enclosure wall thickness and construction requirements shall meet UL 508.
SUBSTANTIATION: The minimum thickness requirement as stated does not take into account the enclosure size. UL 508 has minimum thickness tables based on the height and width of the enclosure. This provides guidance when enclosure sizes require wall thickness greater than the minimum required thickness as currently stated. These tables are constructed based on deflection testing. UL 508 covers construction and testing of steel, aluminum, cast, and composite enclosures. (See the attached minimum sheet metal thickness table).

Note: Supporting material is available for review at NFPA Headquarters.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See Committee Action and Statement on Proposal 79-84 (Log #54) (12.4.6).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 24
NEGATIVE: 1

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:
DEFELICE: Many machine manufacturers construct the electrical enclosures as an integral part of their machine. 12.1.2 mandates that these enclosures be constructed to UL 508 standard. The requirement to construct the enclosure to the UL 508 standard necessitates the purchase of this document ($355.00; almost 15 times the price of NFPA 79-1997). We have seen no evidence which supports the need for this requirement and believe that it is unduly restrictive.

COMMITTEE STATEMENT:

12.1.2 mandates that these enclosures be constructed to UL 508 standard.

AFFIRMATIVE: 25
NEGATIVE: 1

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 24
NEGATIVE: 1

COMMITTEE STATEMENT: The language of proposed Exception No. 5 but move text to be located as new Exception No. 5 to subclause 6.2.3.5. The committee understands that this proposal modifies the Committee Action on Proposal 79-25 (Log #68) [Clause 6].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25
NEGATIVE: 1

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:
SAUNDERS: The panel action on Proposal 79-25 (Log #68) has deleted the referenced paragraph 6.2.3.5.

The requirement for interlocking the enclosure door with the disconnect device furnished within the enclosure should be based on the same requirements whether the enclosure is the "main" control panel for a complex system or an enclosure fed from another "machine power panel" as part of a distributed system. If the interlock requirements are not necessary on the "distributed enclosures", where the hazard of unintended or uncontrolled access "could" be the same as for the "main" control enclosure, then the requirements for the "main" control enclosure should be reevaluated.

The term "main" control enclosure, while often used and generally understood, is not defined in this standard and will cause problems in interpretation and enforcement.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See Committee Action and Statement on Proposal 79-84 (Log #54) (12.4.8).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25
NEGATIVE: 1

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The references in the Committee Statement do not appear to match the proposal. I believe the correct reference is the Committee Statement on Proposal 79-84 (Log #54) (12.4.6).

97-89 - (11.6 [12.4.7 and 12.4.8]): Accept in Principle

SUBMITTER: Glen Kampa, Hoffman

RECOMMENDATION: Revise text to read as follows

11.6 Doors. Enclosure or compartments shall have one or more hinged doors that shall swing about a vertical axis and shall be held closed with captive fasteners or vault-type hardware. The thickness of the door shall not be less than that indicated in 11.4. The width of the doors shall not exceed 40 inches.

SUBSTANTIATION: The problem is some control enclosures are required and designed to be mounted in a landscape foot print; where these are wide and not very high. Many of these utilize horizontal hinges usually mounted to swing the door down. Consoles and desk top style enclosures also utilize horizontal hinges. Deleting the portion shown above allows for horizontal hinges.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See Committee Action and Statement on Proposal 79-84 (Log #54) (12.4.8).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25
NEGATIVE: 1

NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: The Technical Correlating Committee directs the committee to consider the comments expressed in the voting. This action will be considered by the committee as a public comment.

SUBMITTER: Mark A. Rauch, Boeing Company

RECOMMENDATION: Add Exception to read as follows

Exception No. 5: Where an electrical enclosure is not the main control enclosure, and this control enclosure door or cover is marked with a warning indicating that power shall be removed by the disconnecting means before the enclosure is opened, and further provided that a tool is required to open the enclosure.

SUBSTANTIATION: Machines often need modifications where no room is available in the main control enclosure. An auxiliary enclosure must be added to the machine, and requiring door interlocks is very burdensome, and does not add the electrical safety of the machine, many machines have electrical door interlock overrides that are tool operated.

COMMITTEE ACTION: Accept in Principle.

79-90 - (11.8 Exception No. 5 [6.2.3.5]): Accept in Principle

COMMITTEE STATEMENT: This text more appropriately belong as a new Exception No. 5 to subclause 6.2.3.5.

The committee understands that this proposal modifies the Committee Action on Proposal 79-25 (Log #68) [Clause 6].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 24
NEGATIVE: 1

COMMITTEE STATEMENT: The term "main" control enclosure, while often used and generally understood, is not defined in this standard and will cause problems in interpretation and enforcement.

EXPLANATION OF NEGATIVE:

79-91 - (11.9 [12.4.5]): Reject

SUBMITTER: Glen Kampa, Hoffman

RECOMMENDATION: Revise text to read as follows

11.9 Interior, exterior and panel(s) of control enclosures and exposed surfaces of panels mounted therein shall be have a protective finished suitable for the intended environment in a light color.

Note: It is recommended the panel be finished white or in a protective metallic finish.

SUBSTANTIATION: The requirement to be light in color is vague and not clearly defined. Different users will specify specific colors for the enclosure interior. There is a need to require a durable finish that will not deteriorate within its environment. The note was added to recommend a white or reflective panel to improve visibility. The changed and added text addresses finish for both interior and exterior of the enclosure and ensures a finish type adequate for the environment.
COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The proposal is too restrictive. Environmental concerns are addressed in the Action on Proposal 79-24 (Log #60) (4.4.1). See Committee Action and Statement on Proposal 79-84 (Log #54).

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-92 - (11.10 [17.2.1]): Accept in Principle in Part

SUBMITTER: Loren Mills, Van Dorn Demag Corp./Rep. SPI

RECOMMENDATION: Revise text to read as follows:

17.2.1 Enclosures that do not clearly show that they contain electrical devices shall be marked with a safety sign, a black lightning flash on a yellow background within a black triangle, shaped in accordance with the graphical symbol 2036 of IEC 60417, the whole in accordance with symbol 13 of ISO 3864, as shown in Figure 3. ****Insert Figure 3 Here****

It is permitted to omit this warning safety sign on:
— an enclosure equipped with a supply disconnecting device;
— an operator-machine interface or control station;
— a single device with its own enclosure (e.g. position sensor).

The warning safety sign shall be plainly visible on the enclosure door or cover.

SUBSTANTIATION: The safety sign and description in Section 11.10 of NFPA 79 does not meet the current requirements of the ANSI Z535 safety sign standards.

COMMITTEE ACTION: Accept in Principle in Part

1) Revise the title of 17.2 to read as follows:

17.2 Warning marking and signs Safety Signs for Electrical Enclosures

2) Revise 17.2.2 to read as follows:

17.2.2 Safety signs shall be plainly visible on the enclosure door or cover.

3) Revise 17.2.3 to read as follows:

It shall be permitted to omit this warning safety sign on:
— an enclosure equipped with a supply disconnecting device;
— an operator-machine interface or control station;
— a single device with its own enclosure (e.g. position sensor).

4) The insertion of the artwork is rejected.

COMMITTEE STATEMENT: 1) The revised title better reflects the intent of the committee and the material covered in 17.2.
2) This correlates with the change in title.
3) Changed "warning" to "safety" to correlate with the title revision.
4) The artwork has not been included because of the Committee Action on Proposal 79-79/3 (Log #29).
5) The part of the text that was not accepted is already covered by the Committee Action on Proposal 79-93 (Log #26).
6) The committee understands that this proposal modifies the Committee Action on Proposal 79-18 (Log #26).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

GARSIDE: The proposed wording is too restrictive. The IEC symbol that has been permitted by the current version of NFPA 79, and is used in IEC/EN 60204-1, and (I believe) in other US standards, is widely used and well understood. Use of the symbol alone should continue to be allowed.

FREUDENBERG: There is no justification to remove the safety sign printed in NFPA79-1997. Since this specific safety sign has been previously printed in NFPA79-1997, new developments in ANSI Z535 should be added as an exception. The safety sign required by NFPA79-1997 has been included on all machines. This proposal will only reverse a practice used for years but will make the established safety sign unacceptable. Using English text per ANSI Z535 will require local language translation by notified bodies and authorities having jurisdiction in all other countries worldwide.

SALZENSTEIN: A uniform and well-understood (by the general and working public) pictorial is essential to warn off hazards. The pictorial which has not been generally recognized by the public.

STARK: The proposed pictorial has been tested and found to comply with ANSI Z535 criteria for pictorial acceptability. Further, the ANSI Z535 Series of standards prescribes procedures for preparing product warnings and should be adopted in the current proposal.

COMMITTEE ACTION: Accept in Part.

Add the following new text:

17.2.1 Enclosures that do not clearly show that they contain electrical devices shall be marked with a safety sign, in accordance with ANSI Z535 series, dealing with product safety signs.

COMMITTEE STATEMENT: The committee does not accept the second sentence and the associated artwork because it is overly restrictive. The committee understands that this proposal modifies the Committee Action on Proposal 79-18 (Log #23).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 22
NEGATIVE: 3
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

DOBROWSKY: In the Committee Action text the word "the" should be "they".

WITHROW: Within the committee action, add the following new text:

17.2.1 Enclosures that do not clearly show that they contain electrical devices shall be marked with a safety sign, in accordance with ANSI Z535 Series, dealing with product safety signs.

COMMENT: Strike ANSI Z535 Series and add the specific ANSI Z535 Standard such as ANSI Z535-4-1998. Add this ANSI Standard to Clause 2.
79-94 - (12.1 [12.2.1]): Accept in Principle
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Add new text to read as follows:
"Control stations (including that of auxiliary or third party supplied equipment) shall be located within easy reach of the equipment operator and placed so that the operator does not have to reach past moving parts, or through any unsafe guarding perimeter device."

SUBSTANTIATION: With additional automation and presence sensing safe guarding devices being installed on existing equipment, many control enclosures are being located outside of the reach or observation of the machine operator, or due to mounting, requires the operator to penetrate the PSD perimeter (for the case of the installer to mount).

COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: The proposal is already covered in 12.5.2 and 10.1.6.1. See Committee Action on Proposal 79-84 (Log #54) and 79-99 (Log #24).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-95 - (12.1.2 Exception [12.2.2]): Accept
SUBMITTER: Frank C. DeFelice, Jr., Cytac Industries Inc.
RECOMMENDATION: Add Exception No. 2 as follows:
"Where pipelines, tubings, or devices are an integral part of listed equipment and separated by suitable barriers."

SUBSTANTIATION: Equipment containing hydraulic and/or pneumatic solenoids and similar devices, located within a compartment or enclosure common to electrical devices, has been manufactured for many years, with no history of fire or safety problems, provided sufficient barriers are provided.

COMMITTEE ACTION: Accept.
COMMITTEE STATEMENT: The committee understands that this action modifies the Committee Action on Proposal 79-59 (Log #62) in 12.2.2.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-96 - (12.2 [12.2.1.3]): Accept in Principle
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Add new text to read as follows:
"Where required for maintenance, space shall be provided adjacent to all devices mounted on the control panel."

SUBSTANTIATION: Have found Committee Action on Proposal 79-84 (Log #54) (12.2.1.1 and 12.2.1.3) which meets the intent of the submitter.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-97 - (12.2.2 [12.2.4]): Accept in Principle
SUBMITTER: William E. Anderson, The Procter & Gamble Company
RECOMMENDATION: Revise the following paragraph (12.2.1.2)
12.2.1.2 Exposed, nonarcing, bare, live parts within an enclosure or compartment shall have an air space of not less than 13 mm (1/2 inch) between them and the un-insulated walls of the enclosure or compartment, including conduit fittings. The air space for uninsulated doors or doors of the enclosure shall be of flame-retardant, noncarbonizing insulating materials.

COMMITTEE ACTION: Accept.
COMMITTEE STATEMENT: The committee understands that this action modifies the Committee Action on Proposal 79-84 (Log #54) (12.2.1.3). The text of this proposal replaces Section 12.2.1.2. Exposed, nonarcing, bare, ..., of Proposal 79-84 (Log #54).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF VOTE: FREUDENBERG: Exposed?, nonarcing?, bare? The following text is more appropriate for the first sentence 12.2.1.2.3 Uninsulated live parts in the primary circuit shall have an air space of not less than 15 mm (1/2 inch) between exposed metal and the uninsulated walls of the enclosure or compartment, including conduit fittings. "in the primary circuit" is an important limitation because you won't find and don't need 1/2 spacing between parts in secondary circuits & between secondary parts and the enclosure.

COMMITTEE STATEMENT: The committee understands that the action on this proposal modifies the Action on Proposal 79-84 (Log #54) [Clause 12].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

79-98 - (12.5.2 [12.2.1.2]): Accept in Principle
SUBMITTER: William E. Anderson, The Procter & Gamble Company
RECOMMENDATION: Prove the following paragraph (12.2.1.2)
12.2.1.2 Exposed, nonarcing, bare, live parts within an enclosure or compartment shall have an air space of not less than 13 mm (1/2 inch) between them and the un-insulated walls of the enclosure or compartment, including conduit fittings. The air space for uninsulated doors or doors of the enclosure shall be of flame-retardant, noncarbonizing insulating materials.

COMMITTEE ACTION: Accept.
COMMITTEE STATEMENT: The committee understands that this action modifies the Committee Action on Proposal 79-84 (Log #54) (12.2.1.3). The text of this proposal replaces Section 12.2.1.2. Exposed, nonarcing, bare, ..., of Proposal 79-84 (Log #54).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF VOTE: FREUDENBERG: Exposed?, nonarcing?, bare? The following text is more appropriate for the first sentence 12.2.1.2.3 Uninsulated live parts in the primary circuit shall have an air space of not less than 15 mm (1/2 inch) between exposed metal and the uninsulated walls of the enclosure or compartment, including conduit fittings. "in the primary circuit" is an important limitation because you won't find and don't need 1/2 spacing between parts in secondary circuits & between secondary parts and the enclosure.

COMMITTEE STATEMENT: The committee understands that the action on this proposal modifies the Action on Proposal 79-84 (Log #54) [Clause 12].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF VOTE: FREUDENBERG: Exposed?, nonarcing?, bare? The following text is more appropriate for the first sentence 12.2.1.2.3 Uninsulated live parts in the primary circuit shall have an air space of not less than 15 mm (1/2 inch) between exposed metal and the uninsulated walls of the enclosure or compartment, including conduit fittings. "in the primary circuit" is an important limitation because you won't find and don't need 1/2 spacing between parts in secondary circuits & between secondary parts and the enclosure.
enclosure or compartment, including conduit fittings. The air space for un-insulated covers or doors of the enclosure shall be not less than 25 mm (1 inch). Where barriers between metal enclosures or compartments and arcing parts are required, they shall be of flame-retardant, non-carbonizing insulating materials.

10.1 General device requirements. This clause contains requirements for devices mounted outside or partially outside control enclosures.

Note: For further information on device selection, mounting, identification, and coding, see IEC 60073 and IEC 60447.

10.1.2 Location and Mounting.

10.1.2.1 Control devices. As far as is practicable, control devices shall be:

— readily accessible for service and maintenance.
— mounted in such a manner as to minimize the possibility of damage from activities such as material handling.

10.1.2.2 Hand operated control devices. The actuators of hand-operated control devices shall be selected and installed so that:

— they are not less than 2 feet (0.6 m) above the servicing level and are within easy reach of the normal working position of the operator.
— the operator is not placed in a hazardous situation when operating them.
— the possibility of inadvertent operation is minimized.

10.1.3 Protection. Operator interface, control devices, and enclosures shall be suitable for the environment and shall withstand the stresses of expected use.

Note: For further information on degrees of protection, see UL 50, UL 508, Annex XX and IEC 60529.

10.1.4 Position sensors.

10.1.4.1 Position sensors (e.g. limit switches, position switches, proximity switches) shall be so arranged that they will not be damaged in the event of overtravel.

10.1.4.2 Position sensors used in circuits with safety-related functions either shall have positive (direct) opening operation or shall provide similar reliability.

Note: For further information on positive (or direct) opening operation, see IEC 60947-5-1.

10.1.5 Portable and pendant control stations.

10.1.5.1 Portable and pendant operator control stations and their control devices shall be so selected and arranged to minimize the possibility of inadvertent machine operations.

10.1.5.2 Pendant control stations that are vertically suspended from overhead shall be supported by suitable means or flexible electrical conduit or multiconductor cable or cord identified for the purpose.

10.1.6 Operator interface devices.

10.1.6.1 Location of operator interface devices.

10.1.6.1.1 Operator interface devices shall be mounted in locations that will minimize exposure to oil, coolant, and other contaminants.

10.1.6.1.2 Operator interface devices shall be within normal reach of the machine operator and shall be so placed that the operator is not exposed to hazards.

10.1.6.1.3 Operator interface devices shall be located so that unintentional operation by normal movement of the machine, operator, or work will be unlikely.

10.1.6.2 Arrangement of operator interface devices. All Start pushbuttons shall be mounted above or to the left of their associated Stop pushbuttons.

Exception No. 1: Start pushbuttons shall be mounted above or to the left of their associated Stop pushbuttons.

Exception No. 2: Wobble-stick or rod-operated Emergency Stop pushbuttons mounted in the bottom of pendant stations.

10.1.7 Foot-operated switches. Foot-operated switches used for applications where accidental actuation could create a hazardous situation shall be protected to prevent accidental actuation by falling or moving objects and from unintended operation by accidental stepping onto the switch.

Exception: Foot-operated switches used for emergency stop in accordance with 10.7.2.1 shall not be of the covered or hooded type.

10.2 Push-button actuators and action initiating icons. Pushbutton actuators used to initiate a stop function shall be of the extended operator or mushroom-head types.

10.2.1 Colors. Pushbutton actuators and action initiating icons of color touch screen interfaces shall be color coded as follows:

— Start or On - The preferred color of Start or On actuators is GREEN, except that BLACK, WHITE, or GRAY shall be permitted. Red shall not be used for Start or Off actuators.
— Stop or Off - The preferred color of Stop or Off actuators is RED, except that BLACK, WHITE, or GRAY shall be permitted. Green shall not be used for Stop or Off actuators.

Exception: Stop function operators of the wobble-stick or rod-operated types in the bottom of a pendant station need not be colored red.

The color RED shall be used for, Emergency Stop actuators in accordance with 10.7.4.

— Alternate action - Pushbuttons that, when pressed, act alternately as Start and Stop or On and Off shall be BLACK, WHITE, or GRAY. RED or GREEN shall not be used.
— Abnormal conditions - The color YELLOW shall be used for actuators used to respond to abnormal conditions.
— Hold to operate - Pushbuttons that cause movement when pressed and stop movement when they are released (e.g., jogging) shall be BLACK, WHITE, GRAY, or BLUE with a preference for BLACK.
— Reset - Reset pushbuttons shall be BLUE, BLACK, WHITE, or GRAY except when they also act as a Stop or Off button, in which case they shall be RED.

10.2.2 Legends.

10.2.2.1 A legend shall be provided for each operator interface device to identify its function and shall be located so that it can be easily read by the machine operator from the normal operator position. The legends shall be durable and suitable for the operating environment.

10.2.2.2 For illuminated pushbuttons the function(s) of the light is separated from the function(s) of the button by a virgule (/).
10.3.1 Modes of use. Indicator lights and icons used with visual display units shall provide the following information:

— indication: to attract the operator’s attention or to indicate that a certain task should be performed. The colors RED, YELLOW (AMBER), GREEN, and BLUE are normally used in this mode;

— confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colors BLUE and WHITE are normally used in this mode and GREEN shall be permitted to be used in some cases.

10.3.2 Colors. Indicator lights and icons of visual display units shall be color-coded with respect to the condition (status) of the machine in accordance with table XX. Alternate purposes shall be permitted to indicate machine or process status. (See Table below)

10.3.3 Flashing lights. Flashing lights shall be permitted to be used for any of the following purposes:

– to attract attention.
– to request immediate action.
– to indicate a discrepancy between the command and actual states.
– to indicate a change in process (flashing during transition).

10.4 Illuminated push-buttons. Illuminated push-button actuators shall be color-coded in accordance with table XX. The color RED for the emergency stop actuator shall not depend on the illumination source.

10.5 Rotary control devices. Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be relied upon to prevent rotation.

10.6 Start devices. Actuators used to initiate a start function or the movement of machine elements (e.g. slides, spindles, carriers) shall be constructed and mounted to minimize inadvertent operation. Mushroom-type actuators for two-hand control initiation shall conform to the requirements of 9.2.5.6 (two hand control).

10.7 Devices for stop and emergency stop.

10.7.1 Location and operation.

10.7.1.1 Stop and emergency stop pushbuttons shall be continuously operable and readily accessible.

10.7.1.2 Stop and emergency stop pushbuttons shall be located at each operator control station and at other locations where emergency stop is required.

10.7.2 Types.

10.7.2.1 The types of device for emergency stop include, but are not limited to:

– push-button operated switches in accordance with 10.7.4.
– pull-cord operated switches.
– foot-operated switches without a mechanical guard
– push bar operated switches.
– rod operated switches.

10.7.2.2 Pushbutton type devices for emergency stop shall be of the self-latching type and shall have positive (direct) opening operation.

Note: For further information on positive (direct) opening operation, see IEC 60947-5-1.

Exception: For machines which employ only a single emergency stop device, emergency stop actuators of the momentary type shall be permitted.

10.7.3 Restoration of normal function after emergency stop. It shall not be possible to restore an emergency stop circuit until the emergency stop device has been manually reset. Where several emergency stop devices are provided in a circuit, it shall not be possible to restore that circuit until all emergency stop devices that have been operated have been reset.

Exception: Where emergency stop device of the momentary type are used in accordance with 10.7.2.2, exception, the emergency stop circuit shall be manually reset.

10.7.4 Emergency stop actuators. Actuators of emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type. The RED/YELLOW color combination shall be reserved exclusively for emergency stop applications.

Exception: The RED/YELLOW combination shall be permitted for emergency off actuators in accordance with 10.8.4

10.7.5 Local operation of the supply disconnecting means to effect emergency stop.

10.7.5.1 The supply disconnecting means shall be permitted to be locally operated to serve the function of emergency stop where:

– it is readily accessible to the operator;
– it is of the type described in 5.3.2 a), b) or c).

10.7.5.2 Where intended for such use, the supply disconnecting means shall meet the color requirements of 10.7.4.

10.8 Devices for emergency switching off.

10.8.1 Location. Emergency switching off devices as described in 9.2.5.4.3 shall be located as necessary for the given application.

---

**Table XX Colors for indicator lights and their purposes with respect to the condition of the machine**

<table>
<thead>
<tr>
<th>Color</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Safety of persons or environment</td>
</tr>
<tr>
<td>RED</td>
<td>Danger</td>
</tr>
<tr>
<td>YELLOW (AMBER)</td>
<td>Warning/Caution</td>
</tr>
<tr>
<td>GREEN</td>
<td>Safe</td>
</tr>
<tr>
<td>BLUE</td>
<td>Mandatory action</td>
</tr>
<tr>
<td>CLEAR</td>
<td></td>
</tr>
<tr>
<td>WHITE</td>
<td></td>
</tr>
<tr>
<td>GRAY</td>
<td></td>
</tr>
<tr>
<td>BLACK</td>
<td></td>
</tr>
</tbody>
</table>
10.8.2 Types.

10.8.2.1 The types of devices that initiate an emergency switching off operation shall be permitted to include, but are not limited to:

— push-button operated switches.
— pull-cord operated switches.

10.8.2.2 The push-button operated switch shall be permitted in a break-glass enclosure.

10.8.3 Restoration of normal function after emergency switching off. It shall not be possible to restore an emergency switching off circuit until the emergency switching off circuit has been manually reset.

10.8.4 Actuators.

10.8.4.1 Actuators of emergency switching off devices shall be colored RED. The background immediately around the device actuator shall be permitted to be colored YELLOW.

10.8.4.2 Where the emergency switching off initiating device is separate from the emergency stop device, the emergency switching off initiating device shall be functionally identified.

10.8.5 Local operation of the supply disconnecting means to effect emergency switching off. Where the supply disconnecting means is to be locally operated for emergency switching off, it shall be readily accessible and shall meet the color requirements of 10.8.4.1.

10.9 Displays. Displays (e.g. visual display units, alarm annunciators, indicator lights and the action initiating icons of human-machine interface (HMI) devices) shall be selected and installed in such a manner as to be visible from the normal position of the operator.

Note: It is recommended that displays intended to be warning devices be of the flashing or rotary type and be provided with an audible warning device.

SUBSTANTIATION: This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

Historical Background

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization – Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC-60204-1.

Importance of Issue – Harmonization

Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization – Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause 13 with IEC 60204-1 Clause 10. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber NFPA 79-1997 Clause 13 to correspond with IEC 60204-1 Clause 10. The task group proposes the following changes to further improve usability.

Substantiation for changes to NFPA 79-1997 Clause 13, subclause 12.6.2 and subclause 12.7

10 Operator interface and control devices

Revise the NFPA 79-1997 Clause 13 heading "Operator's control stations and equipment" to harmonize with the IEC Clause 10 heading "Operator interface and control devices."

Substantiation: The new Clause 10 heading recognizes that operator interfaces includes pushbuttons, foot-operated switches, and other types of devices.

10.1 General

Add IEC 60204-1 subclause 10.1 heading.

Substantiation: The IEC subclause heading is added for general information on operator interface and control devices.

10.1.1 General device requirements

(a) Add the IEC 60204-1 subclause 10.1.1 heading.

Substantiation: The new subclause clarifies the intent of subclause 10.1.

(b) Add the first paragraph of IEC 60204-1 subclause 10.1.

This clause contains requirements for devices mounted outside or partially outside control enclosures.

Substantiation: This new paragraph specifies which devices are included in subclause 10.1.

(c) Add a note in place of the second paragraph of IEC 60204-1 subclause 10.1.1. This new note reads:

Note: For further information on device selection, mounting, identification, and coding, see IEC 60073 and IEC 60447.

Substantiation: This note provides additional information where required for the application.

10.1.2 Location and mounting

Add the IEC 60204-1 subclause 10.1.2 heading.

Substantiation: The IEC subclause heading is added for grouping of all proposed subclauses.

10.1.2.1 Control devices
Add a new subclause number 10.1.2.2 to be in compliance with the NFPA Manual of Style and add the new heading “Hand operated control devices.”

Substantiation: The new subclause heading clarifies the intent of the subclause.

(b) Add the revised IEC 60204-1 second paragraph and bullets of subclause IEC 10.1.2:

The actuators of hand-operated control devices shall be selected and installed so that:

— readily accessible for service and maintenance, mounted in such a manner as to minimize the possibility of damage from activities such as material handling.”

Substantiation: This new paragraph simplifies ergonomic and machine protection criteria already covered in NFPA 79-1997 subclause 12.6.

10.1.2.2 Hand operated control devices

(a) Add a new subclause number 10.1.2.2 to be in compliance with the NFPA Manual of Style and add the new heading “Hand operated control devices.”

Substantiation: The new subclause heading clarifies the intent of the subclause.

(b) Add the revised IEC 60204-1 first paragraph and bullets of subclause IEC 10.1.2:

As far as is practicable, control devices shall be:

— They are not more than 2 feet (0.6 m) above the servicing level and are within easy reach of the normal working position of the operator.
— The operator is not placed in a hazardous situation when operating them.
— The possibility of inadvertent operation is minimized.”

Substantiation: This new paragraph amplifies ergonomic, safety and machine protection criteria already covered in NFPA 79-1997 subclause 12.6.

10.1.3 Protection

(a) Add the IEC 60204-1 subclause 10.1.3 heading.

(b) Delete the NFPA 79-1997 subclause 13.1.1 paragraph and exception.

(c) Add the revised first sentence of IEC 60204-1 subclause 10.1.3 and add a new note:

Operator interface, control devices, and enclosures shall be suitable for the environment and shall withstand the stresses of expected use.

Note: For further information on degrees of protection, see UL 50, UL 508, Annex XX and IEC 60529.

Substantiation: The proposed language permits a broader classification of devices to meet environmental conditions. NFPA 79-1997 subclause 13.1.1 is too restrictive. Annex XX is a comparison between IEC IP and NEMA/UL Type enclosures.

10.1.4 Position sensors

Add the IEC 60204-1 subclause 10.1.4 heading.

10.1.4.1

(a) Add a new subclause number 10.4.1.1 to be in compliance with the NFPA Manual of Style.

(b) Add the revised first paragraph of IEC 60204-1 subclause 10.1.4:

Position sensors (e.g., limit switches, position switches, proximity switches) shall be arranged so that they will not be damaged in the event of overtravel.

(c) Delete the NFPA 79-1997 subclause 12.6.2 paragraph that reads “All limit switches or position sensors shall be installed so that accidental overtravel by the machine will not damage the limit switch or sensor.”

10.1.4.2

(a) Add a new subclause number 10.1.4.2 to be in compliance with the NFPA Manual of Style.

(b) Add the revised second paragraph of IEC 60204-1 subclause 10.1.4:

Position sensors used in circuits with safety-related functions either shall have positive (direct) opening operation or shall provide similar reliability.

(c) Add a note in place of deleted IEC text in the second paragraph:

Note: For further information on positive (or direct) opening operation, see IEC 60947-5-1.

Substantiation: The proposed language reflects the intent of this subclause and is harmonized with IEC 60204-1.

10.1.5 Portable and pendant control stations

Revise the NFPA 79-1997 subclause 13.8 heading “Pendant stations” to harmonize with IEC 60204-1.

Substantiation: The proposed language reflects the intent of this subclause and is harmonized with IEC 60204-1.

10.1.5.1

(a) Add a new subclause number 10.1.5.1 to be in compliance with the NFPA Manual of Style.

(b) Add the revised paragraph of IEC 60204-1 subclause 10.1.5:

Portable and pendant operator control stations and their control devices shall be arranged so that they will not be damaged in the event of overtravel.


(c) Delete the NFPA 79-1997 subclause 13.8.1 “Pendant operator control station enclosures shall be oiltight.”

Substantiation: NFPA 79-1997 subclause 13.8.1 is too restrictive and this requirement is covered under 10.1.3.

(d) Delete the NFPA 79-1997 subclause 13.8.2 “A wobble stick or rod operator at the bottom of the station shall be permitted for Emergency Stop controls.”

Substantiation: This information is included in subclause 10.2.1 Colors exception.

10.1.5.2

(a) Add a new subclause number 10.1.5.2 to be in compliance with the NFPA Manual of Style.

(b) Revise the NFPA 79-1997 subclause 13.8.3 to read:

Pendant control stations that are vertically suspended from overhead shall be supported by suitable means or flexible...
electrical conduit or multiconductor cable or cord identified for the purpose.


(c) Delete the NFPA 79-1997 subclause 13.8.4 “Grounding and bonding shall comply with 19.2, 19.3, 19.4, and 19.6.”

Substantiation: This is covered elsewhere in NFPA 79-2002

10.1.6 Operator interface devices

Add the new subclause 10.1.6 heading “Operator interface devices.”

Substantiation: The new heading was added for the NFPA 79-1997 subclauses 13.4 and 13.7. The original heading was “Control station components” was changed it to “Operator interface devices.” Because the term more closely reflects the components covered in clause 10 such as touch screens and visual displays. The term is currently used in IEC 60204-1 extensively.

10.1.6.1 Location of operator interface devices

(a) Add a new subclause number 10.1.6.1 to be in compliance with the style manual.

(b) Add the new heading for 10.1.6.1 ”Location of operator interface devices”


10.1.6.1.1

(a) Add a new subclause number 10.1.6.1.1 to be in compliance with the NFPA Manual of Style.

(b) Revise the NFPA 79-1997 subclause 13.7.1 to read:

Operator interface devices shall be mounted in locations that will minimize exposure to oil, coolant, and other contaminants.

Substantiation: “Operator interface devices” is used instead of “all stations” because 10.1.6 was revised.

(c) Delete the NFPA 79-1997 subclause 13.4 paragraph which reads “All operator control station enclosures shall be dusttight, moistureright, and oiltight.”

Substantiation: NFPA 79-1997 subclause 13.4 is deleted to be consistent with 10.1.3. Similar environmental protection is provided in 10.1.6.1.1.

(d) Delete the exception in NFPA 79-1997 subclause 13.4 “Exception; Non-oiltight control station enclosures shall be permitted on machines where suitable for the environment.”

Substantiation: Same as item (c).

(d) Delete the NFPA 79-1997 subclause 13.7 heading “Location of control stations.”

Substantiation: This heading is Included in 10.1.6.1.

10.1.6.1.2

(a) Add a new subclause number 10.1.6.1.2 to be in compliance with the NFPA Manual of Style.

(b) Revise the NFPA 79-1997 subclause 13.7.2 to read:

Operator interface devices shall be within normal reach of the machine operator and shall be so placed that the operator is not exposed to hazards.

10.1.6.1.3

(a) Add a new subclause number 10.1.6.1.3 to be in compliance with the NFPA Manual of Style.

(b) Revise the NFPA 79-1997 subclause 13.7.3 to read:

Operator interface devices shall be located so that unintentional operation by normal movement of the machine, operator, or work will be unlikely.

Substantiation: This is already appears in NFPA 79-1997 subclauses 13.7.1, 13.7.2, and 13.7.3.

10.1.6.2 Arrangement of operator interface devices

(a) Revise the NFPA 79-1997 subclause 13.5 heading “Arrangement of control station components” and the IEC 60204-1 subclause heading “Arrangement of control station components.”

Substantiation: Editorial change of subclause 13.5 heading to be consistent with 10.1.6.

(b) Insert NFPA 79-1997 subclause 13.5 without changes, including exceptions No.1 and No. 2.

All Start pushbuttons shall be mounted above or to the left of their associated Stop pushbuttons.

Exception No. 1: Start pushbuttons in series, such as operating pushbuttons on punch presses.

Exception No. 2: Wobble-stick or rod-operated Emergency Stop pushbuttons mounted in the bottom of pendant stations.

10.1.7 Foot-operated switches

(a) Add the NFPA 79-1997 subclause 13.3 heading

(b) Revise the NFPA 79-1997 subclause 13.3.1 paragraph to read:

Foot-operated switches used for applications where accidental actuation could create a hazardous situation shall be protected to prevent accidental actuation by falling or moving objects and from unintended operation by accidental stepping onto the switch.

Substantiation: Re-statement on NFPA79-1997 subclause 13.3.1, clarifying the conditions where protection is required.

(c) Add the new exception:

Exception: Foot-operated switches used for emergency stop in accordance with 10.7.2 shall not be of the covered or hooded type.

Substantiation: Emergency stop actuators including foot-operated switches shall not be covered. It is imperative that emergency stop actuators be readily accessible.

10.2 Push-button actuators and action initiating icons

(a) Revise the NFPA 79-1997 subclause 13.1 heading “Pushbuttons, selector switches, indicating lights” and the IEC 60204-1 subclause 10.2 heading “Push-button.”

Substantiation: Change the heading to take into account the usage of a variety of actuators, such as push buttons, selectors and computer icons. Push buttons, selector switches and indicating lights are separated into different headings in order to harmonize with IEC 60204-1.

(b) Revise the NFPA 79-1997 subclause 13.1.3 to read:

Pushbutton actuators used to initiate a stop function shall be of the extended operator or mushroom-head types.

Substantiation: NFPA 79-1997 subclause 13.1.3 is modified to change “operators” to “actuators” so as to be more general and consistent with 10.2.
10.2.1 Colors

(a) Add the IEC 60204-1 subclause 10.2.1 heading colors.

(b) Revise the NFPA 79-1997 subclause 13.1.2 paragraph to read:

Pushbutton actuators and action initiating icons of color touch screen interfaces shall be color coded as follows:

Substantiation: NFPA 79-1997 subclause 13.1.2 is expanded to include computer icons and to be consistent with 10.2.

(c) First bullet - Revise the NFPA 79-1997 subclause 13.1.2 second bullet to read:

Start or On - The preferred color of Start or On actuators is GREEN, except that BLACK, WHITE, or GRAY shall be permitted. Red shall not be used for Start or On actuators.

Substantiation: The prohibition of “red” for a “start” or “on” function is added to comport with industrial practice and to prevent confusion with stop function.

(d) Second bullet – Create a new bullet to read:

Stop or Off - The preferred color of Stop or Off actuators is RED, except that BLACK, WHITE, or GRAY shall be permitted. Green shall not be used for Stop or Off actuators.

Substantiation: Colors other than red may be used for stop in order to harmonize with IEC 60204-1. In addition, there are certain integrated factory applications where differentiation is necessary. This revision will permit the utilization of other designated color schemes for STOP or OFF functions.

(e) Insert the NFPA 79-1997 subclause 13.1.2 exception after “Stop or Off”.

Exception: Stop function operators of the wobble-stick or rod-operated types in the bottom of a pendant station need not be colored red.

(f) Revise and insert after the exception NFPA 79-1997 subclause 13.1.2 first bullet to read:

The color RED shall be used for Emergency Stop actuators in accordance with 10.7.4.

Substantiation: Stop and emergency stop shall only be red in order to increase recognition of the function and improve safety.

(g) Third bullet – Revise the NFPA 79-1997 subclause 13.1.2 third bullet to read:

Alternate action - Pushbuttons that, when pressed, act alternately as Start and Stop or On and Off shall be BLACK, WHITE, or GRAY. RED or GREEN shall not be used.

(h) Fourth bullet - Add a new bullet to read:

Abnormal conditions - The color YELLOW shall be used for actuators used to respond to abnormal conditions.

Substantiation: Although not included in NFPA 79-1997, the use of “yellow” to signify response to abnormal conditions reflects current industrial practice, and improves operator recognition and safety.

(i) Fifth bullet - Revise the NFPA 79-1997 subclause 13.1.2 fourth bullet:

Hold to operate - Pushbuttons that cause movement when pressed and stop movement when they are released (e.g., jogging) shall be BLACK, WHITE, GRAY, or BLUE with a preference for BLACK.

(j) Sixth bullet - Retain NFPA 79-1997, 13.1.2, fifth bullet and read:

Reset - Reset pushbuttons shall be BLUE, BLACK, WHITE, or GRAY. Where reset pushbuttons also act as a Stop or Off button, the preferred color is RED.

Substantiation: Clarification of reset button colors so as not to conflict with other function/color combinations listed above.

(k) Delete NFPA 79-1997 Table 8 “Color coding for pushbuttons, indicator (pilot) lights, and illuminated pushbuttons”

Substantiation: The inclusion of the table adds confusion to proper applications to the mandatory text.

10.2.2 Legends

Insert NFPA 79-1997 subclause 13.6 Legends in place of IEC 60204-1 subclause 10.2.2 Markings.

10.2.2.1

(a) Add a new subclause number 10.2.2.1 to be in compliance with the NFPA Manual of Style.

(b) Revise the NFPA 79-1997 subclause 13.6 first paragraph to read:

A legend shall be provided for each operator interface device to identify its function and shall be located so that it can be easily read by the machine operator from the normal operator position. The legends shall be durable and suitable for the operating environment.

Substantiation: NFPA 79-1997 subclause 13.6 is adopted except “operator interface device” replaces “control station component”. Term is consistent with 10.1.8.

10.2.2.2

(a) 10.2.2.2 Add a new subclause number 10.2.2.2 to be in compliance with the NFPA Manual of Style.

(b) Add the note at the bottom NFPA 79-1997 table 8:

For illuminated pushbuttons the function(s) of the light is separated from the function(s) of the button by a virgule (/).

Substantiation: Separate the titles for the light and pushbutton functions on the legend plate.

10.3 Indicator lights and icons of visual display units

Revise the NFPA 79-1997 subclause 13.1 heading “Pushbuttons, selector switches, indicating lights” and the IEC 60204-1 subclause 10.3 heading “Indicator lights and displays.”

Substantiation: The heading was revised to reflect usage of computer icons as visual indicators and to consistent with 10.2.1. Pushbuttons, selector switches and indicating lights are separated into different headings in order to harmonize with IEC 60204-1.

10.3.1 Modes of use

(a) Add the IEC 60204-1 subclause 10.3.1 heading.

(b) Add the revised paragraph and bullets of IEC 60204-1 subclause 10.3.1:

Indicator lights and icons used with visual display units provide the following of information:

— indication: to attract the operator’s attention or to indicate that a certain task should be performed.
The colors RED, YELLOW (AMBER), GREEN, and BLUE are normally used in this mode;
— confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colors BLUE and WHITE are normally used in this mode and GREEN shall be permitted to be used in some cases.

Substantiation: Addressed, in part, by NFPA 79-1997, sub-clause 13.1.2 and table 8 and re-stated in 10.3.1. Visual computer display icons are added to reflect current industrial practice. Modes of use are simplified and reflect typical industrial practice.

10.3.2 Colors

(a) Add the IEC 60204-1 subclause 10.3.2 heading.

(b) Add the revised IEC 60204-1 subclause 10.3.2 paragraph.

Indicator lights and icons of visual display units shall be color-coded with respect to the condition (status) of the machine in accordance with table XX. Alternate purposes shall be permitted to indicate machine or process status.

(c) Add the revised indicating light table from IEC 73. This table replaces NFPA 79-1997 table 8 and IEC 60204-1 table 3 (See Table below).

Substantiation: Addressed, in part, by NFPA 79-1997, sub-clause 13.1.2 and table 8 and re-stated in 10.3.1. Visual computer display icons are added to reflect current industrial practice. Table XX reduces the number of meanings of each color to minimize operator confusion.

Table XX reflects typical industrial practice. The color BLUE was changed from any function not covered to a mandatory function.

10.3.3 Flashing lights

(a) Add the IEC 60204-1 subclause 10.3.3 heading

(b) Add the following new paragraph, bullets, and note:

Flashing lights shall be permitted to be used for any of the following purposes:

- to attract attention.
- to request immediate action.
- to indicate a discrepancy between the command and actual states
- to indicate a change in process (flashing during transition).

Substantiation: A new subclause not addressed in NFPA 79-1997. Flashing lights increase operator/machine safety by calling attention to process faults or changes.

10.4 Illuminated push-buttons

(a) Add the IEC 60204-1 subclause 10.4 heading.

(b) Delete the NFPA 79-1997 subclause 13.1.2 paragraph “Pushbutton operator, indication (pilot) light lenses, and illuminated pushbutton lenses shall be color coded in accordance with Table 8.”

Substantiation: This subclause was also deleted in subclause 10.2.1 Colors.

(c) Add the modified IEC 60204-1 subclause 10.4 paragraph:

Illuminated push-button actuators shall be color-coded in accordance with table XX. The color RED for the emergency stop actuator shall not depend on the illumination source.

Substantiation: The color of illuminated pushbuttons, pilot lights, and lenses is addressed in NFPA 79-1997 sub-clause 13.1.2; however, the colors and their meanings have been modified, as described to harmonize with IEC 60204-1 table 3. Operator and machine safety are enhanced if the emergency stop actuator appears red, whether illuminated or not.

10.5 Rotary control devices

(a) Retain the NFPA 79-1997 subclause 12.7 heading.

(b) Revise the NFPA 79 subclause 12.7 paragraph to read:

Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be relied upon to prevent rotation.


10.6 Start devices

(a) Add the IEC 60204-1 subclause 10.6 heading.

(b) Add the revised IEC 60204-1 subclause 10.6 paragraph:

Actuators used to initiate a start function or the movement of machine elements (e.g. slides, spindles, carriers) shall be constructed and mounted to minimize inadvertent operation. Mushroom-type actuators for two-hand control initiation shall conform to the requirements of 9.2.5.6 (two hand control).

Substantiation: A new subclause not addressed in NFPA 79-1997. Flashing lights increase operator/machine safety by calling attention to process faults or changes.

Table XX Colors for indicator lights and their purposes with respect to the condition of the machine

<table>
<thead>
<tr>
<th>Color</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Safety of persons or environment</td>
</tr>
<tr>
<td>RED</td>
<td>Danger</td>
</tr>
<tr>
<td>YELLOW</td>
<td>Warning/Caution</td>
</tr>
<tr>
<td>(AMBER)</td>
<td></td>
</tr>
<tr>
<td>GREEN</td>
<td>Safe</td>
</tr>
<tr>
<td>BLUE</td>
<td>Mandatory action</td>
</tr>
<tr>
<td>CLEAR</td>
<td></td>
</tr>
<tr>
<td>WHITE</td>
<td></td>
</tr>
<tr>
<td>GRAY</td>
<td></td>
</tr>
<tr>
<td>BLACK</td>
<td></td>
</tr>
</tbody>
</table>
10.7 Devices for stop and emergency stop

Revise the NFPA 79-1997 subclause 13.2 heading "Emergency stop devices."

Substantiation: This subclause also includes specifications for stop devices.

10.7.1 Location and operation

Add the revised IEC 60204-1 subclause 10.7.1 heading.

Substantiation: This subclause includes specifications for stop and emergency stop location and operation.

10.7.1.1

(a) Add a new subclause number 10.1.7.1 to be in compliance with the NFPA Manual of Style.

(b) Revise the NFPA 79-1997 subclause 13.2.2 to read:

Stop and emergency stop pushbuttons shall be continuously operable and readily accessible.

Substantiation: Harmonization with IEC 60204-1. The term "readily accessible" was added to clarify that "continuously operable" includes an element of quick and ready access.

10.7.1.2

(a) Add a new subclause number 10.1.7.2 to be in compliance with the NFPA Manual of Style.

(b) Revise the NFPA 79-1997 subclause 13.2.1 paragraph to read:

Stop and emergency stop pushbuttons shall be located at each operator control station and at other locations where emergency stop is required.

Substantiation: Editorial change of NFPA 79-1997 subclause 13.2.1 to clarify location criteria.

10.7.2 Types

Add the IEC 60204-1 subclause 10.7.2 heading.

10.7.2.1 The types of device for emergency stop include, but are not limited to:

(a) Add a new subclause number 10.7.2.1 to be in compliance with the NFPA Manual of Style.

(b) Add the revised IEC 60204-1 subclause 10.7.2 first paragraph, and bullets:

The types of device for emergency stop include, but are not limited to:

- push-button operated switches in accordance with 10.7.4.
- pull-cord operated switches.
- foot-operated switches without a mechanical guard
- push bar operated switches.
- rod operated switches.


10.7.2.2

(a) Add a new subclause number 10.7.2.2 to be in compliance with the NFPA Manual of Style.

(b) Add the revised IEC 60204-1 subclause 10.7.2 second paragraph, exception, and note:

Devices for emergency stop shall be of the self-latching type and shall have positive (direct) opening operation.

Note: For further information on positive (direct) opening operation, see IEC 60947-5-1.

Exception: For machines which employ only a single emergency stop device, emergency stop actuators of the momentary type shall be permitted.

(c) Delete the NFPA 79 subsection 13.2.4 “The emergency stop actuator shall be either a momentary or self latching type.”

Substantiation: New material not addressed in NFPA 79-1997. The use of self-latching devices improves safety to personnel. For example, a self-latching device would be beneficial in ensuring proper coil drop-out. The requirement for positive direct operation was added to ensure that in the event of a failure that results in direct welded contacts, it could be overcome. An exception is made for a single emergency stop on the machine since it is typically in the same area as the other operating controls. Replaces NFPA 79-1997 subclause 13.2.4

10.7.3 Restoration of normal function after emergency stop

(a) Add the IEC 60204-1 subclause 10.7.3 heading.

(b) Add the modified IEC 60204-1 subclause 10.7.3 paragraph and new exception:

It shall not be possible to restore an emergency stop circuit until the emergency stop device has been manually reset. Where several emergency stop devices are provided in a circuit, it shall not be possible to restore that circuit until all emergency stop devices that have been operated have been reset.

Exception: Where emergency stop device of the momentary type are used in accordance 10.7.2.2, exception, the emergency stop circuit shall be manually reset.

Substantiation: New material not addressed in NFPA 79-1997. The use of reset devices improves safety to personnel. This is in harmonization with the proposed SAE HS 1738-2000 standard.

10.7.4 Emergency stop actuators

(a) Add the IEC 60204-1 subclause 10.7.4 heading.

(b) Revise the NFPA 79-1997 subclause 13.2.3 paragraph to read:

Actuators of emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type. The RED/YELLOW color combination shall be reserved exclusively for emergency stop applications.

Exception: The RED/YELLOW color combination shall be permitted for emergency off actuators in accordance with 10.8.4

Substantiation: Replaces NFPA 79-1997 subclause 13.2.3, but remains the same in principle. Adds
language to preserve prescribed colors to reduce confusion to an operator and improve safety. Clarifies which actuators are to utilize the color combination.

10.7.5 Local operation of the supply disconnecting means to effect emergency stop.

Add the revised IEC 60204-1 clause 10.7.5 heading.

10.7.5.1

(a) Add a new clause number 10.7.5.1 to be in compliance with the NFPA Manual of Style.

(b) Add the IEC 60204-1 clause 10.7.5 first paragraph and bullets:

The supply disconnecting means shall be permitted to be locally operated to serve the function of emergency stop where:

(i) it is readily accessible to the operator;
(ii) it of the type described in 5.3.2 a), b) or c).

10.7.5.2

(a) Add a new clause number 10.7.5.2 to be in compliance with the NFPA Manual of Style.

(b) Add the IEC 60204-1 clause 10.7.5 second paragraph:

Where intended for such use, the supply disconnecting means shall meet the color requirements of 10.7.4.

Substantiation: 10.7.5.1 and 10.7.5.2 is new material not addressed in NFPA 79-1997. Allows an appropriate disconnect device to serve as an emergency stop under certain conditions. More economical for smaller machines but preserves safety to the operator.

10.8 Devices for emergency switching off.

Add the IEC 60204-1 clause 10.8 heading

10.8.1 Location.

(a) Add the IEC 60204-1 clause 10.8.1 heading

(b) Add the revised IEC 60204-1 clause 10.8.1 paragraph:

Emergency switching off devices as described in 9.2.5.4.3 shall be located as necessary for the given application.

Substantiation: New material not addressed in NFPA 79-1997. Improves safety to personnel and provides additional protection to machine and property.

10.8.2 Types.

Add the IEC 60204-1 clause 10.8.2 heading

10.8.2.1

(a) Add a new clause number 10.8.2.1 to be in compliance with the NFPA Manual of Style.

(b) Add the modified IEC 60204-1 paragraphs and bullets to 10.8.2:

The types of devices that initiate an emergency switching off operation shall be permitted to include, but are not limited to:

- push-button operated switches.
- pull-cord operated switches.


10.8.2.2

(a) Add a new clause number 10.8.2.2 to be in compliance with the NFPA Manual of Style.

(b) Add the IEC 60204-4 text:

The push-button operated switch shall be permitted in a break-glass enclosure.

10.8.3 Restoration of normal function after emergency switching off.

(a) Addition: Add the IEC 60204-1 clause 10.8.3 heading.

(b) Addition: Add the revised IEC 60204-1 10.8.3 paragraph:

It shall not be possible to restore an emergency switching off circuit until the emergency switching off circuit has been manually reset.


10.8.4 Actuators.

Add the IEC 60204-1 clause 10.8.4 heading.

10.8.4.1

(a) Add a new clause number 10.8.4.1 to be in compliance with the NFPA Manual of Style.

(b) Add the IEC 60204-1 clause 10.8.4 first paragraph:

Actuators of emergency switching off devices shall be colored RED. The background immediately around the device actuator shall be permitted to be colored YELLOW.

Substantiation: Where emergency stop devices are present, identification of function is required. The color yellow reduces the confusion to the operator and improves safety.

10.8.4.2

(a) Add a new clause number 10.8.4.2 to be in compliance with the NFPA Manual of Style.

(b) Add the revised IEC 60204-1 clause 10.8.4 second paragraph:

Where the emergency switching off initiating device is separate from the emergency stop device, the emergency switching off initiating device shall be functionally identified.

Substantiation: Where the emergency switching off initiating device is separate from the emergency stop device, the emergency switching off initiating device shall be functionally identified.

10.8.5 Local operation of the supply disconnecting means to effect emergency switching off.

(a) Add the IEC 60204-1 clause 10.8.5 heading.

(b) Add the modified IEC 60204-1 clause 10.8.5 paragraph:

Where the supply disconnecting means is to be locally operated for emergency switching off, it shall be readily accessible and shall meet the color requirements of 10.8.4.1.

Substantiation: New material not addressed in NFPA 79-1997. The switching off device is to be accessible and appropriately colored, if the same as the disconnect. Improves device recognition and safety.
10.8.9 Displays

(a) Add the IEC 60204-1 subclause 10.9 heading

(b) Add the modified IEC 60204-1 subclause 10.9 paragraph and new note.

Displays (e.g., visual display units, alarm annunciators, indicator lights and the action initiating icons of human-machine interface (HMI) devices) shall be selected and installed in such a manner as to be visible from the normal position of the operator.

Note: It is recommended that displays intended to be warning devices be of the flashing or rotary type and be provided with an audible warning device.


### CLAUSE NUMBER CROSS REFERENCE -- NFPA 79-1997 AND PROPOSED NFPA 79-2002

<table>
<thead>
<tr>
<th>NFPA 79-1997</th>
<th>Proposed NFPA 79-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause</td>
<td>Heading</td>
</tr>
<tr>
<td>13</td>
<td>Operator’s control stations and equipment</td>
</tr>
<tr>
<td>13.1</td>
<td>Pushbuttons, selector switches, indicating lights</td>
</tr>
<tr>
<td>13.1.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.1.2</td>
<td>paragraph and bullets</td>
</tr>
<tr>
<td>13.1.2</td>
<td>Table 8</td>
</tr>
<tr>
<td>13.1.2</td>
<td>Color coding for pushbuttons, indicator (pilot) lights, and illuminated pushbuttons</td>
</tr>
<tr>
<td>13.1.3</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.1.4</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.2</td>
<td>Emergency stop devices</td>
</tr>
<tr>
<td>13.2.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.2.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.2.3</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.2.4</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.2.4</td>
<td>Foot-operated switches</td>
</tr>
<tr>
<td>13.3.1</td>
<td>Paragraph</td>
</tr>
<tr>
<td>13.4</td>
<td>Control station enclosures</td>
</tr>
<tr>
<td>13.5</td>
<td>Arrangement of control station components</td>
</tr>
<tr>
<td>13.6</td>
<td>Legends</td>
</tr>
<tr>
<td>13.6</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.7</td>
<td>Location of control stations</td>
</tr>
<tr>
<td>13.7.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.7.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.7.3</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.8</td>
<td>Pendant stations</td>
</tr>
<tr>
<td>13.8.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.8.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.8.3</td>
<td>paragraph</td>
</tr>
<tr>
<td>13.8.4</td>
<td>paragraph</td>
</tr>
<tr>
<td>12.6.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>12.7</td>
<td>Rotary control devices</td>
</tr>
</tbody>
</table>
## Clause Number Cross Reference — Proposed NFPA 79-2002 and NFPA 79-1997

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause</td>
<td>Heading</td>
</tr>
<tr>
<td>10</td>
<td>Operator interface and control devices</td>
</tr>
<tr>
<td>10.1</td>
<td>General</td>
</tr>
<tr>
<td>10.1.1</td>
<td>General device requirements</td>
</tr>
<tr>
<td>10.1.2</td>
<td>Location and mounting</td>
</tr>
<tr>
<td>10.1.2.1</td>
<td>Control devices</td>
</tr>
<tr>
<td>10.1.3</td>
<td>Protection</td>
</tr>
<tr>
<td>10.1.4</td>
<td>Position sensors</td>
</tr>
<tr>
<td>10.1.4.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.1.4.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.1.5</td>
<td>Portable and pendant control stations</td>
</tr>
<tr>
<td>10.1.5.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.1.5.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.1.6</td>
<td>Operator interface devices</td>
</tr>
<tr>
<td>10.1.6.1</td>
<td>Location of operator interface devices</td>
</tr>
<tr>
<td>10.1.6.1.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.1.6.1.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.1.6.1.3</td>
<td>Paragraph</td>
</tr>
<tr>
<td>10.1.6.2</td>
<td>Arrangement of operator interface devices</td>
</tr>
<tr>
<td>10.1.7</td>
<td>Foot-operated switches</td>
</tr>
<tr>
<td>10.2</td>
<td>Push-button actuators and action initiating icons</td>
</tr>
<tr>
<td>10.2.1</td>
<td>Colors</td>
</tr>
<tr>
<td></td>
<td>Colors, Push-buttons – Table 8</td>
</tr>
<tr>
<td>10.2.2</td>
<td>Legends</td>
</tr>
<tr>
<td>10.2.2.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.2.2.2</td>
<td>Table 8 note</td>
</tr>
<tr>
<td>10.3</td>
<td>Indicator lights and icons of visual display units</td>
</tr>
<tr>
<td>10.3.1</td>
<td>Modes of use</td>
</tr>
<tr>
<td>10.3.2</td>
<td>Colors</td>
</tr>
<tr>
<td>10.3.2.1</td>
<td>Table XX</td>
</tr>
<tr>
<td>10.3.3</td>
<td>Flashing lights</td>
</tr>
<tr>
<td>10.4</td>
<td>Illuminated push-buttons</td>
</tr>
<tr>
<td>10.5</td>
<td>Rotary control devices</td>
</tr>
<tr>
<td>10.6</td>
<td>Start devices</td>
</tr>
<tr>
<td>10.7</td>
<td>Devices for stop and emergency stop</td>
</tr>
<tr>
<td>10.7.1</td>
<td>Location</td>
</tr>
<tr>
<td>10.7.1.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.7.2</td>
<td>Types</td>
</tr>
<tr>
<td>10.7.2.1</td>
<td>Paragraph</td>
</tr>
<tr>
<td>10.7.2.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.7.3</td>
<td>Restoration of normal function after emergency stop</td>
</tr>
<tr>
<td>10.7.4</td>
<td>Emergency stop actuators</td>
</tr>
<tr>
<td>10.7.5</td>
<td>Location of the supply disconnecting device to effect emergency stop</td>
</tr>
<tr>
<td>10.7.5.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.7.5.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.8</td>
<td>Devices for emergency switching off</td>
</tr>
<tr>
<td>10.8.1</td>
<td>Location and paragraph</td>
</tr>
<tr>
<td>10.8.2</td>
<td>Types</td>
</tr>
<tr>
<td>10.8.2.1</td>
<td>Paragraph and bullets</td>
</tr>
<tr>
<td>10.8.2.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.8.3</td>
<td>Restoration of normal function after emergency switching off</td>
</tr>
<tr>
<td>10.8.4</td>
<td>Actuators</td>
</tr>
<tr>
<td>10.8.4.1</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.8.4.2</td>
<td>paragraph</td>
</tr>
<tr>
<td>10.8.5</td>
<td>Local operation of the supply disconnecting device to effect emergency switching off</td>
</tr>
<tr>
<td>10.9</td>
<td>Displays</td>
</tr>
</tbody>
</table>
## NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000

<table>
<thead>
<tr>
<th>NFPA 79-1997</th>
<th>Proposed NFPA 79-2002</th>
<th>Comments (see attachment B for details)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1 General</td>
<td></td>
<td>Add IEC 60204-1 subclause 10.1 heading and move to proposed NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.1.1 General device requirements</td>
<td></td>
<td>Add IEC 60204-1 subclause 10.1.1 heading, add the first paragraph, revise the second paragraph into a note, and move to proposed NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.1.2 Location and Mounting</td>
<td></td>
<td>Add IEC 60204-1 subclause 10.2 heading and move to proposed NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.1.2.1 Control devices</td>
<td></td>
<td>Add the proposed NFPA 79-2002 subclause 10.1.2.1 heading. Add IEC 60204-1 subclause 10.1.2 first paragraph with bullets, and move to proposed NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.1.2.2 Hand operated control devices</td>
<td></td>
<td>Add the proposed NFPA 79-2002 subclause 10.1.2.2 heading. Add the IEC 60204-1 subclause 10.1.2 second paragraph with bullets, and move to proposed NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>13.1.1 All pushbutton and selector switch operators, indicating (pilot) lights, and illuminated pushbuttons shall be of the oiltight type. <strong>Exception: Machines identified (see 3.49) for the environment.</strong></td>
<td>10.1.3 Protection</td>
<td>Delete NFPA 79-1997 subclause 13.1.1 and exception. Add the IEC 60204-1 subclause 10.1.3 heading, revise the first paragraph, delete the bullets, revise the note, and move to proposed NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.1.4 Position sensors</td>
<td></td>
<td>Add the IEC 60204-1 subclause 10.1.4 heading and move to the proposed NFPA 79-2002 Clause 10.</td>
</tr>
</tbody>
</table>
**NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000 (Continued)**

<table>
<thead>
<tr>
<th>12.6.2</th>
<th>All limit switches or position sensors shall be installed so that accidental overtravel by the machine will not damage the limit switch or sensor.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.4.1</td>
<td>Position sensors (e.g., limit switches, position switches, proximity switches) shall be so arranged that they will not be damaged in the event of overtravel. Delete NFPA 79-1997 subclause 12.6.2. Add the proposed NFPA 79-2002 subclause 10.1.4.1 number, add the IEC 60204-1 subclause 10.1.4 first paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.1.4.2</td>
<td>Position sensors used in circuits with safety-related functions either shall have positive (direct) opening operation or shall provide similar reliability. Note: For further information on positive (or direct) opening operation, see IEC 60947-5-1. Add the proposed NFPA 79-2002 subclause 10.1.4.2 number, add the IEC 60204-1 subclause 10.1.4 revised second paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
</tbody>
</table>

### 13.8 Pendant stations

<table>
<thead>
<tr>
<th>13.8.1</th>
<th>Pendant operator control station enclosures shall be oiltight. 13.8.2 A wobble stick or rod operator at the bottom of the station shall be permitted for Emergency Stop control.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.5.1</td>
<td>Portable and pendant control stations and their control devices shall be so selected and arranged to minimize the possibility of inadvertent machine operations. Add the proposed NFPA 79-2002 subclause 10.1.5.1 number, add the IEC 60204-1 subclause revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
</tbody>
</table>

### 13.8.3 Pendant pushbutton stations shall be supported by suitable means other than the flexible electrical conduit or multiconductor cable. 13.8.4 Grounding and bonding shall comply with 19.2, 19.3, 19.4, and 19.6. 10.1.5.2 | Pendant control stations that are vertically suspended from overhead shall be supported by suitable means or flexible electrical conduit or multiconductor cable or cord identified for the purpose. Add the proposed NFPA 79-2002 subclause 10.1.5.2 number, revise the NFPA 79-1997 subclause 13.8.3 paragraph and move to NFPA 79-2002 Clause 10. Delete the NFPA 79-1997 subclause 13.8.4 and move to another NFPA 79-2002 Clause. |

<table>
<thead>
<tr>
<th>10.1.6</th>
<th>Operator interface devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.1.6.1</td>
<td>Location of operator interface devices Add the proposed NFPA 79-2002 subclause 10.1.6.1 number, add the NFPA 79-1997 subclause 13.4 paragraph with exception, add the NFPA 79-1997 subclause revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
</tbody>
</table>

### 13.4 Control station enclosures

<table>
<thead>
<tr>
<th>13.7</th>
<th>Location of control stations</th>
</tr>
</thead>
</table>

### 13.4 All operator control station enclosures shall be dusttight, moisturetight, and oiltight. Exception: Non-oiltight control station enclosures shall be permitted on machines where suitable for the environment. 13.7.1 | All stations shall be mounted in locations that will minimize exposure to oil, coolant, and other contaminants. Add the proposed NFPA 79-2002 subclause 10.1.6.1.1 number, delete NFPA 79-1997 subclause 13.4 paragraph with exception, add the NFPA 79-1997 subclause revised paragraph, and move to NFPA 79-2002 Clause 10. |

---

**NFPA 79 — May 2002 ROP — Copyright 2001, NFPA**
| NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000 (Continued) |  |
|---|---|---|
| **13.7.2** Controls shall be within normal reach of the machine operator and shall be so placed that the operator does not have to reach past spindles or other moving parts. | **10.1.6.1.2** Operator interface devices shall be within normal reach of the machine operator and shall be so placed that the operator is not exposed to hazards. | Add the proposed NFPA 79-2002 subclause 10.1.6.1.2 number, add the NFPA 79-1997 subclause 13.7.2 revised paragraph, and move to NFPA 79-2002 Clause 10. |
| **13.7.3** Controls shall be located so that unintentional operation by normal movement of the machine, operator, or work will be unlikely. | **10.1.6.1.3** Operator interface devices shall be located so that unintentional operation by normal movement of the machine, operator, or work will be unlikely. | Add the proposed NFPA 79-2002 subclause 10.1.6.1.3 number, add the NFPA 79-1997 subclause 13.7.3 revised paragraph, and move to NFPA 79-2002 Clause 10. |
| **13.5 Arrangement of control station components** | **10.1.6.2** Arrangement of operator interface devices | Add the NFPA 79-1997 subclause 13.5 revised heading, add paragraph with exceptions, and move to NFPA 79-2002 Clause 10. |
| All Start pushbuttons shall be mounted above or to the left of their associated Stop pushbuttons. |  |
| Exception No. 1: Start pushbuttons in series, such as operating pushbuttons on punch presses. |  |
| Exception No. 2: Wobble-stick or rod-operated Emergency Stop pushbuttons mounted in the bottom of pendant stations. |  |
| **13.3 Foot-operated switches** | **10.1.7** Foot-operated switches | Add the proposed NFPA 79-2002 subclause number, add the NFPA 79-1997 subclause 13.3 heading, add the NFPA 79-1997 subclause 13.3.1 revised paragraph, add the exception, and move to NFPA 79-2002 Clause 10. |
| **13.3.1** Foot-operated switches shall be protected to prevent accidental actuation by falling or moving objects and from unintended operation by accidental stepping onto the switch. | Foot-operated switches used for applications where accidental actuation could create a hazardous situation shall be protected to prevent accidental actuation by falling or moving objects and from unintended operation by accidental stepping onto the switch. |  |
| Exception: Foot-operated switches used for emergency stop in accordance with 10.7.2.1 shall not be of the covered or hooded type. |  |
| **13.1 Pushbuttons, selector switches, indicating lights** | **10.2 Push-button actuators and action initiating icons** | Delete the NFPA 79-1997 subclause 13.1 heading and add the IEC 60204-1 subclause 10.2 revised heading. |
| **13.1.3** Pushbutton operators used to initiate a stop function shall be of the extended operator or mushroom-head types. | Pushbutton actuators used to initiate a stop function shall be of the extended operator or mushroom-head types. | Add the NFPA 79-1997 subclause 13.1.3 paragraph and move to NFPA 79-2002 Clause 10. |
10.2.1 Colors

Pushbutton actuators and action initiating icons of color touch screen interfaces shall be color coded as follows:

- **Start or On** - The preferred color of Start or On actuators is GREEN, except that BLACK, WHITE, or GRAY shall be permitted. Red shall not be used for Start or On actuators.

- **Stop or Off** - The preferred color of Stop or Off actuators is RED, except that BLACK, WHITE, or GRAY shall be permitted. Green shall not be used for Stop or Off actuators.

**Exception:** Stop function operators of the wobble-stick or rod-operated types in the bottom of a pendant station need not be colored red.

- The color RED shall be used for Stop, Emergency Stop, or Off operators only.

- **Alternate action** - Pushbuttons that, when pressed, act alternately as Start and Stop or On and Off shall be BLACK, WHITE, or GRAY. RED or GREEN shall not be used.

- **Abnormal conditions** - The color YELLOW shall be used for actuators used to respond to abnormal conditions.

- **Hold to operate** - Pushbuttons that cause movement when pressed and stop movement when they are released (e.g., jogging) shall be BLACK, WHITE, GRAY, or BLUE with a preference for BLACK.

- **Reset** - Reset pushbuttons shall be BLUE, BLACK, WHITE, or GRAY. Where reset pushbuttons also act as a Stop or Off button, the preferred color is RED.

Colors other than red may be used for stop in order to harmonize with IEC 60204-1.

---

### NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000 (continued)

---

13.6 Legends

**A story shall be provided for each control station component to identify its function and shall be located so that it can be read easily by the equipment operator from the normal operator position. The legends shall be durable and suitable for the operating environment.**

---

10.2.2 Legends

**A legend shall be provided for each operator interface device to identify its function and shall be located so that it can be easily read by the machine operator from the normal operator position. The legends shall be durable and suitable for the operating environment.**

---

Add the IEC 60204-1 subclause 10.2.1 heading and move to NFPA 79-2002 Clause 10.

Delete NFPA 79-1997 Table 8 for pushbuttons. Table adds confusion to proper applications to the mandatory text.

Add the NFPA 79-1997 subclause 13.1.2 revised paragraph, revised bullets, and move to NFPA 79-2002 Clause 10.

Colors other than red may be used for stop in order to harmonize with IEC 60204-1.
### NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000 (continued)

<table>
<thead>
<tr>
<th>Table 8 note</th>
<th>10.2.2.2 For illuminated pushbuttons the function(s) of the light is separated from the function(s) of the button by a virgule (/).</th>
<th>Add the proposed NFPA 79-2002 subclause 10.2.2.2 number, add the NFPA 79-1997 table 8 note, and move to NFPA 79-2002 Clause 10.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10.3.1 Modes of use</td>
<td>Add the IEC 60204-2 subclause 10.3.1 heading, revise paragraph and bullets, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td></td>
<td>Indicator lights and icons used with visual display units provide the following information:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— indication: to attract the operator’s attention or to indicate that a certain task should be performed. The colors RED, YELLOW (AMBER), GREEN, and BLUE are normally used in this mode;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>— confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colors BLUE and WHITE are normally used in this mode and GREEN shall be permitted to be used in some cases.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Table 8 is not shown here. See NFPA 79-1997 page 27.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.3.2 Colors</td>
<td>Add the IEC 60204-1 subclause 10.3.2 heading, revise the paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td></td>
<td>Indicator lights and icons of visual display units shall be color-coded with respect to the condition (status) of the machine in accordance with table XX. Alternate purposes shall be permitted to indicate machine or process status.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Table XX is not shown here. See Table XX in Attachment A.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.3.3 Flashing lights</td>
<td>Add the revised IEC 73 table for indication lights, rename Table XX, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td></td>
<td>Flashing lights shall be permitted to be used for any of the following purposes:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– to attract attention.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– to request immediate action.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– to indicate a discrepancy between the command and actual states</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– to indicate a change in process (flashing during transition).</td>
<td></td>
</tr>
<tr>
<td>3.1.2 Pushbutton operator, indicating (pilot) light lenses, and illuminated pushbutton lenses shall be color coded in accordance with Table 8</td>
<td>10.4 Illuminated push-buttons</td>
<td>Delete NFPA 79-1997 subclause 3.1.2 paragraph.</td>
</tr>
<tr>
<td></td>
<td>Illuminated push-button actuators shall be color-coded in accordance with table XX. The color RED for the emergency stop actuator shall not depend on the illumination source.</td>
<td>Add IEC 60204-1 subclause 10.4 heading, revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
</tbody>
</table>
**NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000 (continued)**

<table>
<thead>
<tr>
<th>12.7 Rotary control devices</th>
<th>10.5 Rotary control devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Devices such as potentiometers and selector switches having a rotating member shall be mounted to prevent rotation of the stationary member. Friction alone is not sufficient.</td>
<td>Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be relied upon to prevent rotation.</td>
</tr>
</tbody>
</table>

| 13.1.4 Pushbutton operators used to initiate a start function or movement of machine elements (e.g., slides, spindles, and carriers) shall be constructed or mounted to minimize inadvertent operation. |  
| 10.6 Start devices | Delete NFPA 79-1997 subclause 13.1.4 paragraph and exception. |
| *Exception: Mushroom-head type operators shall be permitted to initiate start functions where installed in accordance with 9.15.* | Actuators used to initiate a start function or the movement of machine elements (e.g., slides, spindles, carriers) shall be constructed and mounted to minimize inadvertent operation. Mushroom-type actuators for two-hand control initiation shall conform to the requirements of 9.2.5.6 (two hand control). | Add IEC 60204-1 subclause 10.6 heading, revise paragraph, and move to NFPA 79-2002 Clause 10. |

| 13.2 Emergency stop devices |  
| 10.7 Devices for stop and emergency stop | Delete NFPA 79-1997 subclause 13.2. |
| 13.2.1 Emergency stop pushbuttons shall be located at each operator control station and at other operating stations where emergency shutdown shall be required. |  
| 10.7.1 Location and operation | Add IEC 60204-1 subclause 10.7 revised heading. |
| 10.7.1.1 Stop and emergency stop pushbuttons shall be continuously operable and readily accessible. | Add the NFPA 79-1997 subclause 13.2.2 revise the paragraph, and move to NFPA 79-2002 Clause 10. |
| 10.7.1.2 Stop and emergency stop pushbuttons shall be located at each operator control station and at other locations where emergency stop is required. | Add the NFPA 79-1997 subclause 13.2.1 revise the paragraph, and move to NFPA 79-2002 Clause 10. |

| 13.2.4 The emergency stop actuator shall be either a momentary or self-latching type. |  
| 10.7.2 Types | Add the IEC 60204-1 subclause 10.7.2 heading and move to NFPA 79-2002 Clause 10. |
| 10.7.2.1 The types of device for emergency stop include, but are not limited to: | Add the NFPA 79-2002 subclause 10.7.2.1 heading number, add the IEC 60204-1 subclause 10.7.2 revised first paragraph, add the revised bullets, and move to NFPA 79-2002 Clause 10. |
| — push-button operated switches in accordance with 10.7.4. |  
| — pull-cord operated switches. |  
| — foot-operated switches without a mechanical guard |  
| — push bar operated switches. |  
| — rod operated switches. |  

| 10.7.2.2 Devices for emergency stop shall be of the self-latching type and shall have positive (direct) opening operation. | Delete the NFPA 79-1997 subclause 13.2.4 paragraph. |
| Note: For further information on positive (direct) opening operation, see IEC 60947-3-1. | Add the NFPA 79-2002 subclause 10.7.2.2 heading number, add the IEC 60204-1 subclause 10.7.2 revised first paragraph, add the revised bullets, and move to NFPA 79-2002 Clause 10. |
| *Exception: For machines which employ only a single emergency stop device, emergency stop actuators of the momentary type shall be permitted.* |  

1603
<table>
<thead>
<tr>
<th>NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000 (continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10.7.3 Restoration of normal function after emergency stop</strong></td>
</tr>
<tr>
<td>It shall not be possible to restore an emergency stop circuit until the emergency stop device has been manually reset. Where several emergency stop devices are provided in a circuit, it shall not be possible to restore that circuit until all emergency stop devices that have been operated have been reset.</td>
</tr>
<tr>
<td><em>Exception:</em> Where emergency stop device of the momentary type are used in accordance 10.7.2.2, exception, the emergency stop circuit shall be manually reset.</td>
</tr>
<tr>
<td><strong>Add the IEC 60204-4 subclause 10.7.3 heading, add the revised paragraph, and move to NFPA 79-2002 Clause 10.</strong></td>
</tr>
<tr>
<td><strong>10.7.4 Emergency stop actuators</strong></td>
</tr>
<tr>
<td>Actuators of emergency stop devices shall be colored RED. The background immediately around the device actuator shall be colored YELLOW. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type.</td>
</tr>
<tr>
<td><strong>Delete NFPA 79-1997 subclause 13.2 paragraph.</strong></td>
</tr>
<tr>
<td><strong>Add the IEC 60204-1 subclause 10.7.4 revised heading, add the revised paragraph, and move to NFPA 79-2002 Clause 10.</strong></td>
</tr>
<tr>
<td><strong>10.7.5 Local operation of the supply disconnecting means to effect emergency stop</strong></td>
</tr>
<tr>
<td>The supply disconnecting means shall be permitted to be locally operated to serve the function of emergency stop where:</td>
</tr>
<tr>
<td>– it is readily accessible to the operator;</td>
</tr>
<tr>
<td>– it of the type described in 5.3.2 a), b) or c).</td>
</tr>
<tr>
<td><strong>Add IEC 60207-1 subclause 10.7.5 heading and move to NFPA 79-2002 Clause 10.</strong></td>
</tr>
<tr>
<td><strong>10.7.5.1 The supply disconnecting means shall be permitted to be locally operated to serve the function of emergency stop where:</strong></td>
</tr>
<tr>
<td><strong>Add the proposed NFPA 79-2002 subclause number 10.7.5.1, add the IEC 60204-1 subclause 10.7.5 first paragraph with bullets, and move to NFPA 79-2002 Clause 10.</strong></td>
</tr>
<tr>
<td><strong>10.7.5.2 Where intended for such use, the supply disconnecting means shall meet the color requirements of 10.7.4.</strong></td>
</tr>
<tr>
<td><strong>Add the proposed NFPA 79-2002 subclause number 10.7.5.2, add the IEC 60204-1 subclause 10.7.5 second paragraph, and move to NFPA 79-2002 Clause 10.</strong></td>
</tr>
<tr>
<td><strong>10.8 Devices for emergency switching off</strong></td>
</tr>
<tr>
<td><strong>Add the IEC 60204-1 subclause 10.8 heading and move to NFPA 79-2002 Clause 10.</strong></td>
</tr>
</tbody>
</table>
**NFPA 79 SUBCLAUSE 12.6.2, SUBCLAUSE 12.7, AND CLAUSE 13 CROSS REFERENCE TO PROPOSED NFPA 79-2000 (continued)**

<table>
<thead>
<tr>
<th>Subclause</th>
<th>Description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.8.1</td>
<td><strong>Location</strong>&lt;br&gt;Emergency switching off devices as described in 9.2.5.4.3 shall be located as necessary for the given application.</td>
<td>Add the IEC 60204-1 clause 10.8.1 heading, add the revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.8.2</td>
<td><strong>Types</strong></td>
<td>Add the IEC 60204-1 clause 10.8.2 heading and move to NFPA 79-2002 Subclause 10.</td>
</tr>
<tr>
<td>10.8.2.1</td>
<td>The types of devices that initiate an emergency switching off operation include, but are not limited to:&lt;br&gt;— push-button operated switches.&lt;br&gt;— pull-cord operated switches.</td>
<td>Add the proposed NFPA 79-2002 clause 10.8.2.1 number, IEC 60204-1 clause 10.8.2 first paragraph with bullets, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.8.2.2</td>
<td>The push-button operated switch shall be permitted in a break-glass enclosure.</td>
<td>Add the proposed NFPA 79-2002 clause 10.8.2.2 number, add the IEC 60204-1 clause 10.8.2 second paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.8.3</td>
<td><strong>Restoration of normal function after emergency switching off</strong>&lt;br&gt;It shall not be possible to restore an emergency switching off circuit until the emergency switching off circuit has been manually reset.</td>
<td>Add the IEC 60204-1 clause 10.8.3 heading, add the revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.8.4</td>
<td><strong>Actuators</strong></td>
<td>Add the IEC 60204-1 clause 10.8.4 heading and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.8.4.1</td>
<td>Actuators of emergency switching off devices shall be colored RED. The background immediately around the device actuator shall be permitted to be colored YELLOW.</td>
<td>Add the proposed NFPA 79-2002 clause 10.8.4.1 number, add the IEC 60204-1 clause 10.8.4 revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.8.4.2</td>
<td>Where the emergency switching off initiating device is separate from the emergency stop device, the emergency switching off initiating device shall be functionally identified.</td>
<td>Add the proposed NFPA 79-2002 clause 10.8.4.2 number, add the new paragraph text, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.8.5</td>
<td><strong>Local operation of the supply disconnecting device to effect emergency switching off</strong>&lt;br&gt;Where the supply disconnecting device is to be locally operated for emergency switching off, it shall be readily accessible and shall meet the color requirements of 10.8.4.1.</td>
<td>Add the IEC 60204-1 clause 10.8.5, add the IEC 60204-1 heading, add the revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
<tr>
<td>10.9</td>
<td><strong>Displays</strong>&lt;br&gt;Displays (e.g. visual display units, alarm annunciators, indicator lights and the action initiating icons of human-machine interface (HMI) devices) shall be selected and installed in such a manner as to be visible from the normal position of the operator.&lt;br&gt;Note: It is recommended that displays intended to be warning devices be of the flashing or rotary type and be provided with an audible warning device.</td>
<td>Add the IEC 60204-1 clause 10.9, IEC 60204-1 heading, add the revised paragraph, and move to NFPA 79-2002 Clause 10.</td>
</tr>
</tbody>
</table>
COMMITTEE ACTION: Accept in Principle.

10 Operator interface and control devices.

10.1 General.

10.1.1 General device requirements. This clause contains requirements for devices mounted outside or partially outside control enclosures.

Note: For further information on device selection, mounting, identification, and coding, see IEC 60073 and IEC 60447.

10.1.2 Location and Mounting.

10.1.2.1 Control devices. As far as is practicable, control devices shall be:
— readily accessible for service and maintenance.
— mounted in such a manner as to minimize the possibility of damage from activities such as material handling.

10.1.2.2 Hand operated control devices. The actuators of hand-operated control devices shall be selected and installed so that:
— they are not less than 2 feet (0.6 m) above the servicing level and are within easy reach of the normal working position of the operator.
— the operator is not placed in a hazardous situation when operating them.
— the possibility of inadvertent operation is minimized.

10.1.3 Protection. Operator interface, control devices, and enclosures shall be suitable for the environment and shall withstand the stresses of expected use.

Note: For further information on degrees of protection, see UL 50, UL 508, Annex XX and IEC 60529.

10.1.4 Position sensors.

10.1.4.1 Position sensors (e.g. limit switches, position switches, proximity switches) shall be so arranged that they will not be damaged in the event of overtravel.

10.1.4.2 Position sensors used in circuits with safety-related functions either shall have positive (direct) opening operation or shall provide similar reliability.

Note: For further information on positive (or direct) opening operation, see IEC 60947-5-1.

10.1.5 Portable and pendant control stations.

10.1.5.1 Portable and pendant operator control stations and their control devices shall be so selected and arranged to minimize the possibility of inadvertent machine operations.

10.1.5.2 Pendant control stations that are vertically suspended from overhead shall comply with 14.4.2.4 or 14.5.10, be supported by suitable means, or flexible electrical conduit or multiconductor cable or cord identified for the purpose.

10.1.6 Operator interface devices.

10.1.6.1 Location of operator interface devices.

10.1.6.1.1 Operator interface devices shall be mounted in locations that will minimize exposure to oil, coolant, and other contaminants.

10.1.6.1.2 Operator interface devices shall be within normal reach of the machine operator and shall be so placed that the operator is not exposed to hazards.

10.1.6.1.3 Operator interface devices shall be located so that unintentional operation by normal movement of the machine, operator, or work will be unlikely.

10.1.6.2 Arrangement of operator interface devices. All Start pushbuttons shall be mounted above or to the left of their associated Stop pushbuttons.

10.1.6.3 Pushbutton actuators used to initiate is RED, associated Stop pushbuttons.

10.1.6.4 All Start — Foot-operated switches. Foot-operated switches used for applications where accidental actuation could create a hazardous situation shall be protected to prevent accidental actuation by falling or moving objects and from unintended operation by accidental stepping onto the switch.

Exception: Foot-operated switches used for emergency stop in accordance with 10.7.2.1 shall not be the covered or hooded type.

10.2 Push-button actuators and color graphic interface devices action initiating icons.

10.2.1 Pushbutton Actuators. Pushbutton actuators used to initiate a stop function shall be of the extended operator or mushroom-head types.

10.2.2 Colors. Pushbutton actuators and action initiating icons of color touch screen graphic interface devices shall be color coded as follows:

— Start or On - The preferred color of Start or On actuators is GREEN, except that BLACK, WHITE, or GRAY shall be permitted. Red shall not be used for Start or On.

— Stop or Off - The preferred color of Stop or Off actuators is RED, except that BLACK, WHITE, or GRAY shall be permitted. Green shall not be used for Stop or Off.

Exception: Stop function operators of the wobble-stick or rod-operated types in the bottom of a pendant station need not be colored red.

The color RED shall be used for, Emergency Stop actuators in accordance with 10.7.4.

— Alternate action - Pushbuttons that, when pressed, act alternately as Start and Stop or On and Off shall be BLACK, WHITE, or GRAY. RED or GREEN shall not be used.

— Abnormal conditions - The color YELLOW shall be used for actuators used to respond to abnormal conditions.

— Hold to operate - Pushbuttons that cause movement when pressed and stop movement when they are released (e.g., jogging) shall be BLACK, WHITE, GRAY, or BLUE with a preference for BLACK.

— Reset - Reset pushbuttons shall be BLUE, BLACK, WHITE, or GRAY except when they also act as a Stop or Off button, in which case they shall be RED.

10.2.3 Legends.

10.2.3.1 A legend shall be provided for each operator interface device to identify its function and shall be located so that it can be easily read by the machine operator from the normal operator position. The legends shall be durable and suitable for the operating environment.

10.2.3.2 For illuminated pushbuttons the function(s) of the light is separated from the function(s) of the button by a virgule (/).

10.3 Indicator lights and icons of visual display units color graphic interface devices.

10.3.1 Modes of use. Indicator lights and icons used with visual display units of color graphic interface devices shall provide the following information:

— indication: to attract the operator’s attention or to indicate that a certain task should be performed. The colors RED, YELLOW (AMBER), GREEN, and BLUE are normally used in this mode;

— confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colors BLUE and WHITE are normally used in this mode and GREEN shall be permitted to be used in some cases.
10.3.2 Colors. Indicator lights and icons of color graphic interface devices shall be color-coded with respect to the condition (status) of the machine in accordance with table XX. Alternate purposes shall be permitted to indicate machine or process status. (See table below)

10.3.3 Flashing lights. Flashing lights shall be permitted to be used for any of the following purposes:
- to attract attention,
- to request immediate action,
- to indicate a discrepancy between the command and actual states
- to indicate a change in process (flashing during transition).

10.4 Illuminated push-buttons. Illuminated push-button actuators shall be color-coded in accordance with table XX. The color RED for the emergency stop actuator shall not depend on the illumination source.

10.5 Rotary control devices. Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be relied upon to prevent rotation.

10.6 Start devices. Actuators used to initiate a start function or the movement of machine elements (e.g. slides, spindles, carriers) shall be constructed and mounted to minimize inadvertent operation. Mushroom-type actuators for two-hand control initiation shall conform to the requirements of 9.2.5.6 (two hand control).

10.7 Devices for stop and emergency stop.

10.7.1 Location and operation.

10.7.1.1 Stop and emergency stop pushbuttons shall be continuously operable and readily accessible.

10.7.1.2 Stop and emergency stop pushbuttons shall be located at each operator control station and at other locations where emergency stop is required.

10.7.2 Types.

10.7.2.1 The types of device for emergency stop include, but are not limited to:
- push-button operated switches in accordance with 10.7.4,
- pull-cord operated switches,
- foot-operated switches without a mechanical guard
- push bar operated switches.
- rod operated switches.

10.7.2.2 Pushbutton type devices for emergency stop shall be of the self-latching type and shall have positive (direct) opening operation.

10.7.3 Restoration of normal function after emergency stop. It shall not be possible to restore an emergency stop circuit until the emergency stop device has been manually reset. Where several emergency stop devices are provided in a circuit, it shall not be possible to restore that circuit until all emergency stop devices that have been operated have been reset.

10.7.4 Emergency stop actuators. Actuators of emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type. The RED/YELLOW color combination shall be reserved exclusively for emergency stop applications.

10.7.5 Local operation of the supply disconnecting means to effect emergency stop.

10.7.5.1 The supply disconnecting means shall be permitted to be locally operated to serve the function of emergency stop where:
- it is readily accessible to the operator;
- it is of the type described in 5.3.2 a), b) or c).

10.7.5.2 Where intended for such use, the supply disconnecting means shall meet the color requirements of 10.7.4.

10.8 Devices for emergency switching off.

10.8.1 Location. Emergency switching off devices as described in 9.2.5.4.3 shall be located as necessary for the given application.

10.8.2 Types.

10.8.2.1 The types of devices that initiate an emergency switching off operation shall be permitted to include, but are not limited to:
- push-button operated switches,
- pull-cord operated switches.

10.8.2.2 The push-button operated switch shall be permitted in a break-glass enclosure.

10.8.3 Restoration of normal function after emergency switching off. It shall not be possible to restore an emergency switching off circuit until the emergency switching off circuit has been manually reset.

10.8.4 Actuators.

Table XX Colors for indicator lights and icons of color graphic interface devices and their purposes with respect to the condition of the machine

<table>
<thead>
<tr>
<th>Color</th>
<th>Purposes</th>
<th>State of Equipment</th>
<th>Condition of process</th>
<th>Safety of persons or environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>Danger</td>
<td>Faulty</td>
<td>Emergency</td>
<td>Safety of persons or environment</td>
</tr>
<tr>
<td>YELLOW</td>
<td>Warning/Caution</td>
<td>Abnormal</td>
<td>Abnormal</td>
<td></td>
</tr>
<tr>
<td>BLUSH</td>
<td>Abnormal</td>
<td>Abnormal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GREEN</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>BLUE</td>
<td>Mandatory action</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEAR</td>
<td>No specific meaning assigned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHITE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLACK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10.8.4.1 Actuators of emergency switching off devices shall be colored RED. The background immediately around the device actuator shall be permitted to be colored YELLOW.

10.8.4.2 Where the emergency switching off initiating device is separate from the emergency stop device, the emergency switching off initiating device shall be functionally identified.

10.8.5 Local operation of the supply disconnecting means to effect emergency switching off. Where the supply disconnecting means is to be locally operated for emergency switching off, it shall be readily accessible and shall meet the color requirements of 10.8.4.1.

10.9 Displays. Displays (e.g., visual display units, alarm annunciators, indicator lights and the action initiating icons of human-machine interface (HMI) devices) shall be selected and installed in such a manner as to be visible from the normal position of the operator.

Note: It is recommended that displays intended to be warning devices be of the flashing or rotary type and be provided with an audible warning device.

COMMITTEE STATEMENT: 1) The revision in 10.1.5.2 was taken to correlate the provision of this section with the requirements in Clause 14.
2) Also an editorial revision to avoid the use of the words "such as" in 10.5.
3) 10.2.1 This text was renumbered and missing title.
4) 10.2.2 New Number 10.2.2 to correspond with new 10.2.1.
5) 10.2.2 "Color Graphic Interface Device" substituted for "touch screen", to agree with the title of the section.
6) 10.2.2 The word "actuators" removed to add clarity.
7) 10.3 "Color Graphic Interface Device" substituted for "visual display unit" to agree with term used in 10.3.2 and Table XX.
8) 10.3.1 "Color Graphic Interface Device" substituted for "visual display unit" to agree with term used in 10.3.2 and Table XX.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:
KNECHT: We recommend putting back the color graphic interface devices to what they were in NFPA 79. As proposed, it is too confusing as to what it is we are talking about.

COMMENT ON AFFIRMATIVE:
BLOODGOOD: I recognize that considerable time and effort went into the development of the proposed clause 10. Even so, if find it unfortunate that a closer agreement between this proposal and the recommended color coding found in IEC 60204-1:2000 (ed. 4.1) could not have been reached. (See 10.2.1 in both documents and table 3 in IEC 60204-1 and table XX in the proposal for the differences.)

DÉFELICE: To acquaint the reader with this term which now appears in Clause 10, the committee may wish to insert the following definition in Clause 3:

Color Graphic Interface Device: an interface between the operator and the machine, where a color video display and either a touch-screen or touch pad or keyboard or mouse are used to initiate machine action by the selection of on-screen icons. (This does not include monochrome or black and white displays)

WITHROW: COMMITTEE STATEMENT: 2) Also an editorial revision to avoid the use of the words "such as" in 10.5.
6) 10.2.2 The word "actuators" removed to add clarity.
REFERENCE: NFPA 79-2002 10.5 Rotary control devices
Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be relied upon to prevent rotation.
NFPA 79-1997 12.7 Rotary control devices
Devices such as potentiometers and selector switches having a rotating member shall be mounted to prevent rotation of the stationary member. Friction alone shall not be considered sufficient.
COMMENT: Item 2 - The Committee did not recommend an editorial replacement for use of the words "such as" in 10.5. If the editorial staff of NFPA can make this revision, this comment can be ignored.
Item 6 - Actuator was removed in the bullets for Start or On and Stop or Off. If YELLOW is used for action indication icons, it is recommended that the word "actuators" also be removed in the fourth bullet as follows:
Abnormal Conditions – The color YELLOW shall be used for actuators used to respond to abnormal conditions.
Exception: For machines which employ only a single emergency stop, emergency stop actuators of the momentary type shall be permitted.

SUBMISSION: Thomas Pilz, Pilz Industrial Electronics Ltd.

RECOMMENDATION: Revise as follows:

"For machines which employ only a single emergency stop device, emergency stop actuators of the momentary type shall be permitted."

EXPLANATION OF NEGATIVE: DROBNICK: I vote negative and urge my colleagues to reconsider. I believe that the red mushroom pushbutton with the yellow background combination is not currently nationally applied or recognized. Additionally, a legend plate clarifies the purpose of this safety device and reduces the chance of pushing the wrong button during an emergency situation.

Substantiation: Emergency stop pushbuttons are required to be labeled by ANSI B11.19-1990 E5.2.2.
16. Accessories and Lighting

16.1 Accessories

16.1.1 Where the machine or its associated equipment is provided with receptacle-outlets to be used for accessory equipment (e.g., hand-held power tools, test equipment), the following conditions shall apply:

a) Receptacles shall be of the grounding type, 125 volt, single-phase, 15 ampere configuration and listed for the applied voltage.

b) Receptacles with their associated attachment plugs (plug/sockets) shall be provided with a grounding pole and so constructed that the grounding pole is made before any current-carrying poles are made, and is not broken until all current-carrying poles of the attachment plug have been disconnected. A grounding pole shall not be used as a current-carrying part.

c) The continuity of the equipment grounding (protective bonding) circuit to the receptacle-outlet shall be verified by clause 19.2. Exception: Verification is not required for PELV circuits in accordance with 19.2.

d) All ungrounded (unearthed) conductors connected to the receptacle-outlet shall be protected against overcurrent in accordance with the provisions of 7.2 and 7.3 separately from the protection of other circuits.

e) Where the power supply to the receptacle-outlet is not disconnected by the supply disconnecting device for the machine or section of the machine, the warning and marking requirements of 3.3.5 shall apply.

f) Shall be suitable for the environment. Receptacles mounted external to the enclosure shall be provided with a means to cover the receptacle when the plug is removed.

16.1.2 Receptacles, part of the industrial machine, either internal or external to the control cabinet and intended for use by maintenance personnel shall be GFCI protected.

16.2 Local lighting of the machine and equipment

16.2.1 General

16.2.1.1 Lighting circuits shall comply with the provisions of 8.5. Where work lights are required, they shall be provided with a means to cover the receptacle when the plug is removed.

16.2.1.2 Where work lights are required, they shall be provided with receptacle-outlets to be used for accessory equipment (e.g., hand-held power tools, test equipment), the following conditions shall apply:

a) Receptacles shall be of the grounding type, 125 volt, single-phase, 15 ampere configuration and listed for the applied voltage.

b) Receptacles with their associated attachment plugs (plug/sockets) shall be provided with a grounding pole and so constructed that the grounding pole is made before any current-carrying poles are made, and is not broken until all current-carrying poles of the attachment plug have been disconnected. A grounding pole shall not be used as a current-carrying part.

c) The continuity of the equipment grounding (protective bonding) circuit to the receptacle-outlet shall be verified by clause 19.2. Exception: Verification is not required for PELV circuits in accordance with 19.2.

d) All ungrounded (unearthed) conductors connected to the receptacle-outlet shall be protected against overcurrent in accordance with the provisions of 7.2 and 7.3 separately from the protection of other circuits.

e) Where the power supply to the receptacle-outlet is not disconnected by the supply disconnecting device for the machine or section of the machine, the warning and marking requirements of 3.3.5 shall apply.

f) Shall be suitable for the environment. Receptacles mounted external to the enclosure shall be provided with a means to cover the receptacle when the plug is removed.

16.2.1.3 The conductors to stationary lights used as an integral part of the machine shall be Type MTW, and the conductors within the fixtures shall be not smaller than No. 18 AWG.

16.2.1.4 Flexible cords shall be Type SO, STO, STOW, or SJO, SJOW, SJTO and shall not incorporate in-line switches.

16.2.1.5 Stroboscopic effects from lights shall be avoided.

16.2.2 Supply

16.2.2.1 The lighting circuit voltage shall not exceed 150 volts between conductors.

16.2.2.2 Lighting circuits shall have overcurrent protection per 7.2.6 and shall be supplied from one of the following sources:

a) A separate isolating transformer connected to the load side of the supply disconnecting means. Overcurrent protection shall be provided in the secondary circuit.

b) A separate isolating transformer connected to the line side of the supply disconnecting means shall be permitted for the supply of a maintenance lighting circuit in control enclosures only.

Overcurrent protection shall be provided in the secondary circuit.

c) A grounded machine circuit with separate overcurrent protection.

d) An isolating transformer connected to the line side of the supply disconnecting device when a separate primary disconnecting means and secondary overcurrent protection are provided and mounted within the control enclosure adjacent to the supply disconnecting device.

e) An externally supplied lighting circuit (e.g., factory lighting supply). This shall be permitted in control enclosures and for the machine work light (s) where the total power rating does not exceed 3 kW.

16.2.3 Protection

16.2.3.1 Local lighting circuits shall be separately protected with overcurrent protection and shall not exceed 15 amperes.

16.2.4 Lighting Fixtures

16.2.4.1 Adjustable lighting fixtures shall be suitable for the physical environment.

16.2.4.2 The lampholders shall be:

a) Rated for the voltage and wattage of the lamp.

b) Constructed with an insulating material protecting the lamp so as to prevent unintentional contact, except where fixed lighting is out of reach of operators during normal operations, the provisions of this subclause do not apply.

16.2.4.3 Reflectors and protectors shall be supported by a bracket and not the lampholder.

SUBSTANTIATION: This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

Historical Background

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization – Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC-60204-1.

Importance of Issue – Harmonization

Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization – Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause 14 with IEC 60204-1 Clause 16. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber NFPA 79-1997 Clause 14 to correspond with IEC 60204-1 Clause 16. The task group proposes the following changes to further improve usability.

Substantiation for changes to NFPA 79-1997 Clause 14

16. Accessories and Lighting

Revision: No change except numbering; Clause 14 now Clause 16.

16.1 Accessories

Add the IEC 60204-1 subclause 16.1 heading.

Substantiation: New subclause heading clarifies the intent of the subclause.
16.1 Add IEC 60204-1 subclause 16.1.1.

Substantiation: This subclause clarifies a subject presently covered in subclause 14.1 of NFPA 79-1997. This subclause is for receptacles provided for portable accessory equipment. New subclause 14.4.5 contains requirements for connection and interconnection of equipment intended to be part of the equipment and required for the typical operation of the equipment.


Substantiation: The requirements for attachment plugs is removed as this subclause is only to address receptacles. For other receptacles with voltages greater than 300 volts the requirements are in new subclause 14.4.5.2. For other receptacles with current ratings exceeding 20 amperes the requirements are in new subclause 14.4.5.5.

16.1.1 b) Revise NFPA 79 paragraph 14.1.2.

Substantiation: Editorial revision only.

16.1.1 c) Add IEC 60204-1 subclause 16.1, second bullet.

Substantiation: This subclause covers a subject not presently in NFPA 79-1997 and is from IEC60204-1. It better addresses the issue of verifying the grounding continuity.

16.1.1 d) Add IEC 60204-1 subclause 16.1, third bullet.

Substantiation: This new subclause is from IEC 60204-1 and is similar to NFPA 79 subclauses 14.2.3 and 14.2.4 requiring overcurrent protection.

16.1.1 e) Add IEC 60204-1 subclause 16.1, fourth bullet.

Substantiation: This subclause covers a subject not presently in NFPA 79 and is from IEC 60204-1. It better addresses a warning marking stating that equipment that is live with the disconnect in the OFF position and enhances safety.

16.1.1 f) Add IEC 60204-1 subclause 16.1, fifth bullet.

Substantiation: This new subclause is from IEC 60204-1 and is similar to NFPA 79 subclause 14.1.3

16.1.2 Add new requirement.

Substantiation: The subclause covers a subject not currently in NFPA 79-1997 and it is intended to increase safety to the service and maintenance personnel using the accessory receptacles.

16.2 Local lighting of the machine and equipment

Revised title.

Substantiation: Revised title clarifies intent of the subclause.

16.2.1 General

Add the IEC 60204-1 subclause 16.2.1 heading.

Substantiation: The new subclause clarifies the intent of the subclause.

16.2.1.1 Addition: Add IEC 60204-1 subclause 16.2.1 first paragraph.

Substantiation: The new subclause is from IEC 60204-1 and is similar to NFPA 79 subclause 14.3.5 relating to grounding.


Substantiation: The panel felt the addition of GFCI requirements on work lights used in wet locations enhanced safety to the personnel using the equipment. The remainder of the subclause contains only editorial revisions and is from NFPA 79 14.3.6.

16.2.1.3 Revision: No change except numbering; subclause 14.3.3 now subclause 16.2.1.3.

16.2.1.4 Revision: No change except numbering; subclause 14.3.4 now subclause 16.2.1.4.

16.2.1.5 Revision: No change except numbering; subclause 14.3.7 now subclause 16.2.1.5.

16.2.2 Supply

Add the IEC 60204-1 subclause 16.2.2 heading.

Substantiation: The new subclause clarifies the content of the subclause.

16.2.2.1 Revision: No change except numbering; subclause 14.3.1 now subclause 16.2.2.1.

16.2.2.2 Add the IEC 60204-1 subclause 16.2.2 second paragraph.

Substantiation: The new subclause is from IEC 60204-1 and is similar to NFPA 79 subclause 14.3.2 relating to overcurrent protection.

16.2.2.2 a) Revisions: No change except numbering; subclause 14.3.2a) now subclause 16.2.2.2a).

16.2.2.2 b) Revisions: No change except numbering; subclause 14.3.2e) now subclause 16.2.2.2b).

16.2.2.2 c) Add the IEC 60204-1 subclause 16.2.2, second paragraph, third bullet.

Substantiation: The new subclause is from IEC 60204-1 and is similar to NFPA 79 subclause 14.3.2b) relating to the use of grounded machine circuits lighting power.

16.2.2.2 d) Add the IEC 60204-1 subclause 16.2.2, second paragraph, fourth bullet.

Substantiation: The new subclause is from IEC 60204-1 and is similar to NFPA 79 subclause 14.3.2f) relating to the source of power from the line side of the disconnect.

16.2.2.2 e) Add the IEC 60204-1 subclause 16.2.2, third paragraph.

Substantiation: The new subclause is from IEC 60204-1 and is similar to NFPA 79 subclause 14.3.2c) relating to the use of plant lighting circuits.

16.2.3 Protection

Add the IEC 60204-1 heading for subclause 16.2.3

Substantiation: The new subclause heading clarifies the content of the subclause.

16.2.3.1 Add the IEC 60204-1 subclause 16.2.3.

Substantiation: The new subclause is from IEC 60204-1 and is similar to NFPA 79 subclause 8.10 relating to protection of lighting branch circuits.

16.2.4 Lighting Fixtures
16.2.4.1 Add the IEC 60924-1 subclause 16.2.4. 

Substantiation: The new subclause is from h IEC 60924-1 and is similar to NFPA 79 subclause 14.3.6 relating to suitability of lighting fixture to the physical environment.

16.2.4.2 Addition: Add the IEC 60924-1 subclause 16.2.4 second paragraph. 

Substantiation: This subclause covers a subject not presently in NFPA 79-1997 and is from IEC 60924-1. It better addresses requirements for lampholders of lighting fixtures on the machine.

16.2.4.2 a) Add new text. 

Substantiation: This subclause covers a subject not presently in NFPA 79-1997 and is from IEC 60924-1. It addresses that the lampholder should be rated for the intended lamp.

16.2.4.2 b) Add the IEC 60924-1 subclause 16.2.4 third paragraph. 

Substantiation: This subclause covers a subject not presently in NFPA 79-1997 and is from IEC 60924-1. It address the issue of unintentional contact of the lampholder by the operator and increases the safety of contacting the lamp.

16.2.4.3 Revision: No change except numbering; subclause 14.3.8 now 16.2.4.3. (See table on following page.)

COMMITTEE ACTION: Accept in Principle.

Revise Clause 16 to read as follows:

16.1 Accessories and Lighting

16.1 Accessories

16.1.1 Where the machine or its associated equipment is provided with receptacle-outlets to be used for accessory equipment (e.g. hand-held power tools, test equipment), the following conditions shall apply:

a) Receptacles shall be of the grounding type, 125 volt, single-phase, 15 ampere configuration and listed for the applied voltage.

b) Receptacles with their associated attachment plugs (plug/sockets) shall be provided with a grounding pole and so constructed that the grounding pole is made before any current-carrying poles of the attachment plug have been disconnected. A grounding pole shall not be used as a current-carrying part.

c) The continuity of the equipment grounding (protective bonding) circuit to the receptacle-outlet shall be verified by clause 19.2. Exception: Verification is not required for PELV circuits in accordance with 19.2.

d) All ungrounded (uncarhed) conductors connected to the receptacle-outlet shall be protected against overcurrent in accordance with the provisions of 7.2.5 and 7.2.6 separately from the protection of other circuits.

e) Where the power supply to the receptacle-outlet is not disconnected by the supply disconnecting device for the machine or section of the machine, the warning and marking requirements of 5.3.5.4 shall apply.

f) Shall be suitable for the environment. Receptacles mounted external to the enclosure shall be provided with a means to cover the receptacle when the plug is removed.

16.1.2 Receptacles, part of the industrial machine, either internal or external to the control cabinet and intended for use by maintenance personnel shall be GFCI protected. 16.2 Local lighting of the machine and equipment

16.2.1 General

16.2.1.1 Lighting circuits shall comply with the provisions of 8.5.

16.2.1.2 Where work lights are required, they shall be provided with an ON-OFF switch conveniently located on the equipment. Lamp holders shall not incorporate a switch or receptacle. Work lights used in wet locations shall be provided with ground fault protection.

16.2.1.3 The conductors to stationary lights used as an integral part of the machine shall be Type MTW, and the conductors within the fixtures shall be not smaller than No. 18 AWG.

16.2.1.4 Flexible cords shall be Type SO, STO, STOW, or SJ, SJOW, SJTO and shall not incorporate in-line switches.

16.2.1.5 Stroboscopic effects from lights shall be avoided.

16.2.2 Supply

16.2.2.1 The lighting circuit voltage shall not exceed 150 volts between conductors.

16.2.2.2 Lighting circuits shall have overcurrent protection per 7.2.6 and shall be supplied from one of the following sources.

a) A separate isolating transformer connected to the load side of the supply disconnecting means. Overcurrent protection shall be provided in the secondary circuit.

b) A separate isolating transformer connected to the line side of the supply disconnecting means shall be permitted for the supply of a maintenance lighting circuit in control enclosures only. Overcurrent protection shall be provided in the secondary circuit.

c) A grounded machine circuit with separate overcurrent protection and not exceeding 150 volts to ground shall be permitted.

d) An isolating transformer connected to the line side of the supply disconnecting device when a separate primary disconnecting means and secondary overcurrent protection are provided and mounted within the control enclosure adjacent to the supply disconnecting device.

e) An externally supplied lighting circuit (e.g. factory lighting supply). This shall be permitted in control enclosures and for the machine work light (s) where the total power rating does not exceed 3 kW.

16.2.3 Protection

16.2.3.1 Local lighting circuits shall be separately protected with overcurrent protection and shall not exceed 15 amperes.

16.2.4 Lighting Fixtures

16.2.4.1 Adjustable lighting fixtures shall be suitable for the physical environment.

16.2.4.2 The lampholders shall be:

a) Rated for the voltage and wattage of the lamp.

b) Constructed with an insulating material protecting the lamp so as to prevent unintentional contact, except where fixed lighting is out of reach of operators during normal operations, the provisions of this subclause do not apply.

c) A grounded machine circuit with separate overcurrent protection and not exceeding 150 volts to ground shall be permitted.

d) An isolating transformer connected to the line side of the supply disconnecting device when a separate primary disconnecting means and secondary overcurrent protection are provided and mounted within the control enclosure adjacent to the supply disconnecting device.

e) An externally supplied lighting circuit (e.g. factory lighting supply). This shall be permitted in control enclosures and for the machine work light (s) where the total power rating does not exceed 3 kW.

16.2.4.3 Reflectors and protectors shall be supported by a bracket and not the lampholder.


2) 16.2.2.2(c) was revised to more closely correlate with the provisions on NFPA 79-1997, 14.3.2(b).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: 

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman
<table>
<thead>
<tr>
<th>Clause</th>
<th>Heading (or topic)</th>
<th>Clause</th>
<th>Heading (or topic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Accessories and lighting</td>
<td>16</td>
<td>Accessories and lighting</td>
</tr>
<tr>
<td>14.1</td>
<td>Attachment plugs and receptacles external to the control enclosure</td>
<td>16.1</td>
<td>Accessories</td>
</tr>
<tr>
<td>14.1.1</td>
<td>(new subclause not in NFPA 79)</td>
<td>16.1.1</td>
<td>(receptacles for use with hand tools, etc., shall)</td>
</tr>
<tr>
<td>14.1.2</td>
<td>(listed and locking if &gt;20amps, skirted if &gt; 300)</td>
<td>16.1.1 a)</td>
<td>(listed, grounding type, 125 volt, single-phase, 15 or 20 amp)</td>
</tr>
<tr>
<td>14.1.2</td>
<td>(provided with grounding pole, make first/break last)</td>
<td>14.4.5.2</td>
<td>(skirted if &gt; 300 volts)</td>
</tr>
<tr>
<td>14.1.2</td>
<td>(provided with grounding pole, make first/break last)</td>
<td>14.4.5.5</td>
<td>(locking type if &gt; 20 amps)</td>
</tr>
<tr>
<td>14.1.3</td>
<td>(suitable for environment)</td>
<td>16.1.1 b)</td>
<td>(provided with grounding pole, make first/break last)</td>
</tr>
<tr>
<td>14.2</td>
<td>Receptacles internal to the control enclosure</td>
<td>16.1.1 c)</td>
<td>(suitable for environment)</td>
</tr>
<tr>
<td>14.2.1</td>
<td>(permitted uses of maintenance and AC distribution)</td>
<td>16.1.1 d)</td>
<td>(suitable for environment)</td>
</tr>
<tr>
<td>14.2.2</td>
<td>(parallel blade, 125 v, 15 A)</td>
<td>16.1.1 e)</td>
<td>(suitable for environment)</td>
</tr>
<tr>
<td>14.2.5</td>
<td>(source from isolating transformer or other)</td>
<td>16.2.1</td>
<td>General</td>
</tr>
<tr>
<td>14.3</td>
<td>Control panel, instrument, and machine work lights</td>
<td>16.2.2</td>
<td>Local lighting of the machine and equipment</td>
</tr>
<tr>
<td>14.3.1</td>
<td>(not to exceed 150 volts and supplied from:)</td>
<td>16.2.2.1</td>
<td>(not to exceed 150 volts)</td>
</tr>
<tr>
<td>14.3.2</td>
<td>(lights supplied from one of the following)</td>
<td>16.2.2.2</td>
<td>(overcurrent protected and supplied from one of the following)</td>
</tr>
<tr>
<td>14.3.2 a)</td>
<td>(iso trans on load side of machine disconnect)</td>
<td>16.2.2.2 a)</td>
<td>(iso trans on load side of machine disconnect)</td>
</tr>
<tr>
<td>14.3.2 b)</td>
<td>(grounded 120 v machine control ckt with o/c protect)</td>
<td>16.2.2.2 c)</td>
<td>(grounded machine circuit with overcurrent protection)</td>
</tr>
<tr>
<td>14.3.2 c)</td>
<td>(plant lighting circuit for maintenance lighting in enclosure only)</td>
<td>16.2.2.2 d)</td>
<td>(external factory lighting circuit in enclosure max 3kW capac)</td>
</tr>
<tr>
<td>14.3.2 d)</td>
<td>(if motors 2 hp or less, can connect to plant lighting)</td>
<td>16.2.2.2 e)</td>
<td>(if 3kW or less, can connect to plant lighting)</td>
</tr>
<tr>
<td>14.3.2 e)</td>
<td>(separate iso transformer on line side of machine disconnect inside control enclosure only)</td>
<td>16.2.2.2 b)</td>
<td>(separate iso transformer on line side of machine disconnect in control enclosures only)</td>
</tr>
<tr>
<td>14.3.2 f)</td>
<td>(separate iso transformer on line side of main disconnect when separate disconnect and secondary overcurrent protection furnished within control enclosure)</td>
<td>16.2.2.2 d)</td>
<td>(separate iso transformer on line side of supply disconnect when separate primary disconnect and secondary overcurrent protection furnished within control enclosure)</td>
</tr>
<tr>
<td>8.10</td>
<td>(lighting branch circuits not to exceed 15 amperes)</td>
<td>16.2.3</td>
<td>Protection</td>
</tr>
<tr>
<td>14.5</td>
<td>(stationary light conductors MTW and min18 AWG conductors used inside fixture)</td>
<td>16.2.3.1</td>
<td>(separately protected lighting branch circuits not to exceed 15 amperes)</td>
</tr>
<tr>
<td>14.5.4</td>
<td>(flex cord SO, STO, STOW, SJO, etc., no switches)</td>
<td>16.2.1.3</td>
<td>(stationary light conductors MTW and min 18 AWG conductors used inside fixture)</td>
</tr>
<tr>
<td>14.5.4</td>
<td>(flex cord SO, STO, STOW, SJO, etc., no switches)</td>
<td>16.2.1.4</td>
<td>(flex cord SO, STO, STOW, SJO, etc., no switches in line)</td>
</tr>
<tr>
<td>14.3.5</td>
<td>(grounding per subclause 19.8)</td>
<td>16.2.1.1</td>
<td>(grounding per subclause 19.8)</td>
</tr>
<tr>
<td>14.3.6</td>
<td>(no switches or receptacles in lights and not exposed to liquids/mists)</td>
<td>16.2.1.2</td>
<td>(ON-OFF switch provided on equipment, lamp holder not to have switch or receptacle lights in wet location provided with GFCI)</td>
</tr>
<tr>
<td>14.3.7</td>
<td>(stroboscopic effects to be avoided)</td>
<td>16.2.1.5</td>
<td>(stroboscopic effects to be avoided)</td>
</tr>
<tr>
<td>14.3.8</td>
<td>(reflectors supported by bracket)</td>
<td>16.2.4.3</td>
<td>(reflectors supported by bracket)</td>
</tr>
<tr>
<td>14.3.8</td>
<td>(reflectors supported by bracket)</td>
<td>16.2.4</td>
<td>Lighting Fixtures</td>
</tr>
<tr>
<td>14.3.8</td>
<td>(new subclause not in NFPA 79)</td>
<td>16.2.4.1</td>
<td>(adjustable fixtures suitable for the environment)</td>
</tr>
<tr>
<td>14.3.8</td>
<td>(new subclause not in NFPA 79)</td>
<td>16.2.4.2 a)</td>
<td>(lampholders shall be rated for voltage and wattage)</td>
</tr>
<tr>
<td>14.3.8</td>
<td>(new subclause not in NFPA 79)</td>
<td>16.2.4.2 b)</td>
<td>(lampholders constructed to prevent unintentional contact)</td>
</tr>
</tbody>
</table>
79-106 - ([16.1.1(b)]): Accept in Principle

SUBMITTER: William E. Anderson, The Procter & Gamble Company

RECOMMENDATION: Revise the following paragraph (16.1.1(b):

(b) Receptacles with their associated attachment plugs (plug/sockets) shall be provided with a grounding pole and so constructed that the grounding pole is made before any current carrying poles are made, and is not broken until all current carrying poles of the attachment plug have been disconnected, so designed that: a protective bonding (equipment grounding) circuit connection is made before any live connections are made; and the protective bonding (equipment grounding) circuit connection is not disconnected until all live connections in the plug are disconnected. A grounding pole shall not be used as a current-carrying part.

SUBSTANTIATION: The requirement is covered in NFPA 79 proposed 2002 Edition 16.1.1(b) and 14.4.5.3. The revision would make 16.1.1(b), consistent with NFPA 79, 2000 edition 14.4.5.3 which the full committee had used set the style for the same requirement.

COMMITTEE ACTION: Accept in Principle.

Revise 16.1.1(b) to read as follows: Receptacles with their associated attachment plugs (plug/sockets) shall be in accordance with 14.4.5.3.

COMMITTEE STATEMENT: The committee revised the proposed wording of the submitter to reference rather than duplicate the requirements in 14.4.5.3. See the Committee Action and Statement on Proposal 79-122 (Log #55). The committee understands that this proposal modifies the Action on Proposal 79-105 (Log #26).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79-107 - (16.1.1(f)): Reject

SUBMITTER: William E. Anderson, The Procter & Gamble Company

RECOMMENDATION: Revise the following paragraph (16.1.1(f)):

(f) shall be suitable for the environment. Receptacles mounted external to the enclosure shall be provided with a means to cover the receptacle when the plug is removed.

SUBSTANTIATION: The requirement is covered in NFPA 79 proposed 2002 Edition 16.1.1(f) and 14.4.5.3. The revision would make this consistent with NFPA 79, 2000 edition 14.4.5.7 in which the full committee had set the style for the same requirement.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The substantiation is incorrect because 16.1.1(a) does not cover this requirement.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79-109 - (16.2.1.2): Reject

SUBMITTER: Paul Dobrowsky, Holley, NY

RECOMMENDATION: Delete the last sentence.

SUBSTANTIATION: The provided substantiation is insufficient. Requiring all receptacles to be GFCI protected could also be considered as "increasing safety". GFCI protection can be provided for maintenance activities by using portable means as permitted in the NEC. Many machines are located in factories that are clean and well maintained. IEC 60994-1 does not have this requirement nor does the existing NFPA 79. The addition of this requirement does not promote the harmonization effort.

MONTEITH: I agree with Mr. Dobrowsky's Explanation of Negative Vote.

PADGET: I agree with Mr. Dobrowsky's Explanation of Negative Vote.

79-110 - (16.3.6 [16.2.1.2]): Accept in Principle

SUBMITTER: Richard Graham, Bridgeport Machines Limited/Rep. CECIMO (European Committee for Co-operation of the Machine Tool Industries)

RECOMMENDATION: Retain the current text.

SUBSTANTIATION: The committee’s proposal to change the current text to what is included in the new 16.2.1.2 has no technical justification. The substantiation is poor. Harmonization is no reason on its own. To say that it is similar to the existing clause is not true. It is the opposite. On many machines the traditional lamp has been replaced with fluorescent lights that do not exhibit stroboscopic problems and on this type of light it is unusual to have an ON/OFF switch.

COMMITTEE ACTION: Accept in Principle.

Add a new first sentence to 16.2.1.2 to read as follows: Machine work lights shall not contain switches or receptacles where exposed to liquids or condensing mists unless identified for the purpose. The committee understands that this action deletes the first sentence only of 16.2.1.2 in Proposal 79-105 (Log #26) with the words of 14.3.6 of NFPA 79-1997. The last two sentence of 16.2.1.2 remains unchanged.
COMMITTEE STATEMENT: The committee understands that the recommended action of the submitter was intended to only delete the first sentence of 16.2.1.2. The committee understands that this proposal modifies the Action on Proposal 79-105 (Log #26) [Clause 16].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE: SAUNDERS: This action if accepted would revise the new paragraph 16.2.1.2 as follows:
"Where work lights are required, they shall be provided with an ON-OFF switch conveniently located on the equipment. Machine work lights shall not contain switches or receptacles where exposed to liquids or condensing mists unless identified for the purpose. Lamp holders shall not incorporate a switch or receptacle. Work lights in wet locations shall be provided with ground fault protection."

Recommendation: The paragraph should be revised to read as follows:
"Where work lights are required, they shall be provided with an On-Off switch conveniently located on the equipment. Lamp holders shall not incorporate a switch or receptacle. Work lights in wet locations shall be provided with ground fault protection."

Log #159

79-111 - ([16.2.1.5]): Reject
SUBMITTER: Paul Dobrowsky, Holley, NY
RECOMMENDATION: Add the following text:
(1) Fluorescent lamps shall only use electronic ballasts.
(2) Other electric discharge lamps shall be supplied by more than one circuit from different phases.

SUBSTANTIATION: The existing text is interpreted many ways. Some say more than one fixture is necessary. Some say more than one circuit, more than one lamp, or more than one ballast. High frequency ballasts do not cause the problem.

COMMITTEE STATEMENT: The solution presented are not the sole solutions to the problem. The committee is not convinced that adequate substantiation has been provided.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

Log #28

79-112 - (Clause 15 [(Clause 13)]: Accept in Principle
SUBMITTER: Melvin K. Sanders, TECâ™, Inc.
RECOMMENDATION: Revise NFPA 79-1997 Clause 18 "Motor and motor compartments" and issue as new Clause 15 "Electric motors and associated equipment" as follows:

13.1 General requirements

Conductors and cables shall be selected so as to be suitable for the operating conditions (e.g., voltage, current, protection against electric shock, grouping of cables) and external influences (e.g., ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses during installation), fire hazards) that can exist. Cables and conductors shall be identified for their intended use.

13.1.2 Wire insulation.

Conductors shall be insulated.

Exception No. 1: Bus bars shall not be required to be insulated.

Exception No. 2: Bare conductors, such as capacitor or resistor leads and jumpers between terminals, shall be permitted where the method of securing provides electrical clearance.

Exception No. 3: Equipment grounding conductors and bonding jumpers shall be permitted to be covered or bare.

13.1.3 Mineral-insulated, metal-sheathed cable, Type MI, shall be permitted. Temperature range – 85°C (185°F) Dry and Wet Locations.

13.1.4 Conductors smaller than 18 AWG used to connect electronic programmable control I/O, and static control, shall be listed.

13.2 Conductors.

13.2.1 Conductor Material.

Conductors shall be copper.

Exception No. 1: Aluminum alloy busbars, located internal to the enclosure, shall be permitted where suitable for the application.

Exception No. 2: The metal frame of the machine shall be permitted to be used as an equipment grounding (protective bonding) conductor.

13.2.2. Stranded Conductors.

Conductors of sizes 22 through 4/0 AWG and sizes 250 through 1000 kcmil shall be only of stranded soft-annealed copper. See Table 9 for conductor cross-sectional area, dc resistance, and stranding.

Exception No. 1: Conductors with stranding other than that specified in Table 9 shall be permitted on individual devices that are purchased completely wired (e.g., motor starters).

Exception No. 2: Conductors subject to temperatures, voltages, environmental conditions, or flexing exceeding the ratings listed in this clause shall have suitable characteristics.
13.2.7 Special cables and conductors.

13.2.7.2 Special conductors such as RG-/U transmission cable shall be permitted where necessary for the proper functioning of the equipment.

13.3 Insulation

13.3.1 The insulation and the finished wires and cables shall have flame retardant properties, and temperature limits and characteristics as listed below:

- MTW—Moisture-, Heat-, and Oil-Resistant Thermoplastic 60°C (140°F) Wet Locations
- THHN—Heat-Resistant Thermoplastic 90°C (194°F) Dry Locations
- THW—Moisture- and Heat-Resistant Thermoplastic 75°C (167°F) Dry and Wet Locations
- THWN—Moisture- and Heat-Resistant Thermoplastic 75°C (167°F) Dry and Wet Locations

13.3.3 The average and the minimum thickness of the insulation in constructions A and B shall be in accordance with Table 10.

13.3.4 Construction B shall have a nylon jacket applied directly over the insulation. The jacket shall be snug over the insulation and shall be at least as thick as indicated in Table 10.

### NFPA 79: Table 9 – Single conductor characteristics

<table>
<thead>
<tr>
<th>Size (AWG/kcmil)</th>
<th>Cross-sectional area nominal (CM/mm²)</th>
<th>DC resistance at 25°C (ohms/1000 ft)</th>
<th>Nonflexing (ASTM class)</th>
<th>Flexing (ASTM class)</th>
<th>Constant flex (ASTM class/AWG size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 1/0</td>
<td>894/0.324</td>
<td>17.7</td>
<td>10(K)</td>
<td>19(M/34)</td>
<td></td>
</tr>
<tr>
<td>20 1/0</td>
<td>1020/0.319</td>
<td>10.7</td>
<td>10(K)</td>
<td>26(M/34)</td>
<td></td>
</tr>
<tr>
<td>18 1/0</td>
<td>1620/0.823</td>
<td>6.77</td>
<td>16(K)</td>
<td>41(M/34)</td>
<td></td>
</tr>
<tr>
<td>16 2/0</td>
<td>2580/1.31</td>
<td>4.26</td>
<td>26(K)</td>
<td>65(M/34)</td>
<td></td>
</tr>
<tr>
<td>14 2/0</td>
<td>4110/2.08</td>
<td>2.68</td>
<td>41(K)</td>
<td>41(K/30)</td>
<td></td>
</tr>
<tr>
<td>12 3/0</td>
<td>6550/3.31</td>
<td>1.68</td>
<td>65(K)</td>
<td>65(K/30)</td>
<td></td>
</tr>
<tr>
<td>10 4/0</td>
<td>10380/5.261</td>
<td>1.060</td>
<td>104(K)</td>
<td>104(K/30)</td>
<td></td>
</tr>
<tr>
<td>8 5/0</td>
<td>16510/8.367</td>
<td>0.6665</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>6 6/0</td>
<td>26240/13.30</td>
<td>0.4192</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>4 7/0</td>
<td>41740/21.15</td>
<td>0.2636</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>3 8/0</td>
<td>52620/26.67</td>
<td>0.2091</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>2 9/0</td>
<td>66300/33.62</td>
<td>0.1659</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>1 10/0</td>
<td>83600/42.41</td>
<td>0.1315</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>1/0</td>
<td>105600/53.49</td>
<td>0.1042</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>2/0</td>
<td>133100/67.43</td>
<td>0.08267</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>3/0</td>
<td>167800/85.01</td>
<td>0.06658</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>4/0</td>
<td>211600/107.2</td>
<td>0.05200</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>250 kcmil</td>
<td>- /127</td>
<td>0.04401</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>- /152</td>
<td>0.03667</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>350</td>
<td>- /177</td>
<td>0.03144</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>- /203</td>
<td>0.02751</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>450</td>
<td>- /228</td>
<td>0.02445</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>- /253</td>
<td>0.02200</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>550</td>
<td>- /279</td>
<td>0.02000</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>- /304</td>
<td>0.01834</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>650</td>
<td>- /329</td>
<td>0.01692</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>700</td>
<td>- /355</td>
<td>0.01572</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>750</td>
<td>- /380</td>
<td>0.01467</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>- /405</td>
<td>0.01357</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>900</td>
<td>- /456</td>
<td>0.01222</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>- /507</td>
<td>0.01101</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
</tbody>
</table>

(B, C, K) ASTM Class designation B and C per ASTM B 8-81, Class designation K per ASTM B 174-1971 (R1980)

(*) A class designation has not been assigned to this conductor but is designated as size 22-7 in ASTM B286-1974 (R1979) and is composed of strands 10 mils in diameter (No. 30 AWG).

(\(^\)) Nonflexing construction shall be permitted for flexing service

(\(^\ast\)) Per ASTM Class designation B 174-1971 (R1980) Table 3

(\(^\ast\)\(^\ast\)\(^\ast\)) Constant flexing cables are not constructed in these sizes

### 13.2 Flexing

#### 13.2.1 Solid Conductors

Solid conductors 24-30 AWG of soft-annealed copper shall be permitted for use within control enclosures where not subject to flexing.

#### 13.2.2 Printed wire assemblies

Printed wire assemblies of flame-retardant material shall be permitted in place of conductor assemblies provided they are within control enclosures and are mounted in such a way as to minimize flexing or stress.

#### 13.2.3 Shielded conductors

Where shielding is used around conductors in single or multiconductor cables, a foil shield shall be permitted for non-flexing applications. A continuous drain wire shall be provided for foil shield types. A braided shield shall be used where subject to longitudinal flexing. Torsional flexing applications (e.g. a robot arm) shall require shields designed specifically for their use. The shields and drain wire shall be covered with an outer jacket that is suitable for the environment. In all cases the shield shall provide a continuous conduction surface in the presence of bending and flexing.
### Table 10 – Single conductor insulation

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Thickness of Insulation (Mils*) [Average/Minimum(Jacket)]</th>
<th>Wire Size</th>
<th>Thickness of Insulation (Mils*) [Average/Minimum(Jacket)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 AWG</td>
<td>30/27 15/13(4)</td>
<td>20</td>
<td>30/27 15/13(4)</td>
</tr>
<tr>
<td>18</td>
<td>30/27 15/13(4)</td>
<td>16</td>
<td>30/27 15/13(4)</td>
</tr>
<tr>
<td>14</td>
<td>30/27 15/13(4)</td>
<td>12</td>
<td>30/27 15/13(4)</td>
</tr>
<tr>
<td>10</td>
<td>30/27 20/18(4)</td>
<td>8</td>
<td>45/40 0/27(5)</td>
</tr>
<tr>
<td>6</td>
<td>60/54 30/27(5)</td>
<td>4</td>
<td>60/54 40/36(6)</td>
</tr>
<tr>
<td>4-2</td>
<td>60/54 40/36(6)</td>
<td>1-4/0</td>
<td>80/72 50/45(7)</td>
</tr>
<tr>
<td>250-500 MCM</td>
<td>95/86 60/54(8)</td>
<td>550-1000</td>
<td>110/99 70/63(9)</td>
</tr>
</tbody>
</table>

(*) UL 1063 Table 1.1 NEC Construction

- **A** No outer covering
- **B** Nylon Covering

13.4 Wire markings.

13.4.1 A durable legend printed on the outer surface of the insulation of construction **A**, on the outer surface of the nylon jacket of construction **B**, on the outer surface of the insulation under the jacket of construction **B** (only if clearly legible through the nylon), or on the outer surface of the jacket of a multiconductor cable shall be repeated at intervals of no more than 24 in. (610 mm) throughout the length of the single-conductor or the multiconductor cable.

*Exception: Sizes smaller than 16 AWG shall be permitted to be marked on the reel or on the smallest unit of the shipping carton.*

13.4.2 The legend shall include the manufacturer’s name or trademark, the wire type, voltage rating, and gauge or size.

13.4.3 Where the conductor size is 16 through 10 AWG and the stranding is intended for flexing service, the legend shall include "flexing" or "Class K."

13.4.4 Wire insulation shall be identified and adequate for the voltage on that conductor.

13.5 Conductor Ampacity.

The continuous current carried by conductors shall not exceed the values given in Table 11. Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity in cable or raceway.

### Table 11 – Conductor ampacity based on copper conductors with 60°C and 75°C insulation in an ambient temperature of 30°C

<table>
<thead>
<tr>
<th>Conductor size (AWG)</th>
<th>60°C Ampacity</th>
<th>75°C Ampacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>–</td>
<td>0.5</td>
</tr>
<tr>
<td>28</td>
<td>–</td>
<td>0.8</td>
</tr>
<tr>
<td>26</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>115</td>
</tr>
<tr>
<td>1</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
<td>150</td>
</tr>
<tr>
<td>2/0</td>
<td>145</td>
<td>175</td>
</tr>
<tr>
<td>3/0</td>
<td>165</td>
<td>200</td>
</tr>
<tr>
<td>4/0</td>
<td>195</td>
<td>230</td>
</tr>
<tr>
<td>250</td>
<td>215</td>
<td>255</td>
</tr>
<tr>
<td>300</td>
<td>240</td>
<td>285</td>
</tr>
<tr>
<td>350</td>
<td>260</td>
<td>310</td>
</tr>
<tr>
<td>400</td>
<td>280</td>
<td>335</td>
</tr>
<tr>
<td>500</td>
<td>320</td>
<td>380</td>
</tr>
<tr>
<td>600</td>
<td>355</td>
<td>420</td>
</tr>
<tr>
<td>700</td>
<td>385</td>
<td>460</td>
</tr>
<tr>
<td>750</td>
<td>400</td>
<td>475</td>
</tr>
<tr>
<td>800</td>
<td>410</td>
<td>490</td>
</tr>
<tr>
<td>900</td>
<td>435</td>
<td>520</td>
</tr>
<tr>
<td>1000</td>
<td>455</td>
<td>545</td>
</tr>
</tbody>
</table>

**NOTE 1:** Wire types listed in Section 13.1 shall be permitted to be used at the ampacities listed in this table.

**NOTE 2:** The sources for the ampacities in this table are Tables 310-16 of the NEC.
13.5.1 Motor circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating.

13.5.2 Combined load conductors shall have an ampacity not less than 125 percent of the full-load current rating of all resistance heating loads plus 125 percent of the full-load current rating of the highest rated motor plus the sum of the full-load current ratings of all other connected motors and apparatus that may be in operation at the same time.

13.5.3 Where ampacity derating is required for ambient temperature correction for other than 30°C or adjusted for more than three current-carrying conductors in a raceway or cable, the factor(s) shall be taken from Table 13-3b. (See Table 13-3b below)

13.5.4 The maximum size of a conductor selected from Table 11 and connected to a motor controller shall not exceed the values given in Table 12.

Exception: Where other motor controllers are used, the maximum conductor size shall not exceed that specified by the manufacturer.

<table>
<thead>
<tr>
<th>Motor Controller Size</th>
<th>Maximum Conductor Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWG or MCM</td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>14</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>000</td>
</tr>
<tr>
<td>5</td>
<td>500</td>
</tr>
</tbody>
</table>

*See ANSI/NEMA ICS 2-[1983] table 2, 110-1

13.5.5 Conductor/terminal compatibility

The conductor(s) shall be compatible with the device terminal(s), and the conductor size(s) shall not exceed the range recommended by the device manufacturer.

13.6 Conductor sizing.

Conductors shall not be smaller than:

13.6.1 Power circuits

No. 14

Exception 1: No. 16 shall be permitted where applied as follows:

a) For non-motor power circuits of 8 amperes or less where protected in accordance with Clause 7 and with Class CC fuses rated at not more than 10 amperes, or
b) For motor loads with a full load ampacity of 8 amperes or less, where protected with Class CC fuses at not more than 250% of full load ampacity, and Class 10 overload protection per UL 508, or
c) For motor loads with a full load ampacity of 5.5 amperes or less, where protected with Class CC fuses at not more than 250% of full load ampacity, and Class 20 overload protection per UL 508, and

13.7.1 General

13.7.1.1 Conductors and cables used for flexing applications shall be selected from Table 9.

13.7.1.2 Cables which are subjected to severe duties shall be of adequate construction to protect against:

- abrasion due to mechanical handling and dragging across rough surfaces;
- kinking due to operation without guides;
- stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums.

NOTE 1 - Cables for such conditions are specified in relevant national standards.

13.7.2 Shielded conductors Shielded conductors shall consist of stranded, annealed copper of 25 AWG or larger for single conductors used in subassemblies and 22 AWG or larger for all other uses.

13.7.3 Control circuits within control enclosures or operator stations No. 18.

13.7.4 Electronic programmable control I/O, and static control.

a) Conductors in raceways 24 AWG.

Exception: In a jacketed, multiconductor cable assembly or cord, 30 AWG or larger shall be permitted.

b) Conductors within control enclosures No. 26 AWG.

Exception: For jumpers and special wiring applications (e.g., solderless wrap or wire-clip type connections or shielded conductors), conductors No. 30 AWG or larger shall be permitted.

13.7.5 Shielded conductors Shielded conductors shall consist of stranded, annealed copper of 25 AWG or larger for single conductors used in subassemblies and 22 AWG or larger for all other uses.

13.7 Conductor and cables used for flexing applications.

<table>
<thead>
<tr>
<th>Ambient Temp. (°C)</th>
<th>Correction Factors Factor 60°C 75°C</th>
<th>Number of Current-Carrying Conductors Exceeding Three</th>
<th>Percent of Values in Tables as Adjusted for Ambient Temperature, if Necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-25</td>
<td>1.08</td>
<td>1.05</td>
<td>4 through 6</td>
</tr>
<tr>
<td>26-30</td>
<td>1.00</td>
<td>1.00</td>
<td>7 through 9</td>
</tr>
<tr>
<td>31-35</td>
<td>.91</td>
<td>.94</td>
<td>10 through 20</td>
</tr>
<tr>
<td>36-40</td>
<td>.82</td>
<td>.88</td>
<td>21 through 30</td>
</tr>
<tr>
<td>41-45</td>
<td>.71</td>
<td>.72</td>
<td>31 through 40</td>
</tr>
<tr>
<td>46-50</td>
<td>.68</td>
<td>.69</td>
<td>41 and above</td>
</tr>
<tr>
<td>51-55</td>
<td>.61</td>
<td>.67</td>
<td></td>
</tr>
<tr>
<td>56-60</td>
<td>---</td>
<td>.58</td>
<td></td>
</tr>
<tr>
<td>61-70</td>
<td>---</td>
<td>.33</td>
<td></td>
</tr>
</tbody>
</table>
NOTE 2 - The operational life of the cable will be reduced where unfavourable operating conditions such as high tensile stress, small radii, bending into another plane and/or where frequent duty cycles coincide.

13.7.2 Mechanical rating

The cable handling system of the machine shall be so designed to keep the tensile stress of the conductors as low as practicable during machine operations. Where copper conductors are used, the tensile stress shall not exceed 15 N/mm² of the copper cross-sectional area.

NOTE 1 - Where the demands of the application exceed the tensile stress limit of 15 N/mm², cables with special construction features should be used. The allowed maximal tensile strength should be agreed upon with the cable manufacturer.

The allowed maximum stress of conductors of flexible cables with material other than copper should be agreed upon with the cable manufacturer.

NOTE 2 - The following conditions affect the tensile stress of the conductors:
– acceleration forces;
– speed of motion;
– dead (hanging) weight of the cables;
– method of guiding;
– design of cable drum system.

13.7.3 Current-carrying capacity of cables wound on drums

Cables to be wound on drums shall be selected with conductors of a cross-sectional area such that, when fully wound on and carrying the normal service load, the maximum allowable operating temperature is not exceeded.

NOTE 1 - Where cables of circular cross-sectional area are installed on drums, the maximum current-carrying capacity in free air should be derated in accordance with table 13-6. For additional information, also refer to clause 44 of IEC 60621-3.

### Table 13-6 - Derating factors for cables wound on drums

<table>
<thead>
<tr>
<th>Drum type</th>
<th>Number of layers of cable</th>
<th>Any number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrical</td>
<td></td>
<td></td>
<td>0.85</td>
<td>0.65</td>
<td>0.45</td>
<td>0.35</td>
</tr>
<tr>
<td>Radial ventilated</td>
<td></td>
<td>0.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radial non-ventilated</td>
<td></td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE 1 - A radial type drum is one where spiral layers of cable are accommodated between closely spaced flanges; if fitted with solid flanges, the drum is described as non-ventilated and if the flanges have suitable apertures, as ventilated.

NOTE 2 - A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and end flanges have suitable ventilating apertures.

NOTE 3 - It is recommended that the use of derating factors be discussed with the cable and the cable drum manufacturers. This can result in other factors being used.

13.9 Cords. Multiconductor flexible cords shall be suitable for the intended use.

**SUBSTANTIATION:** This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

**Historical Background.**

In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are: Harmonisation - Purpose.
13.2.1 Conductor Material.
Recommendation: Add title and retained the copper only requirement. Moved the wire size text to 13.2.2.
Add new Exception No. 1 for aluminum busbars.
Add new Exception No. 2 for machine frame grounding.
Substantiation: Wire sizes given are for stranded conductors and assigned new clause for clarity.
Aluminum busbars are now permitted. Recognizes that machine frames are not insulated or covered.

13.2.2 Stranded Conductors.
Recommendation: Move the wire size portion of NFPA –1997 15.2.1 here and move editorially revise retained and edited its 2nd sentence as follows: "See Table 9 for conductor cross-sectional area, dc resistance, and stranding is listed in Table 9 shown on the following page."
Add NFPA 15.2.1 Exception No. 1 to proposed clause 13.2.2 and edited as follows: “Exception No. 1. Conductors with insulation characteristics consistent with the provisions of this clause but with stranded other than that specified in Table 9 shall be permitted on individual devices that are purchased completely wired (e.g., motor starters).”
Move NFPA 79-1997 15.2.1 Exception No. 2 here and renumber.
Insert Table 9 following this Exception No. 2.
Substantiation: Provides a clause for stranded type conductors and associated exceptions. Revised 2nd sentence and Exceptions for clarity, directs users of this standard to Table 9, and table placement is unknown until press time.

13.2.3 Constant Flexing.
Recommendation: Move NFPA 79-1997 15.2.2 here and renumber.
Substantiation: Match new numbering sequence.

13.2.4 Printed wire assemblies.
Recommendation: Move NFPA 79-1997 15.2.4 here add title and renumber.
Substantiation: Match new numbering sequence.

13.2.5 Shielded conductors.
Recommendation: Move the 1st sentence of NFPA 79-1997 15.2.5 to new 13.6.5. Replace the remainder of the original text with the proposed text. Revise the 4th sentence as follows: “The shields and drain wire shall be covered with an outer jacket that is suitable for the environment, oil- and moisture resistant jacket.”
Substantiation: The first sentence covering the minimum size of shielded conductors was relocated to new 13.6.5. The proposed text is more informative and, in addition, provides information that there are differences in shielding, and foil shielding may not be durable enough for any flexing applications. A drain wire is provided because a foil shield itself does not lend itself to termination and a standard braided shield is not durable enough for torsion flexing applications. The requirement for the jacket to be “oil and moisture resistant” was replaced with the words: ...outer jacket that is suitable for the environment.” because the original words were considered too restrictive. The new phrasing will require that an evaluation be made but not dictate any particular solution.

13.2.6 Special cables and conductors.
Recommendation: Added new title; obtained from NFPA 79-1997 13.2.6 text.
Substantiation: Meet Style Manual guidelines.

13.2.7 Insulation.
Substantiation: Title change is more descriptive of the text.

13.3.1 Recommendation: Move 2nd sentence of NFPA 79-1997 15.1.1 here, revise and renumber.

Insert the last sentence of NFPA 79-1997 Section 15.1.1 2nd sentence and its following four bullets as a new second paragraph to proposed 13.3.1 and replace the words “be suitably” with “have”, add “properties,” after “flame retardant” and delete the word “have” after “and”.
Substantiation: Match new numbering sequence, topic sequencing and edited for clarity.

13.3.3 Recommendation: Retain NFPA 79-1997 15.4.3 and re-number.
Substantiation: Match new numbering sequence.

13.3.4 Recommendation: Retain NFPA 79-1997 15.4.4 and re-number.
Retain NFPA 79-1997 Table 10 and insert immediately following Clause 13.3.4 and renumber as necessary.
Substantiation: Match new numbering sequence and provide guidance for table placement.

13.4.1 Recommendation: Retain NFPA 79-1997 15.6.1 and its Exception, re-number and editorially change text “Number” to “AWG”.
Change “18” to “16.”
Substantiation: Match new numbering sequence, and to allow conductors in additional small sizes to use this method for size marking.

13.4.2 Recommendation: Retain NFPA 79-1997 15.6.2 and renumber.
Substantiation: Match new numbering sequence.

13.4.4 Recommendation: Retain NFPA 79-1997 15.4.5 1st sentence here and renumber.
Delete 15.4.5 2nd sentence.
Re-number Clause 15.4.5 Exception and move to Clause 13.1.2 as Exception No. 2.
Substantiation: Match new numbering sequence, NFPA 79-1997 15.4.5 2nd sentence has been deleted because it is a wiring practice that is already covered in 14.1.3 text, and move 13.1.2 Exception No. 2 for topic correlation.

13.5.2 Conductor Ampacity.
Recommendation: Retain NFPA 79-1997 15.5 and renumber as 13.5.
Insert the “obelisk” note of NFPA 79 Table 11 as a new second sentence to comply with the Style Manual and revise as follows: “Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity of the cable or raceway.”
Substantiation: Match the numbering sequence, the “obelisk” note of NFPA 79 Table 11 was inserted into 13.5 as new second sentence to comply with the style manual that mandatory language can not be placed in Notes. Table 11 Control Enclosure column has been deleted because nearly all devices are now rated for connection to NFPA 70, Table 310-16, 75 degree C, selected wire. Reference to Table 310-17 is no longer necessary with the column deletion.

13.5.3.1 Recommendation: Retain NFPA 79-1997 15.5.2 and renumber.
Substantiation: Match new numbering sequence.

13.5.2 Recommendation: Retain NFPA 79-1997 15.5.3 and renumber.
Substantiation: Match new numbering sequence.

13.5.3 Recommendation: Add new text, incorporating Table 11 NOTE 2, and renumber proposed table 13.3b as necessary.
Substantiation: Provides ambient temperature information and minimize the number of references that is needed. The temperature correction factors of the proposed table have been correlated with NFPA 70 Table 310-16.
Substantiation: Match new numbering sequence.

13.5.5 Conductor/terminal compatibility
Recommendation: Add new text.
Substantiation: Provides information on termination requirements.
This new text will help ensure that components will be compatible.

13.6 Conductor sizing.
Retain NFPA 79-1997 15.3 1st sentence and make a complete sentence: “Conductors shall not be smaller than those required for the following conditions.”
Substantiation: Match new numbering sequence, and complete sentence direction.

13.6.1 Recommendation: Retain NFPA 79-1997 15.3 (a) here and renumber.
Provide new exceptions to address small motor circuitry. NFPA 79-1997 15.3 (b) and Exception renumbered to 13.6.2 and Exception.
NFPA 79-1997 15.3 (c) renumbered to 13.6.3.
NFPA 79-1997 15.3 (d) renumbered to 13.3.4.
NFPA 79-1997 15.3 (d)(1) and Exception renumbered to 13.6.4 (a) and Exception.
NFPA 79-1997 15.3 (d)(2) and Exception renumbered to 13.6.4 (b) and Exception.
Substantiation: The present parts of NFPA 79-1997 15.3 were re-identified to match the numbering sequence.
These proposed new exceptions permit the use of 16/18 AWG conductors, and factory assembled 16/18 AWG multi-conductor cables, in small motor branch circuit applications. This exception will also allow a common, desirable, practice unutilized on small horsepower, multi-motor machinery.
Wire sizes of 0.75 mm² and 1 mm² are commonly applied where the load currents are very small in applications based upon the IEC 60204-1. Wire sizes of 0.75 mm² and 1 mm² have an ampacity similar to 18 AWG and 16 AWG wire respectively.
Conservative based calculations were evaluated relative to short circuit and overload concerns. After considering many variables, it was determined that a similar use of 18 AWG and 16 AWG wire would constitute a reasonable approach and give application guidance to a present practices under the detailed requirements as proposed in 13.6.1 Exceptions 1 and 2.
In order to limit exposure to physical damage the use of these conductors would be limited to multiconductor cables, and to individual conductors when used in a cabinet or enclosure.
The following information is provided to detail the evaluation process.

<table>
<thead>
<tr>
<th>16 AWG Data</th>
<th>Time (sec)</th>
<th>Area (CM²)</th>
<th>Isc (Amps) ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>.004</td>
<td>2.580</td>
<td>2.580</td>
<td>1620</td>
</tr>
<tr>
<td>.008</td>
<td>2.580</td>
<td>2.580</td>
<td>1257</td>
</tr>
<tr>
<td>.0167</td>
<td>2.580</td>
<td>2.580</td>
<td>1057</td>
</tr>
<tr>
<td>.1</td>
<td>2.580</td>
<td>2.580</td>
<td>192</td>
</tr>
<tr>
<td>1</td>
<td>2.580</td>
<td>2.580</td>
<td>137</td>
</tr>
<tr>
<td>3</td>
<td>2.580</td>
<td>2.580</td>
<td>51</td>
</tr>
<tr>
<td>10</td>
<td>2.580</td>
<td>2.580</td>
<td>43</td>
</tr>
<tr>
<td>20</td>
<td>2.580</td>
<td>2.580</td>
<td>31</td>
</tr>
<tr>
<td>30</td>
<td>2.580</td>
<td>2.580</td>
<td>25</td>
</tr>
</tbody>
</table>

¹ Data based upon ICEA (Insulated Cable Engineers Association) insulation Damage Formulas

<table>
<thead>
<tr>
<th>UL508 Test Points</th>
<th>Class</th>
<th>Current @ 600% ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>40</td>
<td>34</td>
</tr>
</tbody>
</table>

² Value shown in table is based upon 6 X the limited current specified in the proposed 13.6.1

<table>
<thead>
<tr>
<th>UL 248 Test Point @ 50KA</th>
<th>Time (sec)</th>
<th>Max Current Allowed (Amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.004</td>
<td>707 ³</td>
<td>707 ³</td>
</tr>
</tbody>
</table>

³ Current Level Extrapolated from UL I²t limit by dividing out time (.004)

The Insulated Cable Engineers Association (ICEA) tables for insulation damage was used to create the worst case condition for the wire. The formula as developed by ICEA is based upon an adiabatic process where all the heat will be contained within the wire(conductor). This does not take into account the heat bleed off into the terminations and components. As a result, a damage curve was generated for thermoplastic insulation at 150 deg. C. This was the worst case of the three main types evaluated by ICEA which include:
- thermoplastic (150 deg. C)
- rubber, paper, varnished cloth (200 deg. C)
- crosslinked polyethylene & ethylene propylene rubber (250 deg. C)

This damage curve then supplied the worst possible condition to which the wire (conductor) would be subjected.
After laying the groundwork for wire damage, various overcurrent protective devices were reviewed.
Current limiting devices were decided upon in order to cover the variety of fault current conditions that could apply to a machine. Upon examination of Underwriters Laboratories (UL) "General Information for Electrical Equipment" (White Book), peak let-through currents of various current limiting branch circuit fuses were considered. Selecting Class CC fuses and protecting 16 and 18 AWG wire according to UL limits allowed a maximum let-through current to be determined.
Next, motor controller characteristics were explored. Based upon the information provided in UL508, test points were plotted on the time current curve to evaluate the performance of the overload device under long term heating conditions. (Note: Under these conditions there is a high probability the heat will be dissipated from the conductor into the terminals and associated components).
Guidelines were selected for proper fuse sizing and maximum full load current rating of motors based upon the above data. The criteria for determining the maximum full load current rating was (1) the maximum current value the conductor could handle for the set amount of time (10 sec for class 10, etc.), (2) add 10% for a conservative heat bleed off factor, and (3) divide by 6 per the requirements of UL 508. This then derived the FLC value.
13.6.2 Recommendation: NFPA 79-1997 15.3 (b) and Exception moved here and renumbered.

Substantiation: Match new numbering sequence

13.6.3 Recommendation: NFPA 79-1997 15.3 (c) moved here and renumbered.

Substantiation: Match new numbering sequence

13.6.4 Recommendation: NFPA 79-1997 15.3 (d) moved here and renumbered.

Substantiation: Match new numbering sequence

13.6.5 Shielded conductors.

Recommendation: Relocate existing first sentence of NFPA 79-1997, 15.2.5 here. This provides a minimum wire size for use in subassemblies that is less than for other uses.

Substantiation: Proposed new title provides for general conditions.

13.7.1.1 Recommendation: Relocate NFPA 79-1997 16.3.5 here and renumber. Replace “Connections for frequently moving parts” with “Conductors and cables used for flexing applications.”

Deleted NFPA 79-1997 16.5.3 2nd sentence and Exception and refer it to 14.1.4. “Conduit” is to be deleted at that time.

Substantiation: Match new numbering sequence, and text is modified because it is conductors and cables that are covered here and not the connections.

The deleted text is referred to 14.1.4 because it is a wiring practice and not a wiring method. “Conduit” is not germane to the subject.

13.7.1.2 Recommendation: This proposed new 13.7.1.2 provides information for cable mechanical considerations.


13.7.2 Mechanical rating

Recommendation: Proposed 13.7.2 text provides additional information for cabling handling systems. The “Note” provides additional items for consideration.


13.7.3 Current-carrying capacity of cables wound on drums

Recommendation: Proposed new 13.7.3 and proposed new Table 13.6 provide additional information for cable conductor ampacities when wound on a reel.

Proposed table is to immediately follow Clause 13.7.3.

Substantiation: No comparable text in NFPA 79-1997, and provides guidance for table placement.

13.9 Cords.


Substantiation: Flexible cords must be suitable for the intended use. The “shopping” list has been deleted because the list is overly restrictive for some applications and may not be adequate for other applications.


15 15
15.1 15.1
15.1.1 13.1.1
15.1.1 13.3.1
15.1.2 13.9
15.1.3 13.1.3
15.1.4 13.1.4
15.2 13.2
15.2.1 13.2.2
15.2.1 Ex 1 13.2.2 Ex 1
15.2.1 Ex 2 13.2.2 Ex 2
15.2.2 13.2.3
15.2.3 13.2.4
15.2.4 13.2.5
15.2.5 13.6.5
15.2.7 13.2.7; 13.2.7.2
15.3 13.6
15.3(a) 13.6.1
15.3(b) 13.6.1 Ex 1
15.3(c) 13.6.1 Ex 2
15.3(d) 13.6.3
15.3(d)(1) 13.6.4
15.3(d)(1) Ex 1 13.6.4.1
15.3(d)(2) 13.6.4.2
15.3(d)(2) Ex 13.6.4.2 Ex
15.4 13.3
15.4.1 13.1.2
15.4.2 Refer to Clause 14
15.4.3 13.3.3
15.4.6 13.3.4 1st sentence was not acted upon at 1st review but accepted at the 2nd review; 2nd sentence was rejected at 1st review but accepted at 2nd review
The current, in amperes, that a conductor can carry

16.3.5 2nd sentence & Ex Move to Clause 14.1.4
16.3.5 1st sentence
13.7.1
15.6.3 13.4.3
15.6.2 13.4.2
15.6.1 13.4.1
15.6 13.4
15.5.4 Ex
15.6.1 Ex
15.6.2
15.6.3
16.3.5 1st sentence
15.7
13.7.1
13.7.1.1
13.7.1.2
13.7.2
13.7.3
Table 13-6
13.9
15.1.2

COMMITTEE ACTION: Accept in Principle.

3. Definitions

Note: Chapter 3, “Definitions” contains only those definitions essential to the proper application of this Standard. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. In general, only those terms that are used in two or more places are defined. Other definitions are included in the article in which they are used. Spelling and definitions of general words and terms follow Webster’s Collegiate Dictionary, 10th edition.

The terms in parenthesis, used throughout this standard are from the English version of IEC 60204-1, and are based on the Oxford English dictionary.

3.1 accessible (as applied to equipment): Admitting close approach; not guarded by locked doors, elevation, or other effective means. [NFPA 70]

3.2 accessible, readily (readily accessible): Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, etc. [NFPA 70]

3.3 actuator: The part of the actuating system to which an external actuating force is applied. [IEV 441-15-22]

Notes—
1 The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.
2 There are some actuating means that do not require an external actuating force but only an action.
3 See also 3.74 "machine actuator."

3.4 adjustable speed drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner. This includes ac and dc voltage modes and frequency mode controls. Belt, chain, or roller shifting controllers are not included.

3.5 ambient temperature: The temperature of the air or other medium where the equipment is to be used. [IEV 826-01-04]

Note—Ambient air temperature as applied to an enclosure or housing is the average temperature of the surrounding air that comes in contact with the enclosure or housing. Ambient air temperature as applied to a component or device within the enclosure is the average temperature of the surrounding air that comes in contact with the component.

3.6 ampacity: The current, in amperes, that a conductor can carry continuously under the conditions of use, without exceeding the design limits for the temperature rating of the insulation, the conductor and the wire termination.

3.6 ampacity: The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating. [NFPA 70]

3.7 approved: Acceptable to the authority having jurisdiction. [NFPA 70]
3.8 attachment plug (plug cap) (plug): A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [NFPA 70]

3.9 Authority Having Jurisdiction: The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

NOTE: The phrase “authority having jurisdiction” is used in NFPA documents in a broad manner because jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshals; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

3.10 barrier: A part providing protection against direct contact from any usual direction of access. [IEV 820-02-13]

3.10 Barrier: A physical obstruction that is intended to prevent contact with equipment or live parts or to prevent unauthorized access to a work area. [NFPA 70E-2000]

3.11 bonding (bonded): The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct any current likely to be imposed. [NFPA 70]

Note: See “protective bonding circuit.”

3.12 branch circuit: The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [NFPA 70]

3.13 cable tray system: A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways. [NFPA 70]

3.14 cable trunking system: A system of enclosures comprised of a base and a removable cover intended for the complete surrounding of insulated conductors, cables, and cords [IEV 826-06-04, modified]

Note: See “wireway.”

3.15 circuit breaker: A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [NFPA 70]

3.16 concurrent: Acting in conjunction; used to describe a situation wherein two or more control devices exist in an actuated condition at the same time (but not necessarily simultaneously).

3.17 conduit, intermediate metal: A listed steel raceway of circular cross-section with integral or associated couplings, connectors, and fittings approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [NFPA 70]

3.18 conduit, rigid metal: Rigid metal conduit is a listed metal raceway of circular cross-section with integral or associated couplings, approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [NFPA 70]

3.19 conduit, rigid nonmetallic: A type of conduit and fittings of suitable nonmetallic material that is resistant to moisture and chemical atmospheres, flame retardant, resistant to impact and crushing, and resistant to distortion from heat or low temperatures under conditions likely to be encountered in service. [NFPA 70]

3.20 control circuit (of a machine): The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller but does not carry the main power current.

Note: Power circuit protection can be provided by control shunt-tripping.

3.21 control circuit transformer: A voltage transformer utilized to supply a voltage suitable for the operation of control devices. [IEEE 160]

3.22 control circuit voltage: The voltage utilized for the operation of control devices.

3.23 control device: A device connected into the control circuit and used for controlling the operation of the machine (e.g. position sensor, manual control switch, relay, magnetically operated valve). [IEC 60924–1]

3.24 controlled stop: The stopping of machine motion, while retaining power to the machine actuators during the stopping process.

3.25 controlgear: A general term covering switching devices and their combination with associated control, measuring, protective, and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures, and supporting structures, intended in principle for the control of electrical energy-consuming equipment. [IEC 61411-42]

Possible alternate term: control equipment: Operating elements such as relays, contactors, circuit breakers, switches, solenoids, brakes and similar types of components, intended to govern or perform a given function in the operation, including measuring, sensing, monitoring, protection, and regulation of machinery.

3.26 controller: A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. [NFPA 70]

3.27 cord(flexible): Flexible cords are constructed as described in, and listed for use in accordance with Article 400 of the National Electrical Code (NFPA 70). All conductors are stranded copper.

3.28 device: A unit of an electrical system that is intended to carry but not utilize electric energy. (NFPA 70)

3.29 digital: Operated by the use of discrete signals to represent data in the form of numbers or other characters. [IEC-60204–1]

3.30 direct contact: Contact of persons or livestock with live parts. [IEEE 826-03-05]

3.31 disconnecting means: A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [NFPA 70]

3.32 dry location: A location not normally subject to dampness or wetness.

Note: A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction. [NFPA 70]

3.33 duct: An enclosed channel designed expressly for holding and protecting electrical conductors, cables, and busbars.

NOTE: Conduits, cable trunking systems (see 3.10) and underfloor channels are types of duct. See “raceway.”

3.34 dwelling unit: One or more rooms for the use of one or more persons as a housekeeping unit with space for eating, living, and sleeping, and permanent provisions for cooking and sanitation. (NFPA 70)
3.35 earth: See "ground."

3.36 electromechanical: Applied to any device in which electrical energy is used to magnetically cause mechanical movement.

3.37 electrical operating area: A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons, by the opening of a door or the removal of a barrier without the use of a key or tool, and which is clearly marked by appropriate warning signs.

3.38 electronic equipment: That part of the electrical equipment containing circuitry mainly based on electronic devices and components.

3.39 Emergency switching off: An emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved.

3.40 enclosed electrical operating area: A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs.

3.41 enclosure: A surrounding case constructed to provide a degree of protection against accidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

3.42 energized: Electrically connected to a source of potential difference (NFPA 70).

3.43 equipment: A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation. NFPA 70

3.44 exposed (as applied to live parts): Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. [NFPA 70]

3.45 failure of equipment: The termination of the ability of an item to perform a required function.

3.46 fault: The state of an item characterized by inability to perform a required function, excluding the inability, during preventive maintenance or other planned actions, or due to lack of external resources.

NOTE: A fault is often the result of a failure of the item itself, but may exist without prior failure [IEV 191-05-01]

3.47 feeder: All circuit conductors between the service equipment or the source of a separately derived system and the final branch-circuit overcurrent device. (NFPA 70)

3.48 flame retardant: So constructed or treated that it will not support flame. [IEEE 100]

3.49 ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth. [NFPA 70]

3.50 grounded: Connected to earth or to some conducting body that serves in place of the earth. [NFPA 70]

3.51 grounded conductor: A system or circuit conductor that is intentionally grounded. [NFPA 70]

3.52 grounding conductor: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes. [NFPA 70]

3.53 grounding conductor, equipment: The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system. [NFPA 70]

3.54 grounding electrode conductor: The conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system. [NFPA 70]

3.55 guard: Part of a machine specifically used to provide protection by means of a physical barrier. Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard. [ISO/TR 12100-1, 3.22, modified]

3.56 harm: Physical injury or damage to health.

3.57 hazard: A source of possible injury or damage to health. [ISO/TR 12100-1, 3.5, modified]

3.58 hazardous condition situation: A circumstance in which a person is exposed to a hazard(s), the exposure can immediately or over a long period of time have the potential to result in harm.

3.59 identified (as applied to equipment): Recognizable as suitable for the specific purpose, function, use, environment, application, etc. where described in a particular code requirement. (See "equipment.")

NOTE—Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeling or listing. [NFPA 70]

3.60 indirect contact: Contact of persons with exposed conductive parts which have become live under fault conditions. [IEV 826-03-06]

3.61 industrial machine: A power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting, forming, pressure, electrical, thermal, or optical techniques, lamination, or a combination of these processes. It can include associated equipment used to transfer material or tooling (including fixtures), assemble/disassemble, inspect or test, or package. (The associated electrical equipment including the logic controller(s) and associated software or logic together with the machine actuators and sensors are considered as part of the industrial machine.)

3.62 industrial manufacturing system: A systematic array of one or more industrial machines that are not portable by hand and that includes any associated material handling, manipulating, gauging, measuring, or inspection equipment.

3.63 Input
1 The terminals where current, voltage, power, or driving force may be applied to a circuit or device;
2 The state or sequence of states occurring on a specific input channel;
3 The device or collective set of devices used for bringing data into another device. [IEC 60204–1]

3.64 In sight from, within sight from, within sight: Where this standard specifies that one equipment shall be "in sight from," "within sight from," or "within sight," etc., of another equipment, one of the equipments specified is to be visible and not more than 50 ft (15.24 m) distant from the other. (NFPA 70)

3.65 inrush current (solenoid): The inrush current of a solenoid is the steady-state current taken from the line at rated voltage and frequency with the plunger blocked in the rated maximum open position.

3.66 inrush locked rotor current (motor): See "locked rotor motor current."

3.67 (electrically) instructed person: A person adequately advised or supervised by an electrically skilled person to enable him or her
to perceive risks and to avoid hazards which electricity can create. [IEV 826-09-02, modified]

3.68 (electrically) skilled person: A person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create. [IEV 826-09-01, modified]

3.69 interlock (for safeguarding): An arrangement that interconnects guard(s) or device(s) with the control system or all or part of the electrical energy distributed to the machine.

3.70 interrupting rating: The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

NOTE—Equipment intended to interrupt current at other than fault levels may have its interrupting rating implied in other ratings, such as horsepowr or locked motor current.

3.71 jogging (inching): The quickly repeated closure of the circuit to start a motor from rest for the purpose of accomplishing small movements of the driven machine.[IEEE 100]

3.72 Labeled: Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner. [NFPA 70]

3.72 listed: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets identified standards or has been tested and found suitable for a specified purpose. (NFPA 70)

NOTE—The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product.

3.73 live part (as applied to being energized during normal use): A conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor.

NOTE—This term does not necessarily imply a risk of electric shock. [IEV 826-03-01]

3.74 live parts: Energized conductive components. [NFPA 79-2002] (as applied to exposure to an existing shock hazard): Electric conductors, busbars, terminals, or components that are uninsulated or exposed and a shock hazard exists.

3.75 locked rotor motor current: The steady-state current taken from the line with the rotor locked and with rated voltage (and rated frequency in the case of alternating-current motors) applied to the motor. [IEEE 100]

3.76 machine actuator: A power mechanism used to effect motion of the machine.

3.77 marking: Signs or inscriptions for the identification of the type of a component or device attached by the manufacturer of the component or device.

3.78 neutral conductor (symbol N): A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy. [IEV 826-01-03]

3.79 obstacle: A part preventing unintentional direct contact, but not preventing direct contact by deliberate action. [IEV 826-03-14]

3.80 output: 1. The terminals where current, voltage, power, or driving force may be delivered by a circuit or device; 2. The state or sequence of states occurring on a specific output channel.

3.81 overcurrent: Any current in excess of the rated current of the equipment or the rated ampacity (current-carrying capacity) of the conductor. It may result from overload, short circuit, or electrical fault. [NFPA 70]

3.82 overload: Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or a ground fault, is not an overload. (See "overcurrent.") [NFPA 70]

NOTE—Overload should not be used as a synonym for overcurrent.

3.83 Panel: An element of an electric controller consisting of a slab or plate on with various component parts of the controller are mounted or wired. [IEEE 100]

3.83 plug/socket combination: A plug and socket-outlet, a cable coupler, or an appliance coupler, in accordance with IEC 60309-1.

3.84 point of operation: The location in the (machine) where the material or workpiece is positioned and work is performed.

3.85 positive opening operation (of a contact element): The achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (e.g. not dependent upon springs). [IEC 60947-5-1, chapter 3.2.2]

3.86 power circuit: A circuit used for supplying power from the supply network to units of equipment used for productive operation and to transformers supplying control circuits.

3.87 programmable electronic system (PES): A system based on one or more central processing units (CPUs), connected to sensors or actuators, or both, for the purpose of control or monitoring.

NOTE: The term “programmable electronic system; PES includes all elements in the system extending from sensors to other input devices via data highways or other communication paths to the actuators or other output devices.

3.88 protective bonding circuit: The whole of the protective conductors and conductive parts used for protection against electric shock in the event of an insulation failure. See "bonding.”

3.89 protective conductor: A conductor required by some measures for protection against electric shock for electrically connecting any of the following parts: 1. exposed conductive parts; 2. extraneous conductive parts; 3. main earthing terminal. [IEV 826-04-05, modified]

3.90 qualified person: At a minimum, a qualified person shall be trained and knowledgeable of the construction and operation of equipment or some specific work method, and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools and test equipment. [NFPA 70E]

See “(electrically) instructed person” and “(electrically) skilled person.”

3.91 raceway: An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, wireways, and busways.
3.1012 switching device: A device designed to make or break the current in one or more electric circuits.  [IEV 826-09-01.]

3.111 supplementary overcurrent protective device: A device used where protection is required for lighting fixtures, appliances, and other equipment or for internal circuits and components of equipment.  It shall not be used as a substitute for power circuit overcurrent devices in place of the power circuit protection.

3.1012 switching device: A device designed to make or break the current in one or more electric circuits.  [IEV 826-09-01.]

3.113 tap conductor: A conductor that has overcurrent protection ahead of its point of supply, that exceeds the value permitted for similar conductors that are protected as described elsewhere in this standard.

3.114 terminal: A conductive part of a device provided for electrical connection to circuits external to the device.

3.115 tight (suffix): So constructed that the specified material is excluded under specified conditions.  (ANSI/IEEE Standard No. 100)

3.116 uncontrolled stop: The stopping of machine motion by removing power to the machine actuators, all brakes and/or other mechanical stopping devices being activated.  [IEC 60924-1]

3.117 undervoltage protection: The effect of a device that operates on the reduction or failure of voltage, to cause and maintain the interruption of power.

NOTE—The principal objective of this device is to prevent automatic restarting of the equipment.  Standard undervoltage or low-voltage protection devices are not designed to become effective at any specific degree of voltage reduction.

3.118 user: An entity that utilizes the machine and its associated electrical equipment.

3.119 variable speed drives: An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner.  This includes ac and dc voltage modes and frequency mode controls.  Belt, chain, or roller shifting controllers are not included.

3.120 ventilated: Provided with a means to permit circulation of air sufficient to remove excess heat, fumes, or vapors.  [NFPA 70]

3.121 Voltage, Nominal.  A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480V/277 volts, 600 volts).  The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

3.121 wet location: Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle washing areas, and locations exposed to weather and unprotected.  [NFPA 70]

3.122 wireway: A sheet-metal or flame retardant nonmetallic trough with hinged or removable covers for housing and protecting electrical wires and cables and in which conductors are laid in place after the wireway has been installed as a complete system.  [NFPA 70]

COMMITTEE STATEMENT:  1) Add title inadvertently omitted.
  2) Editorially correct phrase "Conductors and cables" to read "Conductors, cables and flexible cords." since cords are already permitted.
  3) Complete the cord requirements by an ampacity from Table 400.5(A) from the 2002 NEC in 13.9.1

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
DEFELICE: The text currently contained in 13.1.4 might be more appropriately located in a new 13.2.7.3.
The following is provided in response to the Editorial Review Committee Report ROP meeting March 12-16, 2001.

This was originally submitted with the Proposal subsequently identified as log 27 with Jack C. Sanders incorrectly identified as the author, and is revised to respond to the ER committee comments.

13 Conductors and cables

Recommendation: Replace NFPA 79-1997 title “15 Conductors” with “13 Conductors and cables”. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1. The proposed title more clearly states the subject matter within this clause.

13.1 General requirements

13.1.1 General

Recommendation: Move NFPA 79-1997 section 15.1.1 2nd sentence to clause 13.3.1.

Substantiation: Retained by NFPA 79 Technical Committee action.

13.1.2 Wire insulation.

Recommendation: Insert title of NFPA 79-1997 section 15.4 here, renumber as clause 13.1.2 and add text that conductors are expected to be insulated. Add three exceptions. Clause 13.1.2 Exception No. 1 added to address busbars within switchgear.

Move NFPA 79-1997 section 15.4.5 Exception here and renumber as clause 13.1.2 Exception No. 2.

Substantiation: Retained by NFPA 79 Technical Committee action.

Added text is to disallow the use of bare or covered conductors as a general condition.

Exception No. 1 acknowledges that busbars within switchgear are bare.

Exception No. 2 allows common practices within switchgear.

Exception No. 3 was added in order to recognize that grounding conductors do not have to be insulated.

13.1.3

Recommendation: Insert NFPA 79-1997 section 15.1.3 here and renumber as clause 13.1.3.

Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence.

13.1.4


Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence.

13.2 Conductors.


Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence.

13.2.1 Conductor Material.

Recommendation: Add title to clause 13.2.1 and retained the copper only requirement here.

Moved the wire size text to clause 13.2.2.

Add new clause 13.2.1 Exception No. 1 for aluminum busbars. Add new clause 13.2.1 Exception No. 2 for machine frame grounding.

Substantiation: Retained by NFPA 79 Technical Committee action.

Wire sizes given are for stranded conductors and assigned new clause number for clarity. Aluminum busbars are now permitted. Recognizes that machine frames are not insulated or covered.

13.2.2. Stranded Conductors.

Recommendation: Move the wire size portion of NFPA 79-1997 section 15.2.1 here, identify as clause 13.2.2 and editorially revise and edit its 2nd sentence as follows: “See Table 9 for conductor cross-sectional area, dc resistance, and stranding as listed in Table 9 shown on the following page.”

1628
Recommendation: Retain NFPA 79-1997 section 15.4.3 and re-number as clause 13.3.4.

Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence.

13.3.4 Wire markings.

Recommendation: Retain NFPA 79-1997 section 15.6.1 title here and re-number as clause 13.4.

Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence.

13.4.1 Conductors.

Recommendation: Retain NFPA 79-1997 section 15.4.1 and its Exception here, re-number as clause 13.4.1 and editorially change text “Number” to “AWG”. Change “18” to “16.”

Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence, and to allow conductors in additional small sizes to use this method for size marking.

13.4.2 Conductor Ampacity.

Recommendation: Add NFPA 79-1997 section 15.4.2 here and re-number as clause 13.4.2.

Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence.

13.4.3 Conductor Ampacity (cont.).

Recommendation: Retain NFPA 79-1997 section 15.4.3 1st sentence here and re-number as clause 13.4.3. Delete NFPA 79-1997 section 15.4.3 2nd sentence. Re-number section 15.4.3 Exception and move to clause 13.1.2 as Exception No. 2.

Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence. NFPA 79-1997 section 15.4.3 2nd sentence has been deleted because it is a wiring practice that is already covered in proposed clause 14.1.3 text, and move to clause 13.1.2 Exception No. 2 for topic correlation.

13.5 Conductor Ampacity (cont.).

Recommendation: Retain NFPA 79-1997 section 15.5 and re-number as clause 13.5. Insert the “obelisk” note of NFPA 79 Table 11 as a new second sentence of clause 13.6 to comply with the Style Manual and revise as follows: “Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity in cables or raceway.”

Existing Table 11 from the NFPA 79-1997 following this proposed clause 15.6 with modification and revise it by deleting the “Control Enclosure” column and changing the middle column title as follows: Ampacity in Cable or Raceway.”

Delete NOTE 2 and re-number “NOTE 3” as “NOTE 2” and delete “...and 310-17...”

Substantiation: Retained by NFPA 79 Technical Committee action. Match the numbering sequence, the “obelisk” note of NFPA 79 Table 11 was inserted into clause 13.5 as a new second sentence to comply with the style manual that mandatory language can not be placed in Notes.

Revised the 2nd sentence to add clarity and to emphasize it is the ampacity of conductors being determined when within a cable or raceway, and it is not the cable or raceway that has the ampacity.

Table 11 Control Enclosure column has been deleted because nearly all devices are now rated for connection to NFPA 70, Table 310-16, 75 degree C, selected wire. Reference to Table 310-17 is no longer necessary with the column deletion.

Table 11 Note 2 information is covered by proposed new clause 13.5.3.

13.5.1
Conductors shall not be smaller than 18 AWG. Retain NFPA 79-1997 section 15.3.2 and renumber as clause 13.5.2. Recommendation: Retain NFPA 79-1997 section 15.3.3 and renumber as clause 13.5.3. Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence.

13.5.4 Conductor Sizing

13.5.5 Conductor/terminal compatibility
Recommendation: Add new text, incorporating Table 11 NOTE 2, and renumber proposed table 13.3b as necessary. Substantiation: Retained by NFPA 79 Technical Committee action. Provides ambient temperature information and minimize the number of references that are needed. The temperature correction factors of the proposed table have been correlated with NFPA 70 Table 310-16.

13.5.6 Conductor Sizing
Recommendation: Retain NFPA 79-1997 section 15.3.6 title and renumber as clause 13.6. Retain NFPA 79-1997 section 15.3 1st sentence and make a complete sentence: "Conductors shall not be smaller than those required for the following conditions."
Substantiation: Retained by NFPA 79 Technical Committee action. Match new numbering sequence, and complete sentence direction.

13.6.1 Conductor Sizing
Recommendation: Retain NFPA 79-1997 section 15.3 (a) here and renumber as clause 13.6.1. Provide new exceptions to address small motor circuitry. NFPA 79-1997 section 15.3 (b) and Exception renumbered to clause 13.6.2 and Exception. NFPA 79-1997 section 15.3 (c) renumbered to clause 13.6.3. NFPA 79-1997 section 15.3 (d) renumbered to clause 13.3.4. NFPA 79-1997 section 15.3 (d)(1) and Exception renumbered to clause 13.6.4 (a) and Exception. NFPA 79-1997 section 15.3 (d)(2) and Exception renumbered to clause 13.6.4 (b) and Exception. Substantiation: Retained by NFPA 79 Technical Committee action. The present parts of NFPA 79-1997 section 15.3 were re-identified as clause 13.6.1, etc., to match the numbering sequence. These proposed new exceptions permit the use of 16/18 AWG conductors, and factory assembled 16/18 AWG multi-conductor cables, in small motor branch circuit applications. This exception will also allow a common, desirable, practice unutilized on small horsepower, multi-motor machinery.
Wire sizes of 0.75 mm² and 1 mm² are commonly applied where the load currents are very small in applications based upon the IEC 60204-1. Wire sizes of 0.75 mm² and 1 mm² have an ampacity similar to 18 AWG and 16 AWG wire, respectively. Conservative based calculations were evaluated relative to short circuit and overload concerns. After considering many variables, it was determined that a similar use of 18 AWG and 16 AWG wire would constitute a reasonable approach and give application guidance to a present practices under the detailed requirements as proposed in 13.6.1 Exceptions 1 and 2. In order to limit exposure to physical damage the use of these conductors would be limited to multicore cables, and to individual conductors when used in a cabinet or enclosure. The following information is provided to detail the evaluation process.
This damage curve then supplied the worst possible condition to which the wire (conductor) would be subjected.

After laying the groundwork for wire damage, various overcurrent protective devices were reviewed.

Current limiting devices were decided upon in order to cover the variety of fault current conditions that could apply to a machine. Upon examination of Underwriters Laboratories (UL) “General Information for Electrical Equipment” (White Book), peak let-through currents of various current limiting branch circuit fuses were considered. Selecting Class CC fuses and protecting 16 and 18 AWG wire according to UL limits allowed a maximum let-through current to be determined.

Next, motor controller characteristics were explored. Based upon the information provided in UL508, test points were plotted on the time current curve to evaluate the performance of the overload device under long term heating conditions. (Note: Under these conditions there is a high probability the heat will be dissipated from the conductor into the terminals and associated components.)

Guidelines were selected for proper fuse sizing and maximum full load current rating of motors based upon the above data. The criteria for determining the maximum full load current rating was (1) the maximum current value the conductor could handle for the set amount of time (10 sec for class 10, etc.), (2) add 10% for a conservative heat bleed off factor, and (3) divide by 6 per the requirements of UL 508. This then derived the FLC value.

### Existing Figure 16 AWG

### Existing Figure 18 AWG

13.6.2  
**Recommendation:** NFPA 79-1997 section 15.3 (b) and Exception moved here and renumbered as clause 13.6.2.  
**Substantiation:** Retained by NFPA 79 Technical Committee action. Match new numbering sequence

13.6.3  
**Recommendation:** NFPA 79-1997 section 15.3 (c) moved here and renumbered as clause 13.6.3.  
**Substantiation:** Retained by NFPA 79 Technical Committee action. Match new numbering sequence

13.6.4  
**Recommendation:** NFPA 79-1997 section 15.3 (d) moved here and renumbered as clause 13.6.4.  
**Substantiation:** Retained by NFPA 79 Technical Committee action. Match new numbering sequence

13.6.5  
**Shielded conductors.**  
**Recommendation:** Relocate existing first sentence of NFPA 79-1997section 15.2.3 here and renumbered as clause 13.6.5.  
**Substantiation:** Retained by NFPA 79 Technical Committee action. This provides a minimum wire size for use in subassemblies that is less than for other uses.

13.7  
**Conductors and cables used for flexing applications.**  
**Recommendation:** Add topic clause 13.7.1.  
**Substantiation:** Retained by NFPA 79 Technical Committee action. Proposed new title added to provide appropriate location for these wiring methods.

13.7.1  
**General.**  
**Recommendation:** Add topic clause 13.7.1.1.  
**Substantiation:** Retained by NFPA 79 Technical Committee action. Proposed new title provides for general conditions.

13.7.1.1  
**Recommendation:** Relocate NFPA 79-1997 section 16.3.5 here and renumber as clause 13.7.1. Replace “Connections for frequently moving parts” with “Conductors and cables used for flexing applications.”

The deleted text is referred to clause 14.1.4 because it is a wiring practice and not a wiring method. “Conduit” is not germane to the subject.

13.7.1.2  
**Recommendation:** This proposed new clause 13.7.1.2 provides information for cable mechanical considerations. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** Provides information for which there is no comparable text in NFPA 79-1997.

13.7.2  
**Mechanical rating**  
**Recommendation:** Proposed clause 13.7.2 text provides additional information for cabling handling systems. The “Note” provides additional items for consideration. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** Provides information for which there is no comparable text in NFPA 79-1997.

13.7.3  
**Current-carrying capacity of cables wound on drums**  
**Recommendation:** Proposed new clause 13.7.3 and proposed new Table 13.6 provide additional information for cable conductor ampacities when wound on a reel. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1. Proposed table is to immediately follow clause 13.7.3.

**Substantiation:** Provides information for which there is no comparable text in NFPA 79-1997, and provides guidance for table placement.

13.9  
**Cords.**  
**Recommendation:** Move NFPA 79-1997 section 15.1.2 here and renumber as clause 13.9.  
**Substantiation:** Retained by NFPA 79 Technical Committee action. Flexible cords must be suitable for the intended use. The “shopping” list has been deleted because the list is overly restrictive for some applications and may not be adequate for other applications.

**Proposal Number:** 79-112  
**Log Number:** 28  
**Type:** Affirmative Comment  
The original recommendation dated 3-26-01 should have read: “Revise NFPA 79-1997 “Clause 15 Conductors” and issue as new “Clause 13 Conductors and cables”. The committee should continue to accept the resultant Technical Committee action to further change the title to “13 Conductors, Cable, and Flexible Cords”, as shown on page 1 of A2 and identified as “NFPA 79 / Log #28 / Committee Action / A2002 ROP / Page 1 of 1 (sic).”

**Proposal Number:** 79-112  
**Log Number:** 28  
**Type:** Affirmative Comment  
The following text is provided to consolidate the ROP actions taken and to provide a working draft for ease of review. The underlined items are explained immediately following the draft 13.9.1.2.

### 13 Conductors, Cables, and Flexible Cords

13.1  
**General requirements**

13.1.1  
**General.**  
Conductors, cables, and flexible cords shall be selected so as to be suitable for the operating conditions (e.g. voltage, current, protection against electric shock, grouping of cables) and external influences (e.g. ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses during installation), fire hazards) that can exist. Conductors, cables, and conductors flexible cords shall be identified for their intended use.

13.1.2  
**Wire insulation.**  
Conductors shall be insulated.

*Exception No. 1: Bus bars shall not be required to be insulated.*

*Exception No. 2: Bare conductors, such as capacitor resistor leads and jumpers between terminals, shall be permitted where the method of securing provides electrical clearance.*

*Exception No. 3: Equipment grounding conductors and bonding jumpers shall be permitted to be covered or bare.*

13.1.3  
**Mineral-insulated, metal-sheathed cable, Type MI, shall be permitted. Temperature range – 85°C (185°F) Dry and Wet Locations.**

13.1.4  
**Conductors smaller than 18 AWG used to connect electronic programmable control I/O, and static control, shall be listed.**
NFPA 79 — May 2002 ROP — Copyright 2001, NFPA

13.2 Conductors.

13.2.1 Conductor Material.

Conductors shall be copper.

Exception No. 1: Aluminum alloy busbars, located internal to the enclosure, shall be permitted where suitable for the application.

Exception No. 2: The metal frame of the machine shall be permitted to be used as an equipment grounding (protective bonding) conductor.

13.2.2 Stranded Conductors.

Conductors of sizes 22 through 4/0 AWG and sizes 250 through 1000 kcmil shall be only of stranded soft-annealed copper. See Table 9 for conductor cross-sectional area, dc resistance, and stranding.

Exception No. 1: Conductors with stranding other than that specified in Table 9 shall be permitted on individual devices that are purchased completely wired (e.g., motor starters).

Exception No. 2: Conductors subject to temperatures, voltages, environmental conditions, or flexing exceeding the ratings listed in this clause shall have suitable characteristics.

### NFPA 79: Table 9 – Single conductor characteristics

<table>
<thead>
<tr>
<th>Size (AWG/kcmil)</th>
<th>Cross-sectional area – nominal (CM/mm²)</th>
<th>DC resistance at 25°C (ohms/1000 ft)</th>
<th>Minimum number of strands</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>640/0.324</td>
<td>17.2</td>
<td>7( )</td>
</tr>
<tr>
<td>20</td>
<td>1020/0.519</td>
<td>10.7</td>
<td>10(K)</td>
</tr>
<tr>
<td>18</td>
<td>1400/0.823</td>
<td>6.77</td>
<td>16(K)</td>
</tr>
<tr>
<td>16</td>
<td>1620/1.31</td>
<td>4.26</td>
<td>19(C)</td>
</tr>
<tr>
<td>14</td>
<td>4110/2.08</td>
<td>2.68</td>
<td>19(C)</td>
</tr>
<tr>
<td>12</td>
<td>6530/3.31</td>
<td>1.68</td>
<td>19(C)</td>
</tr>
<tr>
<td>10</td>
<td>10380/5.261</td>
<td>1.060</td>
<td>19(C)</td>
</tr>
<tr>
<td>8</td>
<td>16510/8.367</td>
<td>0.6063</td>
<td>19(C)</td>
</tr>
<tr>
<td>6</td>
<td>26240/13.30</td>
<td>0.4192</td>
<td>19(C)</td>
</tr>
<tr>
<td>4</td>
<td>41740/21.15</td>
<td>0.2636</td>
<td>19(C)</td>
</tr>
<tr>
<td>3</td>
<td>52620/26.67</td>
<td>0.2091</td>
<td>19(C)</td>
</tr>
<tr>
<td>2</td>
<td>65360/33.62</td>
<td>0.1659</td>
<td>19(C)</td>
</tr>
<tr>
<td>1</td>
<td>83690/42.41</td>
<td>0.1315</td>
<td>19(B)</td>
</tr>
<tr>
<td>1/0</td>
<td>105600/53.49</td>
<td>0.1042</td>
<td>19(B)</td>
</tr>
<tr>
<td>2/0</td>
<td>131100/67.43</td>
<td>0.08267</td>
<td>19(B)</td>
</tr>
<tr>
<td>3/0</td>
<td>167900/85.01</td>
<td>0.06658</td>
<td>19(B)</td>
</tr>
<tr>
<td>4/0</td>
<td>211600/107.2</td>
<td>0.05200</td>
<td>19(B)</td>
</tr>
<tr>
<td>250 kcmil</td>
<td>- /127</td>
<td>0.04401</td>
<td>37(B)</td>
</tr>
<tr>
<td>300</td>
<td>- /152</td>
<td>0.03667</td>
<td>37(B)</td>
</tr>
<tr>
<td>350</td>
<td>- /177</td>
<td>0.03114</td>
<td>37(B)</td>
</tr>
<tr>
<td>400</td>
<td>- /203</td>
<td>0.02751</td>
<td>37(B)</td>
</tr>
<tr>
<td>450</td>
<td>- /228</td>
<td>0.02445</td>
<td>37(B)</td>
</tr>
<tr>
<td>500</td>
<td>- /253</td>
<td>0.02200</td>
<td>37(B)</td>
</tr>
<tr>
<td>550</td>
<td>- /279</td>
<td>0.02000</td>
<td>61(B)</td>
</tr>
<tr>
<td>600</td>
<td>- /304</td>
<td>0.01834</td>
<td>61(B)</td>
</tr>
<tr>
<td>650</td>
<td>- /329</td>
<td>0.01692</td>
<td>61(B)</td>
</tr>
<tr>
<td>700</td>
<td>- /355</td>
<td>0.01572</td>
<td>61(B)</td>
</tr>
<tr>
<td>750</td>
<td>- /380</td>
<td>0.01467</td>
<td>61(B)</td>
</tr>
<tr>
<td>800</td>
<td>- /405</td>
<td>0.01375</td>
<td>61(B)</td>
</tr>
<tr>
<td>900</td>
<td>- /456</td>
<td>0.01222</td>
<td>61(B)</td>
</tr>
<tr>
<td>1000</td>
<td>- /507</td>
<td>0.01101</td>
<td>61(B)</td>
</tr>
</tbody>
</table>

(B, C, K) ASTM Class designation B and C per ASTM B 8-81, Class designation K per ASTM B 174-1971 (R1980)

(‘) A class designation has not been assigned to this conductor but is designated as size 22-7 in ASTM B286-1974 (R1979) and is composed of strands 10 mils in diameter (No. 30 AWG).

(‘) Nonflexing construction shall be permitted for flexing service

* Per ASTM Class designation B 174-1971 (R1980) Table 3

(^) Constant flexing cables are not constructed in these sizes
13.3.3 Constant flexing.
Where constant flexing service is required, conductor stranding shall conform to Table 9.

13.4.2 Solid Conductors.
Solid conductors 24-30 AWG of soft-annealed copper shall be permitted for use within control enclosures where not subject to flexing.

13.5.4 Wire insulation shall be identified and adequate for the voltage on that conductor.

13.5 Conductor Ampacity.
The continuous current carried by conductors shall not exceed the values given in Table 11. Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity in cable or raceway.

**Table 11 – Conductor ampacity based on copper conductors with 60°C and 75°C insulation in an ambient temperature of 30°C**

<table>
<thead>
<tr>
<th>Conductor size (AWG)</th>
<th>60°C</th>
<th>75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>–</td>
<td>0.5</td>
</tr>
<tr>
<td>28</td>
<td>–</td>
<td>0.8</td>
</tr>
<tr>
<td>26</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>115</td>
</tr>
<tr>
<td>1</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
<td>150</td>
</tr>
<tr>
<td>2/0</td>
<td>145</td>
<td>175</td>
</tr>
<tr>
<td>3/0</td>
<td>165</td>
<td>200</td>
</tr>
<tr>
<td>4/0</td>
<td>195</td>
<td>250</td>
</tr>
<tr>
<td>250</td>
<td>215</td>
<td>225</td>
</tr>
<tr>
<td>300</td>
<td>240</td>
<td>280</td>
</tr>
<tr>
<td>350</td>
<td>280</td>
<td>310</td>
</tr>
<tr>
<td>400</td>
<td>280</td>
<td>335</td>
</tr>
<tr>
<td>500</td>
<td>320</td>
<td>380</td>
</tr>
<tr>
<td>600</td>
<td>355</td>
<td>420</td>
</tr>
<tr>
<td>700</td>
<td>385</td>
<td>460</td>
</tr>
<tr>
<td>750</td>
<td>400</td>
<td>475</td>
</tr>
<tr>
<td>800</td>
<td>410</td>
<td>490</td>
</tr>
<tr>
<td>900</td>
<td>435</td>
<td>520</td>
</tr>
<tr>
<td>1000</td>
<td>455</td>
<td>545</td>
</tr>
</tbody>
</table>

**NOTE 1:** Wire types listed in Section 13.1 shall be permitted to be used at the ampacities listed in this table. **NOTE 2:** The sources for the ampacities in this table are Tables 310-16 of the NEC.
Exception 2: No. 18 shall be permitted where applied as follows:

Exception 1: No. 16 shall be permitted where applied as follows:

13.6.1 Conductors shall not be smaller than:

13.5.5 Conductor/terminal compatibility

The conductor(s) shall be compatible with the device terminal(s), and the conductor size(s) shall not exceed the range recommended by the device manufacturer.

13.6 Conductor sizing

Conductors shall not be smaller than:

13.6.1 Power circuits

No. 14

Exception 1: No. 16 shall be permitted where applied as follows:

a) For non-motor power circuits of 8 amperes or less where protected in accordance with Clause 7 and with branch circuit rated circuit breakers listed for use with No. 16 wire or Class CC circuit rated circuit breakers listed for not more than 10 amperes, or
b) For motor loads with a full load ampacity of 8 amperes or less, where protected in accordance Clause 7 with branch circuit rated circuit breakers listed for use with No. 16 wire or Class CC circuit rated circuit breakers listed for not more than 250% of full load ampacity and Class 10 overload protection per UL 508, or

c) For motor loads with a full load ampacity of 5.5 amperes or less, where protected in accordance with Clause 7 with branch circuit rated circuit breakers listed for use with No. 16 wire or Class CC circuit rated circuit breakers listed for not more than 250% of full load ampacity and Class 20 overload protection per UL 508, or

d) Where part of a multiconductor cable assembly or flexible cord, or as individual conductors in a cabinet or enclosure.

13.6.2 Lighting and control circuits on the machine and in raceways No. 16

Exception: In a jacketed, multiconductor cable assembly, No. 18 shall be permitted.

13.6.3 Control circuits within control enclosures or operator stations No. 18.

13.6.4 Electronic programmable control I/O, and static control.

a) Conductors in raceways 24 AWG.

Exception: In a jacketed, multiconductor cable assembly or cord, 30 AWG or larger shall be permitted.

b) Conductors within control enclosures No. 26 AWG

Exception: For jumpers and special wiring applications (e.g., solderless wrap or wire-clip type connections or shielded conductors), conductors No. 30 AWG or larger shall be permitted.

13.6.5 Shielded conductors

Shielded conductors shall consist of stranded, annealed copper of 25 AWG or larger for single conductors used in subassemblies and 22 AWG or larger for all other uses.

13.7 Conductors and cables used for flexing applications

13.7.1 General

13.7.1.1 Conductors and cables used for flexing applications shall be selected from Table 9.

13.7.1.2 Cables which are subjected to severe duties shall be of adequate construction to protect against:

- abrasion due to mechanical handling and dragging across rough surfaces;
- kinking due to operation without guides;
- stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums.

NOTE 1 - Cables for such conditions are specified in relevant national standards.

NOTE 2 - The operational life of the cable will be reduced where unfavourable operating conditions such as high tensile stress, small radii, bending into another plane and/or where frequent duty cycles coincide.

13.7.2 Mechanical rating

The cable handling system of the machine shall be so designed to keep the tensile stress of the conductors as low as practicable during machine operations. Where copper conductors are used, the tensile stress shall not exceed 15 N/mm² of the copper cross-sectional area.

NOTE 1 - Where the demands of the application exceed the tensile stress limit of 15 N/mm², cables with special construction features should be used. The allowed maximal tensile strength should be agreed upon with the cable manufacturer.

The allowed maximum stress of conductors of flexible cables with material other than copper should be agreed upon with the cable manufacturer.

NOTE 2 - The following conditions affect the tensile stress of the conductors:

- acceleration forces;
- speed of motion;
- dead (hanging) weight of the cables;
- method of guiding;
- design of cable drum system.

# Table 13-3b

<table>
<thead>
<tr>
<th>Ambient Temp. (°C)</th>
<th>60°C</th>
<th>75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-25</td>
<td>1.08</td>
<td>1.05</td>
</tr>
<tr>
<td>26-30</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>31-35</td>
<td>.91</td>
<td>.94</td>
</tr>
<tr>
<td>36-40</td>
<td>.82</td>
<td>.88</td>
</tr>
<tr>
<td>41-45</td>
<td>.74</td>
<td>.79</td>
</tr>
<tr>
<td>46-50</td>
<td>.68</td>
<td>.73</td>
</tr>
<tr>
<td>51-55</td>
<td>.41</td>
<td>.57</td>
</tr>
<tr>
<td>56-60</td>
<td>---</td>
<td>.58</td>
</tr>
<tr>
<td>61-70</td>
<td>---</td>
<td>.55</td>
</tr>
</tbody>
</table>

*See ANSI/NEMA ICS 2-[1983] table 2, 110-1
13.7.3 Current-carrying capacity of cables wound on drums

Cables to be wound on drums shall be selected with conductors of a cross-sectional area such that, when fully wound on and carrying the normal service load, the maximum allowable operating temperature is not exceeded.

NOTE 1 - Where cables of circular cross-sectional area are installed on drums, the maximum current-carrying capacity in free air should be derated in accordance with table 13-4. For additional information, also refer to clause 44 of IEC 60021-3.

| Table 13-5—Derating factors for cables wound on drums |
|--------------------------|------------------|
| Drum type                | Number of layers of cable |
| Any number               | 1    | 2    | 3    | 4    |
| Cylindrical ventilated   | -    | 0.8  | 0.6  | 0.4  | 0.35 |
| Radial ventilated        | 0.85 | -    | -    | -    | -    |
| Radial non-ventilated    | 0.75 | -    | -    | -    | -    |

NOTE 1 - A radial type drum is one where spiral layers of cable are accommodated between closely spaced flanges; if fitted with solid flanges, the drum is described as non-ventilated and if the flanges have suitable apertures, as ventilated.

NOTE 2 - A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and end flanges have suitable ventilating apertures.

NOTE 3 - It is recommended that the use of derating factors be discussed with the cable and the cable drum manufacturers. This can result in other factors being used.

13.9 Flexible Cords. Multiconductor flexible cords shall be suitable for the intended use.

13.9.1 Ampacity of Flexible Cords. The continuous current by flexible cords shall not exceed the values given in Table XX.

Existing NFPA 70-2002, Table 400-5(A) along with notes

Note: The following items are not part of clause 13 and are only to clarify the actions taken at the ROP meeting in order to correct the mislabeling of the original submitted document for ROP review. This will provide the committee with a working draft and is intended to incorporate all ROP actions except for the Staff insertion of ROP mandated NFPA 79-2002 Table 400-5(A), which is to immediately follow proposed 13.9.1.

1. Add the clause title “Conductors and cables” omitted from the originally submitted text, NFPA 79 Technical Committee accepted the proposed title and further modified it as follows: “13. Conductors and Flexible Cords”, because clause 13 covers flexible cords as well as conductors and cables.

2. Change 13.1.1 last sentence from originally text submitted: “Cables and conductors shall be identified for their intended use” to ROP accepted “Conductors, cables, and conductors flexible cords shall be identified for their intended use.”

This will parallel the word sequence of the title.

3. The relocation of the second sentence of 13.5 "Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity in cable or raceway.” to 13.5.3 follows the action of ROP 79-120 Log 90.

4. Table 13-3(b) was split in two and re-identified as "Table 13-3(b) (1) Adjustment" and "Table 13-3(b) (2) Correction" under a single heading to reflect the committee’s action on ROP 79-121 Log 91 and meet the intent of the submitters.

5. The change to 13.6.1 Exception Nos. 1 and 2 incorporates committee actions on ROP 79-116 Log 162, ROP 79-118 Log 120, and ROP 79-50 Log 32.

6. Add the following text: "13.9.1 Ampacity of Flexible Cords. The continuous current by flexible cords shall not exceed the values given in Table XX."

Existing NFPA 70-2002, Table 400-5(A) along with notes

This reflects the committee’s action at the ROP meeting in the clause title change and the text change in 13.1.1. The committee elected to include flexible cord ampacities here to enhance usability, and Staff has agreed to assign an appropriate table number.

Proposal Number: 79-112
Log Number: 28
Type: Affirmative Comment
In Note 2 of 13.7.1.2 change “unfavorable” to “unfavorable” for editing purposes only as found on the page identified as page 7 of 2 NFPA 79 / Log #28 / Committee Action / A2002 ROP / Page 7 of (sic).

Proposal Number: 79-112
Log Number: 28
Type: Affirmative Comment
Renumber 13.9 and change "by" to "for" so it will read as follows: "13.9 Flexible Cords."

13.9.1 Multiconductor flexible cords shall be suitable for the intended use.

13.9.2 Ampacity of Flexible Cords. The continuous current for flexible cords shall not exceed the values given in Table XX. Renumber per MOS, and text change is to clarify it is the current rating for flexible cords being added.

79-113 - (Clause 15 [13.2]): Reject
SUBMITTER: Endell Mell, Husky Injection Molding Systems Ltd.
RECOMMENDATION: Add some wording to outline what the permitted types of conductors.
SUBSTANTIATION: Permissible cords are given, and requirements for certain types of conductors are given. There is no indication of what types of conductors are permitted/required.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The proposal does not comply with the Regulations Governing Committee projects, Section 4.3.3(c) since the submitter has not provided the specific recommended text.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1

EXPLANATION OF NEGATIVE: GARSIDE: The current standard is indeed vague. For example, it states, "15.1.2 Multiconductor flexible cords, Type SO, STO, STOW or SJO, SJOW, SJTO shall be permitted." It does not give any guidance as to whether they can be used for any connection within a machine, or only for certain connections. Many machines are therefore incorrectly (IMHO) built using SO-type flexible cords for functions where MTW cable should be used, for example, in place of the fixed wiring of the machine.

79-114 - (13.2.1 Exception No. 2): Reject
SUBMITTER: Melvin K. Sanders, TEGos., Inc.
RECOMMENDATION: Delete the proposed Exception No. 2 to 13.2.1 in its entirety.

The original propose text is as follows:

13.2.1 Conductor Material. Conductors shall be copper.

Exception No. 1: Aluminum alloy busbars, located internal to the enclosure, shall be permitted where suitable for the application.

Exception No. 2: The metal frame of the machine shall be permitted to be used as an equipment grounding (protective bonding) conductor.

SUBSTANTIATION: The proposed Exception No. 2 violates the parent document NFPA 70 1999 Edition of Section 250-118 for the types of permitted equipment grounding conductors. They are limited to the following: copper or other corrosion resistant conductors, rigid or IMC or EMT raceway, flexible metal conduit where both the conduit and fittings are listed, and certain types of non-listed flexible metal conduit, listed lightweight flexible metal conduit meeting certain criteria, flexible metal tubing with fittings that meet certain criteria, Type AC armored cable, copper sheath
of MI cable, some MC types, certain cable trays, cablebus framework or other electrically continuous metal raceway listed for grounding.

In addition, it violates the parent document NFPA 70 1999 Edition of Section 300-3(b) that requires that all conductors of the same circuit must be run in the same conduit, when possible, said conduit and all equipment grounding conductors to be contained within the same raceway, auxiliary gutter, cable tray, trench, cable, or cord, unless permitted in accordance with 4 conditions (parallelized, short flexible wiring methods, nonferrous wiring methods and column-type panelboards).

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The committee disagrees with the submitters submission. Machine frames have been successfully used for this purpose with no reported problems.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NEGATIVE: 2

NOT RETURNED: 1 Normal

EXPLANATION OF NEGATIVE:

GARVEY: The submitter’s substantiation is correct. The metal conduits permitted as equipment grounding conductors are generally galvanized. In addition, the NEC requires raceways used as equipment grounding conductors to be installed as a complete system prior to pulling a single wire. All connections must be made up tight. Additional rules assure continuity when the system operates at over 250-volts to ground. And the NEC rules never contemplate that the equipment-grounding conductor may be taken apart, shipped out on a rail car and reassembled in another plant.

SANDERS: Delete the second sentence of 13.2.1.13.2.1.1 Conductor Material.

Exception No. 1: Aluminum alloy busbars, located internal to the enclosure, shall be permitted where suitable for the application.

Exception No. 2: The metal frame of the machine shall be permitted to be used as an equipment grounding (protective bonding) conductor.

I submit the following:

1. The committee response that there are no reported problems ignores the fact that these tend to contribute to other problems and may not be seen as a separate item. They may be masked by having no physical symptom until failure and then take years to match the problem with the solution; the solution arrived at only by applying electrical theory which may task the capabilities of the harried electrical personnel charged with maintaining production.

There are many reasons why this practice should be discontinued. Among them are:

1. If this is retained, it would be possible to connect a permitted supplemental equipment grounding electrode to any part/portion of the machine structural member as long as the termination met the objective of 2.7. If the main purpose of the supplemental electrode is to provide a reference for electronic control activity, its usefulness would be compromised if not negated.

2. The stated objective of this revision is to move closer to other international documents (i.e. IEC 60294-1) and this Exception would not achieve that concept. The uncontrolled use of machine structural members where personnel safety and electronic controls may be compromised is simply unconscionable. A copy of IEC 60294-1 (1997 Edition) clause 8 Figure 3 is provided at the end of this discussion for the committee’s review once more. Note that the possible termination points are to electrical terminals and not the machine structural members.

3. The use of machine members as an equipment grounding conductor is no longer suitable for the modern machine age. Machines are using ASD control and replacing mechanical speed changing mechanisms where none were contemplated just a few months ago, such as single motor drill presses, conveyors, blowers, heaters and the like. These must have a reliable grounding reference and a defined path controlled by the designer for optimum result.

2. The proposal would permit the use of metals of dubious electrical conductivity not contemplated by the NEC. Machine parts are too prone to corrosions, non-conductive painted surfaces and paint bonding agents, and loose fittings for them to provide a reliable grounding path and be used as an equipment grounding conductor from any point on the machine to any other point on the machine. This Standard should not be considered complete if it addresses grounding and bonding concerns that are effective at 3 kHz or less but have compromised at higher frequencies.

5. Machines operating solely with 60 Hz equipment may very well function with grounding and bonding following the parent NFPA 70 but with machine rebuilds to extend machine life employing the latest techniques, they as well as new equipments not “out of the box” become susceptible to radiated frequencies and energies.

6. Using a machine frame as part of the equipment grounding path eliminates the first line of defense in maintaining power quality. The use of machine members to provide protection against such hazards at 60 Hz, or other frequencies, is only part of the answer. Employing recommended equipment bonding and equipment grounding procedures will also provide protection against machine malfunctioning and as well as providing for personnel safety.

7. Many organizations are devoting much time and effort to alert industrial users to some of the problems and solutions. Among them the Institute of Electrical and Electronic Engineers (IEEE) Standards 1100-1999 (aka Emerald Book) have been concerned about grounding as it relates to power, safety and performance of electronic equipment in the commercial and industrial environment.

Chapter 4 Fundamentals, Section 4.2 Impedance considerations states four fundamental parts: power source; distribution; load impedances; grounding/bonding system’s impedances (e.g., power/safety and performance parts). Section 4.2.1 indicates the power safety range is from DC to 10’s of fundamental frequency harmonics, typically to the 50th harmonic (3 kHz for 60 Hz) and the NEC mandated safety features work well in this range.

However, Section 4.2.1.2 Performance range (defined as between two fundamental frequencies) is the first to recognize that high frequency content can have a significant part in the performance of most electronic equipment. The area of concern is where the conductive path is a solicitude frequency under consideration. Normal circuit theory, that works well at NEC contemplated frequencies, no longer applies unless augmented by special design techniques.

Wave and transmission line theory (once the domain of radio-frequency applications) must be applied when addressing the performance needs of electronic equipment as they respond to these extremely short wavelengths and their harmonics.

Previous benign equipment may be the source or at least part of the problem instead of being part of the solution. Those who believe they are immune because their equipment operate with pulse counters, etc., appearing to operate at lower frequencies are not immune, because embedded in each pulse is the higher frequency of the electronic controller that generates the pulsed signal in the first place.

Local distribution systems in buildings and the like are mostly resistive and inductive at 60 Hz to 3 kHz (h = 50) and mostly inductive and capacitive at higher frequencies, especially above 1 MHz. At the higher frequencies, circuit wave theory predominates over power circuit theory and impedance mismatches can occur at every point in some other point between, which will produce reflections and re-reflections of transient currents (or voltages) on the circuit path.

The purpose of supplemental grounding and bonding consist of conductors interconnected and terminated that, taken together, form a useful low impedance path for all frequencies of interest and provide for current flow through them. Depending upon machine mating surfaces to meet all the conditions for power, safety and performance needs of electronic equipment in the commercial and industrial environment is simply unsound.

It must be stressed that the low and high frequency characteristics of most grounding related bonding techniques are quite different. Six major concerns are:

1. Contact resistance (at termination and mating parts surfaces, aging effects); (2) dissimilar materials (galvanic half-cells, corrosion failure, EMI generation); (3) skin effect (shallow penetrations into conductive materials, high frequency effect on bonding paths); (4) bond reactance (size, shape, introduce reactance, avoid self-inductance); (5) conductor resistance (DC and frequency effect on voltage drops across parts); and (6) overheating and fusing parts (with respect to NEC ampacity limits on 12k fusing of conductors or terminations).

The shallow penetration of conductive paths due to frequency driven skin effects (approximately 8.3 mm (5/16-in.),at 60 Hz and reducing to 0.006 mm (0.0026 in.), at 1 MHz, the resultant reduced cross-sectional-area (CSA) of the effective grounding/bonding path more closely couples the return current path to the source path, and sets up reflection and re-reflection waves between assumed conductive points. In addition, normal machine operations, causing vibration, oscillation and incidental machine movement, makes connections that are tight when first installed to become loose and will compromise the best grounding/bonding at higher frequencies.

Committee members used to take note of the frequency effect and provided 60 Hz multipliers in Chapter 9, Table 9.)
Using machine parts for any possible kind of circuit path that has unknown and unsuspecting impact on machine operations, ranging from machine in-operation to machine malfunction, either posing a threat to personnel safety should not be tolerated.

Figure 3 – Example of equipotential bonding for electrical equipment of a machine
4.3 - The application of overload devices between a servo or stepper motor driver and its motor is not recommended by motor drive manufacturers. Transients created by interruption of current between a stepper or servo motor drive and its motor when under load will commonly result in the destruction of the drive.

4.4 - Machinery used in the Surface Mount Technology (SMT) Printed Circuit Assembly (PCA). Industry machinery commonly utilizes ten to twenty-five small stepper or servo motors, each with four power conductors. It would often be impossible to accommodate the number of overload protection devices called for by the proposed text of N13 PR03.DOC within the envelope of an SMT / PCA machine.

4.5 - The proposed additional exceptions allow for use of 16 or 18 gauge wire for the motor control circuits when such wires are protected by Class CC fuses in accordance with Table 11.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: Subclause 13.6.1 deals specifically with wire size. The text under discussion argues the necessity of overcurrent protection is addressed by clause 7. The submitters intended use is addressed by Proposal 79-112 (Log #28), specifically 13.6.1, Exceptions No. 1 and No. 2.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

SUBMITTER: Craig J. Fabbio, Speedline Technologies, Inc.

RECOMMENDATION: Revise text to read as follows:

3. Proposal - Add the underscored text to the text proposed by the Committee under N13 PR03.DOC (proposal date 11/20/00), posted to NFPA 79 Web Board 11/14/00 Clause 13.6.1. The reference Clause is a renumbering with revisions and additional text of Clause 15.3 of NFPA 79, 1997 edition.

13.6.1 Power circuits No. 14

Exception 1: No. 16 shall be permitted where applied as follows:

a) For non-motor power circuits of 8 amperes or less where protected in accordance with Clause 7 and with Class CC fuses rated at not more than 10 amperes, or

b) For motor loads with a full load ampacity of 8 amperes or less, where protected with Class CC fuses at not more than 250% of full load ampacity, and Class 10 overload protection per UL 508, or

c) For motor loads with a full load ampacity of 5.5 amperes or less, where protected with Class CC fuses at not more than 250% of full load ampacity, and Class 20 overload protection per UL 508, and

d) Where part of a jacketed multiconductor cable assembly of flexible cord, or as individual conductors when used in a cabinet or enclosure.

e) For stepper-motor loads, servo-motor loads, impedance-protected motor loads and thermally-protected motor loads of 8 amperes or less, where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors when used in a cabinet or enclosure, and

f) Where protected in accordance with Clause 7 with Class CC fuses rated at not more than 10 amperes.

Exception 2: No. 18 shall be permitted where applied as follows:

a) For non-motor power circuits of 5.6 amperes or less where protected in accordance with Clause 7 and with Class CC, J, or T fuses rated at not more than 10 amperes, or

b) For motor loads with a full load ampacity of 8 amperes or less, where protected in accordance with Clause 7, Class CC, J, or T fuses at not more than 250 percent of full load ampacity, and Class 10 overload protection per UL 508, or

c) For motor loads with a full load ampacity of 3.5 amperes or less, where protected in accordance with Clause 7, Class CC, J, or T fuses at not more than 250 percent of full load ampacity, and Class 20 overload protection per UL 508, and

d) Where part of a jacketed multiconductor cable assembly of flexible cord, or as individual conductors when used in a cabinet or enclosure.

e) For stepper-motor loads, servo-motor loads, impedance-protected motor loads and thermally-protected motor loads of 5 amperes or less, where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors when used in a cabinet or enclosure, and

f) Where protected in accordance with Clause 7 with Class CC fuses rated at not more than 7 amperes.

SUBSTANTIATION: 4.1 - Automation equipment commonly utilizes small-frame motors that provide current and thermal limitation under overload or locked rotor conditions without the need for external overload protection.

Such motor circuits include:

a) Stepper-motor circuits, which draw constant current regardless of speed, load or overload conditions.

b) Servo-motor circuits, which shut down in response to overload conditions.

c) Impedance-protected motor circuits, which limit fault current under overload conditions.

d) Thermally protected motor circuits, which shut down in response to overload conditions.

4.2 - The text proposed under N13 PR03.DOC (proposal date 11/20/00, posted to NFPA 79 Web Board 11/14/00 Clause 13.6.1, Exceptions 1 and 2, does not take into account the inherent overload protection provided by the above types of motors and motor/drive systems. The addition of external overload protection would not provide additional protection from electrical shock and fire.

<table>
<thead>
<tr>
<th>UL Class of Fuse</th>
<th>Current Rating</th>
<th>Between Threshold and 50 KA</th>
<th>At 100 KA</th>
<th>At 200 KA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ip (A)</td>
<td>Ft (A’s)</td>
<td>Ip (A)</td>
<td>Ft (A’s)</td>
</tr>
<tr>
<td>Class CC</td>
<td>50</td>
<td>6,000</td>
<td>7,000</td>
<td>7,500</td>
</tr>
<tr>
<td>Class J</td>
<td>50</td>
<td>6,000</td>
<td>7,000</td>
<td>7,500</td>
</tr>
<tr>
<td>Class T (600V)</td>
<td>50</td>
<td>6,000</td>
<td>7,000</td>
<td>7,500</td>
</tr>
</tbody>
</table>

1638
Further research of the UL standard for low voltage fuses, UL248, uncovered that fuses other than just Class CC have established UL.I2 levels through values that prove they could be used to protect 16 and 18 gauge wire. Since UL has umbrella limits for let through currents on fuses a comparison could be made to the other classes of fuses. The following table shows the limits set forth in UL248:

The values shown in this table are the maximum acceptable levels in order to achieve UL listing. The testing is conducted on one fuse, at a full 600V. Also the test uses a controlled closing angle for the voltage in order to achieve the highest instantaneous voltage possible during opening of the fault current. The values shown in the table are true worst case and can be used as a ceiling for let through energy that would be imposed on the conductor during fault conditions. These UL.I2 levels are measurable performance criteria for the overcurrent protective devices and are periodically checked by UL follow up tests.

The Insulated Cable Engineers Association (ICEA) tables for insulation damage was used to create the worst case condition for the wire. The formula as developed by ICEA is based upon an adiabatic process where all the heat will be contained within the wire (conductor). This does not take into account the heat bleed off into the terminations and components. As a result, a damage curve was generated for thermoplastic insulation at 150°C. This was the worst case of the three main types evaluated by ICEA which include:

- thermoplastic (150°C)
- rubber, paper, varnished cloth (200°C)
- crosslinked polyethylene and ethylene propylene rubber (250°C)

The following data can be used to perform an engineering analysis on the protection of the cable.

The I² levels can be used to verifying the heating effects that would be imposed on the wire. The insulated cable withstand I² levels are as follows:

<table>
<thead>
<tr>
<th>Wiring Size</th>
<th>$I^2_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 16 wire</td>
<td>18,662 A²s</td>
</tr>
<tr>
<td>No. 18 wire</td>
<td>7,355 A²s</td>
</tr>
</tbody>
</table>

Noting the maximum permissible levels allowed by UL, it is shown that under all conditions of heating imposed by short circuit currents, both the 16 and 18 AWG wire will be protected, even under worst case conditions.

Lower level overcurrents will be taken care of by the class 10 or 20 overload relay on motor circuits and the fuses on non motor circuits.

This proposal will be supported by actual testing in order to show that the engineering analysis conducted here is accurate.

COMMITTEE ACTION: Accept in Principle.

Revise text to read as follows:

13.6.1 Exception 1: No. 16 shall be permitted where applied as follows:

- For non-motor power circuits of 8 amperes or less where protected in accordance with Clause 7 and with branch circuit rated circuit breakers listed for use with No.16 wire or Class CC, J, or Fuses rated at not more than 10 amperes or
- For motor loads with a full load ampacity of 8 amperes or less, where protected in accordance with Clause 7 with branch circuit rated circuit breakers listed for use with No.16 wire or Class CC, J, or Fuses and Class 10 overload protection per UL 508, or
- For motor loads with a full load ampacity of 5.5 amperes or less, where protected in accordance with Clause 7 with branch circuit rated circuit breakers listed for use with No.16 wire or Class CC, J, or Fuses and Class 10 overload protection per UL 508, or
- Where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors when used in a cabinet or enclosure.

Exception 2: No. 18 shall be permitted where applied as follows:

- For non-motor power circuits of 5.6 amperes or less where protected in accordance with Clause 7 and with Class CC fuses rated at not more than 7 amperes, or
- For motor loads with a full load ampacity of 5.6 amperes or less, where protected in accordance with Clause 7 with branch circuit rated circuit breakers listed for use with No.18 wire or Class CC, J, or Fuses and Class 20 overload protection per UL 508, or
- For motor loads with a full load ampacity of 3.5 amperes or less, where protected in accordance with Clause 7, with branch circuit rated circuit breakers listed for use with No.18 wire or Class CC, J, or Fuses and Class 20 overload protection per UL 508, or
- Where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors when used in a cabinet or enclosure.

COMMITTEE STATEMENT: The language is modified to include all appropriate means of overcurrent protection as substantiated in Proposal 79-118 (Log #129). The words "branch circuit rated" were added for consistency with Proposal 79-50 (Log #32). The committee understands that this proposal modifies the action on Proposal 79-112 (Log #98).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24

NEGATIVE: 1

NOT RETURNED: 1

EXPLANATION OF NEGATIVE:

KNECHT: The reference was made to Listed circuit breakers that don’t require yet and the UL at the meeting didn’t know about it. There was no indication that UL is pursuing this. We don’t even know if this is what they might call these breakers or if the marking will be “circuit breakers for use with 16 AWG or 18 AWG wire...”. Why didn’t we give this same latitude to Mr. Pilz regarding his testing done on safety control circuits? In addition, a good power point presentation with some test results noted...these details were submitted but not substantiated by a third party. I do not recommend going forward with this wording on circuit breakers until we have some assurance from UL that this even exists.

COMMENT ON AFFIRMATIVE:

ANDERSON: The attempt in using the “branch circuit rated circuit breakers” requirement to supplement overcurrent protection devices are not to be considered for use in power circuit, protection applications. The proposal modification is to use “branch circuit rated circuit breakers”, however this “rated” requirement is not directly defined. Defined terminology needs to be found and applied, e.g. “circuit breakers suitable for branch circuit over current protection”.

COMMITTEE ACTION:

Proposals 79-112 (Log #98)

79-117 - (15.3(a) Exception (New) [13.6.1 Exception]): Accept in Principle

SUBMITTER: Gary J. Locke, Lockheed Martin Systems Integration

RECOMMENDATION: This proposal is to add new text to NFPA 79-1997 as additional content for the newly proposed Clause 13 which was reconciled with EN 60947-1 by Technical Committee on Electrical Equipment of Industrial Machinery action.

Add text to read as follows:

13.6.1 Power Circuits No. 14 Exception 1: No. 16 shall be permitted where applied as follows:

- For non-motor power circuits of 8 amperes or less where protected in accordance with Clause 7 and with Class CC fuses rated at not more than 10 amperes, or
- For motor loads with a full load ampacity of 8 amperes or less, where protected with Class CC fuses at not more than 250 percent of full load ampacity, and Class 10 overload protection per UL 508, or
- For motor loads with a full load ampacity of 5.5 amperes or less, where protected with Class CC fuses at not more than 250 percent of full load ampacity, and Class 20 overload protection per UL 508, or
- Where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors when used in a cabinet or enclosure.

Exception 2: No. 18 shall be permitted where applied as follows:

- For non-motor power circuits of 5.6 amperes or less where protected in accordance with Clause 7 and with Class CC fuses rated at not more than 7 amperes, or
- For motor loads with a full load ampacity of 5.6 amperes or less, where protected with Class CC fuses at not more than 250 percent of full load ampacity and Class 10 overload protection per UL 508, or
- For motor loads with a full load ampacity of 3.5 amperes or less, where protected with Class CC fuses at not more than 250 percent of full load ampacity and Class 20 overload protection per UL 508, or
- Where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors when used in a cabinet or enclosure.

SUBSTANTIATION:

The present parts of NFPA 79-1997 15.3(a) was reidentified to match the numbering sequence.

The proposed new exceptions permit the use of 16/18 AWG conductors, and factory assembled 16/18 AWG multi-conductor or small modular circuit applications. This exception will also allow a common, desirable, practice unutilized on small horsepower, multi-power machinery.
Wire sizes of 0.75 mm² and 1 mm² are commonly applied where the load currents are very small in applications based upon the IEC 60204-1. Wire sizes of 0.75 mm² and 1 mm² have an ampacity similar to 18 AWG and 16 AWG wire respectively.

Conservative based calculations were evaluated relative to short circuit and overload concerns. After considering many variables, it was determined that a similar 18 AWG and 16 AWG wire would constitute a reasonable approach and give application guidance to a present practices under the detailed requirements as proposed in 13.6.1 Exceptions 1 and 2.

In order to limit exposure to physical damage the use of these conductors would be limited to multiconductor cables, and to individual conductors when used in a cabinet or enclosure. The following information is provided to detail the evaluation process.

### 16 AWG Data

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Area (CM)</th>
<th>Isc (Amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.004</td>
<td>1620</td>
<td>1356</td>
</tr>
<tr>
<td>.008</td>
<td>1620</td>
<td>990</td>
</tr>
<tr>
<td>.010</td>
<td>1620</td>
<td>664</td>
</tr>
<tr>
<td>1</td>
<td>1620</td>
<td>271</td>
</tr>
<tr>
<td>5</td>
<td>1620</td>
<td>38</td>
</tr>
<tr>
<td>10</td>
<td>1620</td>
<td>27</td>
</tr>
<tr>
<td>20</td>
<td>1620</td>
<td>19</td>
</tr>
<tr>
<td>30</td>
<td>1620</td>
<td>16</td>
</tr>
</tbody>
</table>

*Data based upon ICEA (Insulated Cable Engineers Association) insulation Damage Formulas.

### UL 508 Test Points

<table>
<thead>
<tr>
<th>Class</th>
<th>Current @ 600% *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
</tr>
<tr>
<td>20</td>
<td>33</td>
</tr>
</tbody>
</table>

*Value shown in table is based upon 6 X the limited current specified in the proposed 13.6.1.

### UL 248 Test Point @ 50KA

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Max Current Allowed (Amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.004</td>
<td>1710</td>
</tr>
</tbody>
</table>

*Current Level Extrapolated from UL F't limit by dividing out time (.004).

### 18 AWG Data

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Area (CM)</th>
<th>Isc (Amps) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>.004</td>
<td>1620</td>
<td>1640</td>
</tr>
<tr>
<td>.008</td>
<td>1620</td>
<td>1260</td>
</tr>
<tr>
<td>.010</td>
<td>1620</td>
<td>714</td>
</tr>
<tr>
<td>1</td>
<td>1620</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>1620</td>
<td>38</td>
</tr>
<tr>
<td>10</td>
<td>1620</td>
<td>27</td>
</tr>
<tr>
<td>20</td>
<td>1620</td>
<td>19</td>
</tr>
<tr>
<td>30</td>
<td>1620</td>
<td>16</td>
</tr>
</tbody>
</table>

*Data based upon ICEA (Insulated Cable Engineers Association) insulation Damage Formulas.

### UL 508 Test Points

<table>
<thead>
<tr>
<th>Class</th>
<th>Current @ 600% *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td>21</td>
</tr>
</tbody>
</table>

*Value shown in table is based upon 6 X the limited current specified in the proposed 13.6.1.

### UL 248 Test Point @ 50KA

<table>
<thead>
<tr>
<th>Time (sec)</th>
<th>Max Current Allowed (Amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.004</td>
<td>707</td>
</tr>
</tbody>
</table>

*Current Level Extrapolated from UL F’t limit by dividing out time (.004).

The Insulated Cable Engineers Association (ICEA) tables for insulation damage was used to create the worst case condition for the wire. The formula as developed by ICEA is based upon an adiabatic process where all the heat will be contained within the wire (conductor). This does not take into account the heat bleed off into the terminations and components. As a result, a damage curve was generated for thermostatic insulation at 150°C. This was the worst case of the three main types evaluated by ICEA which include:

- thermostatic (150°C)
- rubber, paper, varnished cloth (200°C)
- crosslinked polyethylene and ethylene propylene rubber (250°C)

This damage curve then supplied the worst possible condition to which the wire (conductor) would be subjected.

After laying the groundwork for wire damage, various overcurrent protective devices were reviewed.

Current limiting devices were decided upon in order to cover the variety of a fault conditions that could apply to a machine. Upon examination of Underwriters Laboratories (UL) “General Information for Electrical Equipment” (White Book), peak let-through currents of various current limiting branch circuit fuses were considered. Selecting Class CC fuses and protecting 16 and 18 AWG wire according to UL limits allowed a maximum let-through current to be determined.

Next, motor controller characteristics were explored. Based upon the information provided in UL508, test points were plotted on the time current curve to evaluate the performance of the overload device under long term heating conditions. (Note: Under these conditions there is a high probability the heat will be dissipated from the conductor into the terminals and associated components).

Guidelines were selected for proper fuse sizing and maximum full load current rating of motors based upon the above data. The criteria for determining the maximum full load current rating was (1) the maximum current value the conductor could handle for the set amount of time (10 sec for class 10, etc.), (2) add 10 percent for a conservative heat bleed off factor, and (3) divide by 6 per the requirements of UL 508. This then derived the FLC factor.

### Existing 16 AWG

### Existing 18 AWG

<table>
<thead>
<tr>
<th>COMMISSION ACTION:</th>
<th>Accept in Principle.</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMMITTEE STATEMENT:</td>
<td>See the Committee Action on Proposal 79-116 (Log #162).</td>
</tr>
<tr>
<td>NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:</td>
<td>26</td>
</tr>
<tr>
<td>VOTE ON COMMITTEE ACTION:</td>
<td></td>
</tr>
<tr>
<td>AFFIRMATIVE:</td>
<td>24</td>
</tr>
<tr>
<td>NEGATIVE:</td>
<td>1</td>
</tr>
<tr>
<td>NOT RETURNED:</td>
<td>1 Norman</td>
</tr>
<tr>
<td>EXPLANATION OF NEGATIVE:</td>
<td>KNECHT: See my Explanation of Negative Vote on Proposal 79-116 (Log #162).</td>
</tr>
</tbody>
</table>

79-118 (Log #120) 13.6.1 Power circuits . . . . . . . . . . . . No. 14

Exception 1: No. 16 shall be permitted where applied as follows:

- a) For non-motor power circuits of 8 amperes or less where protected in accordance with Clause 7 and with circuit breakers listed for use with No. 16 wire or Class CC fuses rated at not more than 10 amperes, or
- b) For motor loads with a full load ampacity of 8 amperes or less, where protected with circuit breakers listed for use with No. 16 wire or Class CC fuses at not more than 250 percent of full load ampacity, and Class 10 overload protection per UL 508, or
- c) For motor loads with a full load ampacity of 5.6 amperes or less, where protected with circuit breakers listed for use with No. 16 wire or Class CC fuses at not more than 250 percent of full load ampacity, and Class 20 overload protection per UL 508, or
- d) Where part of a jacketed multi-conductor cable assembly or flexible cord, or as individual conductors when used in a cabinet or enclosure.

Exception 2: No. 18 shall be permitted where applied as follows:

- a) For non-motor power circuits of 5.6 amperes or less where protected in accordance with Clause 7 and with circuit breaker listed for use with No. 18 wire or Class CC fuses rated at not more than 7 amperes, or
b) For motor loads with a full load ampacity of 5 amperes or less, where protected with circuit breakers listed for use with No. 16 wire or Class CC fuses at not more than 250 percent of full load ampacity, and Class 10 overload protection per UL 508, or

For motor loads with a full load ampacity of 3.5 amperes or less, where protected with circuit breakers listed for use with No. 16 wire or Class CC fuses at not more than 250 percent of full load ampacity, and Class 20 overload protection per UL 508, and

d) Where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors in a cabinet or enclosure.

**SUBSTANTIATION:** The purpose of this proposal is to include the application of circuit breakers that have been shown by test to protect No. 16 and/or 18 AWG wires in addition to Class CC fuses if the panel determines that application of No. 16 and 18 wires is acceptable. Listed circuit breakers exist in ratings of 10 amperes and less, however, they are tested with the expectation that they will be applied with No. 14 AWG wire used for power circuits. Some of these circuit breakers will protect the smaller No. 16 and 18 AWG wires.

The proposal to use No. 16 and 18 wires in power circuits is new. Up to this time, none of the industry standards or listing programs for branch-circuit overcurrent protective devices (circuit breakers or fuses) covers protection of wires small than No. 14. The UL 489 Standard for Safety for Molded-case Circuit Breakers can be revised to add requirements for protection of the smaller wire if there is a legitimate application for them.

Submitted with this substantiation was a test report that demonstrates protection of No. 18 AWG wire with thermoplastic insulation by a 10-ampere circuit breaker at its interrupting rating of 35,000 ampere-seconds. It is not the intent of this proposal to determine the test program for applying overcurrent protective devices with the smaller wires. The test program should be determined by the standard development organization and should be administered by third party listing organizations. The Test Report is included only to verify that circuit breakers are capable of protecting the smaller wire under short circuit conditions at their interrupting rating. The proposer suggests that additional testing is necessary at lower levels, however, the specific test levels and details should be determined by the standards development organization.

If the committee determines that No. 16 and 18 wires are acceptable for application as indicated in the proposal, circuit breakers should not be excluded as the overcurrent protective device. However, the requirement must indicate that they are to be listed for protection of the smaller wire. A unique marking on the circuit breaker would indicate this feature.

**COMMITTEE ACTION:** Accept in Principle.

**COMMITTEE STATEMENT:** See the Committee Action on Proposal 79-114 (Log #162).

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**

AFFIRMATIVE: 24

NEGATIVE: 1

NOT RETURNED: 1 Normal

**EXPLANATION OF NEGATIVE:**

KNECHT: See my Explanation of Negative Vote on Proposal 79-116 (Log #162).

**COMMENT ON AFFIRMATIVE:**

DOBROWSKY: In the Committee Statement the correct proposal number is 79-116.

**COMMITTEE ACTION:** Reject.

**COMMITTEE STATEMENT:** The proposal does not comply with the Regulations Governing Committee projects, Section 4.3.3(c) since the submitter has not provided the specific recommended text.

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

**SUBMITTER:** John B. Deam, Rep. The Association for Manufacturing Technology

**RECOMMENDATION:** Modify 1997 NFPA 79, Clause 15 or proposed rewrite Clause 13 in 13.5.3.

Delete the second sentence.

**SUBSTANTIATION:** Since Table 11, referred to in the proposed new rewrite clause 13.5 does not contain the last column of Table 11 in NFPA 79-1997, the sentence is not needed nor is it appropriate to include.

**COMMITTEE ACTION:** Accept in Principle.

Instead of deleting this sentence, relocate the sentence to 13.5.3.

**COMMITTEE STATEMENT:** The committee agrees that the location is inappropriate and desires to relocate the provision to 13.5.3 to ensure that the provision remains in the standard. The committee understands that this proposal modifies the Action on Proposal 79-112 (Log #29).

**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 26

**VOTE ON COMMITTEE ACTION:**

AFFIRMATIVE: 25

NOT RETURNED: 1 Normal

**COMMENT ON AFFIRMATIVE:**

SANDERS: The committee action resulted in the following text:

"13.5.3 Where ampacity derating is required for ambient temperature correction for other than 30°C or adjusted for more than three current-carrying conductors in a raceway or cable, the factor(s) shall be taken from Table 13-3b. Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity in cable or raceway." By bringing this sentence to 13.5.3, I believe that additional clarification is possible and propose the following:

"13.5.3 Where ampacity derating is required for ambient temperature correction for other than 30°C or adjusted for more than three current-carrying conductors in a raceway or cable, the factor(s) shall be taken from Table 13-3b. Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity in cable or raceway. These factors shall also apply to control conductors where their continuous load exceeds 10 percent of the conductor ampacity.

This will clarify that derating is also required for all power and lighting conductors bundled within wiring harnesses or channels within an enclosure. The proposed new last sentence correlates with NFPA 70-1999 Section 725-28 (a) and (b)."
79-122 - (Clause 16 and 17 [Clause 14]): Accept in Principle

COMMITTEE ACTION: Accept
COMMITTEE STATEMENT: The committee understands that this proposal modifies the Action on 79-112 (Log #28).

SUBMITTER: William E. Anderson, The Procter & Gamble Company

RECOMMENDATION: 14 Wiring practices

14.1 Connections and routing
14.1.1 General requirements
14.1.1.1 All connections shall be secured against accidental loosening and shall ensure a thoroughly good connection.
14.1.1.2 The means of connection shall be identified for the cross-sectional areas and type of the conductors being terminated.
14.1.1.3 The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one equipment grounding or one bonding conductor (protective conductor) shall be connected to one terminal connecting point.
14.1.1.4 A power distribution block designed for multiple tap conductors (e.g., single or multiple conductors “in” and multiple conductors “out”) shall be permitted for additional tap connections and circuit branching.
14.1.1.5 Soldered connections shall only be permitted where terminals are provided which are identified for soldering.
14.1.1.6 Terminals on terminal blocks shall be plainly identified to correspond with markings on the diagrams.
14.1.1.7 The installation of flexible conduits and cables shall be such that liquids shall drain away from the fittings. Where practicable, raceway connections shall enter the sides or bottom of an enclosure or box.
14.1.1.8 Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals that are not equipped with this facility. Solder shall not be used for that purpose.
14.1.1.9 Shielded conductors shall be terminated so as to prevent fraying of strands and to permit easy disconnection.
14.1.1.10 Identification tags shall be readable, permanent, and identified for use in the physical environment.

NOTE: A single tag bearing the complete identification is preferred.

14.1.1.11 Terminal blocks shall be mounted and wired so that the internal and external wiring does not cross over the terminals.
Note: For additional information on terminal blocks, refer to IEC 60947-7-1 “Low-voltage switchgear and control gear Part 7: Ancillary equipment Section one Terminal blocks for copper conductors”.

14.1.2 Conductor and cable runs
14.1.2.1 Conductors and cables shall be run from terminal to terminal without splices or joints.

Exception No. 1: Splices shall be permitted to leads attached to electrical equipment, such as motors and solenoids; such splices shall be insulated with oil-resistant electrical tape or insulation equivalent to that of the conductors and installed in a suitable enclosure.

Exception No. 2: Where it is impracticable to provide terminals in a bundle provided the method of support and fastening is sufficient to support the mechanical weight and strain of the bundle.

Exception No. 3: Cables shall be fastened where supported.

Exception No. 4: Where runs at not more than a 45 degree angle from horizontal, fastening is not required.

14.1.4.6 Cables shall be fastened with cable ties supported by any of the following methods:

(1) Screw-on cable tie mounts
(2) Hammer-on cable tie mounting clips
(3) Around the machine or system structural members
(4) Through holes in the machine or system structural members
(5) Cable mounting clamps
(6) Other methods identified as acceptable for the purpose

14.1.4.7 The free ends of cable ties shall be cut flush after final adjustment and fastening. Cable ties of the reusable or releasable type shall not be permitted for use as a permanent fastening method.

14.1.4.8 Cables shall be protected from physical damage where follows:

(1) By alternative routing
(2) With additional guarding or railings
(3) When supported by flooring or deck, with walk over or drive over cable protective devices
(4) By installation in a wire way
(5) By installation in a floor or deck covering trapezoidal walk over raceway specifically designed for cable protection

14.1.4.9 Bends in cables shall be made so as not to cause undue stress. The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the cable.

14.1.4.10 Where a cable is used in a length longer than optimally required, the excess cable shall be coiled in loops at or near the load end. The coil shall be fastened to itself and to the machinery structure.

Exception: When an excess cable is associated with a horizontal cable run that is inherently and fully supported, the coil is not required to be fastened to the equipment or system structure.

14.2 Identification of conductors

14.2.1 General requirements

14.2.1.1 Conductors shall be identified at each termination by number, letter, color (either solid or with one or more stripes), or a combination thereof and shall correspond with the technical documentation.
Exception 1: Internal wiring on individual devices purchased completely wired.

Exception 2: Where the insulation used is not available in the colors required (e.g., high temperature insulation, and chemically resistant insulation).

Exception 3: Where multiconductor cable is used and other means of permanent identification is provided.

14.2.1.2 When numbers are used, they shall be Arabic; letters shall be Roman (either upper or lower case).

14.2.2 Identification of the equipment grounding (protective) conductor

14.2.2.1 The color GREEN (with or without one or more YELLOW stripes) shall be used to identify the equipment-grounding conductor where insulated or covered. This color identification shall be strictly reserved for the equipment grounding (protective) conductor.

Exception No. 1: In multiconductor cable-connected assemblies where equipment grounding is not required, the solid color GREEN shall be permitted for other than equipment grounding.

Exception No. 2: It shall be permitted to use conductors of other colors provided the insulation or cover is appropriately identified at all points of access.

Exception No. 3: For grounded control circuits use of a GREEN insulated conductor (with or without one or more YELLOW stripes) or a bare conductor from the transformer terminal to a grounding terminal on the control panel shall be permitted.

Note: The international standards reserve the use of bicolor combination GREEN AND-YELLOW for this purpose. The bicolor combination is such that on any 15-mm (0.6-inch) length, one of the colors covers at least 30 % and not more than 70 % of the surface of the conductor, the other color covering the remainder of the surface.

14.2.2.2 Where the equipment grounding (protective) conductor is identified by its shape, position, or construction (e.g. a braided conductor), or where the insulated conductor is not readily accessible, color coding throughout its length is not necessary. But the ends or accessible positions shall be clearly identified by the 1999 NEC figure 250-126 grounding symbol, (IEC60417-symbol number-5019), or by the color GREEN (with or without one or more YELLOW stripes) or the bicolor combination GREEN AND-YELLOW.

14.2.3 Identification of the grounded circuit conductor

14.2.3.1 Where an AC circuit includes a grounded conductor, this conductor shall be WHITE, GRAY or three continuous WHITE stripes on other than GREEN, BLUE, YELLOW insulation along its entire length.

NOTE: IEC 60204-1 requires the use of the color LIGHT BLUE for the neutral conductor where color is the sole means of identification.

14.2.3.2 The use of other colors for the following applications shall be as follows:

(1) WHITE WITH BLUE STRIPE – grounded (current carrying) AC circuit conductor which remains energized when the main disconnecting means is in the OFF position.

(2) WHITE WITH YELLOW STRIPE – grounded (current carrying) AC circuit conductor which remains energized when the main disconnecting means is in the OFF position.

14.2.3.3 Where identification by color is used, bus bars used as grounded conductors shall be either colored by a stripe, 15 mm (0.6 inch) to 100 mm (3.9 inch) wide in each compartment or unit or at each accessible position, or colored throughout their length.

14.2.4 Identification by color for other conductors

14.2.4.1 Ungrounded circuit conductors that remain energized when the main disconnecting means is in the OFF position shall be either YELLOW or ORANGE (see 5.3.5 “Excepted circuits”).

These color identifications shall be strictly reserved for this application only.

Exception 1: Internal wiring on individual devices purchased completely wired.

Exception 2: Where the insulation used is not available in the colors required (e.g., high temperature insulation, and chemically resistant insulation).

14.2.4.2 Where color is used for identification, the color shall be used throughout the length of the conductor either by the color of the insulation or by color markers.

Exception: Multiconductor cables shall be permitted to be permanently identified at the time of installations.

14.2.4.3 The use of other colors for the purpose of identification shall be as follows:

(1) BLACK: Ungrounded line, load, and control conductors at line voltage.

(2) RED: Ungrounded AC control conductors, at less than line voltage.

(3) BLUE: Ungrounded DC control conductors.

Exception 1: Internal wiring on individual devices purchased completely wired.

Exception 2: Where the insulation used is not available in the colors required (e.g., high temperature insulation, and chemically resistant insulation).

Exception 3: Where multiconductor cable is used and other means of permanent identification is provided.

14.3 Wiring inside enclosures

14.3.1 Panel conductors shall be supported where necessary to keep them in place. Non-metallic ducts shall be permitted only when they are made with a flame-retardant insulating material. Note: For additional information on Flame retardant materials, refer to IEC 60332-1 “Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable”.

14.3.2 Electrical equipment mounted inside enclosures shall be installed in such a way as to permit access to the wiring.

Exception 2: Where the insulation used is not available in the colors required (e.g., high temperature insulation, and chemically resistant insulation).

14.3.3 Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with 13.7. “Conductors and cables used for flexing applications” to allow for the movement of the part. The conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection.

14.3.4 Conductors that do not run in ducts shall be supported.

14.3.5 Multiple-device control panels shall be equipped with terminal blocks or with attachment plugs and receptacles for all outgoing control conductors.

14.5 The direct connection of Power cables and cables of measuring circuits, to the terminals of the devices for which the connections were intended shall be permitted.

14.5.7 AC receptacles, AC plugs, flexible cords, appliance couplers, power cord sets, etc. shall be permitted inside enclosures for internal wiring and connections between assemblies with AC power where used in accordance with their listing.

14.4 Wiring outside enclosures

14.4.1 General requirements

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced.

14.4.2 External raceways (ducts)

14.4.2.1 All conductors of the same AC circuit routed to the same location shall be contained in the same raceway (duct).

14.4.2.2 Conductors external to the electrical equipment enclosure(s) shall be enclosed in raceway (duct) described in 14.5. Exception: Cables and cable connectors need not be enclosed in a raceway where they are otherwise protected and supported.

14.4.2.3 Fittings used with raceways (ducts) or multiconductor cable shall be identified for use in the physical environment.

14.4.2.4 Flexible conduit or multiconductor cable with flexible properties shall be used only where it is necessary to employ flexible connections to pendant push-button stations. The weight of the pendant stations shall be supported by means other than the flexible conduit or the multiconductor cable with flexible properties, except where the conduit or cable is specifically designed for that purpose.

14.4.2.5 Flexible conduit or multiconductor cable with flexible properties shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to stationary motors, to position switches, and to other externally mounted devices. Where pre-wired devices (e.g. position switches, proximity switches) are supplied, the integral cable length shall be permitted.

14.4.3 Connection to moving elements of the machine

14.4.3.1 Connections to moving parts shall be made using conductors in accordance with 13.7. Flexible cable and conduit shall have vertical connections and shall be so installed as to prevent excessive flexing and straining. Horizontal connections shall be permitted where the flexible cable or conduit is adequately supported. Cable with flexible properties and flexible conduit shall be so installed as to prevent excessive flexing and straining, particularly at the fittings.

14.4.3.2 Cables with flexible properties subject to movement shall be supported in such a way that there is neither mechanical strain on the connection nor any sharp flexing. When this is achieved by the use of a loop, it shall provide for a bending radius of the cable of at least 10 times the diameter of cables.

14.4.3.3 Cable with flexible properties of machines shall be so installed or protected as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:
(1) Being run over by the machine itself
(2) Being run over by vehicles or other machines
(3) Coming into contact with the machine structure during movements
(4) Running in and out on cable baskets, or on or off cable drums
(5) Acceleration forces and wind forces on festoon systems or suspended cables
(6) Excessive rubbing by cable collector

14.4.3.4 The cable sheath shall be resistant to the wear from movement and the effects of atmospheric contaminants (e.g. oil, water, coolants, and dust).

14.4.3.5 Where cables subject to movement are close to moving parts, precautions shall be taken to maintain a space of at least 25.4-mm (1-inch) between the moving parts and the cables. Where that distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

14.4.3.6 The cable handling system shall be so designed that lateral cable angles do not exceed 5°, avoiding torsion in the cable when:

(1) Being wound on and off cable-drums and
(2) Approaching and leaving cable guidance devices

14.4.3.7 Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

14.4.3.8 Devices serving to guide and carry a cable with flexible properties, shall be so designed that the inner bending radius is not less than the values given in Table XW, unless the smaller properties, shall be so designed that the inner bending radius is flexible cables always remain on a drum.

14.4.3.9 The straight section between two bends, in an S-shaped length, and a bend into another plane shall be at least 20 times the diameter of the cable.

14.4.3.10 Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit under all conditions of operation. Flexible metallic conduit shall not be used for rapid movements except when specifically designed for that purpose.

14.4.4 Interconnection of devices on the machine

Where practical, machine-mounted switching devices (e.g. position sensors, push buttons) are connected in series or in parallel, the connections between those devices shall be made through terminals forming intermediate test points. Such terminals shall be conveniently placed, protected from the environment, and shown on the relevant diagrams.

14.4.5 Attachment plug and receptacle (plug/socket) combinations

14.4.5.1 Where equipment is removable, connections to it through a polarized attachment plug and receptacle (plug/socket) combination shall be permitted. The male plug shall be connected to the load circuit.

14.4.5.2 Attachment plug and receptacle (plug/socket) combinations shall be listed for the intended use and shall be of the locking type where rated greater than 20 amperes. Where used on circuits of more than 300 volts to ground or 300 volts phase-to-phase, they shall be skirted and constructed to contain any arc generated when a connection is made or broken.

14.4.5.3 Attachment plug and receptacle (plug/socket) combinations, shall be so designed that: a protective bonding (equipment grounding) circuit connection is made before any live connections are made; and the protective bonding (equipment grounding) circuit connection is not disconnected until all live connections in the plug are disconnected; except for connections used in PELV circuits, or the connectors used only to facilitate assembling / disassembling (multi-pole connectors).

14.4.4.4 Attachment plugs and receptacles (plug and socket) combinations used for carrying motor loads shall meet the conditions of 5.3.3.3 if the circuit is likely to be opened under load.

14.4.5.5 Where more than one attachment plug and receptacle (plug/socket) combination is used at the same location, they shall be mechanically coded to prevent incorrect insertion or be clearly identified.

14.4.5.6 Attachment Plug/socket combinations that are used for industrial power purposes or of a type used for domestic applications shall not be used for control circuits.

14.4.5.7 Means shall be provided to cover the receptacle when the plug is removed.

14.4.6 Dismantling for shipment

Where it is necessary that wiring be disconnected for shipment and where practicable, terminals or attachment plug and receptacle (plug/socket) combinations shall be provided at the sectional points. Such terminals shall be suitably enclosed and attachment plug/socket receptacle combinations shall be protected from the physical environment during transportation and storage. Raceway and enclosure openings shall be sealed prior to shipment.

14.5 Raceways (ducts), support systems (cable supports), connection boxes and other boxes used for wiring systems, connection boxes, and pull boxes where the holes would compromise the intended enclosure integrity. Drain holes of 6.4 mm (1/4 inch) diameter shall be permitted in wireways (cable trunking systems), connection boxes, and other boxes used for wiring purposes that are subject to accumulations of oil or moisture.

14.5.2 Percentage fills of raceways (ducts)

The combined cross-sectional area of all conductors and cables shall not exceed 50 percent of the interior cross-sectional area of the raceway (duct). The fill provisions shall be based on the actual dimensions of the conductors or cables used.

Note: It should be recognized that, for certain conditions, a larger size raceway or a lesser raceway fill should be considered.

14.5.3 Rigid conduit and fittings

14.5.3.1 General requirements

14.5.3.1.1 The minimum electrical trade size shall be 1/2 inch.

14.5.3.1.2 The maximum electrical trade size shall be 6 inch.

Note: Metric trade numerical designations for rigid metal conduit are the same as those found in Extra-heavy Duty Rigid Steel Conduits for Electrical Installations, IEC 981-1989; namely: 1/2 = 16, 3/4 = 21, 1 = 27, 1 1/4 = 35, 1_ = 41, 2 = 53, 2 1/2 = 63, 3 = 78, 3 1/2 = 91, 4 = 103, 5 = 129, and 6 = 155.

14.5.3.1.3 Where conduit enters a box or enclosure, a bushing or fitting providing a smoothly rounded insulating surface shall be installed to protect the conductors from abrasion, unless the design of the box or enclosure is such that it provides the same protection. Where conduit bushings are constructed wholly of insulating material, a locknut shall be provided both inside and outside the enclosure to which the conduit is attached.

Exception: Where threaded hubs or bosses that are an integral part of an enclosure provide a smoothly rounded or flared entry for conductors.

14.5.3.1.4 Conduit bends shall be made in such a manner that the conduit shall not be damaged and the internal diameter of the conduit shall not be effectively reduced. The radius of the curve of any field bend shall be not less than shown in Table XX.
### Table XX — Minimum Radius of Conduit Bends

<table>
<thead>
<tr>
<th>Size of Conduit (in.)</th>
<th>Radius of Bend Done by Hand (in.)</th>
<th>Radius of Bend Done by Machine (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3/4</td>
<td>5</td>
<td>4 1/2</td>
</tr>
<tr>
<td>1/2</td>
<td>6</td>
<td>3 1/4</td>
</tr>
<tr>
<td>1/4</td>
<td>8</td>
<td>7 1/4</td>
</tr>
<tr>
<td>3/8</td>
<td>10</td>
<td>8 1/4</td>
</tr>
<tr>
<td>1/2</td>
<td>12</td>
<td>9 1/2</td>
</tr>
<tr>
<td>21/2</td>
<td>16</td>
<td>10 1/2</td>
</tr>
<tr>
<td>3/2</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>41/2</td>
<td>27</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>30</td>
</tr>
</tbody>
</table>

Table XX: SI units: (Radius) 25mm = 1 in.

NOTE 1: For field bends done by hand, the radius is measured to the inner edge of the bend.

NOTE 2: For a single-operation (one-shot) bending machine designed for the purpose, the radius is measured to the centerline of the conduit.

14.5.3.1.5 A run of conduit shall contain not more than four-quarter bends or a combination of bends totaling 360 degrees, between pull points.

14.5.3.2 Metal type nonflexible conduit

14.5.3.2.1 General requirements

14.5.3.2.1.1 Conduits shall be securely held in place and supported at each end.

14.5.3.2.1.2 Fittings shall be compatible with the conduit and identified for the application. Fittings and conduits shall be threaded using an electrical conduit die unless structural difficulties prevent assembly. Running threads shall not be used on conduit for connection at couplings. Metallic tubing shall not be threaded. Where threadless fittings are used, the conduit shall be securely fastened to the equipment.

14.5.3.2.2 Rigid metal conduit and fittings

Rigid metal conduit and fittings shall be of galvanized steel or of a corrosion-resistant material identified for the conditions of service. Note: The use of dissimilar metals in contact that can cause galvanic action should be avoided.

14.5.3.2.3 Intermediate metal conduit

Intermediate metal conduit shall be a steel raceway of circular cross section with integral or associated couplings, approved for the installation of electrical conductors and used with approved fittings to provide electrical continuity. Note: The use of dissimilar metals in contact that can cause galvanic action should be avoided.

14.5.3.2.4 Electrical metallic tubing

Electrical metallic (steel) tubing shall be a metallic tubing of circular cross section approved for the installation of electrical conductors when joined together with approved fittings. The maximum size of tubing shall be the 4-in. electrical trade size. Note: The use of dissimilar metals in contact that can cause galvanic action should be avoided.

14.5.3.3 Rigid non-metallic conduit (PVC Schedule 80)

14.5.3.3.1 Rigid non-metallic conduit (PVC schedule 80) shall be of suitable nonmetallic material approved for the installation of electrical conductors and identified for use where subject to physical damage. Note: For additional information about rigid non-metallic conduit, refer to UL 651.

14.5.3.3.2 Conduit shall be securely held in place and supported as follows:

<table>
<thead>
<tr>
<th>Conduit Size (in.)</th>
<th>Maximum Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 - 1</td>
<td>3</td>
</tr>
<tr>
<td>1 1/4 - 2</td>
<td>5</td>
</tr>
<tr>
<td>2 1/2 - 3</td>
<td>6</td>
</tr>
<tr>
<td>3 1/2 - 5</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: For SI units, 1 ft = 0.3048 m (supports).

In addition, conduit shall be securely fastened within 3 ft (914 mm) of each box, enclosure, or other conduit termination.

14.5.3.3.3 Expansion fittings shall be installed to compensate for thermal expansion and contraction. (NFPA 70-1999 "Table 347-9(A). Expansion Characteristics of PVC Rigid Nonmetallic Conduit Coefficient of Thermal Expansion = 3.38 x 10^-5 in./in./° F")

14.5.3.3.4 All joints between lengths of conduit, and between conduit and couplings, fittings, and boxes, shall be made with fittings approved for the purpose.

14.5.4 Flexible metal conduit and fittings

14.5.4.1 General requirements

14.5.4.1.1 Flexible metal conduit and liquidtight flexible metal conduit, minimum electrical trade size shall be 3/8 inch. Exception: Thermocouples and other sensors.

14.5.4.1.2 The maximum size of flexible metal conduit and liquidtight flexible metal conduit, shall be 4-in trade size.

Note: Metric trade numerical designations for flexible metal conduit and liquidtight flexible metal conduit, are 3/8 = 12, 1/2 = 16, 5/4 = 21, 1 = 27, 1 1/2 = 35, 1 1/4 = 41, 1 1/2 = 43, 1 2/1 = 63, 5 = 78, 3 1/2 = 91, and 4 = 103.

14.5.4.1.3 Liquidtight flexible metal conduit and liquidtight flexible metal conduit shall be installed in such a manner that liquids will tend to run off the surface instead of draining toward the fittings.

14.5.4.1.4 Fittings shall be compatible with the conduit and identified for the application. Connectors shall be the "union" types.

14.5.4.2 Flexible metal conduit

Flexible metal conduit is a raceway of circular cross section made of helical wound, formed, and interlocked metal strip. Flexible metal conduit shall be identified for use in the expected physical environment.

14.5.4.3 Liquidtight flexible metal conduit

Liquidtight flexible metal conduit is a approved raceway of circular cross section having an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core with associated couplings, connectors, and fittings and approved for the installation of electric conductors. Liquidtight flexible metal conduit shall be identified for use in the expected physical environment.

14.5.5 Flexible non-metallic conduit and fittings

14.5.5.1 Liquidtight flexible nonmetallic conduit is a raceway of circular cross section of various types:

1. A smooth, seamless inner core and cover bonded together and having one or more reinforcement layers between the core and cover
2. A smoother inner surface with integral reinforcement within the conduit wall
3. A corrugated internal and external surface with or without integral reinforcement within the conduit wall
4. Liquidtight flexible nonmetallic conduit is oil-, water-, and flame-resistant and, with fittings, is approved for the installation of electrical conductors

14.5.5.2 A flexible non-metallic conduit shall be resistant to kinking and shall have physical characteristics of the sheath of multiconductor cables.

14.5.5.3 The conductors shall be identified for use in the expected physical environment.

14.5.5.4 Liquidtight flexible nonmetallic conduit minimum electrical trade size shall be 3/8 inch. 14.5.5.5 The maximum size of liquidtight flexible nonmetallic conduit shall be 4-in trade size.

Note: Metric trade numerical designations for liquidtight flexible nonmetallic conduit are 3/8 = 12, 1/2 = 16, 5/4 = 21, 1 = 27, 1 1/2 = 35, 1 1/4 = 41, 1 1/2 = 43, 1 2/1 = 63, 5 = 78, 3 1/2 = 91, and 4 = 103.

14.5.5.6 Fittings shall be compatible with the conduit and identified for the application.

14.5.5.7 Flexible conduit shall be installed in such a manner that liquids will tend to run off the surface instead of draining toward the fittings.

14.5.6 Wireways (cable trunking systems)

14.5.6.1 Wireways (cable trunking systems) external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the machine.

14.5.6.2 Covers shall be shaped to overlap the sides; gaskets shall be permitted. Covers shall be attached to wireways (cable trunking systems) by hinges or chains and held closed by means of captive screws or other suitable fasteners. On horizontal wireway (cable trunking systems), the cover shall not be on the bottom. Hinged covers shall be capable of opening at least 90 degrees. 14.5.6.3 Where the wireway (cable trunking system) is furnished in sections, the joints between sections shall fit tightly but shall not be required to be gasketed.

14.5.6.4 The only openings permitted shall be those required for wiring or for drainage.
14.5.6.5 Wireways (cable trunking systems) shall not have opened but unused knockouts.

14.5.7 Machine compartments and wireway (cable trunking systems)
The use of compartments or wireways (cable trunking systems) within the column or base of a machine to enclose conductors shall be permitted provided the compartments or wireways (cable trunking systems) are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments wireways (cable trunking systems) shall be so secured and arranged that they can not be subject to damage. (See 17.2. "Warning marking and signs")

14.5.8 Connection boxes and other boxes
14.5.8.1 Connection boxes and other boxes used for wiring purposes shall be readily accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influences under which the machine is intended to operate.

14.5.8.2 Those boxes shall not have opened but unused knockouts or any other openings and shall be so constructed as to exclude materials such as dust, flyings, oil, and coolant.

14.5.9 Motor connection boxes
14.5.9.1 Motor connection boxes shall enclose only connections to the motor and motor-mounted devices (e.g. brakes, temperature sensors, plugging switches, tachometer generators).

14.5.9.2 Electrical connections to motors, solenoids and other devices with integral leads, sizes No. 14 AWG through No. 4 AWG, shall be made with ring type pressure connectors (pressure-tool applied) and bolted.

14.5.9.3 Connectors shall be insulated with a material that will not support combustion.

14.5.9.4 Soldered or insulation piercing type connectors (lugs) shall not be used.

14.5.10 Cord.
14.5.10.1 Manufactured assemblies with factory applied molded connectors applied to cord shall be permitted.

Note: For additional information on flexible cords, refer to ANSI UL 62 "Flexible cord and fixture wireways (cable trunking systems) shall be so secured and arranged that they can not be subject to damage. (See 17.2. "Warning marking and signs")

14.5.10.2 The use of cord shall be limited to individual exposed lengths of 50 feet or less.

14.5.10.3 Cord shall be installed in accordance with the provision of clause 14.1.4.

14.5.10.4 Cord shall be permitted for use for flexible connections to pendant push-button stations. Chains or wire rope external to the cord shall support the weight of pendant stations.

14.5.10.5 Cord shall be permitted for use for connections involving small or infrequent movements. Cord shall also be permitted to complete the connection to normally stationary motors, limit switches, and other externally mounted devices.

14.5.10.6 Connectors to frequently moving parts shall be made with conductors for flexing service in accordance with 13.7. Cord with conductors for flexing service shall have vertical connections and shall be installed to avoid excessive flexing and straining. Exception: Horizontal connections shall be permitted where the cord is adequately supported.

14.5.11 Cable trays
Cable trays shall be used for cable or raceway support on industrial machines shall be permitted. Cable trays shall be permitted to support single conductors 1/0 or larger that are otherwise permitted on industrial machines, cables that are otherwise permitted on industrial machines, and raceways functionally associated with industrial manufacturing systems.

SUBSTANTIATION: Historical Background.
In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are:

Harmonization - Purpose
As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machinery safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Importance of Issue - Harmonization
Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization - Objective
This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result
The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 29 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group for Clause 14 consisted of Bill Anderson, Frank DeFlece Jr., Gary Locke, and John Knecht. The Task Group compared NFPA-79-1997, Clauses 16 and 17 and related material with IEC 60204-1 Clause 14. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber Clauses 16 and 17 of NFPA 79-1997 to correspond with IEC 60204-1. The task group proposes the following changes to further improve usability.

Substantiation for NFPA 79-2002 Chapter 14 Wiring practices

14 Recommendation: Combine NFPA 79 1997 Editions Clause 16 title, "Wiring methods and practices" and Clause 17 title, "Raceways, junction boxes, and pull boxes with Chapter 14 title, "Wiring practices"


Substantiation: Delete "Wire" as unnecessary and change "connections" to "routing" encompasses the circuit from termination to termination and reflects the additional material included in section 14.1. Chapter 14 is divided into 5 sections 1 Connections and routing, 2 Identification of conductors, 3 Wiring inside enclosures, 4 Wiring outside enclosures and 5 Raceways (ducts), support systems (cable supports), connection boxes and other boxes. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.


14.1.1.1 Recommendation: Revise NFPA 79 1997 Edition 16.1.9 with new text, "All connections shall be secured against accidental loosening and shall ensure a thoroughly good connection". Move to 14.1.1.1 Substantiation: Proposed text is more inclusive and adds the information connections are to be secured against loosening to
clarify the quality of work requirements. "Thoroughly good connection" from NFPA 70:1999 110.4 "Electrical Connections"
(a) "Terminals", to clarify the quality of work requirements.

14.1.1.2 Recommendation: Add new text "The means of connection shall be identified for the cross-sectional areas and type of the conductors being terminated".

Substantiation: Provides additional information for connections.


Substantiation: The restriction for the equipment-grounding conductor is a part of the general requirements for the connections and routing.

The 1st sentence is moved to 14.1.11 as the more logical location.

14.1.1.4 Recommendation: Add new text.

Substantiation: Text has been added to recognize current practice and the need for connection of multiple conductors. UL "General Information for Electrical Equipment", states that a power distribution block consists of a connector(s) mounted on an insulating base. Each individual connector has provisions for connection of one or more conductors and multiple smaller tap-off conductors.


14.1.1.7 Recommendation: Relocate NFPA 79 1997 Edition 16.3.11 here, renumber and add: "Where practicable, raceway connections shall enter the sides or bottom of an enclosure or box."

Substantiation: The added restriction on enclosure entry reflects current practice.


Substantiation: Provides less prescriptive language and meets the intent of the present standard. NFPA 79 1997 Edition 16.4.1 Exception No. 1 was moved to 14.1.1.5. Exception No. 2 was not retained as the practice is limited in use.


Substantiation: The new text contains the desired results without the existing text requirements that contain design details that are not in common use today. The note states the preferred current practice without restricting other acceptable options.

14.1.1.11 Recommendation: Locate NFPA 79 1997 Edition 16.1.18 1st sentence here, renumber and replace the 2nd sentence by adding the following as a note: "For additional information on Terminal blocks refer to IEC 60947-7-1 "Low-voltage switchgear and control gear Part 7: Auxiliary equipment Section one Terminal blocks for copper conductors."

Substantiation: The added text provides an additional source of information for terminal blocks.
14.1.4.1 Recommendation: Add new text to provide installation information.

Substantiation: Specific application analysis will identify precisely how cables need to be run. In addition to conventional cable routing methodology, the routing of cables along either the inside or outside of the machine will at some point typically become necessary. Clause 14.1.4.1 recognizes and permits cables routed along the exterior of the surface of the structural members of the machinery, as well as cables routed through chases inherent to the machinery structure, or through chases added to the machinery structure for the purpose. Cables associated with a machine or machinery system is an integral part of that machine or machinery system. Supporting cables by the equipment or system structure clearly indicates and maintains that association.

14.1.4.2 Recommendation: Add new text to provide cable support requirements.

Substantiation: Provides information not in the present standard. Some cable types may be more susceptible to physical damage that others. Care should be taken to ensure that all applied cables type would not be subjected to physical damage under conditions of normal use. Although this requirement may appear obvious to most readers, Clause 14.1.4.2(a) codifies a requirement that the proper care be taken to ensure the integrity of the cable installation.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that cables supported at greater that 12 inches in a non-vertical run can make for an installation that would not satisfy a reasonable persons understanding of what constitutes “a neat and workman like” installation. Clause 14.1.4.2(b) helps ensure a conscientious “workman like” installation of cables.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that it may be impractical or undesirable to support cables in a non-vertical run at 12 inches intervals at all times. This exception to Clause 14.1.4.2(b) allows a reasonable extension of the support distance to cover such circumstances.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that cables supported at less than 36 inches in a vertical run can make for an installation that would not satisfy a reasonable persons understanding of what constitutes “a neat and workman like” installation. Clause 14.1.4.2(c) helps ensure a conscientious “workman like” installation of cables.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that it may be impractical or undesirable to support cables in a vertical run at 36 inches intervals at all times. This exception to Clause 14.1.4.2(c) allows a reasonable extension of the support distance to cover such circumstances.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that cables suspended in an uncoiling a distance greater than 18 inches can make for an installation that would not satisfy a reasonable persons understanding of what constitutes “a neat and workman like” installation. Clause 14.1.4.2(d) helps ensure a conscientious “workman like” installation of cables.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that it may be impractical or desirable for cables to span distances greater than 18 inches at some times. This exception to Clause 14.1.4.2(d) allows a reasonable extension of the span distance to cover such circumstances.

14.1.4.3 Recommendation: Add new text prohibiting supporting cables on removable machinery guard work.

Substantiation: The supporting of cables on machinery guard work that is likely to be removed for maintenance access would make for a potentially unsafe installation. The integrity of the installation would be compromised as soon as maintenance access to the equipment behind the guard work was required. Guard work likely to be removed for maintenance access may be removed on a routine basis. It is therefore reasonable to expect that the integrity of the cable installation will ultimately not be restored, and is therefore prohibited.

14.1.4.4 Recommendation: Add new text on multiple cable support.

Substantiation: Where multiple cables are routed together, it is often common practice to fasten those cables together in a bundle as to create a neat and workman like installation. Clause 14.1.4.4 recognizes this practice, and requires that the fasteners and supports employed be of such construction so as to being substantial enough for the application.

14.1.4.5 Recommendation: Add new text requiring attachment of cables to their support and exceptions where the nature of the support does not need the cable to be fastened.

Substantiation: In order to maintain a well managed, safe, installation effected in a neat and workman like manner, cables must be fastened where supported. Unfastened cables may be come a hazard if left hanging around unfastened. Unfastened cables may cause a person or object (e.g., tools) to hang up on the equipment causing personal injury or equipment damage. Exception 1 allows horizontal runs of cables where inherently supported by the machine or machinery system structure, floor or deck, to lay where supported without fastening. Fastening is not practical when cables are laying on the floor or deck within the structure of the machine or machinery system. Fasting is not warranted where the inherent design and natural construction of the machine or machinery system allows for cable runs at 45 degrees or less without fastening. Fastening is not practical when cables are lying within the structure of the machine or machinery system, and is not warranted where the inherent design and natural construction of the machine or machinery system naturally supports the cable runs. At 45 degrees or less cables are not likely to move once in place.

14.1.4.6 Recommendation: Add new text describing acceptable cable fastening methods.

Substantiation: Cable clamps and cables ties are a readily available, low cost and effective method of fastening cables in place, and are used in common practice for the purpose. Cable ties alone, however, are not a complete fastening solution. In order to fasten a cable with a cable tie additional hardware is required. That additional hardware is defined in the text of Clause 14.1.4.6. Cable tie mounts are a common usage item. A substantial mechanical fastening method for cable tie mounts is desirable in order to maintain the integrity of the assembly. Screw fastening is such a substantial method. The structural members of machines are typically of substantial construction, and can serve as a safe and effective fastening platform when cables are fastened with cable ties around the members or through holes in the members. Cable mounting clamps are acceptable based on the judgment of the applicable authority having jurisdiction.

14.1.4.7 Recommendation: Add new text describing current practices.

Substantiation: In order to maintain a neat and workman like assembly, cable ties should be cut flush once installed. Reusable cable ties have a propensity to loosen with time, and therefore do not maintain the integrity of the assembly over time.

14.1.4.8 Recommendation: Add new text describing protection of cable.

Substantiation: Cables must not be subjected to physical damage. Clause 14.1.4.8 identifies methods by which physical damage to a cable can be avoided.

Routing cables in such a way so as to ensure that cable runs cannot be damaged, or using a commercially available walk or drive over cable protective devices are acceptable and effective methods of protection. Routing cables in a cable trunk (wire way) or using a trapezoidal walk over roadway can be specifically designed and constructed by the machinery supplier for the purpose cable protection are also acceptable and effective methods of protecting cables.

14.1.4.9 Recommendation: Add new text restricting the cable-bending radius.

Substantiation: Bends in cables should not be made in a manner that places undue stress on the integrity of the cable. A requirement for a inner edge bend radius of not less than five times the diameter of the cable will ensure the integrity of the cable at
bends in the cable run. A typical cable manufacturer recommended minimum bending radius, for fixed installation of
cables, is between 3 and 5 times the cable diameter.

14.1.4.10 Recommendation: Add new text concerning the handling of excess cable installed on a machine.
Substantiation: Cables, as typically applied for industrial machinery can be either of a perfect length, or longer than required. Clause 14.1.4.10 provides requirements for the neat and workmanlike handling of excess cable lengths in a consistent, identifiable manner. The exception to Clause 14.1.4.10 is consistent with the practices outlined in Exception 1 to Clause 14.1.4.5.

Substantiation: Chapter 14 is divided into 5 sections 1 Connections and routing, 2 Identification of conductors, 3 Wiring inside enclosures, 4 Wiring outside enclosures and 5 Raceways (ducts), support systems (cable supports), connection boxes and other boxes. The proposed new title more accurately reflects the text. Editorial addition to help organize the material and follow IEC 60920-1 1997 Edition and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

Under the old 16.1 General requirements, 16.1.1 through 16.1.3, though not in the title, deals with the general topic of the identification of conductors. In the new proposal for section 14.2, the topic, identification or conductors, is more broadly covered in four subsections

Substantiation: This subsection, "General requirements", is used to consolidate information that applies to all the parts of the section 14.2 into one area for clarity. Section 14.2 is divided into 4 subsections 1 General requirements, 2 Identification of the equipment grounding (protective) conductor, 3 Identification of the grounded circuit conductor, and 4 Identification by color for other conductors. Editorial addition to help organize the material and follow IEC 60920-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.2.1.1 Recommendation: Replace existing NFPA 79 1997 Edition 16.1.1 1st sentence with new text expanding general identification of conductors requirements. Move existing NFPA 79 1997 Edition 16.1.3 Exception 1, Exception 2, Exception 3 to proposed 14.2.1.1 "General requirements" of "Identification of conductors" Substantiation: The requirements from the existing NFPA 79 1997 Edition 16.1.1. first sentence are covered in 14.2.1.1. The requirement for the identification to appear on the diagrams is covered in new proposed chapter 18. Position of exceptions 1 & 3 to clarify what is to apply. Previous position NFPA79 1997 16.1.3 did not reflect the original intention that it should apply to conductors identified either by number / letter or by color. Position of exception 2 to clarify when it is to apply. Previous position NFPA79 1997 16.1.3 did not reflect the original intention that it should apply to conductors identified by color.

<<The requirements from the existing 16.1.1. first sentence are covered in 14.2.1.1, and the second sentence is covered in 14.2.2.1 and 14.2.3.1.>>

14.2.2 Recommendation: Add new text clarifying conductor identification marking requirements
Substantiation: Although not specifically stated in the current NFPA79 the use of Arabic numbers and Roman letters is still the expected normal practice. The most direct reference to the exclusive use of Roman letters and Arabic numbers in NFPA 79 1997 Annex E Device and component designations.

14.2.2 Recommendation: Add new title, "Identification of the equipment grounding (protective) conductor". Move 16.1.2 to subsection 14.2.2 "Identification of the equipment grounding (protective) conductor". The subsection includes the material from 16.1.2 and some additional material Substantiation: Section 14.2 is divided into 4 subsections 1 General requirements, 2 Identification of the equipment grounding (protective) conductor, 3 Identification of the grounded circuit conductor, and 4 Identification by color for other conductors. Editorial addition to help organize the material and follow IEC 60298-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.


14.2.2.1 Recommendation: Retain NFPA 79 1997 Edition 16.1.2 and renumber as 14.2.2.1, and add a new 2nd sentence: “This color identification shall be strictly reserved for the equipment grounding (protective) conductor”. Add exception 1, which is exception 3 from NFPA 79 1997 Edition 16.1.3, it is added here to clarify that it is also directed to the equipment-grounding conductor. Move NFPA 79 1997 Edition 16.1.2 Exception 1 to 14.2.2.1 Exception 2. Move NFPA 79 1997 Edition 16.1.3 Exception 2 to 14.2.2.1 Exception 3. Move the note from NFPA 79 1997 16.1.2, as a note in 14.2.2.1.

“European standards require the use of the bicolor (GREEN-AND-YELLOW for this purpose”, has been corrected. The word "require" is not a correct statement. The note was correct only when color is the sole means of identification, additional information may be found in IEC 609204-1 1997 14.2.2.

Added a description of bicolor marking to the note.

<<The requirements from the existing NFPA 79 1997 Edition16.1.1, 1st sentence is covered in 14.2.1.1, and the second sentence is covered in 14.2.2.1 and 14.2.3.1.>>

14.2.2.2 Recommendation: Add new equipment grounding (protective) conductor is identified option text.
Substantiation: The new text adds a solution to the situation where the identification of the equipment grounding conductor is difficult, at least require that it be clearly identify at the ends or accessible position in a uniform way.


14.2.3.1 Recommendation: Locate NFPA 79 1997 Edition 16.1.3 requirements for a grounded circuit conductor, the 5th and 6th bulleted items, and the note following the 6th bullet here, editorially revise text and renumber. Substantiation: In 14.2.3.1 the identification of the grounded circuit conductor, though the requirement is clearer, it has not changed. Natural Gray will become just Gray in the next edition of the NEC.
The existing note was corrected, the color light blue is only required when color is the sole means of identification ref. IEC 60204-1. Editorial change to NFPA 79 1997 Edition 16.1.3, material location is following IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.2.3.2 Recommendation: Retain NFPA 79 1997 Edition 16.1.3, 6th bullet and 7th bullet, the 1st sentence of bullet 7 is revised and renamed. Substantiation: In 14.2.3.2 the identification of other grounded circuit conductors, though the requirement is clearer, it has not changed. Information for use of other than grounded conductors placed here for clarity, and revised for grammar. Editorial change to NFPA 79 1997 Edition 16.1.3, material location is following IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition

14.2.3.3 Recommendation: Add new color identification of grounded circuit bus bar text. Substantiation: Opens the possibility of using color to identify the grounded circuit conductor when bus bars are used.


14.2.4.1 Recommendation: Retain and revise NFPA 79 1997 Edition 16.1.3 4th bullet here that covers the identification by color for conductors that remain energized when the main disconnecting means is in the OFF position. Move existing NFPA 79 1997 Edition 16.1.3 Exception 1 to proposed 14.2.1.1 and 14.2.4.1 “General requirements” and “Identification of color for other conductors” of section 14.2 “Identification of conductors”. Move NFPA 79 1997 Edition 16.1.3 Exception 2 to 14.2.4.1 Exception 2. NFPA 79 1997 Edition 16.1.3 Exception 3 applied to ungrounded circuit conductors is covered in 14.2.4.2. Substantiation: Clarifies that the reserved colors yellow or orange are for circuits that remain energized when the main disconnect is in the off position. The note following the NFPA 79 1997 Edition 16.1.3 4th bullet, has been revised to allow for the use of either yellow or orange identification for this purpose. 14.2.4.1 Clarifies that the reserved colors yellow or orange are for circuits that remain energized when the main disconnect is in the off position. This is not a new requirement only expands to either yellow or orange are to be used for this purpose. The original choice of yellow over orange was the then availability of orange wire versus yellow. Orange is used in IEC built machines to warn of and outside voltage for control circuits in a cabinet that remain energized when the main disconnect is in the off position. Yellow is used in NEMA built machines to warn of a outside voltage for control circuits in a cabinet that remain energized when the main disconnect is in the off position. Either color would represent the same hazard, thus both colors are reserved for this use. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.2.4.2 Recommendation: The new text adds the requirement, that when color is used for identification, that it be consistent and reflects the current good practice. The exception adds the option to be able to re-identify color coding on multi conductor cables

Substantiation: Adds the requirement that when color is used for identification, it is to be consistent throughout, and to be able to re-identify by color coding conductors in multi conductor cables. The exception also requires the re-identification for multiconductor cables to be made at time of installation. The requirement is consistent with the identification / re-identification means in NFPA 79: 1999 2000 ”Use and Identification of Grounded conductors” – 6 “Means of Identifying Grounded Conductors” (e) “Grounded Conductors of Multiconductor Cables” Exception 1. Also 250 “Grounding” – 119 “Identification of Equipment Grounding conductors.” (b) “Multiconductor Cable.”

14.2.4.3 Recommendation: Move NFPA 79 1997 Edition 16.1.3 1st, 2nd and 3rd bulleted items and include copy of the exceptions to clarify where they do apply.

14.3.6
Recommendation: Add new text to clarify that the requirement of 14.3.5 for control wiring is not a requirement for power and instrument measuring circuits. Substantiation: Provides information for a practice not presently covered in this standard.

14.3.7
Recommendation: Add new text to include current practice of using AC receptacles, AC plugs, flexible cords, appliance couplers, power cord sets in panel wiring schemes. Substantiation: Provides information for a current acceptable practice not presently covered in this standard.

14.4

14.4.1
Recommendation: Add new title “General requirements”, and text. Substantiation: Provides information that, though not directly stated, is consistent with existing requirements presently in NFPA 79:1997 Edition. This subsection, “General requirements”, is used to consolidate information that applies to all the parts of the section 14.4 into one area for clarity. Section 14.4 is divided into 6 subsections 1 General requirements, 2 External raceways (ducts), 3 Connection to moving elements of the machine, 4 Interconnection of devices on the machine, 5 Attachment plug and receptacle (plug/socket) combinations, and 6 Dismantling for shipment. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.2

14.4.2.1

14.4.2.2

14.4.2.3

14.4.2.4
Recommendation: Replace NFPA 79 1997 Edition 16.3.3 with text that allows a broader selection of material identified for the application. Substantiation: New text includes the use of conduit or cable identified for use in the physical environment. This addition will help to consolidate similar requirements into one area. Editorial change to NFPA 79 1997 Edition material location is following IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.2.5
Recommendation: Replace NFPA 79 1997 Edition 16.3.4 with text that allows a broader selection of material identified for the application. Effectively includes the NFPA 79 1997 Edition 16.3.6 exception. Substantiation: Provides additional information. New text includes the use of conduit or cable identified for use in the physical environment. This addition will help to consolidate similar requirements into one area. NFPA 79 1997 Edition 16.3.4 was relocated to 14.4.2.5, the clarification and exception are covered by 14.5.1.1 which requires the use of raceway (duct) be identified for use in the physical environment. Note: Paragraph 14.5.10.6 address installation concerns from NFPA 79 1997 Edition 16.3.4 for the use of cords. Editorial change made to NFPA 79 1997 Edition material locations are following IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.3

14.4.3.1
Recommendation: Update NFPA 79 1997 Edition 16.3.5 with editorial changes to the text to include the exception and reference to the same conductor requirements in NFPA 79 1997 Edition that have been relocated in this new edition. Substantiation: NFPA 79 1997 Edition 16.3.5 requirements have been relocated to 14.4.3.1 and 14.4.3.2 and 14.5.10.6. Paragraph 14.5.1.1 addresses material completely in the reference to 13.7, the construction of conductors that are used for flexible and flexing service. The editorial addition is to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.3.2
Recommendation: Update NFPA 79 1997 Edition 16.3.5 with additional new text. Substantiation: NFPA 79 1997 Edition 16.3.5 material has been relocated to the proposed 14.4.3.1 and 14.4.3.2 and 14.5.10.6. Paragraph 14.4.3.2 and 14.5.10.6 address installation concerns. The editorial addition is to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.3.3
Recommendation: Add new text for installation practices and use of cables with flexible properties. Substantiation: Provides information not presently covered in this standard. Requirements were added to this subclause to specify protection for flexible cables against potential abuse. NFPA 79 1997 Edition 16.3.6 is relocated to the new proposed 14.4.3.10 with clarification as to how to accomplish the requirement in the new proposed 14.4.3.3 and 14.4.3.5. The NFPA 79 1997 Edition 16.3.6 exception is covered in the new proposed 14.4.2.5. Editorial additions are to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.
14.4.3.4 Recommendation: Add new text for cable sheath suitability.
Substantiation: Requirements were added to this subclause for the use of a type of cable sheath that is suitable for the environment.

14.4.3.5 Recommendation: Add new text for clarification.
Substantiation: NFPA 79 1997 Edition 16.3.6 is relocated to the new proposed 14.4.3.10 with clarification as to how to accomplish the requirement in the new proposed 14.4.3.3 and 14.4.3.5. The NFPA 79 1997 Edition 16.3.6 exception is covered in the new proposed 14.4.2.5. Editorial additions are to help organize the material and follow IEC 60204-I 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.3.6 Recommendation: Add new text reflecting current practice.
Substantiation: Provides information not presently in this standard.

14.4.3.7 Recommendation: Add new text reflecting current practice.
Substantiation: Provides information not presently in this standard.

14.4.3.8 Recommendation: Add new text reflecting current practice.
Substantiation: Provides information not presently in this standard.

Table XW
Recommendation: Add new Table XW referenced in 14.4.3.8.
Substantiation: Provides information not presently in this standard.

14.4.3.9 Recommendation: Add new text reflecting current practice.
Substantiation: Provides information not presently in this standard.

14.4.3.10
Recommendation: Relocate NFPA 79 1997 Edition 16.3.6 to 14.4.3.10
Substantiation: NFPA 79 1997 Edition 16.3.6 is relocated to the new proposed 14.4.3.10 with clarification as to how to accomplish the requirement in the new proposed 14.4.3.3 and 14.4.3.5. The NFPA 79 1997 Edition 16.3.6 exception is covered in the new proposed 14.4.2.5. Editorial additions are to help organize the material and follow IEC 60204-I 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.4 Recommendation: Add new title, “Interconnection of devices on the machine” and add new text to recommend that accessible test points be provided to assist in maintenance of these devices.
Substantiation: In many cases the new text represents current practice consistent with the requirements in NFPA 79 1997 Edition 12.2 and 12.6, it enhances the safety efficiency during maintenance of the machine, where practicable is to allow for these applications where this requirement cannot be met. Section 14.4.4 is divided into 6 subsections 1 General requirements, 2 External raceways (ducts), 3 Connection to moving elements of the machine, 4 Interconnection of devices on the machine, 5 Attachment plug and receptacle (plug/socket) combinations, and 6 Dismantling for shipment. Editorial addition to help organize the material and follow IEC 60204-I 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.4.5 Recommendation: Add new title, “Attachment plug and receptacle (plug/socket) combinations”.

14.4.5.1 Recommendation: NFPA 79 1997 Edition 16.3.9 is relocated to 14.4.5.1 with slight editorial revision [change “are permitted” to “shall be permitted”].
14.5.1 Recommendation: Move NFPA 79 1997 Edition 17.1 title, "General requirements", to 14.5.1 and renumber. This gives a place for the paragraphs and other material that apply to the entire section.

Substantiation: This subsection, "General requirements", is used to consolidate information that applies to all the parts of the section 14.5 into one area for clarity. Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.1.1 Recommendation: Add new text.

Substantiation: Provides information not in the present standard. The new text is consistent with NFPA 70-1999, Section 110-3(a).


Substantiation: Limits use of drain holes so not to compromise enclosure integrity, and the note is covered in Chapter 8 that contains the grounding information.

14.5.2 Recommendation: Add title "Percentage fills of raceways (ducts)", Move NFPA 79 1997 Edition 17.2 to 14.5.2 and renumber. Add Note from NFPA 70 1999 edition Chapter 9 Table 1 FPNo. 1, 2nd sentence. Substantiation: Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3 Recommendation: Add title, "Rigid conduit and fittings", to 14.5.3, revised and renumber.

Substantiation: This revision is to have this clause cover all conduit types not just metallic. This will help to consolidate information into one area. All non-flexible conduits added or moved under 14.5.3 with common requirements under 14.5.3.1 "General requirements". Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3.1 Recommendation: Add title, "General requirements" to consolidate common requirements for rigid conduit from existing NFPA79.

Substantiation: This addition will help to organize and consolidate common requirements. This (sub)subsection, "General requirements", is used to consolidate information that applies to all the parts of the subsection 14.5.3 into one area for clarity. Subsection 14.5.3 is divided into 3 sub-subsections 1 General requirements, 2 Metal type nonflexible conduit, and 3 Rigid non-metallic conduit (PVC Schedule 80). Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.
14.5.3.2

Recommendation: Add new title “Metal type non flexible conduit”. Substantiation: All metal type, non-flexible, conduit moved to 14.5.3.2 with common NFPA 79 1997 original text requirements to 14.5.3.2.1 “General requirements”. Sub-section 14.5.3.3 is divided into 3 sub-sub-sections 1 General requirements, 2 Metal type non-flexible conduit, and 3 Rigid non-metallic conduit (PVC Schedule 80). Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3.2.1

Recommendation: Add new title, “General requirements”. Substantiation: Sub-subsection 14.5.3.2.3 is divided into 4 (sub)sub-sections 1 General requirements, 2 Rigid metal conduit and fittings, 3 Intermediate metal conduit, and 4 Electrical metallic tubing. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition. This (sub)sub-section, “General requirements”, is used to consolidate information that applies to all the parts of the subsection 14.5.3.2 into one area for clarity

14.5.3.2.1.1


14.5.3.2.1.2

Recommendation: Move NFPA 79 1997 Edition: 17.3.4, 17.4 reference to 17.3.4, 17.5 reference to 17.3.5, here, and renumber. Substantiation: All metal type, non-flexible, conduit fitting and thread, requirements moved to 14.5.3.2.1.2 with common, original text, from NFPA 79 1997 used. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3.2.2

Recommendation: Move NFPA 79 1997 Edition 17.3 title, “Rigid metal conduit and fittings”. Move NFPA 79 1997 Edition 17.3.1 to here, move some text to a note, revise and renumber. Substantiation: This clause will help to consolidate Rigid metal conduit and fittings requirements into one area. The specifications for a particular type of rigid metal conduit are not needed and the requirement “identified for the conditions of service” is sufficient. The caution about dissimilar materials is moved to a note. The NFPA 79 1997 Edition 17.3.1 exception is continued and currently in wide spread use is not needed. This will help to consolidate information into one area. Sub-subsection 14.5.3.2 is divided into 4 (sub)sub-sections 1 General requirements, 2 Rigid metal conduit and fittings, 3 Intermediate metal conduit, and 4 Electrical metallic tubing. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3.2.3


14.5.3.2.4

Recommendation: Move NFPA 79 1997 Edition 17.5 title, “Electrical metallic tubing”, and definition text here, add a note and renumber. Substantiation: This will help consolidate Electrical metallic tubing information to one area. A note has been added concerning dissimilar metals. Sub-subsection 14.5.3.2 is divided into 4 (sub)sub-sections 1 General requirements, 2 Rigid metal conduit and fittings, 3 Intermediate metal conduit, and 4 Electrical metallic tubing. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3.3

Recommendation: Move NFPA 79 1997 Edition 17.6 title, “Rigid nonmetallic conduit (PVC Schedule 80)”, here, and renumber. Substantiation: Subsection 14.5.3.3 “Rigid non-metallic conduit (PVC Schedule 80) paragraph 14.5.3.3.1 through 14.5.3.3.4 consolidates details specific to rigid non-metallic conduit (PVC Schedule 80). Subsection 14.5.3.3 is divided into 3 sub-sub-sections 1 General requirements, 2 Metal type non-flexible conduit, and 3 Rigid non-metallic conduit (PVC Schedule 80). Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3.3.1


14.5.3.3.2

Recommendation: Locate NFPA 79 1997 Edition 17.6.3, original text and tabulated information here and renumber.<insert table heading: “Maximum Spacing”. Following paragraph 14.5.3.3.2 colons then follow with “In addition, conduit shall be securely fastened within 3 ft (914 mm) of each box, enclosure, or other conduit terminus.” Substantiation: Editorial for the location, and table heading will make the information easier to locate. Editorial change to NFPA 79 1997 Edition location following IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.3.3.3


14.5.3.3.4


14.5.4

Recommendation: Add title, "Flexible metal conduit and fittings". Move NFPA 79 1997 Edition 17.7, and 17.9 titles to 14.5.4, combine, revise and renumber. Substantiation: This will help to consolidate flexible metal conduit and fittings information into one area. Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.
14.5.4.1
Substantiation: This will help consolidate requirements in one area. Collected general requirements for Flexible metal conduits NFPA79 1997 Edition 17.9.6 and 17.7. This sub-subsection, “General requirements”, is used to consolidate information that applies to all the parts of the subsection 14.5.4 into one area for clarity. Subsection 14.5.4 is divided into 3 sub-subsections 1 General requirements, 2 Flexible metal conduit, and 3 Liquidtight flexible metal conduit. Editorial relocation to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

14.5.4.1.1
Recommendation: Move NFPA 79 1997 Edition 17.7.3 and 17.9.3 and exception here and renumber.

14.5.4.1.2
Recommendation: Add new maximum size text including note.
Substantiation: This helps to consolidate information into one area and to be consistent with NEC on the range of conduit sizes from NFPA 70-1999, 351-5 (b) and FPN

14.5.4.1.3
Recommendation: Move NFPA 79 1997 Edition 17.7.5 here, revise and renumber. Add “metal” and “liquidtight flexible metal conduit”.

14.5.4.1.4
Recommendation: Move NFPA 79 1997 Edition 17.7.2 and 17.9.2 here, revise and renumber. Expanded concept to include any flexible conduit. Add as a new 2nd sentence “Connectors shall be of the “union” type.”

14.5.4.2

14.5.4.3

14.5.5
Substantiation: Deleted “liquidtight” to be more inclusive. Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit and fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.
Substantiation: The requirement was added to clarify that the 90-degree cover requirement in NFPA 70-1999, Article 670-5 should apply to wireways.


Recommendation: Move NFPA 79 1997 Edition 17.11 title "Machine compartments and raceways", is relocated and raceway is changed to wireway and IEC nomenclature "(cable trunking systems)", is added to title 14.5.7. Existing NFPA79 1997 Edition 17.11 text is included with minor editorial revisions, re-number.
Substantiation: Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

Recommendation: Change NFPA 79 1997 Edition 17.12 title, "Junction and pull boxes", to "14.5.8 Connection boxes and other boxes"

Recommendation: Add new accessibility text.
Substantiation: This new text clarifies that the accessibility, required in existing NFPA 79 1997 11.3, still includes connection boxes


Substantiation: Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

Recommendation: Add new text.
Substantiation: Provides direction for termination to specific types of equipment. The requirements represent current good practice

Recommendation: Add new text.
Substantiation: Change represents current good practice

Recommendation: Add new text.
Substantiation: The prohibition of soldered or insulation piercing type termination’s for motors, and that the new text represent current "good practice".

Recommendation: Provide a title, "Cord", for this new subsection.
Substantiation: Because the construction of cord is different than that of cable its use is limited. 14.5.10 was added for application purposes. Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

Recommendation: Add new text and note.
Substantiation: Adds cord to machine wiring practice. Factory applied connectors molded onto cord are commonly utilized on the electrical equipment of industrial machinery. Such connectors are attached in a controlled environment where comprehensive quality assurance, test, and validation measures are applied.

Recommendation: Add new text.
Substantiation: Adds cords to machine wiring practice for utilization of cord for connection to the field I/O and similar. Length of a cord is restricted to 50 feet to limit exposure to physical damage.

Recommendation: Add new text.
Substantiation: Provides reference for application methodology.
14.5.10.4
Substantiation: The 1st sentence revision will allow cords to be used.

14.5.10.5
Recommendation: Locate NFPA 79 1997 Edition 16.3.4 text here, renumber and revise the 1st sentence to add cord to be used for this purpose.

14.5.10.6
Recommendation: Copy NFPA 79 1997 Edition 16.3.5 here and revise the 2nd sentence by changing “Flexible cable and conduit” to “Cords with conductors for flexing service”. And adding exception. Substantiation: More logical topic location and better covers the anticipated usage. NFPA 79 1997 Edition 16.3.5 has been relocated to the proposed 14.4.3.1 and 14.4.3.2 and 14.5.10.6. Paragraph 14.5.10.6 address installation concerns for the uses of cords.

14.5.11
Recommendation: Add title and text for cable tray to be a recognized support system for machines.
Substantiation: Wire and cable that is currently allowed to be supported by the machine frame and other means would not place any additional hazard if a standard cable tray support system was used for those same wire and cables on a machine. Section 14.5 is divided into 11 subsections: 1 General requirements, 2 Percentage fills of raceways (ducts), 3 Rigid conduit and fittings, 4 Flexible conduit and fittings, 5 Flexible non-metallic conduit an fittings, 6 Wireways (cable trunking systems), 7 Machine compartments and wireway (cable trunking systems), 8 Connection boxes and other boxes, 9 Motor connection boxes, 10 Cord, and 11 Cable trays. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

NFPA 79 1997 Edition 14.1.3 Exception

NFPA 79 1997 Edition 16.1.3 First Note
Substantiation: When color is used to identify conductors either yellow or orange conductors will be encountered with the same expectation of a remote disconnection point should be expected. In view if more harmonization the note is not relevant.

NFPA 79 1997 Edition 16.4.1 Exception 2
Substantiation: NFPA 79 1997 Edition 16.4.1 Exception 2, “Wire-wrapped connections” was not retained as the practice is limited in use, if at all, for industrial machine construction.

NFPA 79 1997 Edition 16.4.2
Substantiation: NFPA 79 1997 Edition 16.4.2 concerning solder connections is too prescriptive concerning solder connections, is unnecessary and prohibits other current and possible future methods and materials.

Substantiation: The necessary requirements for wiring between machines are included in the scope 1.1.4. The requirements in 16.5 were to describe the needed support system for the Scope 1.1.4 exception, however the support system requirements in the new 14.5 meets the original need for 16.5 thus 16.5 is not retained.

NFPA 79 1997 Edition 17.1.2 Note
Substantiation: Grounding issues are covered in the new proposed chapter 8.

NFPA 79 1997 Edition 17.3.1 Exception
Substantiation: The NFPA 79 1997 Edition 17.3.1 exception is for a practice not currently in wide spread use and is not needed.

NFPA 79 1997 Edition 17.10.2
Substantiation: Too proscriptive, necessary requirements covered in listing tests and 14.3.1.1.

Proposed NFPA 79: 20002 clauses not listed in this table are included as additions to NFPA 79: 2000

<table>
<thead>
<tr>
<th>Clause</th>
<th>Heading / description / notes</th>
<th>Chapter / Sections</th>
<th>Heading / description / notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1.1</td>
<td></td>
<td>14.4.3.2</td>
<td></td>
</tr>
<tr>
<td>14.1.2</td>
<td></td>
<td>14.4.3.3</td>
<td></td>
</tr>
<tr>
<td>14.1.3</td>
<td></td>
<td>14.4.3.7</td>
<td></td>
</tr>
<tr>
<td>14.1.4</td>
<td>Exception</td>
<td>14.4.3.2</td>
<td>In revised text</td>
</tr>
<tr>
<td>16</td>
<td>Wiring methods and practices</td>
<td>14.4.2.1</td>
<td>General requirements</td>
</tr>
<tr>
<td>16.1</td>
<td>General requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.1.1</td>
<td>Grounding conductor</td>
<td>14.4.2.1</td>
<td></td>
</tr>
<tr>
<td>16.1.2</td>
<td>Note</td>
<td>14.4.2.1</td>
<td></td>
</tr>
<tr>
<td>16.1.3</td>
<td>Exception 1</td>
<td>14.4.2.1</td>
<td></td>
</tr>
<tr>
<td>16.1.4</td>
<td>Exception 2</td>
<td>14.4.2.1</td>
<td></td>
</tr>
<tr>
<td>16.1.5</td>
<td>Ungrounded conductor (Black, Red and Blue)</td>
<td>14.4.2.3</td>
<td></td>
</tr>
<tr>
<td>16.1.6</td>
<td>Ungrounded conductor</td>
<td>14.4.2.1</td>
<td></td>
</tr>
<tr>
<td>16.1.7</td>
<td>Ungrounded conductor note</td>
<td>14.2.3</td>
<td>Identification of the grounded circuit conductor subsection</td>
</tr>
<tr>
<td>16.1.8</td>
<td>Grounded conductor</td>
<td>14.2.3</td>
<td></td>
</tr>
<tr>
<td>16.1.9</td>
<td>Grounded conductor note</td>
<td>14.2.3</td>
<td></td>
</tr>
<tr>
<td>16.1.10</td>
<td>Exception 1 Ungrounded conductor (Black, Red and Blue)</td>
<td>14.2.4.3</td>
<td>Exception 1 Ungrounded conductor (Black, Red and Blue)</td>
</tr>
<tr>
<td>16.1.11</td>
<td>Exception 2 Ungrounded conductor (Black, Red and Blue)</td>
<td>14.2.4.3</td>
<td>Exception 2 Ungrounded conductor (Black, Red and Blue)</td>
</tr>
<tr>
<td>16.1.12</td>
<td>Exception 3 Ungrounded conductor (Black, Red and Blue)</td>
<td>14.2.4.3</td>
<td>Exception 3 Ungrounded conductor (Black, Red and Blue)</td>
</tr>
<tr>
<td>16.1.13</td>
<td>Exception 4 Ungrounded conductor (Black, Red and Blue)</td>
<td>14.2.4.3</td>
<td></td>
</tr>
<tr>
<td>16.1.14</td>
<td>General requirements</td>
<td>14.1.1.10</td>
<td></td>
</tr>
<tr>
<td>16.1.15</td>
<td>Exception</td>
<td>14.1.1.1</td>
<td>Exception 1</td>
</tr>
<tr>
<td>16.1.16</td>
<td>First sentence</td>
<td>14.1.1.11</td>
<td></td>
</tr>
<tr>
<td>16.1.17</td>
<td>Second sentence</td>
<td>14.1.1.12</td>
<td></td>
</tr>
<tr>
<td>16.1.18</td>
<td>Exception</td>
<td>14.1.1.3</td>
<td>In revised text</td>
</tr>
<tr>
<td>16.1.19</td>
<td>Panel wiring</td>
<td>14.3</td>
<td>Wiring inside enclosure</td>
</tr>
<tr>
<td>16.2</td>
<td>Panel wiring</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>16.2.1</td>
<td>Machine wiring</td>
<td>14.4</td>
<td>Wiring outside enclosures</td>
</tr>
<tr>
<td>16.2.2</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.2.3</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.1</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.2</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.3</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.4</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.5</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.6</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.7</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.8</td>
<td>Machine wiring</td>
<td>14.4</td>
<td>Constructions of different circuits</td>
</tr>
<tr>
<td>16.3.9</td>
<td>Machine wiring</td>
<td>14.4</td>
<td>Dismantling for shipment</td>
</tr>
<tr>
<td>16.3.10</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.11</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.3.12</td>
<td>Machine wiring</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>16.4</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td>Connections and routing</td>
</tr>
<tr>
<td>16.4.1</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>16.4.2</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>16.4.3</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>16.4.4</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>16.4.5</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>16.4.6</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>16.5</td>
<td>Wire connectors and connections</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Raceways, junction boxes, and pull boxes</td>
<td>14.5</td>
<td>Raceways (ducts), support systems (cable supports), connection boxes and other boxes</td>
</tr>
<tr>
<td>17.1</td>
<td>General requirements</td>
<td>14.5.1</td>
<td>General requirements</td>
</tr>
</tbody>
</table>
Clauses in Substantiation are in numerical order, Last section 14.5.11 and plus proposed deletions (continued)

<table>
<thead>
<tr>
<th>Clause 17.1.1</th>
<th>Clause 14.5.1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.1.2</td>
<td>14.5.1.3</td>
</tr>
<tr>
<td>17.1.2 Note</td>
<td>Not carried forward</td>
</tr>
<tr>
<td>17.2</td>
<td>14.5.2 Percentage fills of raceways (ducts)</td>
</tr>
<tr>
<td>17.3</td>
<td>14.5.3 Metal type non flexible conduit</td>
</tr>
<tr>
<td>17.3.1</td>
<td>14.5.3.2.2 Rigid metal conduit and fittings</td>
</tr>
<tr>
<td>17.3.1 Exception</td>
<td>Not carried forward</td>
</tr>
<tr>
<td>17.3.2</td>
<td>14.5.3.1.1</td>
</tr>
<tr>
<td>17.3.3</td>
<td>14.5.3.2.1.1</td>
</tr>
<tr>
<td>17.3.4</td>
<td>14.5.3.2.1.2</td>
</tr>
<tr>
<td>17.3.5</td>
<td>14.5.3.2.1.2</td>
</tr>
<tr>
<td>17.3.6</td>
<td>14.5.3.1.3</td>
</tr>
<tr>
<td>17.3.6 Exception</td>
<td>In revised text</td>
</tr>
<tr>
<td>17.3.7</td>
<td>14.5.3.1.4</td>
</tr>
<tr>
<td>17.3.7 Table 13</td>
<td>Table XX</td>
</tr>
<tr>
<td>17.3.8</td>
<td>14.5.3.1.5</td>
</tr>
<tr>
<td>17.4</td>
<td>Intermediate metal conduit</td>
</tr>
<tr>
<td>17.4 Ref. To 17.5.2</td>
<td>14.5.3.2.3 Intermediate metal conduit</td>
</tr>
<tr>
<td>17.4 Ref. To 17.5.3</td>
<td>14.5.3.2.1.1</td>
</tr>
<tr>
<td>17.4 Ref. To 17.5.4</td>
<td>14.5.3.2.1.2</td>
</tr>
<tr>
<td>17.5</td>
<td>Electrical metallic tubing</td>
</tr>
<tr>
<td>17.5 Ref. To 17.5.2</td>
<td>14.5.3.2.4 Electrical metallic tubing</td>
</tr>
<tr>
<td>17.5 Ref. To 17.5.3</td>
<td>14.5.3.1.1</td>
</tr>
<tr>
<td>17.5 Ref. To 17.5.4</td>
<td>14.5.3.2.1.1</td>
</tr>
<tr>
<td>17.6 Schedule 80 rigid nonmetallic conduit</td>
<td>14.5.3.3 Rigid non-metallic conduit (PVC Schedule 80)</td>
</tr>
<tr>
<td>17.6.1</td>
<td>14.5.3.3.1</td>
</tr>
<tr>
<td>17.6.2</td>
<td>14.5.3.3.1</td>
</tr>
<tr>
<td>17.6.3</td>
<td>14.5.3.3.2</td>
</tr>
<tr>
<td>17.6.4</td>
<td>14.5.3.3.3</td>
</tr>
<tr>
<td>17.6.5</td>
<td>14.5.3.1.3</td>
</tr>
<tr>
<td>17.6.6</td>
<td>14.5.3.1.4</td>
</tr>
<tr>
<td>17.6.7</td>
<td>14.5.3.1.5</td>
</tr>
<tr>
<td>17.6.8</td>
<td>14.5.3.3.4</td>
</tr>
<tr>
<td>17.7</td>
<td>Liquidtight flexible metal conduit and fittings</td>
</tr>
<tr>
<td>17.7.1</td>
<td>14.5.4.3 Liquidtight flexible metal conduit</td>
</tr>
<tr>
<td>17.7.2</td>
<td>14.5.4.1.4</td>
</tr>
<tr>
<td>17.7.3</td>
<td>14.5.4.1.1</td>
</tr>
<tr>
<td>17.7.4</td>
<td>14.5.4.3</td>
</tr>
<tr>
<td>17.7.5</td>
<td>14.5.4.1.3</td>
</tr>
<tr>
<td>17.8</td>
<td>Liquidtight flexible nonmetallic conduit and fittings</td>
</tr>
<tr>
<td>17.8.1</td>
<td>14.5.5.1</td>
</tr>
<tr>
<td>17.8.2</td>
<td>14.5.5.2</td>
</tr>
<tr>
<td>17.8.3</td>
<td>14.5.5.3</td>
</tr>
<tr>
<td>17.8.4</td>
<td>14.5.5.6</td>
</tr>
<tr>
<td>17.8.5</td>
<td>14.5.5.4</td>
</tr>
<tr>
<td>17.8.6</td>
<td>14.5.5.7</td>
</tr>
<tr>
<td>17.9 Flexible metal (non-liquidtight) conduit and fittings</td>
<td>14.5.4.2 Flexible metal conduit</td>
</tr>
<tr>
<td>17.9.1</td>
<td>14.5.4.2</td>
</tr>
<tr>
<td>17.9.2</td>
<td>14.5.4.1.4</td>
</tr>
<tr>
<td>17.9.3</td>
<td>14.5.4.1.1</td>
</tr>
<tr>
<td>17.9.3 Exception</td>
<td>Exception</td>
</tr>
<tr>
<td>17.10 Wireways</td>
<td>14.5.6 Wireways (cable trunking systems)</td>
</tr>
<tr>
<td>17.10.1</td>
<td>14.5.6.1</td>
</tr>
<tr>
<td>17.10.2</td>
<td>Not carried forward</td>
</tr>
<tr>
<td>17.10.3</td>
<td>14.5.6.2</td>
</tr>
<tr>
<td>17.10.4</td>
<td>14.5.6.3</td>
</tr>
<tr>
<td>17.10.5</td>
<td>14.5.6.4 And 14.5.6.5</td>
</tr>
<tr>
<td>17.11 Machine compartments and raceways</td>
<td>14.5.7 Machine compartments and wireway (cable trunking system subsection</td>
</tr>
<tr>
<td>17.12 Junction and pull boxes</td>
<td>14.5.8 Connection boxes and other boxes subsection</td>
</tr>
<tr>
<td>17.13 Motor terminal boxes</td>
<td>14.5.9 Motor connection boxes subsection</td>
</tr>
</tbody>
</table>
14 Wiring practices

14.1 Connections and routing

14.1.1 General requirements
14.1.2 Conductor and cable runs
14.1.3 Conductors of different circuits
14.1.4 Cable runs

14.2 Identification of conductors

14.2.1 General requirements
14.2.2 Identification of the equipment grounding conductor (protective conductor)
14.2.3 Identification of the grounded circuit conductor
14.2.4 Identification by color for other conductors

14.3 Wiring inside enclosures

14.4 Wiring outside enclosures

14.4.1 General requirements
14.4.2 External raceways (ducts)
14.4.3 Connection to moving elements of the machine
14.4.4 Interconnection of devices on the machine
14.4.5 Attachment plug and receptacle (plug/socket) combinations
14.4.6 Dismantling for shipment

14.5 Raceways (ducts) support systems (cable supports), connection boxes and other boxes

14.5.1 General requirements
14.5.2 Percentage fills of raceways
14.5.3 Rigid conduit and fittings

14.5.3.1 General requirements
14.5.3.2 Metal type nonflexible conduit requirements
14.5.3.2.1 General
14.5.3.2.2 Rigid metal conduit and fittings
14.5.3.2.3 Intermediate
14.5.3.2.4 Electrical metallic tubing
14.5.3.3 Rigid non metallic conduit (PVC Schedule 80)
14.5.4 Flexible metal conduit an fittings

14.5.4.1 General requirements
14.5.4.2 Flexible metal conduit
14.5.4.3 Liquidtight flexible metal conduit

14.5.5 Flexible non-metallic conduit and fittings
14.5.6 Wireways (cable trunking systems)
14.5.7 Machine compartments and wireway (cable trunking system)
14.5.8 Connection boxes and other boxes
14.5.9 Motor connection boxes
14.5.10 Cord

COMMITTEE ACTION: Accept in Principle.

14 Wiring practices
14.1 Connections and routing
14.1.1 General requirements
14.1.1.1 All connections shall be secured against accidental loosening and shall ensure a thoroughly good connection.

14.1.1.2 The means of connection shall be identified for the cross-sectional areas and type of the conductors being terminated.
14.1.1.3 The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one equipment grounding or one bonding conductor (protective conductor) shall be connected to one terminal connecting point.

Terminals for more than one conductor shall be so identified.

14.1.1.4 A power distribution block designed for multiple tap conductors (e.g., single or multiple conductors “in” and multiple conductors “out”) shall be permitted for additional tap connections and circuit branching.
14.1.1.5 Soldered connections shall only be permitted where terminals are provided which are identified for soldering.
14.1.1.6 Terminals on terminal blocks shall be plainly identified to correspond with markings on the diagrams.
14.1.1.7 The installation of flexible conduits and cables shall be such that liquids shall drain away from the fittings. Where practicable, raceway connections shall enter the sides or bottom of an enclosure or box.
14.1.1.8 Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals that are not equipped with this facility. Solder shall not be used for that purpose.
14.1.1.9 Shielded conductors shall be terminated so as to prevent fraying of strands and to permit easy disconnection.
14.1.1.10 Identification tags shall be readable, permanent, and identified for use in the physical environment.

NOTE: A single tag bearing the complete identification is preferred.

14.1.1.11 Terminal blocks shall be mounted and wired so that the internal and external wiring does not cross over the terminals.

Note: For additional information on terminal blocks, refer to NFPA 609-947-7-1 “Low-voltage switchgear and control gear Part 7: Ancillary equipment Section one Terminal blocks for copper conductors”).

14.1.2 Conductor and cable runs
14.1.2.1 Conduits and cables shall be run from terminal to terminal without splices or joints.

Exception No. 1: Splices shall be permitted to leads attached to electrical equipment, such as motors and solenoids; such splices shall be insulated with oil-resistant electrical tape or insulation equivalent to that of the conductors and installed in a suitable enclosure.

Exception No. 2: Where it is impracticable to provide terminals in a junction box (e.g. on mobile machines, on machines having long flexible cables) the use of splices or joints shall be permitted.

14.1.2.2 Factory applied connectors molded onto cables shall be considered as splices or joints. Such connectors shall not be considered as splices or joints.
14.1.2.3 Where it is necessary to connect and disconnect cables and cable assemblies, an additional length shall be provided for that purpose.
14.1.2.4 The terminations of cables shall be supported to prevent mechanical stresses at the termination of the conductors.
14.1.3 Conductors of different circuits shall be permitted to be laid side by side, and occupy the same raceway (duct) e.g. wireway (cable trunking), or be in the same multi-conductor cable assembly provided that the arrangement does not impair the functioning of the respective circuit. Functionally associated circuit conductors including power, control, remote I/O, signaling, and communication cables shall be permitted in the same raceway or cable assembly regardless of voltage, provided all are insulated for the maximum voltage of any circuit within the raceway or cable assembly. Where those circuits operate at different voltages, the conductors shall be separated by barriers or shall be insulated for the highest voltage to which any conductor within the same raceway (duct) or cable assembly is subjected.

Exception: Different voltage insulation levels or conductor properties shall be permitted in the same cable assembly, provided the cable assembly has been designed and tested to the identified application.

14.1.4.1 Cables run exposed along the structure of the equipment or system, or in the chases of the machinery shall be permitted.

Exposed cables shall be installed to closely follow the surface and structural members of the machinery.
14.1.4.2 Cables shall be supported by the equipment or system structure as follows:

(1) In such a manner that the cable will not be damaged by normal equipment use
(2) Every 12 inches in a non-vertical run
Exception: The supporting distance may be increased up to 36 inches
where the structure of the machine or system makes support impractical
every 12 inches.
(3) Every 36 inches in a vertical run
Exception: Supporting distance may be increased to 96 inches, where the
structure of the machine or system makes support impractical every 36
inches.
(4) When suspended in air spanning a distance up to 18 inches
Exception: Span distance may be increased up to 36 inches, where the
structure of the machine or system makes support impractical every 18
inches.
14.1.4.3 Cables shall not be supported by machinery guard work
likely to be removed for maintenance access.
14.1.4.4 Multiple cables can be supported and fastened together in a
bundle provided the method of support and fastening is sufficient
to support the mechanical weight and strain of the bundle.
14.1.4.5 Cables shall be fastened where supported.
Exception No. 1: Where horizontal runs are inherently supported by the
machine or system structure, or by a floor or deck, fastening is not
required.
Exception No. 2: Where run at not more than a 45 degree angle from
horizontal, fastening is not required.
14.1.4.6 Cables shall be fastened with cable ties supported by any of
the following methods:
(1) Screw-on cable tie mounts
(2) Hammer-on cable tie mounting clips
(3) Around the machine or system structural members
(4) Through holes in the machine or system structural members
(5) Cable mounting clamps
(6) Other methods identified as acceptable for the purpose
14.1.4.7 The free ends of cable ties shall be cut flush after final
adjustment and fastening. Cable ties of the reusable or releasable
type shall not be permitted for use as a permanent fastening
method.
14.1.4.8 Cables shall be protected from physical damage where follows:
(1) By alternative routing
(2) With additional guarding or railings
(3) When supported by flooring or decking, with walk over or
drive over cable protective devices
(4) By installation in a wire way
(5) By installation in a floor or deck covering trapezoidal
walk over raceway specifically designed for cable protection
14.1.4.9 Bends in cables shall be made so as not to cause undue
straining. The radius of the curve of the inner edge of any bend shall
not be less than five times the diameter of the cable.
14.1.4.10 Where a cable is used in a length longer than optimally
required, the excess cable shall be coiled in loops at or near the
load end. The coil shall be fastened to itself and to the machinery
structure.
Exception: When an excess cable is associated with a horizontal cable run
that is inherently and fully supported, the coil is not required to be
fastened to the equipment or system structure.
14.2 Identification of conductors
14.2.1 General requirements
14.2.1.1 Conductors shall be identified at each termination by
number, letter, color (either solid or with one or more stripes), or
a combination thereof and shall correspond with the technical
documentation.
Exception 1: Internal wiring on individual devices purchased completely
wired.
Exception 2: Where the insulation used is not available in the colors
required (e.g., high temperature insulation, and chemically resistant
insulation).
Exception 3: Where multiconductor cable is used and other means of
permanent identification is provided.
14.2.1.2 When numbers are used, they shall be Arabic; letters shall
be Roman (either upper or lower case).
14.2.2 Identification of the equipment grounding (protective)
conductor
14.2.2.1 The color GREEN (with or without one or more YELLOW
stripes) shall be used to identify the equipment-grounding
conductor when insulated or covered. This color identification
shall be strictly reserved for the equipment grounding (protective)
conductor.
Exception No. 1: In multiconductor cable-connected assemblies where
equipment grounding is not required, the solid color GREEN shall be
permitted for other equipment grounding.
Exception No. 2: It shall be permitted to use conductors of other colors
provided the insulation or cover is appropriately identified at all points of
access.
14.2.2.2 Where the equipment grounding (protective) conductor is
identified by its shape, position, or construction (e.g. a braided
conductor), or where the insulated conductor is not readily
distinguishable, color coding throughout its length is not necessary.
But the ends or accessible positions shall be clearly identified by the
1999 NEC figure 250-120 grounding symbol, (IEC60364-symbols
number-5019), or by the color GREEN (with or without one or
more YELLOW stripes) or the bicolor combination GREEN-AND-
YELLOW.
14.2.3 Identification of the grounded circuit conductor
14.2.3.1 Where an AC circuit includes a grounded conductor, this
conductor shall be WHITE, GRAY, or three continuous WHITE
stripes on other than GREEN, BLUE, ORANGE, YELLOW
insulation along its entire length.
NOTE: IEC 60060-4-1 requires the use of the color LIGHT BLUE for the
neutral conductor where color is the sole means of identification.
14.2.3.2 The use of other colors for the following applications shall be
as follows:
(1) WHITE WITH BLUE STRIPE – grounded (current carrying) DC circuit conductor
(2) WHITE WITH ORANGE STRIPE OR WHITE WITH
YELLOW STRIPE – grounded (current carrying) AC circuit
conductor which remains energized when the main disconnecting
means is in the off position. The color choice of the stripe shall be
consistent with the ungrounded conductor of the excepted circuit.
14.2.3.3 Where identification by color is used, bus bars used as
grounded conductors shall be either colored by a stripe, 15 mm
(0.6 inch) to 100 mm (3.9 inch) wide in each compartment or unit
or at each accessible position, or colored throughout their length.
14.2.4 Identification by color for other conductors
14.2.4.1 Ungrounded circuit conductors that remain energized
when the main disconnecting means is in the OFF position shall be
either YELLOW or ORANGE (see 5.3.5 “Excepted circuits”).
These color identifications shall be strictly reserved for this
application only.
Exception 1: Internal wiring on individual devices purchased completely
wired.
Exception 2: Where the insulation used is not available in the colors
required (e.g., high temperature insulation, and chemically resistant
insulation).
14.2.4.2 Where color is used for identification, the color shall be
used throughout the length of the conductor either by the color of
the insulation or by color markers.
Exception: Multiconductor cables shall be permitted to be permanently re-
identified at the time of installations.
14.2.4.3 The use of other colors for the purpose of identification
shall be as follows:
(1) BLACK: Ungrounded line, load, and control conductors
at line voltage.
(2) RED: Ungrounded ac control conductors, at less than
line voltage.
(3) BLUE: Ungrounded dc control conductors.
Exception 1: Internal wiring on individual devices purchased completely
wired.
Exception 2: Where the insulation used is not available in the colors
required (e.g., high temperature insulation, and chemically resistant
insulation).
Exception 3: Where multiconductor cable is used and other means of
permanent identification is provided.
14.3 Wiring inside enclosures
14.3.1 Panel conductors shall be supported where necessary to
keep them in place. Non-metallic ducts shall be permitted only
when they are made with a flame-retardant insulating material.
Note: For additional information on Flame retardant materials,
refer to IEC 60332-1 “ Tests on electric cables under fire conditions
Part 1: Test on a single vertical insulated wire or cable”.
14.3.2 Electrical equipment mounted inside enclosures shall be
installed in such a way to permit access to the wiring.
14.3.3 Connections to devices mounted on doors or to other
movable parts shall be made using flexible conductors in
accordance with 13.7. “Conductors and cables used for flexing
applications to allow for the movement of the part. The conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection.

14.3.4 Conductors that do not run in ducts shall be supported.

14.3.5 Multiple-device control panels shall be equipped with terminal blocks or with attachment plugs and receptacles for all outgoing control conductors.

14.3.6 The direct connection of Power cables and cables of measuring circuits, to the terminals of the devices for which the connections were intended shall be permitted, except for control circuits.

14.3.7 AC receptacles, AC plugs, flexible cords, appliance couplers, power cord sets, etc., shall be permitted inside enclosures for internal wiring and connections between assemblies with AC power where used in accordance with their listing.

14.4 Wiring outside enclosures

14.4.1 General requirements

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced.

14.4.2 External raceways (ducts)

14.4.2.1 All conductors of the same AC circuit routed to the same location shall be contained in the same raceway (duct).

14.4.2.2 Conductors external to the electrical equipment enclosure(s) shall be enclosed in raceway (duct) described in 14.5. Exception: Cables and cable connectors need not be enclosed in a raceway where they are otherwise protected and supported.

14.4.2.3 Fittings used with raceways (ducts) or multiconductor cable shall be identified for use in the physical environment.

14.4.2.4 Flexible conduit or multiconductor cable with flexible properties shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of the pendant stations shall be supported by means other than the flexible conduit or the multiconductor cable with flexible properties, except where the conduit or cable is specifically designed for that purpose.

14.4.2.5 Flexible conduit or multiconductor cable with flexible properties shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to stationary motors, to position switches, and to other externally mounted devices. Where pre-wired devices (e.g., position switches, proximity switches) are supplied, the integral cable need not be enclosed in a raceway (duct).

14.4.3 Connection to moving elements of the machine

14.4.3.1 Connections to moving parts shall be made using conductors in accordance with 13.7. Flexible cable and conduit shall have vertical connections and shall be installed to avoid excessive flexing and straining. Horizontal connections shall be permitted where the flexible cable or conduit is adequately supported. Cable with flexible properties and flexible conduit shall be so installed as to prevent excessive flexing and straining, particularly at the fittings.

14.4.3.2 Cables with flexible properties subject to movement shall be supported in such a way that there is neither mechanical strain on the connection points nor any sharp flexing. When this is achieved by the use of a loop, it shall provide for a bending radius of 6 to 8 times the diameter of the cable.

14.4.3.3 Cable with flexible properties of machines shall be so installed or protected as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:

1. Being run over by the machine itself
2. Being run over by vehicles or other machines
3. Coming into contact with the machine structure during movements
4. Running in and out on cable baskets, or on or off cable drums
5. Acceleration forces and wind forces on festoon systems or suspended cables
6. Excessive rubbing by cable collector
7. Exposure to an excessive radiated heat source

14.4.3.4 The cable sheath shall be resistant to the wear from movement and the effects of atmospheric contaminants (e.g., oil, water, coolants, and dust).

14.4.3.5 Where cables subject to movement are close to moving parts, precautions shall be taken to maintain a space of at least 25.4-mm (1-inch) between the moving parts and the cables. Where that distances is not practicable, fixed barriers shall be provided between the cables and the moving parts.

14.4.3.6 The cable handling system shall be so designed that lateral cable angles do not exceed 5 degrees, avoiding torsion in the cable when:
1. Being wound on and off cable-drums and
2. Approaching and leaving cable guidance devices

14.4.3.7 Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

14.4.3.8 Devices serving to guide and carry a cable with flexible properties, shall be so designed that the inner bending radius is not less than the values given in Table XW, unless the smaller bending radius is agreed to by the cable manufacturer, taking into account the permissible tension and the expected fatigue life.

Table XW – Minimum permitted bending radii for the forced guiding of flexible cables

<table>
<thead>
<tr>
<th>Application</th>
<th>Cable diameter or thickness of flat cable (d) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d ≤ 8</td>
</tr>
<tr>
<td>Cable drums</td>
<td>6 d</td>
</tr>
<tr>
<td>Guide rollers</td>
<td>6 d</td>
</tr>
<tr>
<td>Festoon systems</td>
<td>6 d</td>
</tr>
<tr>
<td>All others</td>
<td>6 d</td>
</tr>
</tbody>
</table>

Table XW note: 8mm = 0.315-inch, 20mm = 0.787-inch

14.4.3.9 The straight section between two bends, in an S-shaped length, and a bend into another plane shall be at least 20 times the diameter of the cable.

14.4.3.10 Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit under all conditions of operation. Flexible metallic conduit shall not be used for rapid movements except when specifically designed for that purpose.

14.4.4 Interconnection of devices on the machine

Where practicable, machine-mounted switching devices (e.g., position sensors, push buttons) are connected in series or in parallel, the connection between those devices shall be made through terminals forming intermediate test points. Such terminals shall be conveniently placed, protected from the environment, and shown on the relevant diagrams.

14.4.5 Attachment plug and receptacle (plug/socket) combinations

14.4.5.1 Where equipment is removable, connections to it through a polarized attachment plug and receptacle (plug/socket) combination shall be permitted. The male plug shall be connected to the live circuit.

14.4.5.2 Attachment plug and receptacle (plug/socket) combinations shall be listed for the intended use and shall be of the locking type where rated greater than 20 amperes. Where used on circuits of more than 300 volts to ground or 300 volts phase-to-phase, they shall be skirted and constructed to contain any arc generated when a connection is made or broken.

14.4.5.3 Attachment plug and receptacle (plug/socket) combinations shall be so designed that: a protective bonding (equipment grounding) circuit connection is made before any live connections are made; and the protective bonding (equipment grounding) circuit connection is not disconnected until all live connections in the plug are disconnected.

14.4.5.4 Attachment plugs and receptacles (plug and socket) combinations used for carrying motor loads shall meet the conditions of 5.3.3 if the circuit is likely to be opened under load.

14.4.5.5 Where more than one attachment plug and receptacle (plug/socket) combination is used at the same location, they shall be mechanically coded to prevent incorrect insertion or be clearly identified.

14.4.5.6 Attachment Plug/socket combinations that are used for industrial power purposes or of a type used for domestic applications shall not be used for control circuits.

14.4.5.7 Means shall be provided to cover externally mounted receptacles (socket) when the plugs are removed.

14.4.6 Dismantling for shipment. Where it is necessary that wiring be disconnected for shipment and where practicable, terminals or attachment plug and receptacle (plug/socket) combinations shall be provided at the sectional points. Such terminals shall be suitably enclosed and attachment plug and receptacle (plug/socket) combinations shall be protected from the physical environment during transportation and storage. Raceway and enclosure openings shall be sealed prior to shipment.

14.5 Raceways (ducts), support systems (cable supports), and connection boxes and other boxes

14.5.1 General requirements

14.5.1.1 Raceways (ducts) shall be identified for the environment.

14.5.1.2 All sharp-edges, flash, burrs, rough-surfaces, or threads on the connection boxes and other boxes openings shall be sealed prior to shipment.
14.5.1.3 Drain holes shall not be permitted in raceways (ducts), junction boxes, and pull boxes where the holes would compromise the intended enclosure integrity. Drain holes of 6.4 mm (1/4 inch) diameter shall be permitted in wireways (cable trunking systems), connection boxes, and other boxes used for wiring purposes that are subject to accumulations of oil or moisture.

14.5.2 Percentage fills of raceways (ducts). The combined cross-sectional area of all conductors and cables shall not exceed 50 percent of the interior cross-sectional area of the raceway (duct). The fill provisions shall be based on the actual dimensions of the conductors or cables used.

Note: It should be recognized that, for certain conditions, a larger size raceway or a lesser raceway fill should be considered.

14.5.3 Rigid conduit and fittings

14.5.3.1 General requirements

14.5.3.1.1 The minimum electrical trade size shall be 1/2 inch.

14.5.3.1.2 The maximum electrical trade size shall be 6 inch.

Note: Metric trade numerical designations for rigid metal conduit are the same as those found in Extra-heavy Duty Rigid Steel Conduits for Electrical Installations, IEC 981-1989; namely: \( _1 = 16, _2 = 21, _3 = 27, _4 = 35, _5 = 41, _6 = 53, _7 = 63, _8 = 78, _9 = 91, 4 = 105, 5 = 129, \) and \( 6 = 155. \)

14.5.3.1.3 Where conduit enters a box or enclosure, a bushing or fitting providing a smoothly rounded insulating surface shall be installed to protect the conductors from abrasion, unless the design of the box or enclosure is such that it provides the same protection. Where conduit bushings are constructed wholly of insulating material, a locknut shall be provided both inside and outside the enclosure to which the conduit is attached.

Exception: Where threaded hubs or bosses that are an integral part of an enclosure provide a smoothly rounded or flared entry for conductors.

14.5.3.1.4 Conduit bends shall be made in such a manner that the conduit shall not be damaged and the internal diameter of the conduit shall not be effectively reduced. The radius of the curve of any field bend shall be not less than shown in Table XX.

**Table XX: Minimum Radius of Conduit Bends**

<table>
<thead>
<tr>
<th>Size of Conduit</th>
<th>Radius of Bend Done by Hand (in.)</th>
<th>Radius of Bend Done by Machine (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3/4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>4.7</td>
</tr>
<tr>
<td>11/4</td>
<td>8</td>
<td>7.4</td>
</tr>
<tr>
<td>11/2</td>
<td>10</td>
<td>8.1/4</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>9.1/2</td>
</tr>
<tr>
<td>21/2</td>
<td>15</td>
<td>10/1/2</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>11/2</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>30</td>
</tr>
</tbody>
</table>

Table XX: SI units: (Radius) \( 25\text{mm} = 1\text{ in.} \)

Note: 1. For field bends done by hand, the radius is measured to the centerline of the conduit.

**14.5.3.1.5** A run of conduit shall contain not more than four-quarter bends or a combination of bends totaling 360 degrees, between pull points.

14.5.3.2 Metal type nonflexible conduit

14.5.3.2.1 General requirements

14.5.3.2.1.1 Conduits shall be securely held in place and supported at each end.

14.5.3.2.1.2 Fittings shall be compatible with the conduit and identified for the application. Fittings and conduits shall be threaded using an electrical conduit die unless structural difficulties prevent assembly. Running threads shall not be used on conduit for connection at couplings. Metallic tubing shall not be threaded. Where threadless fittings are used, the conduit shall be securely fastened to the equipment.

14.5.3.2.2 Rigid metal conduit and fittings. Rigid metal conduit and fittings shall be of galvanized steel or of a corrosion-resistant material identified for the conditions of service.

Note: The use of dissimilar metals in contact that can cause galvanic action should be avoided.

14.5.3.2.3 Intermediate nonmetallic conduit. Intermediate metal conduit shall be a steel raceway of circular cross section with integral or associated couplings, approved for the installation of electrical conductors and used with approved fittings to provide electrical continuity.

Note: The use of dissimilar metals in contact that can cause galvanic action should be avoided.

14.5.3.2.4 Electrical metallic tubing. Electrical metallic (steel) tubing shall be a metallic tubing of circular cross section approved for the installation of electrical conductors when joined together with approved fittings. The maximum size of tubing shall be the 4-in. electrical trade size.

Note: The use of dissimilar metals in contact that can cause galvanic action should be avoided.

14.5.3.3 Rigid non-metallic conduit (PVC Schedule 80)

14.5.3.3.1 Rigid non-metallic conduit (PVC schedule 80) shall be of suitable nonmetallic material approved for the installation of electrical conductors and identified for use where subject to physical damage.

Note: For additional information about rigid non-metallic conduit, refer to UL 651.

14.5.3.3.2 Conduit shall be securely held in place and supported as follows:

**Maximum Spacing Between Supports (ft)**

<table>
<thead>
<tr>
<th>Conduit Size (in)</th>
<th>Maximum Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>1</td>
</tr>
<tr>
<td>1/2</td>
<td>1/4 - 2</td>
</tr>
<tr>
<td>2/3</td>
<td>2/7 - 3</td>
</tr>
<tr>
<td>2/3</td>
<td>2/5 - 4</td>
</tr>
<tr>
<td>3/4</td>
<td>3/4</td>
</tr>
<tr>
<td>3/4</td>
<td>3/5</td>
</tr>
<tr>
<td>3/4</td>
<td>3/7</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: For SI units, 1 \( = 0.3048\text{ m} \) (supports).

In addition, conduit shall be securely fastened within 3 ft (914 mm) of each box, enclosure, or other conduit termination.

14.5.3.3.3 Expansion fittings shall be installed to compensate for thermal expansion and contraction. (NFPA 70-1999 Table 347-9(A).

14.5.3.3.4 All joints between lengths of conduit, and between conduit and couplings, fittings, and boxes, shall be made with fittings approved for the purpose.

14.5.4 Flexible metal conduit and fittings

14.5.4.1 General requirements

14.5.4.1.1 Flexible metal conduit and liquidtight flexible metal conduit, minimum electrical trade size shall be 3/8 inch.

14.5.4.1.2 The maximum size of flexible metal conduit and liquidtight flexible metal conduit shall be 4-in trade size.

Note: Metric trade numerical designations for flexible metal conduit and liquidtight flexible metal conduit, shall be 4-in trade size.

14.5.4.1.3 Flexible metal conduit and liquidtight flexible metal conduit shall be installed in such a manner that liquids will tend to run off the surface instead of draining toward the fittings.

14.5.4.1.4 Fittings shall be compatible with the conduit and identified for the application. Connectors shall be the "union" type.

14.5.4.2 Flexible metal conduit. Flexible metal conduit is a raceway of circular cross section made of helical wound, formed, and interlocked metal strip. Flexible metal conduit shall be identified for use in the expected physical environment.

14.5.4.3 Liquidtight flexible metal conduit. Liquidtight flexible metal conduit is a approved raceway of circular cross section having an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core with associated couplings, connectors, and fittings and approved for the installation of electric conductors.

14.5.5.1 Liquidtight flexible nonmetallic conduit is a raceway of circular cross section of various types:

1. A smooth, seamless inner core and cover bonded together and having one or more reinforcement layers between the core and cover

2. A smoother inner surface with integral reinforcement within the conduit wall

3. A corrugated internal and external surface with or without integral reinforcement within the conduit wall

4. Liquidtight flexible nonmetallic conduit is oil-, water-, and flame-resistant and, with fittings, is approved for the installation of electrical conductors

1663
14.5.5.2 A flexible non-metallic conduit shall be resistant to kinking and shall have physical characteristics of the sheath of multiconductor cables.

14.5.5.3 The conduit shall be identified for use in the expected physical environment.

14.5.5.4 Liquidtight flexible nonmetallic conduit minimum electrical trade size shall be 3/8 inch.

14.5.5.5 The maximum size of liquidtight flexible nonmetallic conduit shall be 4-in trade size.

Note: Metric trade-numerical designations for liquidtight flexible nonmetallic conduit are 3/8 = 12.7 = 16.0 = 21.1 = 27.1 = 35.1 = 41.2 = 53.2 = 63.3 = 78.3 = 91.4 = 103.

14.5.6.1 Wireways (cable trunking systems) external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the machine.

14.5.6.2 Covers shall be shaped to overlap the sides; gaskets shall be permitted. Covers shall be attached to wireways (cable trunking systems) by hinges or chains and held closed by means of captive screws or other suitable fasteners. On horizontal wireway (cable trunking systems), the cover shall not be on the bottom. Hinged covers shall be capable of opening at least 90 degrees.

14.5.6.3 Where the wireway (cable trunking system) is furnished in sections, the joints between sections shall fit tightly but shall not be required to be gasketed.

14.5.6.4 The only openings permitted shall be those required for wiring or for drainage.

14.5.6.5 Wireways (cable trunking systems) shall not have open but unused knockouts.

14.5.6.6 Machine compartments and wireway (cable trunking systems). The use of compartments or wireways (cable trunking systems) within the column or base of a machine to enclose conductors shall be permitted provided the compartments or wireways (cable trunking systems) are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments wireways (cable trunking systems) shall be so secured and arranged that they can not be subject to damage. (See 17.2 "Warning marking and signs"

14.5.8 Connection boxes and other boxes

14.5.8.1 Connection boxes and other boxes used for wiring purposes shall be readily accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influences under which the machine is intended to operate.

14.5.8.2 Those boxes shall not have open but unused knockouts or any other openings and shall be so constructed as to exclude materials such as dust, flyings, oil, and coolant.

14.5.9 Motor connection boxes

14.5.9.1 Motor connection boxes shall enclose only connections to the motor and motor-mounted devices (e.g. brakes, temperature sensors, plugging switches, tachometer generators).

14.5.9.2 Electrical connections to motors, solenoids and other devices with integral leads, sizes No. 14 AWG through No. 4 AWG, shall be made with ring type pressure connectors (pressure-tool applied) and bolted.

14.5.9.3 Connectors shall be insulated with a material that will not support combustion.

14.5.9.4 Soldered or insulation piercing type connectors (lugs) shall not be used.

14.5.10 Cord

14.5.10.1 Manufactured assemblies with factory applied molded connectors applied to cord shall be permitted.

Note: For additional information on flexible cords, refer to ANSI/UL 62 "Flexible cord and fixture wire".

14.5.10.2 The use of cord shall be limited to individual exposed conductors for flexing service in accordance with 13.7. Cord with conductors for flexing service shall have vertical connections and shall be installed to avoid excessive flexing and straining.

14.5.11 Cable trays. Cable trays to be used for cable or raceway support on industrial machines shall be permitted. Cable trays shall be permitted to support single conductors 1/0 or larger that are otherwise permitted on industrial machines, cables that are otherwise permitted on industrial machines, and raceways functionally associated with industrial manufacturing systems.

COMMITTEE STATEMENT: Additional change to Clause 14 were made for the following reasons:

1) A change was made in 14.1.1.3 to more closely align with and comply with the NFPA 70-1999, Section 110-14(b).

2) The text in 14.1.4.10 about the requirements for loops at load end was removed because it is too restrictive and loops should be permitted at both ends.

3) In 14.2.3.1, the color ORANGE was added to the list of prohibited colors for use with the three white stripes to correlate with the uses of the color ORANGE.

4) In 14.2.3.2, the committee desired to be inclusive with the grounded conductor in excepted circuits. Grounded conductors of AC and DC excepted circuits are required to be color coded in accordance item (2) to identify the grounded conductor of excepted circuits.

5) Section 14.4.5.7 was editorially revised to clarify that the provision only applies to externally mounted receptacles.

NOT RETURNED: 1 Norman

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 24

NEGATIVE: 1

EXPLANATION OF NEGATIVE:

KNECHT: Clause 14.1.1.3:

Observation: The second sentence which did not allow more than one conductor per connection, if removed may create a situation when the bonding path is interrupted when a bonding conductor is inadvertently disconnected when another grounding lead in the same connection point is disconnected.

The avoid this situation, the sentence should be added, "Only one equipment grounding conductor or one bonding conductor shall be connected to one terminal connecting point."

Clause 14.2:

Observation: I interpret the requirements to say that only the grounding (green/yellow), neutral, and continuously on (orange) conductors must always be color coded.

COMMENT ON AFFIRMATIVE:

BLOODGOOD: It is necessary for this proposal to be 57 pages?

I only use this as an example in noting the problem in reviewing the massive amount of paper that has to be studied to make intelligent voting decisions.

DOBROWSKY: Much of the proposed information is too detailed and can be covered using a few generic requirements to increase usability. Some requirements for wiring methods that are common to industrial machinery should be retained and a reference to the NEC should be provided for more detailed requirements.

FISHER: It is noted that the term 'cable trunking system' is indicated to the synonymous with 'wireways'. A 'cable trunking system' is not equivalent to a 'cable tray system' as cover in Article 318 of the NEC.

FREUDENBERG: Color coding requirements used 50% of the time is much more dangerous than no color code at all. The false perception of relying on color is a dangerous work practice. The entrenched them versus us stalemate on color coding around the world is inane because today's multinational suppliers and users are often both them and us where country of origin for systems, assemblies and components is not clear and country of use often shifts with production demands. Many machines are capital equipment that can be transferred down the road or around the world a few times during its useful life. Color coding is the most restrictive barrier to free trade that exists today where we can't move our own manufacturing machines between our own plants without a worldwide solution that removes ALL the color preferences.
SUBMITTER: Heinrich Moedden, German Machine Tool Builders Association (VDW)
RECOMMENDATION: Revise text as follows:
“The color YELLOW-GREEN (with or without one or more YELLOW stripes) shall be used to identify the equipment grounding conductor where insulated or covered.”

SUBSTANTIATION: The definition “YELLOW-GREEN” is more precise than the alternatives “GREEN (with or without one or more YELLOW stripes”. Only one color type should be defined in order to avoid unnecessary conductor variations for the machine tool builders.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The extension of the existing green to include green yellow is to allow for the harmonization with other international standards. Present proposed colors are consistent with NFPA 79-1999 (NEC-250-119).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The concerns of the submitter are already met in Committee Action on Proposal 79-122 (Log #55). (16.1.2 Note)

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

SUBMITTER: William E. Anderson, The Procter & Gamble Company

RECOMMENDATION: Revise the Note to read as follows:
NOTE: The international and European standards require reserve the use of the bicolor GREEN-AND-YELLOW for this purpose. (See IEC 204-1 for specific requirements.)

SUBSTANTIATION: The note is in error. IEC 60204-1:1997 14.2.9
“The protective conductor shall be readily distinguishable by shape, location, marking, or color When identification is by color alone, the bicolor combination GREEN-AND-YELLOW shall be used throughout the length of the conductor. This color identification is strictly reserved for the protective conductor.”

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: The committee understands that this proposal modifies the Committee Action on Proposal 79-122 (Log #55).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMITTEE ACTION: Accept.

COMMITTEE STATEMENT: The committee understands that this proposal modifies the Committee Action on Proposal 79-122 (Log #55).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The change in wording of the statements will comply with OSHA terminology and hazardous voltage level guidelines. More importantly it will provide maintenance personnel a better visual identification of potential danger.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: See my Comment on Affirmative on Proposal 79-122 (Log #55).

SUBMITTER: Wayman L, Withrow, Cincinnati Incorporated

RECOMMENDATION: The proposed NFPA 79-2002 subclause 14.2.4.3 is as follows:
14.2.4.3 The use of other colors for the purpose of identification shall be as follows:
- BLACK: Ungrounded line, load and control conductors at line voltage. Add “ac and dc” after ungrounded. Delete “line voltage”, add “hazardous voltage levels.”
- RED: Ungrounded ac control conductors at less than line voltage. Delete “line voltage”, add “hazardous voltage levels.”
- BLUE: Ungrounded dc control conductors. Add “at less than hazardous voltage levels.”

SUBSTANTIATION: The change in wording of the statements will comply with OSHA terminology and hazardous voltage level guidelines. More importantly it will provide maintenance personnel a better visual identification of potential danger.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The term “hazardous” related to voltage is not defined. Adding this term does not add clarity.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: See my Comment on Affirmative on Proposal 79-122 (Log #55).

SUBMITTER: Bruce Fairweather, Electrical Safety Engineering Inc.

RECOMMENDATION: Revise text:
BLACK: Ungrounded line, load and control conductors at line voltage. Add “ac and dc” after ungrounded. Delete “line voltage”, add “hazardous voltage levels.”
RED: Ungrounded ac control conductors at less than line voltage. Delete “line voltage”, add “hazardous voltage levels.”
BLUE: Ungrounded dc control conductors. Add “at less than hazardous voltage levels.”

SUBSTANTIATION: The change in wording of the statements will comply with OSHA terminology and hazardous voltage level guidelines. More importantly it will provide maintenance personnel a better visual identification of potential danger.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The term “hazardous” related to voltage is not defined. Adding this term does not add clarity.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: See my Comment on Affirmative on Proposal 79-122 (Log #55).

SUBMITTER: Wayman L Withrow, Cincinnati Incorporated

RECOMMENDATION: The proposed NFPA 79-2002 subclause 14.2.4.3 is as follows:
14.2.4.3 The use of other colors for the purpose of identification shall be as follows:
- BLACK: Ungrounded line, load, and control circuits at line voltage.
- RED: Ungrounded AC control circuits, at less than line voltage.
- BLUE: Ungrounded DC control circuits.

Exception No. 1: Internal wiring on individual devices purchased completely wired. Exception No. 2: Where the insulation used is not available in the colors required (e.g. high temperature insulation, chemically resistant insulation).
Exception No. 3: Where multiconductor cable is used. Revise the proposed NFPA 79-2002 subclause 14.2.4.3 paragraph and exceptions to read as follows:

14.2.4.3 It shall be permitted to use additional identification at selected locations as an alternative. This means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means and shall be permanently posted on the inside of the main electrical control panel enclosure in a visible location. The preferred colors for AC and DC power circuits, AC control circuits, and DC control circuits shall be as follows:
COMMITTEE ACTION:

Exception No. 4 permits the use of the currently recognized color codes 60204-1: 1997, and the proposed SAE HS1738. The addition of applications, an exception is given to the mandatory color codes. This addition will harmonize the proposed NFPA 79-2002, IEC 60204-1: 1997, and the proposed SAE HS1738. The addition of the sentence "It shall be permitted to use additional identification at selected locations as an alternative." permits the use of the currently recognized color codes for power and control circuit wiring and allows an exception for machines with special requirements.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT:

See Committee Action on Proposal 79-129 (Log #57).

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 23
NEGATIVE: 3
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

DROBNICK: I believe that straying from the current wire color codes which have been adhered to for years will compromise the safety of electrical personnel. I believe that the first three exceptions allow for current industry practice without the necessity for Exception No. 4.

GARVEY: The proposed new exception is unenforceable. Who determines when compliance is "too restrictive for specific applications"? The exception effectively renders the general requirements of 14.2.4.3 useless. I do agree with the submitter’s substantiation that some limited exceptions are appropriate.

COMMENT ON AFFIRMATIVE:

FREUDENBERG: See my Comment on Affirmative on Proposal 79-122 (Log #55).

79-129 - (16.1.3 [14.2.4.3]): Accept

SUBMITTER: Wayman L. Withrow, Cincinnati Incorporated

RECOMMENDATION: The proposed NFPA 79-2002 subclause 14.2.4.3 is as follows:

14.2.4.3 The use of other colors for the purpose of identification shall be as follows:
- BLACK: Ungrounded line, load, and control circuits at line voltage.
- RED: Ungrounded AC control circuits, at less than line voltage.
- BLUE: Ungrounded DC control circuits.

Exception No. 1: Internal wiring on individual devices purchased – BLACK: Ungrounded DC control circuits.

Exception No. 2: Where the insulation used is not available in the colors required (e.g. high temperature insulation, chemically resistant insulation).

Exception No. 3: Where multiconductor cable is used. Add 14.2.4.3 Exception No. 4 to subclause 12.2.4.3 after exception No. 3 as follows:

Exception No. 4: Where the identification of machine power and control wiring is such that compliance with the mandatory color codes is too restrictive for specific applications, it shall be permitted to use additional identification at selected locations as an alternative. This means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means and shall be permanently posted on the inside of the main electrical control panel enclosure in a visible location.

SUBSTANTIATION: The mandatory ungrounded power and control wire color coding is used in the majority of metal working machine tools manufactured for use in the United States. However, some machine tool manufacturers have specific applications for wire identification, such as different levels of ac and dc voltages. In order to identify the wiring for these special applications, an exception is given to the mandatory color codes.

This addition will harmonize the proposed NFPA 79-2002, IEC 60204-1: 1997, and the proposed SAE HS1738. The addition of exception No. 4 permits the use of the currently recognized color codes for power and control circuit wiring and allows an exception for machines with special requirements.

COMMITTEE ACTION: Accept.

The committee understands the submitter proposed action is to only add a new exception 4 as stated in the proposal.

COMMITTEE STATEMENT:

The committee understands that this proposal modifies the Committee Action on Proposal 79-122 (Log #55) [Clause 14].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 22
NEGATIVE: 3
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

DROBNICK: I believe that straying from the current wire color codes which have been adhered to for years will compromise the safety of electrical personnel. I believe that the first three exceptions allow for current industry practice without the necessity for Exception No. 4.

GARVEY: The proposed new exception is unenforceable. Who determines when compliance is "too restrictive for specific applications"? The exception effectively renders the general requirements of 14.2.4.3 useless. I do agree with the submitter’s substantiation that some limited exceptions are appropriate.

KIHRI: I voted against the Acceptance of this proposal for the following reasons:
1. The new exception #4 states that "Where the identification of machine power and control wiring is such that compliance with the mandatory color codes is too restrictive for specific applications, ..." There is no clear definition of 'too restrictive'.
2. The substantiation given for acceptance of the proposal refers to a specific reason for utilizing different colors (to differentiate multiconductor cable). If this is the reason, then the exception should be for this particular application.
3. As the exception is currently worded, it essentially voids the entire subclause 14.2.4.3. A manufacturer can use any wire color he sees fit, and simply state that to use the colors prescribed in 14.2.4.3 was too restrictive.
4. Any exception should be for very specific applications, which cannot be accommodated by the basic language of the standard. This particular exception can be interpreted in a broad enough sense that it cancels out the entire subclause.

COMMENT ON AFFIRMATIVE:

DOBROWSKY: I am concerned that the phrase "specific applications" and the use of "additional identification at selected locations as an alternative" will not be consistently interpreted.

FREUDENBERG: See my Comment on Affirmative on Proposal 79-122 (Log #55).

SAUNDERS: 14.4.3 specifies the use of black, red, and blue for the purpose of identification. The identification referred to is to provide functional identification of conductors (i.e. ac or dc control) rather than individual identification of each conductor in the circuit. However, subclause 14.2.1.1 requires individual identification of each conductor and allows color to be permitted as one method to accomplish this identification. Therefore, it is impossible to identify each individual conductor by color and still meet the requirements of 14.2.4.3. For example, if there are ten ungrounded dc control conductors in the circuit, they would be required to all be red per subclause 14.2.4.3. Although the proposed exception 4 may cover this, the statement "where ... compliance with the mandatory color codes is too restrictive" lends itself to interpretation of what is considered too restrictive.

Recommendation: Add exception 5 to 14.2.4.3 "Where color is used for identification of each individual conductor."

79-130 - (16.1.3 [14.2.4.1]): Accept

SUBMITTER: Heinrich Moedder, German Machine Tool Builders Association (VDW)

RECOMMENDATION: Revise text as follows:

"Ungrounded circuit conductors that remain energized when the main disconnecting means is in the OFF position shall be either YELLOW or ORANGE (see 5.3.5 "Exempted Circuits")."

SUBSTANTIATION: The definition "ORANGE" is more precise than the alternatives "YELLOW or ORANGE". Only one color type should be defined in order to avoid unnecessary conductor variations for the machine tool builders.

COMMITTEE ACTION: Accept in Principle.

Revise text of the first sentence 14.2.4.1 to read as follow:

"Ungrounded circuit conductors that remain energized when the supply disconnecting means is in the OFF position shall be constantly applied ORANGE." Add a note to the end of this section to read as follows:

Note: For further information on "Exempted Circuits", see 5.3.5. The remainder of the section is to remain unchanged.
COMMITTEE STATEMENT: The committee desires to permit either color as long as the requirement is applied consistently within a machine. The cross reference to 5.3.5.5 was moved to a note to comply with the style manual.

The committee understands that this proposal modifies the Action on Proposal 79-122 (Log #55).

NUMERO OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24
NEGATIVE: 2

EXPLANATION OF NEGATIVE:

GARVEY: The color "Orange" is used to designate "Warning" by OSHA regulations. Often "white" wires turn "yellow" as the insulation ages. Orange should be the preferred color.

COMMENT ON AFFIRMATIVE:

FREUDENBERG: See my Comment on Affirmative on Proposal 79-122 (Log #55).

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: The concerns of the submitter are already addressed in Proposal 79-122 (Log #55). The committee understands that this proposal modifies the Committee Action on Proposal 79-122 (Log #55).

NUMERO OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NEGATIVE: 1

COMMITTEE STATEMENT: The sentence is too long, retain meaning but making a part of the sentence an exception and reword the exception from its existing passive voice.

COMMITTEE ACTION: Accept in Principle.

REVISE TEXT TO READ AS FOLLOWS:

14.4.5.3 Attachment plug and receptacle (plug/socket) combinations, shall be so designed that; a protective bonding (equipment grounding) circuit connection is made before any live connections are made, and the protective bonding (equipment grounding) circuit connection is not disconnected until all live connections in the plug are disconnected; except for connections used in PELV circuits, or the connectors used only to facilitate assembling / disassembling (multi-pole connectors).

Exception: Connections used in PELV circuits, or the connectors used only to facilitate assembling / disassembling (multi-pole connectors) shall not be required to meet these requirements.

COMMITTEE STATEMENT: The committee agrees that the sentence is too long and was reordered for clarity. The exception has been revised to comply with the NFPA Manual of Style. The committee understands that this proposal modifies the Action on Proposal 79-122 (Log #55) [Clause 14].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25
NEGATIVE: 1

COMMITTEE STATEMENT: The committee desires to permit either color as long as the requirement is applied consistently within a machine. The cross reference to 5.3.5.5 was moved to a note to comply with the style manual.

The committee understands that this proposal modifies the Action on Proposal 79-122 (Log #55).

COMMITTEE ACTION: Accept in Principle.

REVISE TEXT TO READ AS FOLLOWS:

14.4.3.8 Devices serving to guide and carry a cable with flexible properties, shall be so designed that the inner bending radius is not less than the values given in table XW, unless the smaller bending radius is agreed to by the cable manufacturer, taking into account the permissible tension and the expected fatigue life. The exposed length of the flexible conduit or cable between connectors shall not exceed three and 1/3/ feet (1 meter). Minimum wire size of cable shall be No. 16 AWG.
shall have
"d) Performance of Fault Current Path. The fault current path
NOT RETURNED: 1 Norman
NEGATIVE: 1 VOTE ON COMMITTEE ACTION:
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
COMMITTEE STATEMENT:
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: This proposal is too restrictive.
Lengths greater than those proposed are currently in IEC 60204-1 as well as in Proposal 79-122 (Log #55) 14.4.2.
The requirements in the new Proposal [79-122 (Log #55)] 14.5.4.3 "Liquid-tight flexible conduit" limits its use to those identified e.g. UL 360. This proposal is more restrictive than application limitations found in UL 360 and is appropriate to only certain limited applications of NFPA 79.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-136 - ([14.1.2]): Offer Improvement
SUBMITTER: William E. Anderson, The Procter & Gamble Company
RECOMMENDATION: Add paragraph to read as follows:
14.1.2 Conductor and cable runs
14.1.2.5 The equipment grounding (protective) conductor shall be placed close as practicable to the associated live conductors in order to decrease the impedance of the loop.
SUBSTANTIATION: In conductor and cable runs the distance between the circuit conductors defines significant part of the circuit impedance. The implicit design requirement for equipment grounding circuits is to have a low impedance path should a fault condition exist. Thus the need for the requirement to locate equipment grounding conductors as close as practicable to the associated live circuits that are likely to be a part of the circuit loop during a fault condition that the equipment grounding conductor is intended to provide protection.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The proposed language is vague and unenforceable.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman
EXPLANATION OF NEGATIVE:
SAUNDERS: The proposal should be accepted. The requirement provides additional definition as to how to accomplish the existing NEC requirement as stated in Article 250-2 (d):
"d) Performance of Fault Current Path. The fault current path shall be permanent and electrically continuous, shall be capable of safely carrying the maximum fault current likely to be imposed on it, and shall have sufficiently low impedance to facilitate the operation of overcurrent devices under fault conditions."
COMMENT ON AFFIRMATIVE:
ANDERSON: The committee's statement in rejecting the proposal is true that the original proposal's approach does contain language that is unenforceable. But, given the desire of low impedance ground return paths, and given the physics that define the variables that determine the impedance of a circuit, the concept contained in the original proposal might still serve the same useful purpose as a note to 14.1.2.1. Also, given that the calculation of power circuit impedances is nominally done in the course of electrical power transmission systems engineering work, and rarely done in machine design work, the point in the note would be helpful to an electrical designer of a machine. The substantiation in the original proposal stands. The proposed revised text to Log # 55 would become:
14.1.2 Conductor and cable runs
14.1.2.1 Conductors and cables shall be run from terminal to terminal without splices or joints.
Exception No. 1: Splices shall be permitted to leads attached to electrical equipment, such as motors and solenoids; such splices shall be insulated with oil-resistant electrical tape or insulation equivalent to that of the conductors and installed in a suitable enclosure.
Exception No. 2: Where it is impracticable to provide terminals in a junction box (e.g. on mobile machines, on machines having long flexible cables) the use of splices or joints shall be permitted.
Note: The equipment ground conductor should be placed as close as practicable to their associated circuit conductors in order to minimize the circuit impedance during the instance of a ground fault.

14.1.2.2 Factory applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.
SUBSTANTIATION: Factory applied connectors molded onto cables are commonly utilized on the electrical equipment of industrial machinery. Such connectors are attached in a controlled environment where comprehensive quality assurance, testing, and validation measures are applied. The robust design and successful utilization history of such connectors indicate that such products are not a safety risk. These connectors are not considered as splices or joints in cable runs for the purpose of this clause.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: The concerns of the submitter are already addressed in Proposal 79-122 (Log #55) (14.1.2.2).
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman
COMMENT ON AFFIRMATIVE:
DOBROWSKI: The word "Listed" should be inserted before "Factory" in the first sentence.
Reason: This method should only be permitted if evaluated by a qualified testing laboratory, not installed at the "factory" where the machine is located.

14.1.4 Cables run exposed along the structure of the equipment or system, or in the chases of the machinery shall be permitted. Exposed cables shall be installed to closely follow the surface and structural members of the machinery.
14.1.4.2 Cables shall be supported by the equipment or system structure as follows:
(1) In such a manner that the cable will not be damaged by normal equipment use
(2) Every 12 in. in a non-vertical run
Exception: Supporting distance may be increased up to 36 in., where the structure of the machine or system makes support impractical every 12 in.
(3) Every 36 in. in a vertical run
Exception: Supporting distance may be increased to 96 in., where the structure of the machine or system makes support impractical every 36 in.
(4) When suspended in air spanning a distance up to 18 in.
Exception: Span distance may be increased up to 36 in., where the structure of the machine or system makes support impractical every 18 in.
14.1.4.3 Cables shall not be supported by machinery guard work likely to be removed for maintenance access.
14.1.4.4 Multiple cables can be supported and fastened together in a bundle provided the method of support and fastening is
sufficient to support the mechanical weight and strain of the bundle.

14.1.4.5 Cables shall be fastened where supported. Exception No. 1: Where horizontal runs are inherently supported by the machine or system structure, or by a floor or deck, fastening is not required.

Exception No. 2: Where run at not more than a 45 degree angle from horizontal, fastening is not required.

14.1.4.6 Cables shall be fastened with cable ties supported by any of the following methods:

(1) Screw-on cable tie mounts
(2) Hammer-on cable tie mounting clips
(3) Around the machine or system structural members
(4) Through holes in the machine or system structural members
(5) Cable mounting clamps
(6) Other methods identified as acceptable for the purpose

14.1.4.7 The free ends of cable ties shall be cut flush after final adjustment and fastening. Cable ties of the reusable or releasable type shall not be permitted for use as a permanent fastening method.

14.1.4.8 Cables shall be protected from physical damage where necessary. Some cable types may be more susceptible to physical damage that others. Care should be taken to ensure that all applied cabalas type would not be subjected to physical damage under conditions of normal use. Although this requirement may appear obvious to most readers, Clause 14.1.4.2(a) codifies a requirement that the proper care be taken to ensure the integrity of the cable installation.

Electrical, safety and application engineering evaluations of industrial machines and machinery systems indicate that cables supported at greater than 18 in. in a non-vertical run can make for an installation that would not satisfy a reasonable persons understanding of what constitutes a “neat and workman like” installation. Clause 14.1.4.2(b) helps ensure a conscientious workman like” installation of cables.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that it may be impractical or undesirable to support cables in a non-vertical run at 12 in. intervals at all times. This exception to Clause 14.1.4.2(b) allows a reasonable extension of the support distance to cover such circumstances.

Electrical, safety and application engineering evaluations of industrial machines and machinery systems indicate that cables suspended in air spanning a distance greater that 18 in. can make for an installation that would not satisfy a reasonable persons understanding of what constitutes a “neat and workman like” installation. Clause 14.1.4.2(c) helps ensure a conscientious “workman like” installation of cables.

Electrical, safety, and application engineering evaluations of industrial machines and machinery systems indicate that cables supported at less than 36 in. in a vertical run can make for an installation that would not satisfy a reasonable persons understanding of what constitutes a “neat and workman like” installation. Clause 14.1.4.2(d) helps ensure a conscientious “workman like” installation of cables.

14.1.4.9 Bends in cables shall be made so as not to cause undue stress. The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the cable.

14.1.4.10 Where a cable is used in a length longer than optimally required, the excess cable shall be coiled in loops at or near the load end. The coil shall be fastened to itself and to the machinery structure.

Exception: When an access cable is associated with a horizontal cable run that is inherently and fully supported, the coil is not required to be fastened to the equipment or system structure.

SUBSTANTIATION: As a common practice cables are extensively applied as part of the electrical controls of industrial machinery. NFPA 79 and EN60201 are both silent on safe cable application methodology, which forces industry to utilize a plethora of ad hoc and sometimes questionable, measures. In order to facilitate the safe and uniform utilization of cables, this text is proposed. It is the intent of these paragraphs [14.1.4.x] to provide cable application methodology that is at least as comprehensive as the methodology outlined for many wiring methods found in Chapter 3 of NFPA 79. The purpose of this proposal is to clearly establish the implementation requirements for cables used on the electrical equipment of industrial machinery.


Substantiation for 14.1.4:
As a common practice cables are extensively applied as part of the electrical controls of industrial machinery. NFPA 79 and EN60201 are both silent on safe cable application methodology, which forces industry to utilize a plethora of ad hoc and sometimes questionable, measures. In order to facilitate the safe and uniform utilization of cables, this text is proposed. It is the intent of these paragraphs [14.1.4.x] to provide cable application methodology that is at least as comprehensive as the methodology outlined for many wiring methods found in Chapter 3 of NFPA 79. Section 14.1 is divided into 4 subsections 1 General requirements, 2 Conductor and cable runs, 3 Conductors of different circuits, and 4 Cables. Editorial addition to help organize the material and follow IEC 60204-1 1997 Edition structure and Manual of Style for NFPA Technical Committee Documents 2000 Edition.

Substantiation for 14.1.4.1:
Specific application analysis will identify precisely how cables need to be run. In addition to conventional cable routing methodology, the routing of cables along either the inside or outside of the machine will at some point typically become necessary. Clause 14.1.4.1 recognizes and permits cables routed along the exterior of the surface of the structural members of the machinery, as well as cables routed through chases inherent to the machinery structure, or through chases added to the machinery structure for the purpose. Cables associated with a machine or machinery system is an integral part of that machinery or machinery system. Supposing cables by the equipment or system structure clearly indicates and maintains that association.

Substantiation for 14.1.4.2:
Provides information not in the present standard.
Cable clamps and cables ties are a readily available, low cost and effective method of fastening cables in place, and are used in common practice for the purpose. Cable ties alone, however, are not a complete fastening solution. In order to fasten a cable with a cable ties additional hardware is required. That additional hardware is defined in the text of 14.1.4.6.

Cable tie mounts are a common usage item. A substantial mechanical fastening method for cable tie mounts is desirable in order to maintain the integrity of the assembly. Screw fastening is such a substantial method. The structural members of machines are typically of substantial construction, and can serve as a safe and effective fastening platform when cables are fastened with cable ties around the members or through holes in the members.

Cable mounting clamps are common usage items that are expressly intended for the purpose of fastening cables in place. As such, cable mounting clamps are acceptable means.

Other methods of cable fastening may be deemed acceptable based on the judgment of the applicable authority having jurisdiction.

Substantiation for 14.1.4.7:
In order to maintain a neat and workman like assembly, cable ties should be cut flush once installed. Reusable cable ties have a propensity to loosen with time, and therefore do not maintain the integrity of the assembly over time.

Substantiation for 14.1.4.8:
Cable must not be subjected to physical damage. Clause 14.1.4.8 identifies methods by which physical damage to a cable can be avoided.

Routing cables in such a way so as to ensure that cable runs cannot be damaged, or using a commercially available walk or drive over cable protective devices are acceptable and effective methods of protection.

Routing cables in a cable trunk (wire way) or using a trapezoidal walk over raceway can be specifically designed and constructed by the machinery supplier for the purpose cable protection are also acceptable and effective.

Substantiation for 14.1.4.9:
Bends in cables should not be made in a manner that places undue stress on the integrity of the cable. A requirement for a inner edge bend radius of not less than five times the diameter of the cable will ensure the integrity of the cable at bends in the cable run. A typical cable manufacturer recommended minimum bending radius, for fixed installation of cables, is between 3 and 5 times the cable diameter.

Substantiation for 14.1.4.10:
Cables, as typically applied for industrial machinery can be either of a perfect length, or longer than required. Clause 14.1.4.10 provides requirements for the neat and workman like handling of excess cable lengths in a consistent, identifiable manner. The exception to Clause 14.1.4.10 is consistent with the practices outlined in Exception 1 to Clause 14.1.4.5.

COMMITTEE ACTION: Accept in Principle.

COMMITTEE STATEMENT: See Committee Action on Proposal 79-122 (Log #55) (14.1.4) which meets the intent of the submitter.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NEGATIVE: 1

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:

DOBROWSKY: I am concerned that "flexible cords" will be used where "cables" are intended. Specific cable types should be specified. The exception to 14.1.4.5 should be deleted or modified because it literally permits cables to be on the floor.

SUBSTANTIATION: The original proposal would exclude door mounted locking and interlocking which require cabling between components that are mounted on and removed with the removable guard. The circuits may function either through an on board battery system or a plug scheme that connects and disconnects with the guard mounting or removal.

COMMITTEE ACTION: Accept in Principle.

Revise the proposed text to read as follows:

14.1.4.3 Cables shall not be supported by machinery guards that are likely to be removed for maintenance access.

Exception: Wiring for components that are an integral part of the guard and designed to remain on the guard when the guard is removed for maintenance access shall be permitted to be supported by the guard.

COMMITTEE STATEMENT: The committee understands that this proposal modifies the Action on Proposal 79-122 (Log #55). The exception has been modified to comply with the NFPA Manual of Style. In addition the word “work” has been removed for clarity and the example was removed because it is not necessary.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

(79-139 — ([14.1.4.3]): Accept in Principle)

SUBMITTER: William E. Anderson, The Procter & Gamble Company

RECOMMENDATION: Add new text to read as follows:

14.4.3 Cables shall not be supported by machinery guard work likely to be removed for maintenance access.

Revise text to read as follows, adding exception:

14.4.3 Cables shall not be supported by machinery guard work likely to be removed for maintenance access.

Exception: Wiring for components that are an integral part of the guard and designed to remain on the guard when the guard is removed for maintenance access. e.g. interlock switching schemes.

(1670)
79-141 - (Clause 17 [14.5.1.4(New)]): Reject
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Revise text to read as follows:
"All joints between lengths...designed for the purpose. Where conduit terminates in a threadless opening, a locknut shall be provided both inside and outside the enclosure, and the conduit end shall be equipped with an insulating bushing. A suitable oiltight means such as an oil-resistant synthetic rubber o-ring and a metal cup shall be provided between the outside locknut and opening. When the conduit enters an opening through a conduit connector, the shoulder of the connector may serve as the outside locknut. The o-ring assembly or an equivalent sealing device should also be furnished when a locknut is used as a jam nut on connectors fitted to threaded hubs."

SUBSTANTIATION: The lack of direction on the method to enter and connect raceway and conduit to boxes and enclosures have caused a lack of sealing to liquids and debris that can cause detrimental effects to conductor insulation, the connections, and insulation capability to "ground".

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The concept of this proposal is already covered in Proposal 79-122 (Log #55), 14.5.3.1.3. There is inadequate substantiation to mandate a suitable oil tight, oil resistant, synthetic rubber O-ring termination.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMITTEE STATEMENT: This standard covers machines beyond the scope of the ANSI B11 series. Equipment must be selected to be suitable for the environment.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

79-142 - (17.4 [14.5.3]): Reject
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Delete text as follows:
"Intermediate metal (steel) conduit shall be permitted. Provisions of 17.3.2 through 17.3.8.
SUBSTANTIATION: Has been seen not to provide sufficient protection in harsh industrial environment as encountered by the machine tools as described in the ANSI B11 series of standards.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: This standard covers machines beyond the scope of the ANSI B11 series. Equipment must be selected to be suitable for the environment.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: See my Comment on Affirmative on Proposal 79-142 (Log #104)

79-143 - (17.5 [14.5.3]): Reject
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Delete text as follows:
"Electrical metallic (steel) tubing shall be permitted. Provisions of 17.5.2 through 17.5.8.
SUBSTANTIATION: Has been seen not to provide sufficient protection in harsh industrial environment as encountered by the machine tools as described in the ANSI B11 series of standards.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: This standard covers machines beyond the scope of the ANSI B11 series. Equipment must be selected to be suitable for the environment.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: See my Comment on Affirmative on Proposal 79-142 (Log #104)

79-144 - (17.6 [14.5.3]): Reject
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Delete text as follows:
"17.6.1 Rigid nonmetallic conduit Schedule 80 and fittings shall be fitted...and all other sub sections.
SUBSTANTIATION: Has been seen not to provide sufficient protection in harsh industrial environment as encountered by the machine tools as described in the ANSI B11 series of standards.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: This standard covers machines beyond the scope of the ANSI B11 series. Equipment must be selected to be suitable for the environment.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: See my Comment on Affirmative on Proposal 79-142 (Log #104)

79-145 - (17.9.1 [14.5.4.2]): Reject
SUBMITTER: George M. Schreck, Komatsu America Industries LLC
RECOMMENDATION: Delete text as follows:
"17.9.1 Flexible metal conduit shall consist of flexible metal tubing or woven wire armor... and all other sub sections.
SUBSTANTIATION: Conductor insulation damage has been experienced as machine lubrication oil, or process oils have entered the conduit and has caused the insulation of the conductors to become brittle, break (when conduit is "flexed") and cause either conductor to conductor shorting or conductor to conduit (ground fault) shorting. Not suitable for environment encountered by machine tools as identified by the ANSI B11 series of safety standards.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: This standard covers machines beyond the scope of the ANSI B11 series. Equipment must be selected to be suitable for the environment.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: See my Comment on Affirmative on Proposal 79-142 (Log #104)

79-146 - ([14.5.10]): Accept in Principle
SUBMITTER: Gary J. Locke, Lockheed Martin Systems Integration
RECOMMENDATION: This proposal is to add new text to NFPA 79-1997 as additional content for the newly proposed Clause 14 which was reconciled with EN 60004-1 by Technical Committee on Electrical Equipment of Industrial Machinery action. Add text to read as follows:
14.5.10 Cord
14.5.10.1 Manufactured assemblies with factory applied molded connectors applied to cord shall be permitted. Note: For additional information on flexible cords, refer to ANSI/UL 62 "Flexible cord and fixture wire"
14.5.10.2 The use of cord shall be limited to individual exposed lengths of 50 ft or less.

14.5.10.3 Cord shall be installed in accordance with the provision of clause 14.1.4.

14.5.10.4 Cord shall be permitted for use for flexible connections to pendant push-button stations. Chains or wire rope external to the cord shall support the weight of pendant stations.

14.5.10.5 Cord shall be permitted for use for connections involving small or infrequent movements. Cord shall also be permitted to complete the connection to normally stationary motors, limit switches, and other externally mounted devices.

14.5.10.6 Connections to frequently moving parts shall be made with conductors for flexing service in accordance with 13.7 Cord with conductors for flexing service shall have vertical connections and shall be installed to avoid excessive flexing and straining.

Exception: Horizontal connections shall be permitted where the cord is adequately supported.

SUBSTANTIATION: As a common practice, cords are extensively applied as part of the electrical controls of industrial machinery. NFPA 79 and EN60201 are both silent on safe cord application methodology, which forces industry to utilize a plethora of ad hoc, and sometimes questionable, measures. In order to facilitate the safe and uniform utilization of cords, this text is proposed. It is the intent of these paragraphs [14.5.10.x] to provide cord application methodology. The purpose of this proposal is to clearly establish the implementation requirements for cords used on the electrical equipment of industrial machinery.


Because the construction of cord is different than that of cable, its use is limited. 14.5.10 was added for application purposes.


Substantiation for 14.5.10.1:
Add cord to machine wiring practice. Factory applied connectors molded onto cord are commonly utilized on the electrical equipment of industrial machinery. Such connectors are attached in a controlled environment where comprehensive quality assurance, test, and validation measures are applied.

Substantiation for 14.5.10.2:
Add cords to machine wiring practice for utilization of cord for connection to the field I/O and similar. Length of a cord is restricted to 50 ft to limit exposure to physical damage.

Substantiation for 14.5.10.3:
Provides reference for application methodology.

Substantiation for 14.5.10.4:
The first sentence revision will allow cords to be used.

Substantiation for 14.5.10.5:

Substantiation for 14.5.10.6:
More logical topic location and better covers the anticipated usage. NFPA 79 1997 Edition 16.3.5 has been relocated to the proposed 14.4.3.1 and 14.4.5.2 and 14.5.10.6. Paragraph 14.5.10.6 address installation concerns for the use of cords.

COMMITTEE ACTION: Accept in Principle.

The committee understands that the only change made in this proposal is to add a new exception to 14.5.10.4 to read as follows:

Exception: Cords listed for the purpose shall be permitted to be used without an external chain or wire rope.

COMMITTEE STATEMENT: The committee understands that this proposal modifies the Action on Proposal 79-122 Log #55) [Clause 14].

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
DOBROWSKY: The word “Listed” should be inserted before “Manufactured.” See my comment on Proposal 79-137 (Log #90).
SAUNDERS: Subclause 14.4.2.2 requires external conductors to be enclosed in raceway, which conflicts with the proposed 14.5.10.2. Recommendation: Add cord and cord connectors to the exception for 14.4.2.2.
Motors shall be marked in accordance with Section 430-7 of NFPA 15.8 Marking on Motors. The direction arrow shall be installed. The arrow shall be adjacent to the motor compartment requirements, any clearance around the motor compartment from another compartment not meeting the motor compartment requirements. Where a raceway is run into the motor compartment and any other compartment that does not meet the insulation class. The vents shall be such that ingress of swarf, dust, or water spray is prevented. The motor mounting arrangement shall be such that all motor hold-down means can be removed and all terminal boxes are accessible. An adjustable base or other means shall be provided when belt or chain drives are used. Motors shall be mounted so that proper cooling is ensured and the temperature rise remains within the limits of the insulation class. Motor compartments shall be clean and dry, and when required, shall be ventilated directly to the exterior of the machine. The vents shall be such that ingress of swarf, dust, or water spray is prevented at an acceptable level. There shall be no opening between the motor compartment and any other compartment that does not meet the motor compartment requirements. Where a raceway is run into the motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the raceway shall be sealed. Criteria for selection The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environment conditions (see 4.4). The points that shall be considered include: type of motor; type of duty cycle; fixed speed or variable speed operation, (and consequent variable influence of the ventilation); mechanical vibration; type of converter for motor speed control; influence of the harmonic spectrum of the voltage and/or current feeding the motor (when it is supplied from a converter) on the temperature rise; method of starting and possible influence of the inrush current on the operation of other users, taking into account possible special considerations stipulated by the supply authority; variation of counter torque load with time and speed; influence of loads with large inertia; influence of constant torque or constant power operations; possible need of inductive reactors between motor and converter.

15.6 Protective devices for mechanical brakes Operation of the overload and overcurrent protective devices for mechanical brake actuators shall initiate the simultaneous de-energization (release) of the associated machine actuators. NOTE – Associated machine actuators are those associated with the same motion, for example cable drums and long-travel drives.

15.7 Direction Arrow Where reverse rotation can produce an unsafe condition, a direction arrow shall be installed. The arrow shall be adjacent to the motor and plainly visible.

15.8 Marking on Motors Motors shall be marked in accordance with Section 430-7 of NFPA 70.

SUBSTANTIATION: This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

Historical Background In March of 1998, the NFPA 79 committee prepared a statement of work. The major elements of the statement of work are: Harmonization - Purpose As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC-60204-1.

Importance of Issue - Harmonization Today's industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities. Harmonization - Objective This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard. Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council: "The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause. The Task Group compared NFPA-79-1997, Clause 18 in its entirety and with IEC 60204-1 Clause 15. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work. The Task Group proposes to renumber Clause 18 of NFPA 79-1997 to correspond with IEC 60204-1. The task group proposes the following changes to further improve usability.

15 Electric motors and associated equipment

Revise Clause 15 heading “18 Motors and motor compartments” to harmonize with IEC Clause 15 heading and because it addresses more issues than just motors and motor compartments.

15.1 General requirements

The first paragraph restates for motors, the current NFPA 79-1997, 5.2, requiring electrical components and devices to be suitable for the environment in which they are installed. Note 1 is provided to assist users in locating appropriate motor standards, and Note 2 permits users to quickly access related information. A global change provides numbers to multiple paragraph clauses and notes to assist the user.

15.2 [Reserved]

Placeholder for future use.

79-149 - (Clause 18 [Clause 15]): Accept in Principle

SUBMITTER: Melvin K. Sanders, TEGo, Inc.

RECOMMENDATION: Revise NFPA 79-1997 Clause 18 “Motor and motor compartments” and issue as new Clause 15 “Electric motors and associated equipment” as follows: Revised Clause 15

15 Electric motors and associated equipment

15.1 General requirements

Motors shall be suitable for the environment in which they are installed. For additional information related to motor standards, refer to UL 1004, NEMA MG-1, IEEE 841 or IEC 60034-1. The protection requirements for motors and associated equipment are given in 7.2 for overcurrent protection, in 7.5 for overload protection, and in 7.6 for overspeed protection.

15.2 [Reserved]

15.3 Motor dimensions

As far as is practicable, the dimensions of the motors shall comply with those given in NEMA MG-1, IEC 60072-1 or IEC 60072-2 as appropriate.

Note: For a comparison between kilowatt and horsepower size, see Annex X Tables X.1 and X.2.

15.4 Motor mounting and compartments

15.4.1 Each motor and its associated couplings, belts and pulleys, or chains, shall be so mounted that they are adequately protected from physical damage and are easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be such that all motor hold-down means can be removed and all terminal boxes are accessible. An adjustable base or other means shall be provided when belt or chain drives are used.

15.4.2 Motors shall be so mounted that proper cooling is ensured and the temperature rise remains within the limits of the insulation class.

15.4.3 Motor compartments shall be clean and dry, and when required, shall be ventilated directly to the exterior of the machine. The vents shall be such that ingress of swarf, dust, or water spray is prevented at an acceptable level. There shall be no opening between the motor compartment and any other compartment that does not meet the motor compartment requirements. Where a raceway is run into the motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the raceway shall be sealed.

15.5 Criteria for selection

The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environment conditions (see 4.4). The points that shall be considered include:

- type of motor;
- type of duty cycle;
- fixed speed or variable speed operation, (and consequent variable influence of the ventilation);
- mechanical vibration;
- type of converter for motor speed control;
- influence of the harmonic spectrum of the voltage and/or current feeding the motor (when it is supplied from a converter) on the temperature rise;
- method of starting and possible influence of the inrush current on the operation of other users, taking into account possible special considerations stipulated by the supply authority;
- variation of counter torque load with time and speed;
- influence of loads with large inertia;
- influence of constant torque or constant power operations;
- possible need of inductive reactors between motor and converter.

15.6 Protective devices for mechanical brakes

Operation of the overload and overcurrent protective devices for mechanical brake actuators shall initiate the simultaneous de-energization (release) of the associated machine actuators.

NOTE – Associated machine actuators are those associated with the same motion, for example cable drums and long-travel drives.

15.7 Direction Arrow

Where reverse rotation can produce an unsafe condition, a direction arrow shall be installed. The arrow shall be adjacent to the motor and plainly visible.

15.8 Marking on Motors

Motors shall be marked in accordance with Section 430-7 of NFPA 70.

(D) (Log #27)
15.3 Motor dimensions

This subclause covers a subject not presently in NFPA 79-1997. This text is comparable with the requirements of IEC 60204-1, Clause 15. These motor dimensions were added to require the use of standard motor frame sizes where practicable.

A Note has been added to point users to additional information in the Annex. The Annex and its two tables will be identified later.

15.4 Motor mounting and compartments

Replace "NFPA 79-1997, 18.1 Access" and its paragraph as well as "18.2 Mounting arrangement" and its paragraph 18.2.1 with "15.4 Motor mounting and compartments" and paragraph 15.4.1.

This combines information into one paragraph and will provide additional guidance as to the proper care of the motors, what is expected and caution against damage exposure. Specific text concerning sealed bearings is no longer necessary and is better addressed in motor standards.

The words "from physical damage" was inserted in 15.4.1 to specifically state the type of protection desired.

NFPA 79-1997, 18.2.3 and 18.2.4 text is adequately covered in the proposed 15.4.1 1st sentence.

NFPA 79-1997, 18.2.2 text is adequately covered in the proposed 15.4.2.

NFPA 79-1997, 18.4 is adequately covered by proposed 15.4.3 and 15.4.4. "Raceway" is the more generic term, replacing "conduit". "Pipe" incorrectly implies non-electrical fittings can be used.

15.5 Criteria for selection

There is no comparable NFPA 79 text, this will provide selection guidance for motor applications and is intended to cover all types of motors because of the proliferation of AC, DC, servomotors and the like.

15.6 Protective devices for mechanical protection

There is no comparable NFPA 79 text. This new text enhances safety by stopping the machine when the overcurrent device operates provided the machine has a brake.

15.7 Direction Arrow

Retained NFPA 79-1997 18.3 and renumbered for sequencing.

15.8 Marking on Motors

Retained NFPA 79-1997 18.5 and renumbered for sequencing.

Attachment C – Cross reference for clause number changes between NFPA 79-1997 Clause 18 and new Clause 15.

<table>
<thead>
<tr>
<th>From 1997 NFPA 79</th>
<th>To 2002 NFPA 79 Edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>15.1</td>
<td>New</td>
</tr>
<tr>
<td>15.2</td>
<td>Reserved</td>
</tr>
<tr>
<td>15.3</td>
<td>New</td>
</tr>
<tr>
<td>15.4</td>
<td>18.1</td>
</tr>
<tr>
<td>15.4.1</td>
<td>18.2</td>
</tr>
<tr>
<td>15.4.2</td>
<td>18.2.3</td>
</tr>
<tr>
<td>15.4.3</td>
<td>18.4</td>
</tr>
<tr>
<td>15.4.4</td>
<td>18.4</td>
</tr>
<tr>
<td>15.8</td>
<td>18.5</td>
</tr>
<tr>
<td>15.4.4</td>
<td>18.4</td>
</tr>
<tr>
<td>15.5</td>
<td>New</td>
</tr>
<tr>
<td>15.6</td>
<td>New</td>
</tr>
<tr>
<td>15.7</td>
<td>18.3</td>
</tr>
<tr>
<td>15.8</td>
<td>18.3</td>
</tr>
</tbody>
</table>

COMMITTEE ACTION: Accept in Principle.

Revise NFPA 79-1997 Clause 18 “Motor and motor compartments” and issue as new Clause 15 “Electric motors and associated equipment” as follows:

15 Electric motors and associated equipment

15.1 General requirements

Motors shall be suitable for the environment in which they are installed.

NOTE 1: For additional information related to motor standards, refer to UL 1004, NEMA MG-1, IEEE 841 or IEC60034-1.

NOTE 2: The protection requirements for motors and associated equipment are given in 7.2 for overcurrent protection, in 7.3 for overload protection, and in 7.6 for overspeed protection.

15.2 [Reserved]

15.3 Motor dimensions

As far as is practicable, the dimensions of the motors shall comply with those given in NEMA MG-1, IEC 60072-1 or IEC 60072-2 as appropriate.

Note: For a comparison between kilowatt and horsepower size, see Annex X Tables X.1 and X-2

15.4 Motor mounting and compartments

15.4.1 Each motor and its associated couplings, belts and pulleys, or chains and sprockets, shall be so mounted that they are adequately protected from physical damage and are easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be such that all motor hold-down means can be removed and all terminal boxes are accessible. An adjustable base or other means of adjustment shall be provided when belt or chain drives are used.

15.4.2 Motors shall be mounted so that proper cooling is assured and the temperature rise remains within the limits of the insulation class.

15.4.3 Motor compartments shall be clean and dry, and when required, shall be ventilated directly to the exterior of the machine. The vents shall be such that ingress of swarf, dust, or water spray is at an acceptable level.

15.4.4 There shall be no opening between the motor compartment and any other compartment that does not meet the motor compartment requirements. Where a raceway is run into the motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the raceway shall be sealed.

15.5 Criteria for selection

The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environment conditions (see 4.4). The points that shall be considered include:

- type of motor;
- type of duty cycle;
- fixed speed or variable speed operation, and consequent variable influence of the ventilation; mechanical vibration;
- type of converter for motor speed control;
- influence of the harmonic spectrum of the voltage and/or current feeding the motor (when it is supplied from a converter) on the temperature rise;
- method of starting and possible influence of the inrush current on the operation of other users, taking into account possible special considerations stipulated by the supply authority;
- variation of counter torque load with time and speed;
15 Electric motors and associated equipment

**Recommendation:** Revise Clause 15 heading “18 Motors and motor compartments” to harmonize with IEC Clause 15 heading. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** This clause addresses more than just motors and motor compartments.

### 15.1 General requirements

**Recommendation:** This first paragraph retains the present text of NFPA 79-1997 Section 5.2. Notes 1 and 2 have been new. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** Note 1 is provided to assist users in locating appropriate motor standards, and Note 2 permits users to quickly access related information.

A global change also provides a numbering system to multiple paragraph clauses and notes to further assist the user.

### 15.2 [Reserved]

**Recommendation:** Retain reserved number.

**Substantiation:** This will serve as a placeholder for future use.

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>15</th>
<th>18</th>
<th>Electric Motors and associated equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.1</td>
<td></td>
<td>18</td>
<td>Substantiation is a technical statement explaining why a requirement has been added, deleted or changed from the existing NFPA 79-1997. The substantiation is almost non-existent. Please furnish the committee with technical substantiation. Also, the committee is having a hard time understanding exactly what was changed from the 1997 NFPA 79.</td>
</tr>
<tr>
<td>15.2</td>
<td>15</td>
<td>5</td>
<td>Delete the reference &quot;(see 4.4)&quot;</td>
</tr>
</tbody>
</table>

| 15.3 Motor dimensions

**Recommendation:** This new text provides information on a subject not presently in NFPA 79-1997. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** This text is comparable to the requirements of IEC 60204-1, Clause 15. The references will enable users to determine standard motor frame sizes.

A Note has been added to direct users to additional information in Annex G.

### 15.4 Motor mounting and compartments

**Recommendation:** Add title to the clause.

**Substantiation:** The title was added to follow the editing requirements of the Manual of Style April 2000.

#### 15.4.1

**Recommendation:** Combine "NFPA 79-1997, 18.1 Access" and its paragraph as well as "18.2 Mounting arrangement" and its first paragraph first sentence of 18.2.1 into "15.4 Motor mounting and compartments" and paragraph 15.4.1. Delete the second sentence of present 18.2.1. Section 18.2.3 is combined into clause 15.4.1 first sentence. Section 18.2.4 is considered adequately covered by the general requirements of the first sentence of clause 15.4.1. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** This combines information from several sections into one clause and provides additional guidance for the proper maintenance of the motors, what is expected, and cautions against damage exposure. Specific text concerning sealed bearings is better addressed within motor standards.

The words “from physical damage” is inserted in 15.4.1 to specifically state the type of protection desired. The last sentence is added to ensure means of adjustment are provided.

#### 15.4.2

**Recommendation:** Incorporate present section 18.2.2 of present NFPA 79-1997 into clause 15.4.2. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** The proposed text provides additional clarity. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

#### 15.4.3

**Recommendation:** Incorporate the first sentence of present NFPA 79-1997 section 18.4 into clause 15.4.3. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

**Substantiation:** Present section 18.4 covered two separate issues and separating them provides greater clarity. The proposed wording provides additional information concerning motor ventilation.
15.4.4

Recommendation: Move the second and third sentences of present NFPA 79-1997 section 18.4 to clause 15.4.4. Replace "conduit or pipe" with "raceway". This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

Substantiation: "Raceway" is the more generic term, and "pipe" incorrectly implies non-electrical fittings can be used.

15.5 Criteria for selection

Recommendation: This new text provides selection guidance for motor applications. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

Substantiation: There is no comparable NFPA 79-1997 text and it is intended to cover all types of motors because of the proliferation of AC, DC, servomotors and the like.

15.6 Protective devices for mechanical protection

Recommendation: There is no comparable NFPA 79 text. This proposal is part of the package of material submitted by the NFPA WG subcommittee derived from SAE HS-1738 review of IEC 60204-1.

Substantiation: This new text enhances safety by positive stopping of the machine in the event the overcurrent device operates and the machine relies upon a brake to halt operation.

15.7 Direction Arrow

Recommendation: Retain present section 18.3 NFPA 79-1997 18.3 and renumber as clause 15.7.


15.8 Marking on Motors

Recommendation: Retain present section 18.5 NFPA 79-1997 and renumber as clause 15.8.


Note: The terms protective earthing conductor, protective bonding conductor, protective conductor, neutral, and earth are used in other countries.

8.1.1 Connections

Grounded conductors shall not be connected to the equipment grounding (protective bonding) circuit except for at separately derived systems.

8.2 Equipment grounding (protective bonding) circuit

8.2.1 Grounding system

The equipment grounding (protective bonding) circuit consists of:

(1) The equipment grounding (PE) terminal(s);

(2) The conductive structural parts of the electrical equipment and the machine;

(3) The equipment grounding (protective) conductors and equipment bonding jumpers

All parts of the equipment grounding (protective bonding) circuit shall be capable of withstanding the highest thermal and mechanical stress that can be caused by fault currents which could flow in that part of the circuit.

All exposed conductive parts of the electrical equipment and the machine(s) shall be connected to the equipment grounding (protective bonding) circuit.

Exception: Small parts such as screws, rivets and nameplates that are not likely to become energized shall not be required to be grounded.

8.2.1.1 Equipment grounding

The machine and all exposed, noncurrent-carrying conductive parts, material, and equipment likely to be energized shall be effectively grounded. Where electrical devices are mounted on metal mounting panels that are located within nonmetallic enclosures, the metal mounting panels shall be effectively grounded.

8.2.1.2 Equipment grounding terminal

(1) For each incoming supply, an equipment grounding (external protective) conductor terminal shall be provided in the vicinity of the associated phase conductor terminals.

(2) All of the items in 8.2.1.1 shall be interconnected to this terminal.

(3) The terminal shall accommodate an equipment grounding conductor sized in accordance with Table XX.

Note: The minimum cross sectional area of the external protective copper conductor may be required to be larger for IEC applications. See Table 1, IEC 60269-1 for these requirements.

8.2.1.2.1 Equipment grounding terminal marking

The equipment grounding terminal shall be identified with the word "GROUND," the letters "GND" or "GRD," the letter "G," by coloring the terminal GREEN or the following symbol. In addition to the required marking, the letters PE shall also be permitted to identify this terminal.

NOTE: Some other standards require the letters PE for the connection to the external protective earthing system.

Exception: Where an attachment plug and receptacle are used as the disconnecting means, 5.3.3.3 shall apply.
8.2.2 Equipment grounding (protective) conductors and bonding jumpers.

Equipment grounding (protective) conductors and bonding jumpers shall be identified in accordance with 14.2.2.

8.2.2.1 Conductors used for grounding and bonding purposes shall be copper. Stipulations on stranded and flexing as outlined in this standard shall apply.

8.2.2.2 Equipment grounding conductors and bonding jumpers shall be insulated, covered, or bare and shall be protected against physical damage.

8.2.2.3 Equipment grounding conductors and bonding jumpers of the wire type shall not be smaller than shown in Table XX.

Table XX — Size of equipment grounding conductors and bonding jumpers

<table>
<thead>
<tr>
<th>Column “A,” Amperes</th>
<th>Copper Conductor Size, AWG or kcmil</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>16 * or 18 *</td>
</tr>
<tr>
<td>15</td>
<td>14, 16 *, or 18 *</td>
</tr>
<tr>
<td>20</td>
<td>12, 14 *, 16 *, or 18 *</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>100</td>
<td>6</td>
</tr>
<tr>
<td>200</td>
<td>4</td>
</tr>
<tr>
<td>300</td>
<td>3</td>
</tr>
<tr>
<td>400</td>
<td>2</td>
</tr>
<tr>
<td>500</td>
<td>1</td>
</tr>
<tr>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>2/0</td>
</tr>
<tr>
<td>1200</td>
<td>3/0</td>
</tr>
<tr>
<td>1600</td>
<td>4/0</td>
</tr>
<tr>
<td>2000</td>
<td>250</td>
</tr>
<tr>
<td>2500</td>
<td>350</td>
</tr>
<tr>
<td>3000</td>
<td>400</td>
</tr>
<tr>
<td>4000</td>
<td>500</td>
</tr>
<tr>
<td>5000</td>
<td>700</td>
</tr>
<tr>
<td>6000</td>
<td>800</td>
</tr>
</tbody>
</table>

* Permitted only in multiconductor cable where connected to portable or pendant equipment.

(1) Column "A" indicates the maximum rating or setting of the overcurrent device in the circuit ahead of the equipment.

(2) It shall be permitted to use machine members or structural parts of the electrical equipment in the equipment grounding circuit provided that the cross-sectional area of these parts is at least electrically equivalent to the minimum cross-sectional area of the copper conductor required.

8.2.3 Continuity of the equipment grounding (protective bonding) circuit

8.2.3.1 The continuity of the equipment grounding (protective bonding) circuit shall be ensured by effective connections through conductors or structural members.

8.2.3.2 Removing a device shall not interrupt the continuity of the equipment grounding (protective) circuit.

8.2.3.3 Bonding of equipment with bolts or other identified means shall be permitted where paint and dirt are removed from the joint surfaces or where the bonded members are effectively penetrated.

8.2.3.4 Moving machine parts, other than accessories or attachments, having metal-to-metal bearing surfaces shall be considered as bonded. Sliding parts separated by a nonconductive fluid under pressure shall not be considered as bonded.

8.2.3.5 Raceways, wireways, and cable trays shall not be used as equipment grounding or bonding conductors.

8.2.3.6 Doors or Covers.

(1) Where electrical devices are mounted on conductive doors or covers, an equipment (protective) bonding jumper shall be installed.

(2) An equipment (protective) bonding jumper shall connect the conductive door or cover to the equipment enclosure or to an equipment grounding (protective bonding) terminal within the enclosure.

8.2.3.7 Portable, pendant, and resilient-mounted equipment shall be bonded by separate conductors. Where multiconductor cable is used, the bonding conductor shall be included as one conductor of the cable.

8.2.3.8 Where equipment grounding conductors are subject to physical damage they shall be protected or be monitored to ensure continuity.

8.2.4 Exclusion of switching devices

The equipment grounding (protective) circuit shall not contain any switches or overcurrent protective devices. Links or plugs in the grounding circuit shall be permitted if properly labeled or interlocked with the control circuits.

8.2.7 Equipment grounding (protective) conductor connecting points

(1) All equipment grounding (protective) conductors shall be terminated in accordance with 14.1.1. The equipment grounding (protective) conductor connecting points shall have no other function.

(2) The equipment grounding conductor connecting points, other than the equipment grounding terminal, shall be identified by a green color or by use of the symbol that appears in 8.2.1.2.1.

Note: The letters PE or the bicolor green and yellow is used in some countries.

8.3 Control circuits

Control circuits shall be permitted to be grounded or ungrounded. Where grounding is provided, that side of the circuit common to the coils shall be grounded at the control transformer if alternating current or at the power supply terminal if direct current. Where grounding is not provided, an insulation monitoring system shall be utilized as described in 9.4.2.1.

Exception No. 1: Exposed control circuits as permitted by 6.4 shall be grounded.

Exception No. 2: Overload relay contacts shall be permitted to be connected between the coil and the grounded conductor where the conductors between such contacts and coils of magnetic devices do not extend beyond the control enclosure.

Exception No. 3: NFPA 70, Article 725, Class 2, low voltage circuits shall not require insulation monitoring.

8.5 Lighting circuits

8.5.1 One conductor of all machine lighting and maintenance lighting circuits shall be grounded. The grounded conductor(s) shall be identified in accordance with 14.2, Identification of conductors.

8.5.2 Where the lighting circuit is supplied by a separate isolation transformer, the grounding shall occur at the transformer. Where the equipment maintenance lighting circuit is supplied directly from the plant lighting circuit, the grounding shall occur at the grounding terminal.

8.5.3 The grounded conductor, where run to a screw-shell lampholder, shall be connected to the screw-shell.

SUBSTANTIATION: Historical Background.

In March of 1998, the NFPA 70 committee prepared a statement of work. The major elements of the statement of work are:
NFPA 79 — May 2002 ROP — Copyright 2001, NFPA

Harmonization - Purpose

As the users and the manufacturers of industrial machines move toward a global manufacturing community, the need for a harmonized standard affecting industrial machinery becomes an economic necessity. Generally, large users and manufacturers find regulations burdensome. However, multiple regulations as well as conflicting regulations are an economic disincentive to global expansion. In order to ease the burden of differing regulation, and at the same time maintain the high standard of electrical machine safety, the NFPA 79 committee has expressed their desire, through balloted vote, to harmonize NFPA 79 with IEC 60204-1.

Importance of Issue - Harmonization

Today’s industrial machines are very complex and expensive. As manufacturing lines become modular and transportable, industrial machines originally produced for a foreign market may quickly be transported to the domestic market. The reverse is also true. Differing electrical standards add a large cost to multinational manufacturers as they build and sometimes move manufacturing facilities.

Harmonization - Objective

This work is necessary to accomplish the goal of allowing industry to economically build one industrial machine capable of passing a detailed electrical safety inspection using either IEC 60204-1 or NFPA 79 standard.

Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result

The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause 19 with IEC 60204-1 Clause 8. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber Clause 19 of NFPA 79-1997 to correspond with IEC 60204-1. The Task Group proposes the following changes to further improve usability.

Clause 19 (1997 NFPA) has been proposed to be revised for the reasons provided according to each subdivision. The general requirements have been relocated to follow the format of IEC 60204-1 to increase the ease of applying this standard on a global level. The numbering sequence may have gaps to continue to match IEC 60204-1 as much as possible. Editorial changes have been made to improve usability. Additional terms as used in the NEC have been added.

Proposed (new) reference numbers are used as a “base” to facilitate an understanding of the intended concept.

Change the title of Clause 8 to Grounding. The term grounding (as used in the NEC) includes requirements for bonding, grounding and grounded conductors. Equivalent terms were added in parenthesis throughout this clause to increase the ease of globally using this standard.

8.1 Revised existing NFPA79, 1997, subclause 19.1. The proposed language provides a clear description of what this clause covers and allows for a more global application. The figure will help the user with the application of this Clause.

8.1.1 Connections. Inserted new text. This requirement has been highlighted in NEC Article 250 in sections 250-30 and 250-142(b) and needs to be in NFPA 79. Connections between grounded conductors and equipment grounding paths, at more than one location, allow objectionable current to flow and should specifically be prohibited.

8.2. Provides more detail about what the subclause covers.

8.2.1 Provides the information from 19.1 in a list. The satisfactory performance of the equipment grounding path is necessary for safety. Small parts that are not likely to become energized should not have to be grounded.

8.2.1.1 The text from 19.3 was editorially improved.

8.2.1.2 The text from 19.5 was editorially improved and relocated here to provide a better organizational structure.

8.2.1.2.1 Identification means for the equipment grounding terminal should be provided in the body of the standard. The proposed requirement corresponds with the NEC requirements. The appropriate new reference to replace 7.11, as used in 19.5 of NFPA 1997 needs to be inserted here.

Table XX. Revise existing Table 14 (in 1997 NFPA 79) as provided. Overcurrent device sizes and corresponding conductor sizes are necessary for large machines. The information was copied from Table 250-122 of the 1999 NEC.

8.2.2 Inserted new text and clarified the heading. A requirement, for identifying equipment grounding conductors, needs to be in this Clause.

8.2.2.1 Relocated existing text from 19.2.1.

8.2.2.2 Text from 19.2.2 was relocated here to increase the ease of applying this standard on a global level.

8.2.2.3 Revised and combined the existing language from NFPA 79, 1997 19.2.3 and 19.2.4 to improve usability. The table has been revised to include larger conductor size and is similar to NEC Section 250-122. Bonding jumpers were added because size requirements are also applicable to them. The replacement reference number for the existing Table 14 in NFPA 79 needs to be included here.

8.2.3 Revised existing NFPA 79, 1997, 19.6 by inserting the word “equipment” throughout entire 8.2.3.

8.2.3.2 Editorial revision to NFPA 79-1997, 19.6.6

8.2.3.3 Relocated from existing NFPA 79, 1997 19.6.2 and editorially revised for clarity.

8.2.3.4 Relocated from existing NFPA 79, 1997 19.6.3

8.2.3.5 Relocated from existing NFPA 79, 1997 19.6.5 and inserted the word “equipment.”

8.2.3.6 Where devices are located on doors suitable bonding must be provided. Covers can be removed rendering them ungrounded posing a shock hazard.

8.2.3.7 Relocated from existing NFPA 79, 1997 19.6.4

8.2.3.8 Added a new requirement. The continuity of the equipment grounding circuit is necessary for safety.

8.2.4 Relocated from existing NFPA 79-1997, 19.4 and inserted the word “equipment.”

8.2.7 Added new text. The continuity of the equipment grounding conductor termination is important for safety and should not be used for an additional function. The note alerts the user of other concerns.

8.3 Relocated from existing NFPA 79, 1997, 19.7. A sentence was added for insulation monitoring to correlate with 9.4.2.1. Exception No. 3 was added to permit ungrounded Class 2 circuits without insulation monitoring as provided in the NEC.
8.5 Relocated from existing NFPA 79, 1997, 19.8.

8.5.1 Relocated from existing NFPA 79, 1997, 19.8.1. The identification requirement points to Clause 14 to provide all conductor identification requirements in one location. The specific reference number is provided based on preliminary information from the proposed Clause 14 and needs verification of being correct pending action on Clause 14.

8.5.2 Relocated from existing NFPA 79, 1997, 19.8.2.

8.5.3 Relocated from existing NFPA 79, 1997, 19.8.3.

NFPA 79 Grounding Cross Reference Chart

Clause 8 (NEW) Clause 19 (1997)

<table>
<thead>
<tr>
<th>A. Cross Reference from Clause 8 (NEW) to Clause 19 (1997 NFPA 79)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Grounding</td>
</tr>
<tr>
<td>8.1 General</td>
</tr>
<tr>
<td>8.1.1 Connections</td>
</tr>
<tr>
<td>8.2 Equipment grounding (protective bonding) circuit</td>
</tr>
<tr>
<td>8.2.1 Grounding system</td>
</tr>
<tr>
<td>8.2.1.1 Equipment grounding</td>
</tr>
<tr>
<td>8.2.1.2 Equipment grounding terminal</td>
</tr>
<tr>
<td>8.2.1.2.1 Equipment grounding terminal marking</td>
</tr>
<tr>
<td>8.2.2 Equipment grounding (protective) conductors and bonding jumpers.</td>
</tr>
<tr>
<td>8.2.2.1</td>
</tr>
<tr>
<td>8.2.2.2</td>
</tr>
<tr>
<td>8.2.2.3</td>
</tr>
<tr>
<td>8.2.2.3(2)</td>
</tr>
<tr>
<td>8.2.3 Continuity of the equipment grounding (protective bonding) circuit</td>
</tr>
<tr>
<td>8.2.3.1</td>
</tr>
<tr>
<td>8.2.3.2</td>
</tr>
<tr>
<td>8.2.3.3</td>
</tr>
<tr>
<td>8.2.3.4</td>
</tr>
<tr>
<td>8.2.3.5</td>
</tr>
<tr>
<td>8.2.3.6 Doors or Covers</td>
</tr>
<tr>
<td>8.2.3.7</td>
</tr>
</tbody>
</table>

Title Changed to match NEC
Simplified the Clause statement
Added Text
Added Heading
Listed the system components
Editorial improvements
Editorial improvements
Simplified heading and added the identification means
Expanded heading
No change
No change
Added bonding jumpers and combined text
Inserted "equipment"
Inserted "equipment"
No change
No change
Inserted "equipment"
Added bonding requirement for devices on doors.
No change
A. Cross Reference from Clause 8 (NEW) to Clause 19 (1997 NFPA 79) (continued)

<table>
<thead>
<tr>
<th>Clause</th>
<th>1997 NFPA 79</th>
<th>NEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.2.3.8</td>
<td>No comparable text</td>
<td>Added continuity requirement</td>
</tr>
<tr>
<td>8.2.4 Exclusion of switching devices</td>
<td>19.4 Exclusion of switching devices</td>
<td>Inserted &quot;equipment&quot;</td>
</tr>
<tr>
<td>8.2.7 Equipment grounding (protective) conductor connecting points</td>
<td>No comparable text</td>
<td>Added Text</td>
</tr>
<tr>
<td>8.3 Control circuits</td>
<td>19.7 Control circuits</td>
<td>Added Ex. No. 3</td>
</tr>
<tr>
<td>8.5 Lighting circuits</td>
<td>19.8 Lighting circuits</td>
<td>No change</td>
</tr>
<tr>
<td>8.5.1</td>
<td>19.8.1</td>
<td>Added specific reference to 14</td>
</tr>
<tr>
<td>8.5.2</td>
<td>19.8.2</td>
<td>No change</td>
</tr>
<tr>
<td>8.5.3</td>
<td>19.8.3</td>
<td>No change</td>
</tr>
<tr>
<td>Table XX</td>
<td>Table 14 Size of grounding conductors</td>
<td>Added larger conductor sizes.</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Clause</th>
<th>1997 NFPA 79</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 Grounded circuits and equipment grounding</td>
<td>8 Grounding</td>
</tr>
<tr>
<td>19.1 General</td>
<td>8.1, 8.2.1</td>
</tr>
<tr>
<td>No comparable text</td>
<td>8.1.1 Connections (New)</td>
</tr>
<tr>
<td>19.2 Grounding conductors</td>
<td>8.2.2</td>
</tr>
<tr>
<td>19.2.1</td>
<td>8.2.2.1</td>
</tr>
<tr>
<td>19.2.2</td>
<td>8.2.2.2</td>
</tr>
<tr>
<td>19.2.3</td>
<td>8.2.2.3</td>
</tr>
<tr>
<td>19.2.4</td>
<td>8.2.2.3(2)</td>
</tr>
<tr>
<td>19.3 Equipment grounding</td>
<td>8.2.1.1</td>
</tr>
<tr>
<td>19.4 Exclusion of switching devices</td>
<td>8.2.4</td>
</tr>
<tr>
<td>19.5 Grounding terminal</td>
<td>8.2.1, 8.2.1.2, 8.2.1.2.1</td>
</tr>
<tr>
<td>Table 14 Size of grounding conductors</td>
<td>Table XX</td>
</tr>
<tr>
<td>19.6 Continuity of the grounding circuit</td>
<td>8.2.3</td>
</tr>
<tr>
<td>19.6.1</td>
<td>8.2.3.1</td>
</tr>
<tr>
<td>19.6.2</td>
<td>8.2.3.3</td>
</tr>
<tr>
<td>19.6.3</td>
<td>8.2.3.4</td>
</tr>
<tr>
<td>19.6.4</td>
<td>8.2.3.7</td>
</tr>
<tr>
<td>19.6.5</td>
<td>8.2.3.5</td>
</tr>
<tr>
<td>19.6.6</td>
<td>8.2.3.2</td>
</tr>
<tr>
<td>19.7 Control circuits</td>
<td>8.5</td>
</tr>
<tr>
<td>19.8 Lighting circuits</td>
<td>8.5</td>
</tr>
<tr>
<td>19.8.1</td>
<td>8.5.1</td>
</tr>
<tr>
<td>19.8.2</td>
<td>8.5.2</td>
</tr>
<tr>
<td>19.8.3</td>
<td>8.5.3</td>
</tr>
</tbody>
</table>
COMMITTEE ACTION: Accept in Principle.
Revise to read as follows:

8 Grounding.

8.1 General. This clause provides for grounding, bonding and grounded conductor requirements.

Note: The terms protective earthing conductor, protective bonding conductor, protective conductor, neutral, and earth are used in other countries.

8.1.1 Connections. Grounded conductors shall not be connected to the equipment grounding (protective) circuit, except for, at separately derived systems.

8.2 Equipment grounding (protective bonding) circuit.

8.2.1 Grounding system. The equipment grounding (protective bonding) circuit consists of:

(1) The equipment grounding (PE) terminal(s);
(2) The conductive structural parts of the electrical equipment and the machine;
(3) The equipment grounding (protective) conductors and equipment bonding jumpers.

All parts of the equipment grounding (protective bonding) circuit shall be capable of withstanding the highest thermal and mechanical stress that can be caused by fault currents which could flow in that part of the circuit.

All exposed conductive parts of the electrical equipment and the machine(s) shall be connected to the equipment grounding (protective bonding) circuit.

Exception: Small parts such as screws, rivets and nameplates that are not likely to become energized shall not be required to be grounded.

8.2.1.1 Equipment grounding. The machine and all exposed, noncurrent-carrying conductive parts, material, and equipment likely to be energized shall be effectively grounded. Where electrical devices are mounted on metal mounting panels that are located within nonmetallic enclosures, the metal mounting panels shall be effectively grounded.

8.2.1.2 Equipment grounding terminal.

(1) For each incoming supply circuit, an grounding (external protective) conductor terminal shall be provided in the vicinity of the associated phase conductor terminals.
(2) All of the items in 8.2.1.1 shall be interconnected to this terminal.
(3) The terminal shall accommodate an equipment grounding conductor sized in accordance with Table XX.

Note: The minimum cross sectional area of the external protective copper conductor may be required to be larger for IEC applications. See Table 1, IEC 60204-1 for these requirements.

8.2.1.2.1 Equipment grounding terminal marking.

The equipment grounding terminal shall be identified with the word "GROUND," the letters "GND" or "GRD," the letter "G," by coloring the terminal GREEN or the following symbol. In addition to the required marking, the letters PE shall also be permitted to identify this terminal.

NOTE: Some other standards require the letters PE for the connection to the external protective earthing system.

Exception: Where an attachment plug and receptacle are used as the disconnecting means, 5.3.3.3 shall apply.

8.2.2 Equipment grounding (protective) conductors and bonding jumpers.

Equipment grounding (protective) conductors and bonding jumpers shall be identified in accordance with 14.2.2.

8.2.2.1 Conductors used for grounding and bonding purposes shall be copper. Stipulations on stranding and flexing as outlined in this standard shall apply.

8.2.2.2 Equipment grounding conductors and bonding jumpers shall be insulated, covered, or bare and shall be protected against physical damage.

8.2.2.3 Equipment grounding conductors and bonding jumpers of the wire type shall not be smaller than shown in Table XX. Equipment grounding conductors and bonding jumpers of the wire type shall not be smaller than shown in Table XX, but shall not be required to be larger than the circuit conductors supplying the equipment.

8.2.2.3.1 (4) It shall be permitted to use machine members or structural parts of the electrical equipment in the equipment grounding circuit provided that the cross-sectional area of these parts is at least electrically equivalent to the minimum cross-sectional area of the copper conductor required. <<this was note to table but was moved here according to Log #81>>

Table XX — Minimum Size of equipment grounding conductors and bonding jumpers

<table>
<thead>
<tr>
<th>Column “A,” Amperes</th>
<th>Copper Conductor Size, AWG or kcmil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Table XX</td>
</tr>
<tr>
<td>10</td>
<td>16 or 18</td>
</tr>
<tr>
<td>15</td>
<td>14-16 or 18</td>
</tr>
<tr>
<td>20</td>
<td>12-14, 16, or 18</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>200</td>
<td>6</td>
</tr>
<tr>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>400</td>
<td>3</td>
</tr>
<tr>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>600</td>
<td>1</td>
</tr>
<tr>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>2/0</td>
</tr>
<tr>
<td>1200</td>
<td>3/0</td>
</tr>
<tr>
<td>1600</td>
<td>4/0</td>
</tr>
<tr>
<td>2000</td>
<td>250</td>
</tr>
<tr>
<td>2500</td>
<td>350</td>
</tr>
<tr>
<td>3000</td>
<td>400</td>
</tr>
<tr>
<td>4000</td>
<td>500</td>
</tr>
<tr>
<td>5000</td>
<td>700</td>
</tr>
<tr>
<td>6000</td>
<td>800</td>
</tr>
</tbody>
</table>

* Permitted only in multicore conductor, where connected to portable or pendant equipment.

1. Column “A” indicates the maximum rating or setting of the overcurrent device in circuit ahead of the equipment.

2. It shall be permitted to use machine members or structural parts of the electrical equipment in the equipment grounding circuit provided that the cross-sectional area of these parts is at least electrically equivalent to the minimum cross-sectional area of the copper conductor required. <<moved to precede table according to Log #81>>

8.2.3 Continuity of the equipment grounding (protective bonding) circuit.

8.2.3.1 The continuity of the equipment grounding (protective bonding) circuit shall be ensured by effective connections through conductors or structural members.
8.2.3.2 Removing a device shall not interrupt the continuity of the equipment grounding (protective) circuit.

8.2.3.3 Bonding of equipment with bolts or other identified means shall be permitted where paint and dirt are removed from the joint surfaces or where the bonded members are effectively penetrated.

8.2.3.4 Moving machine parts, other than accessories or attachments, having metal-to-metal bearing surfaces shall be considered as bonded. Sliding parts separated by a nonconductive fluid under pressure shall not be considered as bonded.

8.2.3.5 Raceways, wireways, and cable trays shall not be used as equipment grounding or bonding conductors.

8.2.3.6 Doors or Covers.

(1) Where electrical devices are mounted on conductive doors or covers, an equipment (protective) bonding jumper shall be installed.

(2) An equipment (protective) bonding jumper shall connect the conductive door or cover to the equipment enclosure or to an equipment grounding (protective bonding) terminal within the enclosure.

8.2.3.7 Portable, pendant, and resilient-mounted equipment shall be bonded by separate conductors. Where multicore cable is used, the bonding conductor shall be included as one conductor of the cable.

8.2.3.8 Where equipment grounding conductors are subject to physical damage they shall be protected or be monitored to ensure continuity.

8.2.4 Exclusion of switching devices. The equipment grounding (protective) circuit shall not contain any switches or overcurrent protective devices. Links or plugs in the grounding circuit shall be permitted if properly labeled or interlocked with the control circuits.

8.2.7 Equipment grounding (protective) conductor connecting points.

(1) All equipment grounding (protective) conductors shall be terminated in accordance with 14.1.1. The equipment grounding (protective) conductor connecting points shall have no other function.

(2) The equipment grounding conductor connecting points, other than the equipment grounding terminal, shall be identified by a green color or by use of the symbol that appears in 8.2.1.2.1.

Note: The letters PE or the bicolor green and yellow is used in some countries.

8.3 Control circuits. Control circuits shall be permitted to be grounded or ungrounded. Where grounding is provided, that side of the circuit common to the coils shall be grounded at the control transformer if alternating current or at the power supply terminal if direct current. Where grounding is not provided, an insulation-monitoring system shall be utilized as described in 9.4.2.1. Ungrounded control circuits shall be provided with an insulation-monitoring device that either indicates a ground (earth) fault or interrupts the circuit automatically after a ground (earth) fault.

Exception No. 1: Exposed control circuits as permitted by 6.3 shall be grounded.

Exception No. 2: Overload relay contacts shall be permitted to be connected between the coil and the grounded conductor where the conductors between such contacts and coils of magnetic devices do not extend beyond the control enclosure.

Exception No. 3: NFPA 70, Article 725, Class 2, low voltage circuits shall not require insulation monitoring.

8.5 Lighting circuits.

8.5.1 One conductor of all machine lighting and maintenance lighting circuits shall be grounded. The grounded conductor(s) shall be identified in accordance with 14.2. Identification of conductors.
11.2.3 Electrical noise and transient suppression.

11.2.2 Subassemblies

- Manufacturer's recommendations.

11.2.1.1 Where specified by the manufacturer, components and conductive enclosures of power supplies shall be electrically insulating from the power supply housing.

11.2.1.2 Where specified by the manufacturer, components and conductive enclosures of power supplies shall be electrically insulating from the power supply housing.

All input/output racks (remote or local), processor racks, printed circuit boards, electronic components, and other miscellaneous solid state equipment shall

- Be used without modifications, on or with industrial machines, except to detect alterations made by the user.

- Be used without modifications, on or with industrial machines, except to detect alterations made by the user.

- Be used without modifications, on or with industrial machines, except to detect alterations made by the user.

11.2 Basic Requirements

- Listed or labeled electronic equipment shall be permitted to remain in service provided the modification does not affect the functions and performance of the equipment.

- Listed or labeled electronic equipment shall be permitted to remain in service provided the modification does not affect the functions and performance of the equipment.

- Listed or labeled electronic equipment shall be permitted to remain in service provided the modification does not affect the functions and performance of the equipment.

11.1 General

- This clause applies to all types of electronic equipment including programmable electronic systems, subassemblies, printed circuit boards, electronic components, and other miscellaneous solid state equipment.

- This clause applies to all types of electronic equipment including programmable electronic systems, subassemblies, printed circuit boards, electronic components, and other miscellaneous solid state equipment.

- This clause applies to all types of electronic equipment including programmable electronic systems, subassemblies, printed circuit boards, electronic components, and other miscellaneous solid state equipment.

11.1.1 This clause applies to all types of electronic equipment including programmable electronic systems, subassemblies, printed circuit boards, electronic components, and other miscellaneous solid state equipment.

11.1.2 Electronic equipment used as part of an industrial machine, including subassemblies, printed circuit boards, devices, internal wiring, and components must not be inspected at the time of installation of the industrial machine, except to detect alterations or damage, if the equipment has been listed by a qualified software testing laboratory.

11.1.3 Listed or labeled electronic equipment shall be permitted to be used without modifications, on or with industrial machines, where approved for the location and use.

11.2 Basic Requirements

- Equipment Grounding (Equipotential Bonding)

11.2.1 All input/output racks (remote or local), processor racks, and conductive enclosures of power supplies shall be electrically bonded together in accordance with the supplier's specifications and shall be connected to the equipment grounding (protective bonding) circuit.

11.2.1.1 Where specified by the manufacturer, components and conductive enclosures of power supplies shall be electrically bonded together in accordance with the supplier’s specifications and shall be connected to the equipment grounding (protective bonding) circuit.

11.2.2 Subassemblies

- Subassemblies shall be readily removable for inspection or replacement.

- Subassemblies shall be readily removable for inspection or replacement.

11.2.3 Electrical noise and transient suppression.
Both the NEC Technical Correlating Committee and the Standards Council reviewed the statement of work in July of 1998. The TCC unanimously recommended the following action to the Standards Council:

"The Technical Correlating Committee agrees with the efforts of the NFPA 79 committee to harmonize the technical requirements of NFPA 79 and IEC 60204, where feasible and where in concert with the NEC and its related codes and standards."

Result: The NFPA Standards Council considered and concurred with the recommendation. In June of 1999, the NFPA 79 Committee formed 20 Task Groups. Each Task Group was assigned one proposed new clause.

The Task Group compared NFPA-79-1997, Clause 20 with IEC 60204-1 Clause 11. The Task Group presented its work to the entire committee on several occasions for review and comment. This proposal is a result of that work.

The Task Group proposes to renumber NFPA 79-1997 Clause 20 to correspond with IEC 60204-1 Clause 11. The task group proposes the following changes to further improve usability.

11 Electronic Equipment

Revision: No change except numbering; Clause 20 now Clause 11

11.1 General

Revision: No change except numbering; subclause 20.1 now subclause 11.1

11.1.1 Add IEC 60204-1 subclause 11.1.

Substantiation: This new explanatory text clarifies the intent of subclause 11.1.

11.1.2 New subclause.

Substantiation: This new subclause covers a subject not presently in NFPA 79-1997 and it clarifies listed equipment used within industrial machines need not be separately inspected if listed by a qualified testing laboratory.

11.1.3 New subclause.

Substantiation: This new subclause covers a subject not presently in NFPA 79-1997 and it clarifies listed equipment is to be used without modification if approved for the location.

11.2 Basic requirements

Revision: No change except numbering; subclause 20.2 now subclause 11.2.

11.2.1 Equipment Grounding (Equipotential bonding)

Add the IEC 60204-1 subclause 11.2.2 heading.

Substantiation: The new subclause heading clarifies the intent of the subclause.

11.2.1.1 Revision: NFPA 79 paragraph 20.3.2 split in two subclauses.

Substantiation: This is old paragraph 20.3.2 except it is split into two subclauses for clarity.

11.2.1.2 Addition: Second part of paragraph 20.3.2.

Substantiation: This paragraph is the other half of 20.3.2. Split into two paragraphs to clarify the intent.

11.2.2 Subassemblies

Add new subclause heading.

Substantiation: The new heading clarifies the intent of the subclause.

Revision: No change except numbering; subclause 20.2.2 now subclause 11.2.2.

11.2.3 Electrical noise and transient

Add new subclause heading.

Substantiation: The new heading clarifies the intent of the subclause.

Revision: Change numbering from subclause 20.2.3 to 11.2.3 and add "or other appropriate means".

Substantiation: The revision clarifies other means may be used to achieve the same reduction in noise.

11.2.4 Output protection

Add new subclause heading.

Substantiation: The new heading clarifies the intent of the subclause.

Revision: No change except numbering; subclause 20.2.6 now 11.2.4.

11.3 Programmable equipment

Add the IEC 60204-1 subclause 11.3 heading.

Substantiation: The new heading clarifies the content of the subclause.

11.3.1 Software Modification

Add the IEC 60204-1 subclause 11.3.3 heading.

Substantiation: The new heading reads "modification" instead of "verification" which clarifies the content of the subclause.

Revision: No change except numbering; subclause 20.3.1 now 11.3.1.

11.3.2 Memory retention and protection

Add the IEC 60204-1 subclause 11.3.2 heading.

Substantiation: The new heading clarifies the content of the subclause.

11.3.2.1 Add the IEC 60204-1 subclause 11.3.2 first paragraph.

Substantiation: This subclause covers a subject not presently in NFPA 79-1997 and is from IEC 60204-1. It better addresses the issue of programmable electronic systems in NFPA 79 20.3.1 and clarifies the difference between memory alteration and program verification. See 11.3.3.

11.3.2.2 Revise NFPA 79 paragraph 20.2.5.

Substantiation: An editorial change. Intent of requirement not changed.

11.3.2.3 Revision: No change except numbering; subclause 20.2.4 now 11.3.2.3.

11.3.3 Software Verification

Add the IEC 60204-1 subclause 11.3.3.

Substantiation: This subclause covers a subject not presently in NFPA 79-1997. This text is comparable with the requirements of IEC 60204-1. Clause 11. This new subclause addresses the issue of being able to verify the software after installation and use.

11.3.4 Use in Safety-related functions

Add the IEC 60204-1 subclause 11.3.4 heading.

Substantiation: The new heading clarifies the content of the subclause.

Add new text from ANSI/RIA 15.06-1999.

Substantiation: This subclause covers a subject not presently in NFPA 79-1997. This text is somewhat comparable with the requirements from RIA and addresses the new technology in robotics used in industrial machinery. IEC 61508, UL 991, UL 1998 and VDE 0801 are the only published standard known to the committee that may be used for listing of Safety-related function.

11.4 Electronic drives

Add the IEC 60204-1 subclause 11.4 heading.

Substantiation: The new heading clarifies the intent of the subclause.

11.4.1 Add new requirements from the SAE/HS 1738 document.

Substantiation: This subclause covers a subject not presently in NFPA 79-1997. This text from SAE/HS 1738 document clarifies the issues related to automatic starting of motors containing embedded thermal protectors.
COMMITTEE ACTION: Accept in Principle.
Revise NFPA 79-1997 Clause 20 “Electronic equipment” and issue
as new Clause 11 “Electronic equipment” as follows:
11 Electronic Equipment
11.1 General
11.1.1 This clause applies to all types of electronic equipment
including programmable electronic systems, subassemblies,
printed circuit boards, electronic components, and other
miscellaneous solid state equipment.
11.1.2 Electronic equipment used as part of an industrial
machine, including subassemblies, printed circuit boards, devices,
internal wiring and components need not be required to be
inspected at the time of installation of the industrial machine,
except to detect alterations or damage, if the equipment has been
listed by a qualified electrical testing laboratory.
11.1.3 Listed or labeled electronic equipment shall be permitted
to be used without modifications, on or with industrial machines,
where approved for the location and use.
11.2 Basic Requirements
11.2.1 Equipment Grounding (Equipotential Bonding)
11.2.1.1 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.2.1.2 (Bonded to ground per manufacturer’s recommendations)
11.2.2 Subassemblies
11.2.2.1 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.2.2.2 (Subassemblies readily removable)
11.2.2.3 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.2.2.4 (Transient suppression) (Transient suppression)
11.2.3 Electrical noise and transient suppression
(new heading not in NFPA 79)
11.2.3.1 (new subclause not in NFPA 79)
11.2.3.2 (Loss of memory prohibit hazardous conditions)
(new heading not in NFPA 79)
11.2.3.3 (new subclause not in NFPA 79)
11.2.4 Output Protection
11.2.4.1 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.2.4.2 (Power supplies requiring memory)
(new heading not in NFPA 79)
11.2.4.3 (new subclause not in NFPA 79)
11.2.5 Power Supplies Requiring Memory
11.2.5.1 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.2.5.2 (Power supplies requiring memory)
(new heading not in NFPA 79)
11.2.5.3 (new subclause not in NFPA 79)
11.2.6 (Outputs controlled shall be protected)
11.2.6.1 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.2.6.2 (Loss of control prohibit hazardous conditions)
(new heading not in NFPA 79)
11.2.6.3 (new subclause not in NFPA 79)
11.2.7 (Subassemblies readily removable) (new heading not in NFPA 79)
11.2.7.1 (new subclause not in NFPA 79)
11.2.7.2 (Subassemblies readily removable)
(new heading not in NFPA 79)
11.3 Software Modification
11.3.1 Means shall be provided to prevent memory alteration by
unauthorized persons.
11.3.2 Loss of memory shall not result in a hazardous
condition.
11.3.3 Software Verification
11.3.3.1 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.3.3.2 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.3.4 Use in safety-related functions
11.3.4.1 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.3.4.2 (new heading not in NFPA 79) (new subclause not in NFPA 79)
11.3.5 Electronic Drives
11.3.5.1 Electronic Drives Safeguards
11.3.5.2 (Motor overloading and embedded thermal protection)
11.3.5.3 (new heading not in NFPA 79) (new subclause not in NFPA 79)
shall require special equipment or other means to access the
program (e.g., access code, key operated switch).
Exception: For reasons of safety, the manufacturer or supplier shall
be permitted to retain the right not to allow the user to alter the
program.
11.3.2 Memory Retention and Protection
11.3.2.1 Means shall be provided to prevent memory alteration by
unauthorized persons.
11.3.2.2 Loss of memory shall not result in a hazardous
condition.
11.3.2.3 Power supplies for electronic units that require memory
retention shall have battery back-up of sufficient capacity to prevent
memory loss for a period of at least 72 hours.
11.3.3 Software Verification. Equipment using reprogrammable
logic shall have means for verifying that the software is in
accordance with the relevant program documentation.
11.3.4 Use in Safety-Related Functions. Software and firmware-
based controllers used in place of hardware based components with
safety-related devices shall:
(a) Be designed such that any single safety related component or
firmware failure shall:
1) Lead to the shutdown of the system in a safe state, and
2) Prevent subsequent operation until the component failure
has been corrected.
(b) Provide protection equivalent to that of Supply the same
degree of safety achieved by using hardwired/hardware
components.
Note: For example, this degree of safety equivalency may be
achieved by using microprocessor redundancy, microprocessor
diversity, and self-checking.
(c) Be listed to an approved standard for safety-related
functions such as IEC 61508, UL 991 or UL 1998, or VDE 0801.
11.4 Electronic Drives
11.4.1 Electronic Adjustable Speed Drives Safeguards
Where load conditions or reduced speeds can cause motor
overheating, embedded motor thermal protection (effective over
the motor speed range) shall be provided and interlocked with the
electronic adjustable speed drive system.
Note: See 7.3 for requirements regarding automatic restarting of
motors.
COMMITTEE STATEMENT: Editorial corrections and
conversions for consistency were made to comply with the NFPA
Manual of Style.

Changes to 11.3.4 were made to avoid the possibility of being
misconstrued as allowing multiple levels of safety. References to
IEC and VDE standards were deleted because they are not
recognized North American safety standards.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
BLOODGOOD: See my Explanation of Negative for Proposal 79-77
(Log #12)

DOBROWSKI: Sections 11.1.2 and 11.1.3 should be expanded to
include "electrical" equipment and relocated to a general chapter
such as Chapter 4. The same issues apply to electrical equipment.

RECOMMENDATION:
FREUDENBERG: The definitions of listed, labeled, authority
having jurisdiction and other definitions have been extracted from
the NFPA rules governing committee projects and inserted into
NFPA 79. Changes to 11.1.2 and 11.1.3. These paragraphs do not require any additional testing or
inspection where electronic equipment is NOT listed or labeled,
however, where electronic equipment is listed or labeled
paragraphs clarify that the equipment need not be inspected again.
This is essentially the same provision in article 90-7 of the NEC.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The new proposed Chapter 9
(Proposal 79-62 (Log #46)) includes the existing requirements
from NFPA 79-1997 Clause 9. The new proposed Chapter 9 also
includes provisions to permit newer technologies. The NFPA 79-
1997 Clause 9 material has been moved to the new proposed
Chapter 11.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: The definitions of listed, labeled, authority
having jurisdiction and other definitions have been extracted from
the NFPA rules governing committee projects and inserted into
NFPA 79. Changes to 11.1.2 and 11.1.3. These paragraphs do not require any additional testing or
inspection where electronic equipment is NOT listed or labeled,
however, where electronic equipment is listed or labeled
paragraphs clarify that the equipment need not be inspected again.
This is essentially the same provision in article 90-7 of the NEC.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The new proposed Chapter 9
(Proposal 79-62 (Log #46)) includes the existing requirements
from NFPA 79-1997 Clause 9. The new proposed Chapter 9 also
includes provisions to permit newer technologies. The NFPA 79-
1997 Clause 20 material has been moved to the new proposed
Chapter 11.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
FREUDENBERG: The definitions of listed, labeled, authority
having jurisdiction and other definitions have been extracted from
the NFPA rules governing committee projects and inserted into
NFPA 79. Changes to 11.1.2 and 11.1.3. These paragraphs do not require any additional testing or
inspection where electronic equipment is NOT listed or labeled,
however, where electronic equipment is listed or labeled
paragraphs clarify that the equipment need not be inspected again.
This is essentially the same provision in article 90-7 of the NEC.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The new proposed Chapter 9
(Proposal 79-62 (Log #46)) includes the existing requirements
from NFPA 79-1997 Clause 9. The new proposed Chapter 9 also
includes provisions to permit newer technologies. The NFPA 79-
1997 Clause 9 material has been moved to the new proposed
Chapter 11.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
relevant points that are part of the equipment grounding (protective bonding) circuit; the measured voltage between the equipment grounding (PE) terminal and the points of test is not to exceed the values given in table 9 (refer to 8.2.2). Note The concepts of SELV are further explained in UL 60364-1.

19.7 Retesting. Provides a clear intent that after modifications or changes are made, the test may be conducted on machinery to verify the suitability of the grounding system and electrical insulation, especially in cases where a visual examination may not be adequate for a clear identification of the equipment grounding (protective bonding) circuit; the measured voltage between the equipment grounding (PE) terminal and the points of test is not to exceed the values given in table 9 (refer to 8.2.2).

19.2 Continuity of the Equipment Grounding (Protective Bonding) Circuit. It is normally difficult to clearly identify the suitability of the grounding circuit with only a visual examination. IEC 60364-6-61, clause 413.1.3.3 states: “The characteristics of protective devices (see subclause 413.1.3.8) and the circuit impedances shall be such that, if a fault of negligible impedance occurs anywhere in the installation between a phase conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within the specified time, the following condition fulfilling this requirement: $Z_{s} \times I_{a} \leq U_{a}$, where:

$Z$ is the impedance of the fault loop comprising the source, the live conductor up to the point of the fault and the protective conductor between the point of the fault and the source.

$I$ is the current causing the automatic operation of the disconnecting protective device within the time stated in Table 41A as a function of the nominal voltage $U$ or, under the condition stated in clause 413.1.3.5, within a conventional time not exceeding 5 s.

$U$ is the nominal a.c. r.m.s. voltage to earth.

19.3 Insulation resistance tests. This requirement defines a level of insulation resistance which is greater than the level required by the voltage tests.

19.4 Voltage tests. The electrical equipment shall withstand a test voltage applied for a period of at least one second between the conductors of all circuits and the equipment grounding (protective bonding) circuit, except for those circuits intended to operate at or below 30 volts (less than 42.4 volts peak). The test voltage shall:

- have a value of twice the rated supply voltage of the equipment plus 1000 V
- be supplied from an isolated power supply with a minimum rating of 500 VA.

Components that are not rated to withstand the test voltage shall be disconnected during testing.

19.5 Protection against residual voltages. Residual voltage tests shall be performed to ensure compliance with 6.2.4.

19.6 Functional tests. The functions of electrical equipment shall be tested, particularly those related to safety and safeguarding.

19.7 Retesting. Where a portion of the machine and its associated equipment is changed or modified, that portion shall be reverified and retested, as is appropriate (see 19.1).

SUBSTANTIATION: This proposal is part of a package of proposals to rewrite and harmonize NFPA 79, IEC 60204-1, and SAE HS-1738.

19.1 General. Testing is conducted on machinery to verify the suitability of the grounding system and electrical insulation, especially in cases where a visual examination may not be adequate for a clear identification of the equipment grounding (protective bonding) circuit; the measured voltage between the equipment grounding (PE) terminal and the points of test is not to exceed the values given in table 9 (refer to 8.2.2).
19.3 Insulation resistance tests. The insulation resistance measured at 500 V d.c. between the power circuit conductors and the equipment grounding (protective bonding) circuit shall be 1 MΩ. The test may be made on individual sections of the machine.

EXCEPTION—For certain parts of electrical equipment, incorporating for example bushbars, collector wire or collector bar systems or slip-ringing assemblies, a lower minimum value shall be permitted, but that value must be 50 kΩ or greater.

19.4 Voltage tests. The electrical equipment shall withstand a test voltage applied for a period of at least one second between the conductors of all circuits and the equipment grounding (protective bonding) circuit, except for those circuits intended to operate at or below 30 volts (less than 42.4 volts peak). The test voltage shall:

- have a value of twice the rated supply voltage of the equipment plus 1000 V

be supplied from an isolated power supply with a minimum rating of 500 VA.

Components that are not rated to withstand the test voltage shall be disconnected during testing.

19.5 Protection against residual voltages. Residual voltage tests shall be performed to ensure compliance with 19.2.

19.6 Functional tests. The functions of electrical equipment shall be tested, particularly those related to safety and safeguarding.

19.7 Retesting. Where a portion of the machine and its associated equipment is changed or modified, that portion shall be reverified, as appropriate.

COMMITTEE STATEMENT: 1) Remove all parenthetical reference notes to comply with the NFPA Manual of Style.

2) Require documentation of grounding continuity test in 19.1 in order to show or prove a prior test had been made.

3) Add UL 950 and UL 3101-1 to the note for explanation of SELV Circuits.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 21

NEGATIVE: 4

NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:

DEFELICE: 1) AWG 12 wire does not appear in Table 9 of 19.2.

2) Calculations derived using data from Chapter 9, Table 8 of NFPA 70-1999 show that the maximum permissible voltage drops from Table 9 of 19.2 are exceeded at the following conductor lengths (values for test current of 10 amps, as per table):

<table>
<thead>
<tr>
<th>AWG</th>
<th>Resistance from NFPA 70 Table 8</th>
<th>Rmax</th>
<th>Length at which Rmax is reached</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>0.00795 ohms/ft</td>
<td>0.33 ohms</td>
<td>4.5 ft.</td>
</tr>
<tr>
<td>16</td>
<td>0.00999 ohms/ft</td>
<td>0.20 ohms</td>
<td>29.1 ft.</td>
</tr>
<tr>
<td>14</td>
<td>0.0314 ohms/ft</td>
<td>0.19 ohms</td>
<td>60.5 ft.</td>
</tr>
<tr>
<td>10</td>
<td>0.0124 ohms/ft</td>
<td>0.14 ohms</td>
<td>112.9 ft.</td>
</tr>
<tr>
<td>8</td>
<td>0.00078 ohms/ft</td>
<td>0.10 ohms</td>
<td>129.8 ft.</td>
</tr>
</tbody>
</table>

It is not unusual for large machines to exceed these lengths; thereby exceeding the limits permitted by Table 9 of 19.2.

DOBROWSKY: The proposed test values are not practical for large machines. The phrase "where deemed necessary" is vague and will not result in consistent interpretations. See also my comments on Proposal 79-160 (Log #94).

MONTIEITH: The no vote is based upon the lack of panel substantiation for the departure in wording in the proposed NFPA 79-2002 Clause 19.2 from IEC 60204-1 Clause 19.2. IEC 60204-1 recommends tests that "may be performed to verify the continuity of the grounding circuit. The proposed NFPA 79 Clause 19.2 specifies the test and makes it mandatory. It is recommended that Clause 19.2 not mandate tests, but permit the builder to choose the testing methods they determine appropriate (see Proposal 79-160 (Log #94) for recommended wording).

PADGETT: The no vote is based upon the lack of panel substantiation for the departure in wording in the proposed NFPA 79-2002 Clause 19.2 from IEC 60204-1 Clause 19.2. IEC 60204-1 recommends tests that "may be performed to verify the continuity of the grounding circuit. The proposed NFPA 79 Clause 19.2 specifies the test and makes it mandatory. It is recommended that Clause 19.2 not mandate tests, but permits the builder to choose the testing methods they determine appropriate (see Proposal 79-160 (Log #94) for recommended wording). Defining test requirements and procedures is not within the scope of NFPA 79. The scope of NFPA 79 is to define the requirement for the "application of electrical/electronic equipment, apparatus, or systems supplied as part of industrial machines that will promote safety" as stated in Clause 1.6. Testing is the subject matter for other documents and standards (example is the note in Clause 19.1 referencing SEMI S9).

The many variables between different types of industrial machinery, (Annex B of NFPA 79-1997 contains a non-exhaustive list of examples), and even between individual machines of basically the same design, make the prescribed tests and incomplete test procedures of questionable merit. This makes it especially inappropriate for Clause 19.2 to deem these to be mandatory techniques. The details of such testing and test methods are better left to be specified for a given industrial machine by the manufacturer’s individual design team and as directed by company policies and procedures.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: Clause 19 has been sufficiently substantiated. There are methods and means to accomplish the testing required by Clause 19. For example, the Semiconductor Industry (See SEMI S9-1995, Electrical Test Methods for Semiconductor Manufacturing Equipment and S2-1996, Safety Guidelines for Semiconductor Manufacturing Equipment) has for nine years, performed similar tests on machines from table top size to large integrated systems.
19.4 The machine shall withstand the test voltage shall be disconnected during testing. The test described in the SEMI S9 standard basically requires the following:
- Use an impedance measuring device, taking into account any impedance in the measuring circuit. The measured impedance must be 0.1 ohms or less.
- Voltage (Dielectric) tests shall be completed in accordance with the requirements of SEMI S9 "Safety Guideline for Electrical Tests for Semiconductor Manufacturing Equipment".
- The test described in the SEMI S9 standard basically requires the electrical equipment power circuit wiring shall withstand a dielectric withstand potential of 1500 Volts AC or 2121 Volts DC applied for a period of at least one second between the conductors of all circuits and the equipment grounding (protective bonding) circuit.
- Substantiation: The SEMI S9 standard provides the basic philosophy of the test procedure, the safety precautions to use, the test equipment required, and the procedures to be used including the acceptable results.

Note: It is the intent that the reference to the SEMI S9 standard will be updated to the latest version of the document. A version of the DRAFT SEMI S9 Document is available at NFPA for review.

REVISE 19.2 and 19.4 as follows:

19.2 Continuity of the Equipment Grounding (Protective Bonding) Circuit
Verification of the continuity of the equipment grounding conductor shall be completed in accordance with the requirements of SEMI S9 "Safety Guideline for Electrical Tests for Semiconductor Manufacturing Equipment".

19.4 Voltage (Dielectric) tests
Voltage (dielectric) tests shall be completed in accordance with the requirements of SEMI S9 "Safety Guideline for Electrical Tests for Semiconductor Manufacturing Equipment".

The test described in the SEMI S9 standard basically requires a dielectric withstand potential of 1500 Volts AC or 2121 Volts DC applied for a period of at least one second between the conductors of all circuits and the equipment grounding (protective bonding) circuit.

Substantiation: The SEMI S9 standard provides the basic philosophy of the test procedure, the safety precautions to use, the test equipment required, and the procedures to be used including the acceptable results.

Note: It is the intent that the reference to the SEMI S9 standard will be updated to the latest version of the document. A version of the DRAFT SEMI S9 Document is available at NFPA for review.

REVISE 19.2 and 19.4 as follows:

19.2 Continuity of the Equipment Grounding (Protective Bonding) Circuit
Verification of the continuity of the equipment grounding conductor shall be completed in accordance with the requirements of SEMI S9 "Safety Guideline for Electrical Tests for Semiconductor Manufacturing Equipment".

19.4 Voltage (Dielectric) tests
Voltage (dielectric) tests shall be completed in accordance with the requirements of SEMI S9 "Safety Guideline for Electrical Tests for Semiconductor Manufacturing Equipment".

The test described in the SEMI S9 standard basically requires a dielectric withstand potential of 1500 Volts AC or 2121 Volts DC applied for a period of at least one second between the conductors of all circuits and the equipment grounding (protective bonding) circuit.

Substantiation: The SEMI S9 standard provides the basic philosophy of the test procedure, the safety precautions to use, the test equipment required, and the procedures to be used including the acceptable results.

Note: It is the intent that the reference to the SEMI S9 standard will be updated to the latest version of the document. A version of the DRAFT SEMI S9 Document is available at NFPA for review.
COMMENT ON AFFIRMATIVE:
FREUDENTBERG: Using one simple applied voltage of 1500Vac or 2121Vdc will harmonize NFPA79 with SEMI S9 such that the testing requirement and test methods are identical. The semiconductor industry balloted 1000Vac plus twice rated input and found major difference of opinion and confusion over whether rated input for 3 phase machines was rated phase-to-phase voltage or rated phase-to-ground voltage. We felt that since hypot is a phase-to-ground test the phase-to-ground voltage was the more appropriate voltage for the hypot test but the phase-to-phase voltage was the more common input voltage rating. Hence, one value of 1500Vac or 2121Vdc eliminated the confusion and controversy.

GARVEY: The words "primary and Class 1 circuits" should be used instead of "primary circuits". The term "primary circuits" is not commonly used in this context in other NFPA standards such as the NEC.

SAUNDERS: Revise Committee Statement to be: See Action on Proposal 79-160 (Log #94) as suggested in my comment on Negative ballot.

Substantiation: Action for 19.4 meets the intent of the submitter.

TCC NOTE: The TCC directs the committee to review the use of all NOTES throughout the document. The TCC recognizes that the committee desire is in conflict with the NFPA Manual of Style. However, the TCC offers two possible directions for the TC to proceed for this edition of NFPA 79.

Option 1: Convert all of the NOTES to FPN's (as used in the NEC). However, in doing so the committee must review each of the notes and adhere to the strict FPN guidelines as used in the NEC. The FPN cannot contain any requirements, alternatives, interpretations of the requirement, or permissive statements. Examples of unacceptable NOTES are found in, but are not limited to, 1.1 Note 1 (Proposal 79-8), 1.1 Note 2 (Proposal 79-8), 3.5 Note (Proposal 79-11), 3.20 Note (Proposal 79-11), 3.87 Note (Proposal 79-11), 4.4.2 Note (Proposal 79-24). If the material cannot be rewritten to comply with these rules, then it should be deleted.

The TCC would ask the NFPA Standards Council to allow this option for this edition of NFPA 79.

Option 2: The TC is to relocate all explanatory NOTES to Annex A of the document in accordance with the NFPA Manual of Style. In this arrangement, the required rules for the content of the NOTE is not as restrictive of the FPN concept used in the NEC. However, the explanatory material must not offer interpretations of the text, provide alternatives to the mandatory rules or contain requirements.

This action will be considered by the committee as a public comment.

SUBMITTER: John F. Bloodgood, JFB Enterprises

RECOMMENDATION: Add informative annex which contains the notes from the proposed normative text.

SUBSTANTIATION: This annex is in conformance with the requirements of the NFPA MOS which stipulates that all notes in the normative text be transferred to the first annex of the document.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: The committee does not believe that this Annex A as prescribed by the NFPA Manual of Style is user friendly. The committee desires to retain all of the informative or explanatory notes in the body of the normative text for the following reasons:

1. The organization of the standard has been extensively revised.
2. Existing technical requirements have been reworded to effect harmonization.
3. There are a number of technical concepts that are best explained in informative language.
4. The value of the notes is far superior where the notes are located in the body of the text.

Recognizing the Standards Council’s authority in the matter, the committee respectfully requests that the committee be given the liberty to place the notes in the body of the document for the 2002 document cycle.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
BLOODGOOD: I strongly support the Committee Action and Committee Statement regarding this proposal.

GARVEY: The users of the 2002 NFPA 79 will see a major change in the structure of the standard. In addition, the committee has proposed several significant new technical changes. Many current NFPA 79 requirements have been restated in language consistent with both IEC text and the NFPA manual of style. The committee has used the notes to assist the users of the document in finding and correctly applying the rules. Relocating the notes to an annex in the back of the book runs counter to the committee’s objective and will not facilitate the consistent and correct application of the standard.

FREUDENTBERG: The value and meaning of the fine print note is often lost when displaced from the normative text.

---

99-162 - ([Annex A (new)]): Reject

TCC NOTE: The TCC directs the committee to review the use of all NOTES throughout the document. The TCC recognizes that the committee desire is in conflict with the NFPA Manual of Style. However, the TCC offers two possible directions for the TC to proceed for this edition of NFPA 79.

Option 1: Convert all of the NOTES to FPN’s (as used in the NEC). However, in doing so the committee must review each of the notes and adhere to the strict FPN guidelines as used in the NEC. The FPN cannot contain any requirements, alternatives, interpretations of the requirement, or permissive statements. Examples of unacceptable NOTES are found in, but are not limited to, 1.1 Note 1 (Proposal 79-8), 1.1 Note 2 (Proposal 79-8), 3.5 NOTE (Proposal 79-11), 3.20 NOTE (Proposal 79-11), 3.87 NOTE (Proposal 79-11), 4.4.2 NOTE (Proposal 79-24). If the material cannot be rewritten to comply with these rules, then it should be deleted.

The TCC would ask the NFPA Standards Council to allow this option for this edition of NFPA 79.

Option 2: The TC is to relocate all explanatory NOTES to Annex A of the document in accordance with the NFPA Manual of Style. In this arrangement, the required rules for the content of the NOTE is not as restrictive of the FPN concept used in the NEC. However, the explanatory material must not offer interpretations of the text, provide alternatives to the mandatory rules or contain requirements.

This action will be considered by the committee as a public comment.

SUBMITTER: John F. Bloodgood, JFB Enterprises

RECOMMENDATION: Add informative annex to correspond to the normative text, similar to Annex B in IEC 60920-1 as follows:

Annex B (informative): Inquiry form for the electrical equipment of machines

NFPA 79: 2002 (Proposed)

It is recommended that the following information is provided by the intended user of the equipment. It facilitates an agreement between the user and supplier on basic conditions and additional user requirements to ensure proper design, application and utilization of the electrical equipment of the machine (see 4.1). See form on the following page.

---

79-163 - ([Annex B (New)]): Accept

SUBMITTER: John F. Bloodgood, JFB Enterprises

RECOMMENDATION: Add informative annex to correspond to the normative text, similar to Annex B in IEC 60920-1 as follows:

Annex B (informative): Inquiry form for the electrical equipment of machines

NFPA 79: 2002 (Proposed)

It is recommended that the following information is provided by the intended user of the equipment. It facilitates an agreement between the user and supplier on basic conditions and additional user requirements to ensure proper design, application and utilization of the electrical equipment of the machine (see 4.1). See form on the following page.
### Name of manufacturer/supplier

### Name of end user

### Tender/Order No. ________________________ Date ________________________

### Type of Machine/Serial Number

1. Are there to be modifications as allowed for within this standard? **YES** ____ **NO** ____

#### Operating Conditions - Special requirements (see 4.4)

2. Ambient temperature range

3. Humidity range

4. Altitude

5. Environmental (e.g. corrosive atmospheres, particulate matter, EMC)

6. Radiation

7. Vibration, shock

8. Special installation and operation requirements (e.g. flame retardant requirements for cables and conductors)

#### Power supply(ies) and related conditions (see 4.3)

9. Anticipated voltage fluctuations (if more than ± 10%)

10. Anticipated frequency fluctuations (if more than in 4.3.2)

#### Specification of short term value

11. Indicate possible future changes in electrical equipment that will require an increase in the electrical supply requirements

12. Indicate for each source of electrical supply required:
   - Nominal Voltage (V) ______ AC ____ DC ____
   - If AC, number of phases _____ frequency ____ Hz
   - Prospective short circuit current at the point of supply to the machine _____kA rms (see also question 15)
   - Fluctuations outside values given in 4.3.2

13. Type of power supply earthing (see IEC 364-3-31):
   - **TN** (System with one point directly earthed, with a protective conductor (PE) connected directly to that point) ____
   - **TT** (System with one point directly earthed but the protective conductor (PE) not connected to that earth point of the system) ____
   - **IT** (System that is not directly earthed) ____

14. Is the electrical equipment to be connected to a neutral (N) supply conductor? **YES** ____ **NO** ____

15. Does the user or the supplier provide the overcurrent protection of the supply conductors? (see 7.2.2)
   - Type and rating of overcurrent protective devices

16. Supply disconnecting device
   - Is the disconnection of the neutral (N) conductor required? **YES** ____ **NO** ____
   - Is a link for the neutral (N) permissible? **YES** ____ **NO** ____

17. Type of disconnecting device to be provided

18. Limit of power up to which three-phase AC motors may be started directly across the incoming supply lines? _______ HP (KW)

19. May the number of motor overload detection devices be reduced? (see 7.3) **YES** ____ **NO** ____

20. Where the machine is equipped with local lighting:
   - highest permissible voltage _______ V
   - if lighting circuit voltage is not obtained directly from the power supply, state preferred voltage _______ V

#### Other Considerations

21. Functional identification (see 17.3)

22. Inscriptions/Special Markings
   - Mark of Certification **YES** ____ **NO** ____ If YES, which one? ________________________
   - on Electrical Equipment? _______ In which language? ________________________

23. Technical documentation (see 18.1)
   - On what media _______ In which language? ________________________

24. Size, location, and purpose of ducts, open cable trays, or cable supports to be provided by the user (see 18.5) (additional sheets to be provided where necessary)
26. For which of the following classes of persons is access to the interior of enclosures required during normal operation of the equipment?
- Skilled persons
- Instructed persons

27. Are locks with removable keys to be provided for fastening doors or covers (see 6.2.2)?

28. Indicate if special limitations on the size or weight affect the transport of a particular machine or control equipment to the installation site:
- Maximum dimensions
- Maximum weight

29. In the case of machines with frequent repetitive cycles of operation dependent on manual control, how frequently will cycles of operation be repeated?

30. For what length of time is it expected that the machine will be operated at this rate without subsequent pause?

31. In the case of specially built machines, is a certificate of operating tests with the loaded machine to be supplied? YES ____ NO ____

32. In the case of other machines, is a certificate of operating type tests on a loaded prototype machine to be supplied? YES ____ NO ____

33. For cable-less control systems, specify the time delay before automatic machine shutdown is initiated in the absence of a valid signal (see 9.2.7.3)

34. Do you need a specific method of conductor identification to be used for the conductors referred to in 14.2.4.
- Yes__________  No__________ Type___________________________

SUBSTANTIATION: The inquiry form serves as the basis for a buyer-seller agreement for certain normative requirements in the standard.

COMMITTEE ACTION: Accept.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:
- AFFIRMATIVE: 25
- NOT RETURNED: 1 Norman

COMMENT ON AFFIRMATIVE:
- FREUDENBERG: Annex B is NOT normative text, but may be an information tool for custom products. For volume products the supplier manual or site prep guide would typically indicate similar information as part of the product specification.
- SANDERS: Annex B Inquiry form should be revised as follows:
(See form on the following pages.)
Annex B Inquiry form should be revised as follows (details of the proposed changes follow):

Annex B (informative): Inquiry form for the electrical equipment of machines

NFPA 79: 2002 Proposed

It is recommended that the following information is provided by the intended user of the equipment. It facilitates an agreement between the user and supplier on basic conditions and additional user requirements to ensure proper design, application and utilization of the electrical equipment of the machine (see 4.1).

Name of manufacturer/supplier ____________________________

Name of end user ____________________________

Tender/order no. ____________________________ Date __________

Type of machine/serial number ____________________________

1. Are there to be modifications as allowed for within this standard? YES ____ NO ____

   Operating conditions – Special requirements (see 4.4)

2. Ambient temperature range ____________________________

3. Humidity range ____________________________

4. Altitude ____________________________

5. Environmental (e.g. corrosive atmospheres, particulate matter, EMC) ____________________________

6. Non-ionizing radiation ____________________________

7. Vibration, shock ____________________________

8. Special installation and operation requirements (e.g. flame-retardant requirements for cables and conductors) ____________________________

Power supply(ies) and related conditions (see 4.3)

9. Anticipated voltage fluctuations (if more than ±10 %) ____________________________

10. Anticipated frequency fluctuations (if more than in 4.3.2) ____________________________

   Specification of short-term value ____________________________

11. Indicate possible future changes in electrical equipment that will require an increase in the electrical supply requirements ____________________________
12. Indicate for each source of electrical supply required:

Nominal voltage (V) AC _______ DC _______

If AC, number of phases ______ frequency ______Hz

Prospective short-circuit current at the point of supply to the machine ______kA rms

(see also question 15)

Fluctuations outside values given in 4.3.2

13. Type of power supply earthing system grounding (see IEC 60364-3):

- TN (system with one point directly earthed, with a protective conductor (PE) connected directly to that point) ______

- TT (system with one point directly earthed but the protective conductor (PE) not connected to that earth point of the system) ______

- IT (system that is not directly earthed) ______

Wye phases mid-point grounded ______ Delta phase mid-point grounded ______

Delta phases corner grounded ______ High impedance grounded ______

Wye phases mid-point ungrounded ______ Delta phases ungrounded ______

14. Is the electrical equipment to be connected to a neutral (N) supply conductor? (see 5.1) YES ______ NO ______

15. Does the user or the supplier provide the overcurrent protection of the supply conductors? (see 7.2.2) ______

Type and rating of overcurrent protective devices ______

16. Supply disconnecting device

- Is the disconnection of the neutral (N) conductor required? YES ______ NO ______

- Is a link for the neutral (N) permissible? YES ______ NO ______

- Type of disconnecting device to be provided? ______

17. Type of disconnecting device to be provided ______

18. Limit of power up to which three-phase a.c. motors may be started directly across the incoming supply lines? ______ HP kW
19. May the number of motor overload detection devices be reduced? (see 7.3)
   YES ________ NO ________

20. Where the machine is equipped with local lighting:
   - highest permissible voltage ________ V
   - if lighting circuit voltage is not obtained directly from the power supply, state preferred voltage ________ V

Other considerations

21. Functional identification (see 17.3)

22. Inscriptions/special markings

23. - Mark of certification YES _____ NO ______
   If YES, which one? ______________________________________
   - On electrical equipment? ________ In which language? ________

24. Technical documentation (see 18.1)
   On what media? ________ In which language? ______________________________________

25. Size, location, and purpose of ducts, open cable trays or cable supports to be provided by the user? (see 18.5) (additional sheets to be provided where necessary) ______________________________________

26. For which of the following classes of persons is access to the interior of enclosures required during normal operation of the equipment?
   - Skilled persons ______________________________________
   - Instructed persons ______________________________________

27. Are locks with removable keys to be provided for fastening doors or covers? (see 6.2.2) ______________________________________

28. Indicate if special limitations on the size or weight affect the transport of a particular machine or control equipment to the installation site:
   - maximum dimensions ______________________________________
   - maximum weight ______________________________________

29. In the case of machines with frequent repetitive cycles of operation dependent on manual control, how frequently will cycles of operation be repeated? ________ per hour

30. For what length of time is it expected that the machine will be operated at this rate without subsequent pause? ________ min

31. In the case of specially built machines, is a certificate of operating tests with the loaded machine to be supplied? YES ________ NO ________

32. In the case of other machines, is a certificate of operating type tests on a loaded prototype machine to be supplied? YES ________ NO ________

33. For cableless control systems, specify the time delay before automatic machine shutdown is initiated in the absence of a valid signal? (see 9.2.7.3): ________ seconds

34. Do you need a specific method of conductor identification to be used for the conductors referred to in 14.2.1? YES ________ NO ________ Type ________
Details of changes to Annex B.

1. Question 6 changed “Radiation” to “Non-ionizing radiation”.

2. Question 13 “earthing” changed to “system grounding” as more appropriate. IEC reference deleted as unnecessary, and TN, IT, and TT systems are terms not used within this standard. However, it is useful to provide information based upon the system to be encountered.

3. Question 18 “KW” changed to “HP” as term used in this Standard.

4. Question 33 “s” changed to “seconds” for MOS.

---

COMMITTEE ACTION: Accept in Principle.

Replace Annex D from NFPA 79-1997 with a new Annex D.

COMMITTEE STATEMENT: The committee agrees to update the annex material to that submitted by SAE.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

---

SANDERS:

Details of Annex D review:


CSA Z99 – 1975

1. Figure D-17 titles “ANSI Y32.2 – IEC 315/315A SYMBOL TABLE” should be changed to “ANSI Y32.2 – IEEE 315/315A SYMBOL TABLE” for editorial purposes. (The reference numbers added are for this discussion only and are not intended to be included in the final version of this Standard.)

The symbols in the left hand symbol table have been temporarily identified by numbering them from 1 through 15, top to bottom, along the left edge and the symbols in the right hand symbol table have been identified from 16 through 20, top to bottom, along the left edge.

Number 7. The description is wrong, and should be changed to:

“TIMED CONTACT, N.C.T.C.” (Timed switch with TD closing.)

Number 8. The description is wrong, and should be changed to:

“TIMED CONTACT, N.O.T.O.” (Open switch with TD opening.)

Number 9 & 10. They are the same except for the number of contacts shown. Delete Number 9 as redundant.

Number 19. No IEEE standard number. It uses 4.15.5.1 LIMIT SWITCH in a triangle; however, IEEE 315A Symbol number 14.4.6 uses 2 vertical lines between the upper and lower points for a proximity (non-touching) indicator. The non-standard symbol should be changed to the IEEE 14.4.6 type.

Number 20. Although this is a standard IEEE type for an indicator light, the IEEE version does not show lines emanating from 45°, 135°, 225°, and 315° and they should be deleted. A letter can be used to show the color.

---

SUBSTANTIATION: None given.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION:

AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

---

COMMITTEE ACTION: Accept.

SUBMITTER: John F. Bloodgood, JFB Enterprises


SUBSTANTIATION: None given.

---

Temporary Assigned Number | IEEE Number | Temporary Assigned Number | IEEE Number
--- | --- | --- | ---
1 | 4.3.2 | 16 | 4.19.1
2 | 4.3.1 | 17 | 4.20.1
3 | 4.3.2 | 18 | 4.15.5.1
4 | 4.3.1 | 19 | ----
5 | 4.16.1 | 20 | 11.2.7.1
6 | 4.16.2 | 21 | 5.3.4
7 | 4.16.4 | 22 | 4.5
8 | 4.16.3 | 23 | 4.5
9 | 4.6.2 & 4.7.1 | 24 | 4.5
10 | 4.6.2 & 4.7.1 | 25 | 4.5
11 | 4.7.1 | 26 | 4.5.3
12 | 4.7.2 | 27 | ----
13 | 4.25.4 | 28 | 9.4.5 & 9.4.6
14 | 4.18.1 | 29 | ----
15 | 4.17.1 | 30 | 9.1.1
The device and component designations given below are intended for use on diagrams in connection with the corresponding graphical symbols to indicate the function of the particular device. These device and component designations are based on the assignment of a standard letter or letters to the fundamental function of that device. Suitable numbers (1, 2, 3, etc.) and letters (A, B, C, etc.) may be added to the basic designation to differentiate between devices performing similar functions. The assignment of a designation to a device on specific equipment is governed by the function of that device on that equipment and not by the type or nature of the device or its possible use for other functions on other equipment. The same type of device may perform different functions on different equipment or even on the same equipment and, consequently, may be identified by different designations.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE</td>
<td>Alarm or Annunciator Bell</td>
</tr>
<tr>
<td>ABU</td>
<td>Alarm or Annunciator Buzzer</td>
</tr>
<tr>
<td>AH</td>
<td>Alarm or Annunciator Horn</td>
</tr>
<tr>
<td>AM</td>
<td>Ammeter</td>
</tr>
<tr>
<td>AT</td>
<td>Autotransformer</td>
</tr>
<tr>
<td>CAP</td>
<td>Capacitor</td>
</tr>
<tr>
<td>CB</td>
<td>Circuit Breaker</td>
</tr>
<tr>
<td>CI</td>
<td>Circuit Interrupter</td>
</tr>
<tr>
<td>CNC</td>
<td>Computerized Numerical Controller</td>
</tr>
<tr>
<td>CON</td>
<td>Contractor</td>
</tr>
<tr>
<td>COs</td>
<td>Cable Operated (Emergency) Switch</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>CR</td>
<td>Control Relay</td>
</tr>
<tr>
<td>CRA</td>
<td>Control Relay, Automatic</td>
</tr>
<tr>
<td>CRH</td>
<td>Control Relay, Manual</td>
</tr>
<tr>
<td>CRL</td>
<td>Control Relay, Latch</td>
</tr>
<tr>
<td>CRM</td>
<td>Control Relay, Master</td>
</tr>
<tr>
<td>CRT</td>
<td>Cathode Ray Tube, Monitor or Video Display Unit</td>
</tr>
<tr>
<td>CRU</td>
<td>Control Relay, Unlatch</td>
</tr>
<tr>
<td>CS</td>
<td>Cam Switch</td>
</tr>
<tr>
<td>CT</td>
<td>Current Transformer</td>
</tr>
<tr>
<td>CTR</td>
<td>Counter</td>
</tr>
<tr>
<td>D</td>
<td>Diode</td>
</tr>
<tr>
<td>DISC</td>
<td>Disconnect Transformer</td>
</tr>
<tr>
<td>DISP</td>
<td>Display</td>
</tr>
<tr>
<td>DR</td>
<td>Drive</td>
</tr>
<tr>
<td>END</td>
<td>Encoder</td>
</tr>
<tr>
<td>FLD</td>
<td>Field</td>
</tr>
<tr>
<td>FLS</td>
<td>Flow Switch</td>
</tr>
<tr>
<td>FS</td>
<td>Float Switch</td>
</tr>
<tr>
<td>FTS</td>
<td>Foot Switch</td>
</tr>
<tr>
<td>FU</td>
<td>Fuse</td>
</tr>
<tr>
<td>GEN</td>
<td>Generator</td>
</tr>
<tr>
<td>GRD, GND</td>
<td>Ground</td>
</tr>
<tr>
<td>HM</td>
<td>Hour Meter</td>
</tr>
<tr>
<td>HTR</td>
<td>Heating Element</td>
</tr>
<tr>
<td>IC</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>INST</td>
<td>Instrument</td>
</tr>
<tr>
<td>IOL</td>
<td>Instantaneous Overload</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/Output Device</td>
</tr>
<tr>
<td>L</td>
<td>Inductor</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>LS</td>
<td>Limit Switch</td>
</tr>
<tr>
<td>LT</td>
<td>Pilot Light</td>
</tr>
<tr>
<td>LVDT</td>
<td>Linear Variable Differential Transformer</td>
</tr>
<tr>
<td>M</td>
<td>Motor Starter</td>
</tr>
<tr>
<td>MD</td>
<td>Motion Detector</td>
</tr>
<tr>
<td>MF</td>
<td>Motor Starter – Forward</td>
</tr>
<tr>
<td>MG</td>
<td>Motor – Generator</td>
</tr>
<tr>
<td>MR</td>
<td>Motor Starter – Reverse</td>
</tr>
<tr>
<td>MTR</td>
<td>Motor</td>
</tr>
<tr>
<td>OL</td>
<td>Overload Relay</td>
</tr>
<tr>
<td>PB</td>
<td>Pushbutton</td>
</tr>
<tr>
<td>PBL</td>
<td>Pushbutton, Illuminated</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>PDL</td>
<td>Photoelectric Device</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>POT</td>
<td>Potentiometer</td>
</tr>
<tr>
<td>PPS</td>
<td>Proximity Switch</td>
</tr>
<tr>
<td>PS</td>
<td>Pressure Switch</td>
</tr>
<tr>
<td>PWS</td>
<td>Power Supply</td>
</tr>
</tbody>
</table>

The committee understands that this action modifies the Committee Action on Proposal 79-167 (Log #42).
SUBSTANTIATION: None given.
COMMITTEE ACTION: Accepted.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 25
NOT RETURNED: 1 Norman

F.1 Electrical enclosures are (NEMA 250 / UL 50 and UL 508) Type rated, and/or (IEC 60529) IP rated based upon the degree of protection provided.

Type rated enclosures are those which meet the requirements of the Type rating system, which includes additional requirements such as mechanical impact on enclosure walls, gasket aging and oil resistance, and corrosion resistance. IP rated enclosures are those which are rated based upon the degree of protection provided by the enclosure with respect to persons and solid foreign objects entering the enclosure. The second characteristic numeral indicates the degree of protection provided by the enclosure with respect to the harmful ingress of water. The additional letter indicates the degree of protection for a person against access to hazardous parts. A brief description of the additional letter is as follows:

F.2 Arrangement of the IP Code

<table>
<thead>
<tr>
<th>Code letters</th>
<th>(International Protection)</th>
<th>IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>First character</td>
<td>(numerals 0 to 6, or letter X)</td>
<td>N (or letter X)</td>
</tr>
<tr>
<td>Second character</td>
<td>(numerals 0 to 8, or letter X)</td>
<td>N (or letter X)</td>
</tr>
<tr>
<td>Additional letter</td>
<td>(letters A, B, C, D)</td>
<td>L</td>
</tr>
<tr>
<td>Supplementary letter</td>
<td>(letters H, M, S, W)</td>
<td>L</td>
</tr>
</tbody>
</table>

Example: IP 23CH

Where a characteristic numeral is not required to be specified, it shall be replaced by the letter “X” (“XX” if both numerals are omitted). Additional letters and/or supplementary letters may be omitted without replacement.
Where more than one supplementary letter is used, the alphabetic sequence shall apply.

<table>
<thead>
<tr>
<th>Element</th>
<th>Numerals or letters</th>
<th>Meaning for the protection of equipment</th>
<th>Meaning for the protection of persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code letters</td>
<td>IP</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>Against ingress of solid foreign objects</td>
<td>Against access to hazardous parts with</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>(non-protected)</td>
<td>(non-protected)</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>≥ 50 mm diameter back of hand</td>
<td>back of hand</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>≥ 12,5 mm diameter finger</td>
<td>finger</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>≥ 2,5 mm diameter tool</td>
<td>tool</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>≥ 1,0 mm diameter wire</td>
<td>wire</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>dust-protected</td>
<td>wire</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>-</td>
<td>dust-tight</td>
<td>wire</td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>Against ingress of water with harmful effects</td>
<td>-</td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>(non-protected)</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>vertically dripping</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>dripping (15° tilted)</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>spraying</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>splashing</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>jetting</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>powerful jetting</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>temporary immersion</td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>-</td>
<td>continuous immersion</td>
<td></td>
</tr>
<tr>
<td>Additional letter (optional)</td>
<td>A</td>
<td>-</td>
<td>Against access to hazardous parts with:</td>
</tr>
<tr>
<td>Additional letter (optional)</td>
<td>B</td>
<td>-</td>
<td>back of hand</td>
</tr>
<tr>
<td>Additional letter (optional)</td>
<td>C</td>
<td>-</td>
<td>finger</td>
</tr>
<tr>
<td>Additional letter (optional)</td>
<td>D</td>
<td>-</td>
<td>tool</td>
</tr>
<tr>
<td>Additional letter (optional)</td>
<td>E</td>
<td>-</td>
<td>wire</td>
</tr>
<tr>
<td>Supplementary letter (optional)</td>
<td>H</td>
<td>Supplementary information specific to:</td>
<td>-</td>
</tr>
<tr>
<td>Supplementary letter (optional)</td>
<td>M</td>
<td>High-voltage apparatus</td>
<td></td>
</tr>
<tr>
<td>Supplementary letter (optional)</td>
<td>S</td>
<td>Motion during water test</td>
<td></td>
</tr>
<tr>
<td>Supplementary letter (optional)</td>
<td>W</td>
<td>Stationary during water test</td>
<td></td>
</tr>
<tr>
<td>Supplementary letter (optional)</td>
<td>W</td>
<td>Weather conditions</td>
<td></td>
</tr>
</tbody>
</table>

Note: In the case of the first characteristic numeral 3, 4, 5 and 6, protection against access to hazardous parts is satisfied if adequate clearance is kept. Due to the simultaneous requirement specified in Table II the definition “shall not penetrate” is given in Table I.

Electrical enclosures that carry only an IP rating have not been designed to the above additional Type rating requirements. Therefore, a Type rating cannot be assigned to an enclosure that has only been IP rated because of the exclusion of the additional requirements of the Type rating system.

However, because the IP requirements can be interpreted to be inclusive to the Type requirements, a conservative IP rating can be assigned to a Type rated enclosure by referencing Table H-1.

As a practical matter thought, many electrical enclosures are tested to both the IP and Type requirements and carry both IP and Type designations.
A = The First Character Designation is the protection against access to hazardous parts and solid foreign objects. The respective NEMA Enclosure Type meets the requirements for the IEC 529 IP First Character Designation.

B = The IP Second Character Designation is the protection against ingress of water. The respective NEMA Enclosure Type meets the requirements for the IEC 529 IP second Character Designation.

Notes:
1. Type rated enclosures for hazardous locations and potentially explosive areas have been excluded from the table. The additional and supplementary letters for IP ratings have also been excluded from the table. (See NEMA 250 / UL 50 and UL 508 and IEC 529 / IEC 60529.)

2. Table H-I shall only be used to assign an IP rating to a Type rated enclosure, and not to assign a Type rating to an IP rated enclosure. Table H-I assists in specifying enclosure ratings and shall not be used as a definitive guide.

Example: If the conditions of installation require an IP 55, Table H-1 indicates that a Type 3, 3S, 4, 4X, 6, or 6P enclosure can be utilized. However, if the conditions of installation require a NEMA Type 4, an enclosure that is only IP rated cannot be used as a substitute.

Note 3 – Although the corresponding NEMA Type ratings meet or exceed the corresponding IP rating as indicated in Table H-I, IEC does not currently accept these ratings without further IEC testing.

EXPLANATION OF NEGATIVE:
SAUNDERS: The references to the European Standards in ANNEX are for information only and are not a requirement, and therefore should remain as an appropriate reference.

COMMENT ON AFFIRMATIVE:
ANDERSON: I believe the committee action taken was done under the impression that the item to be deleted was part of a standard requirement. In reality all of subsection 4.4.2 “Electromagnetic compatibility (EMC)” is a “note” and probably should be listed as a note similar to the long list of notes near the end of chapter 9 or an editor’s note indicating all the information under 4.4.2 became a non mandatory note.

The submitter is correct in that the bullet does not provide U.S. requirements, and maybe they should be added. But for machine builders using harmonized standards the offending bullet is good introduction to information about international requirements for EMC limits, should they wish to design to a broader market. Because the information is in a note form and not a requirement, those wishing to design and market to only the North American market are free to do so.

I do not understand the proposer’s objection to allowing the information to remain in the standard, unless he also mistakenly thought it was a requirement given the proposal’s substantiation, and the fact later in the process all of the material became a note that was placed under an apparent required sub section [4.4.2]. I believe the bullet should remain as part of the note material describing EMC.

---

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP</td>
<td>NEMA enclosure type</td>
</tr>
<tr>
<td>IP0</td>
<td>AB</td>
</tr>
<tr>
<td>IP1</td>
<td>A</td>
</tr>
<tr>
<td>IP2</td>
<td>B</td>
</tr>
<tr>
<td>IP3</td>
<td>AB</td>
</tr>
<tr>
<td>IP4</td>
<td>B</td>
</tr>
<tr>
<td>IP5</td>
<td>AB</td>
</tr>
<tr>
<td>IP6</td>
<td>A</td>
</tr>
<tr>
<td>IP7</td>
<td>B</td>
</tr>
<tr>
<td>IP8</td>
<td>B</td>
</tr>
</tbody>
</table>

EXPLANATION OF NEGATIVE:
79- 170 - ([Annex G (New)]): Accept
SUBMITTER: John F. Bloodgood, JFB Enterprises
RECOMMENDATION: Add new Annex G to assist with the understanding of certain text in Clause 15. Annex G (informative): Kilowatt Outputs with Horsepower equivalents
G1 Preferred kilowatt outputs with horsepower equivalents
The kilowatt and horsepower values shown are not exact conversion values. They give the approximate relationships between countries employing the two different systems of units.
Note: 1. IEC 60072-1 Annex D tables D.5.1 and D.5.2, Sixth Edition 1991-2, are provided to assist with hp and kW r
2. The kw-hp conversions are approximately 1 hp = 720 W, not the stated 746 W nor even the rounded off metric units which result in 736 W.

<table>
<thead>
<tr>
<th>kW</th>
<th>hp(746W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,06</td>
<td>1/12</td>
</tr>
<tr>
<td>0,09</td>
<td>1/8</td>
</tr>
<tr>
<td>0,12</td>
<td>1/6</td>
</tr>
<tr>
<td>0,18</td>
<td>1/4</td>
</tr>
<tr>
<td>0,25</td>
<td>1/3</td>
</tr>
<tr>
<td>0,37</td>
<td>1/2</td>
</tr>
<tr>
<td>0,55</td>
<td>3/4</td>
</tr>
<tr>
<td>0,75</td>
<td>1</td>
</tr>
<tr>
<td>1,1</td>
<td>1,5</td>
</tr>
<tr>
<td>1,5</td>
<td>2</td>
</tr>
<tr>
<td>2,2</td>
<td>3</td>
</tr>
<tr>
<td>3,7</td>
<td>5</td>
</tr>
</tbody>
</table>
G.2 Preferred horsepower with kilowatt equivalents

<table>
<thead>
<tr>
<th>Primary Series</th>
<th>Secondary Series</th>
<th>hp (746W)</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>11</td>
<td>4</td>
<td>7.5</td>
</tr>
<tr>
<td>7.5</td>
<td>15</td>
<td>6.3</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>13</td>
<td>30</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>17</td>
<td>37</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>33</td>
<td>45</td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>40</td>
<td>55</td>
<td>40</td>
<td>75</td>
</tr>
<tr>
<td>50</td>
<td>63</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>63</td>
<td>75</td>
<td>63</td>
<td>125</td>
</tr>
<tr>
<td>80</td>
<td>90</td>
<td>80</td>
<td>150</td>
</tr>
<tr>
<td>90</td>
<td>100</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>100</td>
<td>110</td>
<td>100</td>
<td>225</td>
</tr>
<tr>
<td>125</td>
<td>132</td>
<td>125</td>
<td>270</td>
</tr>
<tr>
<td>150</td>
<td>150</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>160</td>
<td>160</td>
<td>160</td>
<td>350</td>
</tr>
<tr>
<td>185</td>
<td>185</td>
<td>185</td>
<td>375</td>
</tr>
<tr>
<td>190</td>
<td>190</td>
<td>190</td>
<td>400</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>200</td>
<td>422</td>
</tr>
<tr>
<td>220</td>
<td>220</td>
<td>220</td>
<td>449</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>250</td>
<td>476</td>
</tr>
<tr>
<td>280</td>
<td>280</td>
<td>280</td>
<td>503</td>
</tr>
<tr>
<td>300</td>
<td>300</td>
<td>300</td>
<td>536</td>
</tr>
<tr>
<td>335</td>
<td>335</td>
<td>335</td>
<td>570</td>
</tr>
<tr>
<td>360</td>
<td>360</td>
<td>360</td>
<td>603</td>
</tr>
<tr>
<td>375</td>
<td>375</td>
<td>375</td>
<td>637</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
<td>400</td>
<td>670</td>
</tr>
<tr>
<td>425</td>
<td>425</td>
<td>425</td>
<td>710</td>
</tr>
<tr>
<td>450</td>
<td>450</td>
<td>450</td>
<td>750</td>
</tr>
<tr>
<td>475</td>
<td>475</td>
<td>475</td>
<td>804</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
<td>500</td>
<td>845</td>
</tr>
<tr>
<td>535</td>
<td>535</td>
<td>535</td>
<td>898</td>
</tr>
<tr>
<td>560</td>
<td>560</td>
<td>560</td>
<td>952</td>
</tr>
<tr>
<td>600</td>
<td>600</td>
<td>600</td>
<td>1005</td>
</tr>
<tr>
<td>630</td>
<td>630</td>
<td>630</td>
<td>1072</td>
</tr>
<tr>
<td>670</td>
<td>670</td>
<td>670</td>
<td>1139</td>
</tr>
<tr>
<td>710</td>
<td>710</td>
<td>710</td>
<td>1206</td>
</tr>
<tr>
<td>750</td>
<td>750</td>
<td>750</td>
<td>1273</td>
</tr>
<tr>
<td>800</td>
<td>800</td>
<td>800</td>
<td>1340</td>
</tr>
</tbody>
</table>

hp (746W) kW hp (746W) kW

| 375 | 280 |
| 400 | 298 |
| 425 | 317 |
| 450 | 336 |
| 475 | 354 |
| 500 | 373 |
| 530 | 395 |
| 560 | 418 |
| 600 | 448 |
| 630 | 470 |
| 670 | 500 |

1/ This value is introduced for use in certain countries that prefer rounded off horsepower values.

The notes are to inform the user that additional information is necessary in order to properly exchange motors.

SUBSTANTIATION: IEC 60072-1 Annex D tables D.5.1 and D.5.2 Sixth Edition 1991-2 are provided to assist with hp and kW motor relationships.

COMMITTEE ACTION: Accept.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 25

NOT RETURNED: 1 Norman

79- 171 - (Annex (New) [Annex X New]): Reject

RECOMMENDATION: Add a complete copy of IEC60204 as an annex in the back of the NFPA 79 document.

SUBSTANTIATION: The harmonization effort did not align all requirements and rarely used identical text. Providing NFPA 79 & IEC60204 will provide one source for a complete superset of electrical machinery requirements suitable for use worldwide. Providing one source with both NFPA & IEC text would help educate users of similarities and differences.

COMMITTEE ACTION: Reject.

COMMITTEE STATEMENT: This is an administrative decision to be made by the Standards Administration apart from the committee process. The committee is concerned that by including IEC 60204-1 in this document, it would substantially increase the cost of the document.

NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 26

VOTE ON COMMITTEE ACTION: AFFIRMATIVE: 24
NEGATIVE: 1
NOT RETURNED: 1 Norman

EXPLANATION OF NEGATIVE:
FREUDENBERG: The committee should be on record as wanting to include a copy of IEC60204-1, otherwise, the Standards Administration has no reason to make a decision. The costs have not been determined and the current NFPA viewpoint is an internal perspective of costs. NFPA may be able to provide both NFPA79 and IEC60204 as a set faster and cheaper than users of NFPA79 can obtain one documents from NFPA and the international IEC60204-1 document from another source.

COMMENT ON AFFIRMATIVE:
DOBROWSKY: I do not support combining both standards into one but would support the option of purchasing both standards (as a package of two separate standards) hopefully at a reduced cost.

See the draft of NFPA 79 shown at the end of this book starting on page 1835.
NFPA 79 — May 2002 ROP — DRAFT — Copyright 2001, NFPA

Chapter 1 Administration

1.1* Scope.

1.1.1 The provisions of this standard shall apply to the electrical/electronic equipment, apparatus, or systems of industrial machines operating from a nominal voltage of 600 volts or less, and commencing at the point of connection of the supply to the electrical equipment of the machine.

1.1.2 This standard shall not include the additional requirements for machines intended for use in hazardous (classified) locations.

1.2 Purpose. This standard shall provide detailed information for the application of electrical/electronic equipment, apparatus, or systems supplied as part of industrial machines that will promote safety to life and property.

1.3 Application. This standard shall not apply to the following:

(1) Fixed or portable tools judged under the requirements of a testing laboratory acceptable to the authority having jurisdiction

(2) Machines used in dwelling units

1.4 Specific Provisions Other Than NFPA 79. The size and overcurrent protection of the supply conductors to a machine shall be covered by NFPA 70, National Electrical Code®, Article 670. The wiring between component machines of an industrial manufacturing system shall be covered by NFPA 70, National Electrical Code.

Exception: Wiring of component machines of an industrial manufacturing system that is supplied by the manufacturer and is an integral part of the system, is adequately protected and supported, and meets the requirements of this standard.

1.5* Specific Provisions Not Made Relation to NFPA 70. On any point for which specific provisions are not made in this standard (e.g., some requirements for the application of Design E motors) the provisions of NFPA 70, National Electrical Code, shall be observed.

1.6 State of the Art. This standard shall not limit or inhibit the advancement of the state of the art. Each type of machine has unique requirements that shall be accommodated to provide adequate safety. [ROP 79-8 (Log 35)]

Chapter 2 Referenced Publications

2.1 General.

2.1.1 NFPA Publication. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.


2.1.2 Other Publications.

2.1.2.1 ANSI Publication. American National Standards Institute, Inc., 11 West 42nd Street, 13th floor, New York, NY 10036.

2.1.2.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.


2.1.2.3 IEC Publications. International Electrotechnical Commission, 3 rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.


2.1.2.4 IEEE Publication. Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.


2.1.2.5 NEMA Publications. National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209.


NEMA MG-1, Motors and Generators, 1998.

2.1.2.6 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.


Chapter 3* Definitions

3.1* General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is
acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.3 General Definitions.

3.3.1 Accessible (as applied to equipment). Admitting close approach; not guarded by locked doors, elevation, or other effective means. [70:100]

3.3.2 Accessible, Readily (Readily Accessible). Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, etc. [70:100]

3.3.3* Actuator. The part of the actuating system to which an external actuating force is applied.

3.3.3.1 Machine Actuator. A power mechanism used to effect motion of the machine.

3.3.4* Adjustable Speed Drives. An electrical device or group of electrical devices that alters the drive motor output speed over a range in a controlled manner.

3.3.5* Ambient Temperature. The temperature of the air or other medium where the equipment is to be used.

3.3.6 Ampacity. The current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating. [70:100]

3.3.7 Attachment Plug (Plug Cap) (Plug). A device that, by insertion in a receptacle, establishes a connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle. [70:100]

3.3.8 Barrier. A physical obstruction that is intended to prevent contact with equipment or live parts or to prevent unauthorized access to a work area. [70E:1-2.1]

3.3.9* Bonding (Bonded). The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct any current likely to be imposed. [70:100]

3.3.10 Branch Circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [70:100]

3.3.11 Cable Tray System. A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways. [70:392.2]

3.3.12* Cable Trunking System. A system of enclosures comprised of a base and a removable cover intended for the complete surrounding of insulated conductors, cables, and cords.

3.3.13 Circuit Breaker. A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [70:100]

3.3.14 Concurrent. Acting in conjunction; used to describe a situation wherein two or more control devices exist in an actuated condition at the same time (but not necessarily simultaneously).

3.3.15 Conduit.

3.3.15.1 Intermediate Metal Conduit. A listed steel raceway of circular cross-section with integral or associated couplings, connectors, and fittings approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [70:342.2]

3.3.15.2 Rigid Metal Conduit. Rigid metal conduit is a listed metal raceway of circular cross section with integral or associated couplings, approved for the installation of electrical conductors and used with listed fittings to provide electrical continuity. [70:344.2]

3.3.15.3 Rigid Nonmetallic Conduit. A type of conduit and fittings of suitable nonmetallic material that is resistant to moisture and chemical atmospheres, flame retardant, resistant to impact and crushing, and resistant to distortion from heat or low temperatures under conditions likely to be encountered in service. [70:352.2]

3.3.16 Contact.

3.3.16.1 Direct Contact. Contact of persons with live parts.

3.3.16.2 Indirect Contact. Contact of persons with exposed conductive parts that have become live under fault conditions.

3.3.17* Control Circuit (of a machine). The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller but does not carry the main power current.

3.3.18 Control Circuit Transformer. A voltage transformer utilized to supply a voltage suitable for the operation of control devices.

3.3.19 Control Circuit Voltage. The voltage utilized for the operation of control devices.

3.3.20 Control Device. A device connected into the control circuit and used for controlling the operation of the machine (e.g., position sensor, manual control switch, relay, magnetically operated valve).

3.3.21 Control Equipment. Operating elements, such as relays, contactors, circuit breakers, switches, solenoids, brakes, and similar types of components, intended to govern or perform a given function in the operation, including measuring, sensing, monitoring, protecting, and regulating of machinery.
3.3.22 **Controller.** A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. [70:100]

3.3.23 **Cord (Flexible).** Cords that are constructed as described in and listed for use in accordance with Article 400 of NFPA 70, *National Electrical Code.* All conductors are stranded copper.

3.3.24 **Device.** A unit of an electrical system that is intended to carry but not utilize electric energy. [70:100]

3.3.25 **Digital.** Operated by the use of discrete signals to represent data in the form of numbers or other characters.

3.3.26 **Disconnecting Means.** A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [70:100]

3.3.27* **Duct.** An enclosed channel designed expressly for holding and protecting electrical conductors, cables, and bus bars.

3.3.28 **Dwelling Unit.** One or more rooms for the use of one or more persons as a housekeeping unit with space for eating, living, and sleeping, and permanent provisions for cooking and sanitation. [70:100]

3.3.29 **Earth.** See 3.3.46, Ground.

3.3.30 **(Electrically) Instructed Person.** A person adequately advised or supervised by an electrically skilled person to enable him or her to perceive risks and to avoid hazards that electricity can create.

3.3.31 **(Electrically) Skilled Person.** A person with relevant education and experience to enable him or her to perceive risks and to avoid hazards that electricity can create.

3.3.32 **Electrical Operating Area.** A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier without the use of a key or tool, and that is clearly marked by appropriate warning signs.

3.3.33 **Electromechanical.** Any device in which electrical energy is used to magnetically cause mechanical movement.

3.3.34 **Electronic Equipment.** That part of electrical equipment containing circuitry mainly based on electronic devices and components.

3.3.35 **Emergency Switching Off.** An emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved.

3.3.36 **Enclosed Electrical Operating Area.** A room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool, and that is clearly marked by appropriate warning signs.

3.3.37 **Enclosure.** A surrounding case constructed to provide a degree of protection against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

3.3.38 **Energized.** Electrically connected to a source of potential difference [70:100]

3.3.39 **Equipment.** A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation. [70:100]

3.3.40 **Exposed (as applied to live parts).** Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. [70:100]

3.3.41* **Failure (of equipment).** The termination of the ability of an item to perform a required function.

3.3.42* **Fault.** The state of an item characterized by inability to perform a required function, excluding the inability, during preventive maintenance or other planned actions, or due to lack of external resources.

3.3.43 **Feeder.** All circuit conductors between the service equipment or the source of a separately derived system and the final branch circuit overcurrent device. [70:100]

3.3.44 **Flame Retardant.** So constructed or treated that it will not support flame.

3.3.45 **Flexible Metal Conduit.** A raceway of circular cross section made of helical wound, formed, and interlocked metal strip.

3.3.45.1 **Liquidtight Flexible Metal Conduit.** A raceway of circular cross section having an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core with associated couplings, connectors, and fittings and approved for the installation of electric conductors.

3.3.46 **Ground.** A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth. [70:100]

3.3.47 **Grounded.** Connected to earth or to some conducting body that serves in place of the earth. [70:100]

3.3.48 **Grounded Conductor.** A system or circuit conductor that is intentionally grounded. [70:100]

3.3.49 **Grounding Conductor.** A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes. [70:100]

3.3.50 **Grounding Conductor, Equipment.** The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system. [70:100]

3.3.51 **Grounding Electrode Conductor.** The conductor used to connect the grounding electrode to the equipment grounding conductor, to the grounded conductor, or to both, of the circuit at the service equipment or at the source of a separately derived system. [70:100]

3.3.52* **Guard.** Part of a machine specifically used to provide protection by means of a physical barrier.
3.3.53 **Hazard.** A source of possible injury or damage to health.

3.3.54 **Hazardous Condition.** A circumstance in which a person is exposed to a hazard(s) that has the potential to result in harm immediately or over a long period of time.

3.3.55* **Identified (as applied to equipment).** Recognizable as suitable for the specific purpose, function, use, environment, application, and so forth, where described in a particular code requirement. [70:100]

3.3.56 **In Sight From, Within Sight From, Within Sight.** Where this standard specifies that one equipment shall be “in sight from,” “within sight from,” or “within sight,” etc., of another equipment, one of the equipments specified is to be visible and not more than 50 ft (15.24 m) distant from the other. [70:100]

3.3.57 **Industrial Machinery (Machine).** A power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting; forming; pressure; electrical, thermal, or optical techniques; lamination; or a combination of these processes.

Machine can include associated equipment used to transfer material or tooling, including fixtures, to assemble/disassemble, to inspect or test, or to package. [The associated electrical equipment, including the logic controller(s) and associated software or logic together with the machine actuators and sensors, are considered as part of the industrial machine.] [70:670.2]

3.3.58 **Industrial Manufacturing System.** A systematic array of one or more industrial machines that is not portable by hand and includes any associated material handling, manipulating, gauging, measuring, or inspection equipment. [70:670.2]

3.3.59 **Input.** The terminals where current, voltage, power, or driving force may be applied to a circuit or device; the state or sequence of states occurring on a specific input channel; or the device or collective set of devices used for bringing data into another device.

3.3.60 **Inrush Current (Solenoid).** The inrush current of a solenoid is the steady-state current taken from the line at rated voltage and frequency with the plunger blocked in the rated maximum open position.

3.3.61 **Inrush Locked Rotor Current (Motor).** See 3.3.68 Locked Rotor Motor Current.

3.3.62 **Interlock (for safeguarding).** An arrangement that interconnects guard(s) or device(s) with the control system or all or part of the electrical energy distributed to the machine.

3.3.63* **Interrupting Rating.** The highest current at rated voltage that a device is intended to interrupt under standard test conditions. [70:100]

3.3.64 **Jogging (Inching).** The quickly repeated closure of the circuit to start a motor from rest for the purpose of accomplishing small movements of the driven machine.

3.3.65 **Live Parts.** Energized conductive components. [70:100]

3.3.66 **Liquidtight Flexible Nonmetallic Conduit.** A nonmetallic raceway of circular cross section of oil-, water-, and flame-resistant construction and fittings for the installation of electrical conductors.

3.3.67 **Location.**

3.3.67.1* **Dry Location.** A location not normally subject to dampness or wetness. [70:100]

3.3.67.2 **Wet Location.** Installations underground or in concrete slabs or masonry in direct contact with the earth; and in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather. [70:100]

3.3.68 **Locked Rotor Motor Current.** The steady-state current taken from the line with the rotor locked and with rated voltage (and rated frequency in the case of alternating-current motors) applied to the motor.

3.3.69 **Marking.** Signs or inscriptions attached by the manufacturer, for the identification of the type of a component or device.

3.3.70 **Neutral Conductor.** A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy.

3.3.71 **Obstacle.** A part preventing unintentional direct contact, but not preventing direct contact by deliberate action.

3.3.72 **Output.** The terminals where current, voltage, power, or driving force may be delivered by a circuit or device; the state or sequence of states occurring on a specific output channel; or the device or collective set of devices used for taking data out of another device.

3.3.73 **Overcurrent.** Any current in excess of the rated current of equipment or the ampacity of the conductor. It may result from overload, short circuit, or electrical fault. [70:100]

3.3.74* **Overload.** Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or a ground fault, is not an overload. [70:100]

3.3.75 **Panel.** An element of an electric controller consisting of a slab or plate on which various component parts of the controller are mounted and wired.

3.3.76 **Plug/Socket Combination.** A plug and socket outlet, a cable coupler, or an appliance coupler.

3.3.77 **Point of Operation.** The location in the (machine) where the material or workpiece is positioned and work is performed.

3.3.78 **Positive Opening Operation (of a contact element).** The achievement of contact separation as the direct result of a specified movement of the switch actuator through nonresilient members (e.g. not dependent upon springs).

3.3.79 **Power Circuit.** A circuit used for supplying power from the supply network to units of equipment used for productive operation and to transformers supplying control circuits.

3.3.80* **Programmable Electronic System.** A system based on one or more central processing units (CPUs), connected to sensors or actuators, or both, for the purpose of control or monitoring.
3.3.81* Protective Bonding Circuit. The whole of the protective conductors and conductive parts used for protection against electric shock in the event of an insulation failure.

3.3.82 Protective Conductor. A conductor required by some measures for protection against electric shock for electrically connecting exposed conductive parts, extraneous conductive parts, or main earthing terminal.

3.3.83* Qualified Person. At a minimum, a qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method, and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools and test equipment.

3.3.84 Raceway. An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this standard. Raceways include, but are not limited to, rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquidtight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways. [70:100]

3.3.85 Receptacle. A contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke. [70:100]

3.3.86 Redundancy. The application of more than one device or system, or part of a device or system, with the objective of ensuring that in the event of one failing to perform its function another is available to perform that function.

3.3.87 Reference Designation. A distinctive code that serves to identify an item in a diagram, list, chart, and on the equipment.

3.3.88 Relative Humidity. The ratio between the amount of water vapor in the gas at the time of measurement and the amount of water vapor that could be in the gas when condensation begins, at a given temperature.

3.3.89 Risk. A combination of the probability and the degree of possible injury or damage to health in a hazardous situation.

3.3.90 Safeguard. A guard or protective device used as a safety measure to protect persons from a present or impending hazard.

3.3.91 Safeguarding. Those safety measures consisting of the use of specific means called safeguards to protect persons from hazards that cannot reasonably be removed or are not sufficiently limited by design.

3.3.92 Safety Control Circuit. The part of the control circuit that incorporates safety related components. [ROP 79-16 (Log 154)]

3.3.93 Safety Distance. The distance between the pinch point or point-of-operation and the presence-sensing safety device (PSSD) sensing field that ensures that the operator cannot reach the danger point before the machine comes to a full stop.

3.3.94 Safety Function (Safety Measure). A means that eliminates or reduces a hazard.

3.3.95 Safe Working Procedure. A method of working that reduces risk.

3.3.96 Servicing Level. Location on which persons normally stand when operating or maintaining the electrical equipment.

3.3.97 Short-Circuit Current. An overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit.

3.3.98 Socket. See 3.3.85 Receptacle.

3.3.99 Stop.

3.3.99.1 Controlled Stop. The stopping of machine motion, while retaining power to the machine actuators during the stopping process.

3.3.99.2 Uncontrolled Stop. The stopping of machine motion by removing power to the machine actuators, all brakes and/or other mechanical stopping devices being activated.

3.3.100 Subassembly. An assembly of electrical devices connected together that forms a simple functional unit.

3.3.101 Subplate. An internal metal surface separate from the walls of an enclosure or controller on which various component parts of the controller are mounted and wired.

3.3.102* Supplementary Overcurrent Protective Device. A device used where protection is required for lighting fixtures, appliances, and other equipment or for internal circuits and components of equipment.

3.3.103* Supplier. An entity (e.g., manufacturer, contractor, installer, integrator) that provides equipment or services associated with the machine.

3.3.104 Switching Device. A device designed to make or break the current in one or more electric circuits.

3.3.105 Tap Conductor. A conductor that has overcurrent protection ahead of its point of supply, that exceeds the value permitted for similar conductors that are protected as described elsewhere in this standard. [70:240-2]

3.3.106 Terminal. A conductive part of a device provided for electrical connection to circuits external to the device.

3.3.107 Tight (suffix). So constructed that the specified material is excluded under specified conditions.

3.3.108* Undervoltage Protection. The effect of a device that operates on the reduction or failure of voltage to cause and maintain the interruption of power.

3.3.109* User. An entity that utilizes the machine and its associated electrical equipment.

3.3.110 Ventilated. Provided with a means to permit circulation of air sufficient to remove excess heat, fumes, or vapors. [70:100]
### 3.3.111 Voltage, Nominal

A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240 volts, 480Y/277 volts, 600 volts). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment. [70:100]

### 3.3.112 Wireway

A sheet-metal or flame-retardant nonmetallic trough with hinged or removable covers for housing and protecting electric wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system. [70:_____] [ROP 79-11(Log 37)]

### Chapter 4 General Operating Conditions

#### 4.1 General Considerations

This chapter describes the general requirements and conditions for the operation of the electrical equipment of the machine. The risks associated with the hazards relevant to the electrical equipment shall be assessed as part of the overall requirements for risk assessment of the machine.

#### 4.2 Electrical Components and Devices

Electrical components and devices shall be installed and used assuming the operating conditions of ambient temperature, altitude, humidity, and supply voltage outlined in this chapter, and within their design ratings, taking into account any derating stipulated by the component or device manufacturer.

#### 4.3 Electrical Supply

##### 4.3.1 General

The electrical equipment shall be designed to operate correctly with the conditions of the supply as specified according to one of the following:

1. The requirements in 4.3.2, 4.3.3, and 4.3.4
2. The requirements specified by the user
3. The requirements specified by the supplier

##### 4.3.2 Alternating Current (ac) Supplies

#### 4.3.2.1 Voltage

The electrical equipment shall be designed to operate correctly where the steady state supply voltage is from 90 percent to 110 percent of the nominal voltage.

#### 4.3.2.2 Frequency

The electrical equipment shall be designed to operate correctly where the supply frequency is from 99 percent to 101 percent of the nominal frequency continuously. For short periods of time, the supply frequency shall be permitted to be from 98 percent to 102 percent of the nominal frequency.

#### 4.3.2.3 Harmonics

The electrical equipment shall be designed to operate correctly where the harmonic distortion from the electric supply does not exceed 10 percent of the total voltage (rms value) between ungrounded conductors for the sum of the second through fifth harmonic. An additional percent of the voltage (rms value) between ungrounded conductors for the sum of the sixth through thirtieth harmonic shall be permitted.

#### 4.3.2.4 Voltage Unbalance (in 3-Phase Supplies)

The electrical equipment shall be designed to operate correctly where neither the voltage of the negative sequence component nor the voltage of the zero sequence component in 3-phase supplies exceeds 2 percent of the voltage of the positive sequence component.

### 4.3.2.5 Voltage Impulses

The electrical equipment shall be designed to operate correctly where the supply voltage impulses do not exceed 1.5 milliseconds in duration with a rise/fall time between 500 nanoseconds and 500 microseconds. A peak supply voltage impulse shall not exceed more than 200 percent of the rated supply voltage (rms value).

### 4.3.2.6 Voltage Interruption

The electrical equipment shall be designed to operate correctly where the supply voltage is interrupted at zero voltage for not more than 3 milliseconds at any random time in the supply cycle. The time interval between successive voltage interruptions shall be more than 1 second.

### 4.3.2.7 Voltage Dips

The electrical equipment shall be designed to operate correctly where the supply voltage dips do not exceed 20 percent of the peak voltage of the supply for more than one cycle. The time interval between successive dips shall be more than 1 second.

### 4.3.3 Direct Current (dc) Supplies from Batteries

#### 4.3.3.1 Voltage

The electrical equipment shall be designed to operate correctly where the dc supply voltage of batteries is from 85 percent to 115 percent of the nominal voltage. A supply voltage from 70 percent to 120 percent of the nominal voltage shall be permitted for dc supplies to battery-operated vehicles.

#### 4.3.3.2 Voltage Interruption

The electrical equipment shall be designed to operate correctly where the dc supply voltage of batteries is interrupted for a time interval not exceeding 5 milliseconds.

#### 4.3.3.3 Ripple (Peak-to-Peak)

The electrical equipment shall be designed to operate correctly where the dc supply voltage ripple (peak-to-peak value) of converting equipment does not exceed 0.05 percent of the nominal voltage.

### 4.4 Physical Environment and Operating Conditions

#### 4.4.1 General

The electrical equipment shall be suitable for use in the physical environment and operating conditions specified in 4.4.3 to 4.4.6 and 4.4.8. When the physical environment or the operating conditions are outside those specified, an agreement between the supplier and the user shall be considered.

#### 4.4.2 Electromagnetic Compatibility (EMC)

#### 4.4.3 Ambient Operating Temperature

The electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The ambient operating temperatures for correct operation of the electrical equipment shall be between air temperatures of 5°C and 40°C (41°F to 104°F). [For very hot environments (e.g., hot climates, steel mills, paper mills) and for cold environments, extra requirements may be necessary.]
4.4.4* Relative Humidity. The electrical equipment shall be capable of operating within a relative humidity range of 20 to 95 percent (noncondensing).

Harmful effects of relative humidity outside the permitted range shall be avoided by proper design of the equipment or, where necessary, by proper additional measures (e.g., built-in heaters, air conditioners, humidifiers).

4.4.5* Altitude. Electrical equipment shall be capable of operating correctly at altitudes up to 1000 m (3300 ft) above mean sea level.

4.4.6* Contaminants. Electrical equipment shall be adequately protected against the ingress of solid bodies and liquids (see Section 12.3). Equipment shall be suitable for the environment where contaminants (e.g., dust, acids, corrosive gases, salt) are present.

4.4.7* Nonionizing Radiation.

4.4.8 Vibration, Shock, and Bump. Undesirable effects of vibration, shock, and bump, including those generated by the machine and its associated equipment and those created by the physical environment shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by the use of antivibration mountings.

4.5 Transportation and Storage. The electrical equipment shall be designed to withstand storage and transportation temperatures within the range of -25°C to 55°C (-13°F to +131°F) and up to 65°C (149°F) for short periods not exceeding 24 hours. Suitable means shall be provided to prevent damage from excessive moisture, vibration, stress, and mechanical shock during shipment.

4.6 Provisions for Handling. Heavy and bulky electrical equipment that has to be removed from the machine for transport or that is independent of the machine shall be provided with suitable means for handling by cranes or similar equipment.

4.7 Installation and Operating Conditions. The electrical equipment shall be installed and operated in accordance with the manufacturer's instructions. Any conditions that are outside the operating conditions specified in Chapter 4 shall be permitted where acceptable to both the manufacturer and user. [ROP 79-24 (Log 60)]

Chapter 5 Incoming Supply Circuit Conductor Terminations and Devices for Disconnecting and Removing Power

5.1 Incoming Supply Circuit Conductor Terminations.

5.1.1* Where practicable, the electrical equipment of a machine shall be connected to a single power supply circuit. Where it is necessary to use another supply circuit for certain parts of the equipment (e.g., electronic circuits, electromagnetic clutches), that supply circuit shall, as far as is practicable, be derived from devices (e.g., transformers, converters) forming part of the electrical equipment of the machine.

5.1.2 Connections to guarded terminal blocks or other devices ahead of the disconnecting means shall be permitted for excepted circuits according to 5.3.3. Terminals for more than one conductor shall be so identified.

5.1.3* Where a grounded conductor is used it shall be clearly indicated in the technical documentation of the machine, such as in the installation diagram and in the circuit diagram. A separate insulated terminal shall be provided for the grounded conductor.

5.1.4 All terminals for the incoming supply circuit connection shall be legibly marked.

5.2* Grounding Terminal. A grounding terminal shall be provided for each incoming supply circuit.

5.3 Supply Circuit Disconnecting (Isolating) Means.

5.3.1 General.

5.3.1.1 A supply circuit disconnecting means shall be provided for the following:

(1) Each incoming supply circuit to a machine
(2) The supply circuit to a feeder system using collector wires, collector bars, slip-ring assemblies, or flexible cable systems (reeled, festooned) to a machine or a number of machines
(3) Each on-board power source (e.g., generator)

5.3.1.1.1 Each disconnecting means required by 5.3.1.1 shall be legibly marked to indicate its purpose.

5.3.1.2 Where a machine is supplied by more than one supply circuit, a marking shall be installed at each supply circuit disconnect location denoting the location of all other supply circuit disconnects.

5.3.1.2.1 The supply circuit disconnecting means shall disconnect (isolate) the electrical equipment of the machine, including all control circuits, from the supply circuit when required (e.g., for work on the machine, including the electrical equipment). Circuits that are not required to be disconnected by the supply circuit disconnecting means shall comply with 5.3.5.

5.3.1.3 The supply circuit disconnecting means other than attachment plugs and receptacles shall be mounted within the control enclosure or immediately adjacent thereto.

Exception: Externally mounted supply circuit disconnecting means, whether interlocked or not interlocked with the control enclosure, supplying machines totaling 2 hp or less shall be permitted to be mounted up to 6.56 m (20 ft) away from the enclosure providing that the disconnecting means is in sight from and readily accessible to the operator.

Supply circuit disconnecting means mounted within or adjacent to the control enclosure shall be interlocked with the control enclosure in accordance with 6.2.3. Where the supply circuit disconnecting means is not adjacent to the control enclosure, or where the supply disconnecting means is an attachment plug and receptacle, a tool shall be required to open the control enclosure door. A label shall be attached to that door warning of dangerous voltage inside and advising disconnection of the power before opening.

5.3.1.4 Wire bending space shall be provided for the supply circuit disconnecting means in accordance with 430.10(B) of NFPA 70, National Electrical Code. Space shall be determined by maximum wire size of incoming lines or by maximum capacity of line lugs on the disconnecting means. Accidental contact with the line side live parts shall be inhibited. The supply circuit conductors to the disconnecting means shall be separated from other internal conductors by either of the following:

(1) Mounting the disconnect as near as practicable to the top of the enclosure while dedicating sufficient space between the top of the enclosure and the disconnect for the supply circuit conductors; or
(2) Mounting the disconnect other than at the top of the enclosure and guarding its line side live parts against accidental contact, and by separating the supply circuit conductors from other internal conductors by the use of a barrier.

5.3.1.5 The supply circuit disconnecting means shall have no exposed live parts while in the open (off) position, except those associated with the circuits described in 5.3.5.

5.3.1.6 Where two or more disconnecting means are provided within the control enclosure for multiple supply circuits, they shall be grouped in one location where practicable. Protective interlocks for their correct operation shall be provided where a hazardous condition or damage to the machine or to the work in progress can occur.

[ROP 79-34 (Log 30)]

5.3.2 Type. The supply circuit disconnecting device shall be one of the following types:

(1) A listed motor circuit switch (switch disconnectors) rated in horsepower
(2) A listed, branch circuit-rated, molded case circuit breaker
(3) A listed molded case switch
(4) An instantaneous trip circuit breaker that is part of a listed combination motor controller
(5) A listed self-protected combination controller limited to single motor applications
(6) An attachment plug and receptacle (plug/socket combination) for cord connection to motor loads totaling 2 hp or less

[ROP 79-34 (Log 30)]

5.3.3 Requirements.

5.3.3.1 Where the supply circuit disconnecting device is one of the types in 5.3.2 (1) through (5), the device shall fulfill all of the following requirements:

(1) Isolate the electrical equipment from the supply circuit and have one off (isolated) and one on position only. Circuit breakers are permitted to have a reset (tripped) position between off and on.
(2) Have an external operating means (e.g., handle).

Exception: Power-operated switchgear need not be operable from outside the enclosure where there are other means to open it.

(3) Be provided with a permanent means permitting it to be locked in the open (off) (isolated) position only (e.g., by padlocks) independent of the door position. When so locked, remote as well as local closing shall be prevented.
(4) Simultaneously disconnect all ungrounded conductors of the power supply circuit.
(5) Be operable, by qualified persons, independent of the door position without the use of accessory tools or devices.
(6) Be rated for the application as follows:
   a. The ampere rating shall be at least 115 percent of the sum of the full-load currents required for all equipment that may be in operation at the same time under normal conditions of use.
   b. Where rated in horsepower, the horsepower rating shall be at least equal that which is defined by Table 430.151(B) of NFPA 70, National Electrical Code, for a locked rotor equivalent equal to the largest sum resulting from the locked rotor currents of any combination of motors that can be started simultaneously and the full-load currents of the remaining motor and nonmotor loads that can be operated at that time.
   c. The voltage rating shall be at least equal to the nominal supply circuit voltage.

[ROP 79-41 (Log 31)]

5.3.3.2 Where the supply circuit disconnecting device is one of the types in 5.3.2(1) through (6), the available fault current at the point of the supply to the machine shall not be greater than the short-circuit current rating of the disconnecting device.

5.3.3.3 When the supply circuit disconnecting device is an attachment plug and receptacle (plug/socket combination), it shall fulfill all of the following requirements:

(1) Have a load-break rating or be interlocked with a switching device that is load-break rated, capable of interrupting the locked rotor current of the largest motor plus the sum of the remaining load that is operating at that time
(2) Be of such a type and be so installed as to prevent unintended contact with live parts at any time even during insertion or removal of the connectors
(3) Have a first make, last break grounding (earthing) contact
(4) Have a retaining means to prevent unintended or accidental disconnection where rated at more than 20 amperes
(5) Be located within sight from the operator station and be readily accessible

5.3.3.4 In addition, a switching device on the machine shall be provided for switching the machine on and off.

5.3.4 Operating Handle.

5.3.4.1 The center of the grip of the operating handle of the disconnecting means, when in its highest position, shall be not more than 2.0 m (6 ft 7 in.) above the floor. A permanent operating platform, readily accessible by means of a permanent stair or ladder, shall be considered as the floor for the purpose of this requirement.

5.3.4.2 An operating handle of the disconnecting means shall meet the following criteria:

(1) Be readily accessible with doors in the open or closed position
(2) Maintain the environmental rating of the enclosure
(3) Not be restricted by the enclosure door when the door is in the open position

[ROP 79-41 (Log 31)]

5.3.5 Excepted Circuits.

5.3.5.1 The following circuits shall not be required to be disconnected by the main supply circuit disconnecting means:

(1) Lighting circuits for lighting needed during maintenance or repair
(2) Attachment plugs and receptacles (plug and socket outlets) for the exclusive connection of repair or maintenance tools and equipment (e.g., hand drills, test equipment)
(3) Undervoltage protection circuits that are only used for automatic tripping in the event of supply circuit failure
(4) Circuits supplying equipment that are required to remain energized for satisfactory operation (e.g., temperature-controlled measuring devices, product (work in progress) heaters, program storage devices)
5.3.5.2 Supply circuits for excepted circuits shall comply with all of the following conditions:

   (1) Be a separate primary disconnecting means, isolating transformer, and secondary overcurrent protection furnished in an enclosure and mounted within the control enclosure, adjacent to the main disconnecting means.
   (2) Have line side (of the supply circuit disconnect) supply circuit connections internal to the control enclosure that are separate from and do not share a raceway with other conductors, and that are encased in rigid or flexible conduit if longer than 460 mm (18 in.)

5.3.5.3 The control interlocking circuits shall be capable of being disconnected at the control panel from which they are sourced.

5.3.5.4* Where circuits are not disconnected by the supply circuit disconnecting means, the following requirements shall be met:

   (1) Permanent warning label(s) shall be placed adjacent to the supply circuit disconnecting means indicating that it does not de-energize all exposed live parts when it is in the open (off) (isolated) position.
   (2) A corresponding statement shall be included in the maintenance manual.
   (3) A permanent warning label shall be placed in proximity to each excepted circuit, or the excepted circuit shall be separated from other circuits or shall be identified by color.


5.4.1 Means for removal of power shall be provided when prevention of unexpected start-up is required (e.g., during maintenance where the unexpected start-up of a machine can create a hazard). Such means shall be as follows:

   (1) Appropriate for the intended use.
   (2) Conveniently located.
   (3) Readily identifiable.
   (4) Provided with permanent means for locking in the off position only.

5.4.2 Removal of power can be accomplished by the use of the supply circuit disconnecting means, additional devices conforming to 5.3.2, or other means (e.g., a contactor switched off by a control circuit).

5.4.3 Where other means of removal of power are used, a single failure of any of its components shall not result in an inadvertent or unexpected start-up.

5.4.4 Other means of removal of power shall be employed only for situations that include the following:

   (1) Routine exchange of parts, fixtures, and tools requiring no significant dismantling of the machine.
   (2) Work on the electrical equipment where all of the following conditions exist:
      a. There is no hazard arising from electric shock (See Chapter 6) and burn.
      b. The switching off means cannot be negated by the work.
      c. The work is of a minor nature (e.g., replacement of plug-in devices without disturbing existing wiring).

5.5 Devices for Disconnecting Electrical Equipment.

5.5.1 Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be performed without a risk from electric shock or burn.

5.5.2 The supply circuit disconnecting device (see Section 5.3) shall be permitted to fulfill this requirement where there is no need for isolating individual portions of the electrical circuit.

5.5.3 Where it is expected that it will be necessary to work on separately operable parts of a machine, a disconnecting means shall be permitted for the electrical equipment of each such part of the machine requiring separate isolation.

5.5.4 The following devices shall be permitted to fulfill the isolating function of 5.5.3:

   (1) Devices described in 5.3.2.
   (2) A manual motor controller suitable for motor disconnecting and compliant with UL 508 where located on the load side of the last short-circuit protective device (in the branch).
   (3) A redundantly monitored, remotely operated contactor isolating system that incorporates control lockout provisions and is listed for isolation purposes.

5.5.5 The devices in 5.5.4 shall be as follows:

   (1) Readily accessible.
   (2) Within sight of the part of the machine requiring isolation.
   (3) Readily identifiable.
   (4) For other than attachment plugs, provided with permanent means for locking in the off position only.

Chapter 6 Protection from Electric Shock

6.1 General. The electrical equipment shall provide protection of persons from electrical shock both in normal operation and during fault conditions.

6.2 Protection from Electric Shock During Normal Operation. Live parts operating at 50 volts rms ac or 60 volts dc or more shall be guarded against accidental contact by an enclosure or shall be a listed multiconductor cable or flexible cord.

6.2.1 Protection by Insulation of Live Parts. Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal operating conditions.

Paints, varnishes, lacquers, and similar products are inadequate for protection against electric shock under normal operating conditions.

6.2.2 Protection by Enclosures.

6.2.2.1 Direct Contact from Outside an Enclosure. Live parts shall be located inside enclosures such that there cannot be any direct contact to live parts from the outside of an enclosure when using the test finger. The determination of the suitability of an enclosure as protection from electrical shock shall be determined by using a test finger as described in Figure 6.2.2.1. The test finger shall be applied, without appreciable force, in every opening in the enclosure after...
removal of all parts of the enclosure that can be removed without the use of a tool.

6.2.3.1 Each disconnecting means mounted within or adjacent to a control enclosure that contains live parts operating at 50 volts ac (rms value) or 60 volts dc or more shall be mechanically or electrically interlocked, or both, with the control enclosure doors so that none of the doors can be opened unless the power is disconnected. Interlocking shall be reactivated automatically when all the doors are closed.

Exception No. 1: A disconnecting means used only for maintenance lighting circuits within control enclosures shall not be required to be interlocked with the control enclosure. A safety sign shall be provided that meets the requirements of 17.2.5.

Exception No. 2: A disconnecting means used for power supply circuits within control enclosures to memory elements and their support logic requiring power at all times to maintain information storage shall not be required to be interlocked with the control enclosure doors. A safety sign shall be provided that meets the requirements of 17.2.5.

6.2.3.1.1 Means shall be permitted to be provided for qualified persons, using appropriate work practices, to gain access without removing power.

6.2.3.2 Where a qualified (skilled) person, using appropriate work practices, needs to enter an enclosure that does not have a disconnect, one of the following conditions shall be met:

(1) The use of a key or tool shall be required for opening the enclosure.
(2) An enclosure door shall be permitted to be opened without the use of a key or a tool and without disconnection of live parts only when all live parts inside are separately enclosed or guarded such that there cannot be any direct contact with live parts by a test finger.

6.2.3.3 Where the equipment has two or more sources of power or two or more independent disconnecting means, power wiring from each disconnecting means shall be run in separate raceway and shall not terminate in or pass through common junction boxes.

6.3 Protection by the Use of Protective Extra Low Voltage (PELV).

6.3.1 General Requirements. The use of PELV is to protect persons against electric shock from indirect contact and limited area direct contact. Where PELV circuits are used as control circuits, they shall also fulfill the relevant requirements of Chapter 5.

PELV circuits shall satisfy all of the following conditions:

(1)* The nominal voltage shall not exceed the following:
   a. 30 volts ac (rms value) or 60 volts dc (ripple free) when the equipment is used in normally dry locations and when large area contact of live parts with the human body is not expected
   b. 6 volts ac (rms value) or 15 volts dc ripple free in all other cases
(2)* One side of the circuit or one point of the source of the supply of that circuit shall be connected to the equipment grounding (protective bonding) circuit.
(3) Live parts of PELV circuits shall be electrically separated from other live circuits. Electrical separation shall be not less than that required between the primary and secondary circuits of a safety isolating transformer.
(4) Conductors of each PELV circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation provisions of 14.1.3 shall apply.
(5) Attachment plugs and receptacles (plugs and socket combinations) for a PELV circuit shall conform to the following:
   a. Attachment plugs (plugs) shall not be able to enter receptacles (socket-outlets) of other voltage systems.
   b. Receptacles (socket-outlets) shall not admit plugs of other voltage systems.

6.3.2 Sources for PELV. The source for PELV shall be one of the following:

(1) A safety isolating transformer
(2) A source of current providing a degree of safety equivalent to that of the safety isolating transformer (e.g., a motor generator with winding providing equivalent isolation)
(3) An electrochemical source (e.g., a battery) or another source independent of a higher voltage circuit (e.g., a diesel-driven generator)
(4) An identified electronic power supply conforming to appropriate standards specifying measures to be taken to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in 6.3.1(1)

6.4 Protection Against Residual Voltages.

6.4.1 Live parts having a residual voltage greater than 60 volts after the supply has been disconnected shall be reduced to 60 volts or less within 5 seconds after disconnection of the supply voltage.

Exception No. 1: Exempted from this requirement are components having a stored charge of 60 microcoulombs or less.

Exception No. 2: Where such a provision would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before entry to the enclosure is allowed, shall be displayed at an easily visible location on or immediately adjacent to the enclosure containing the capacitance.

6.4.2 The withdrawal of plugs or similar devices, which results in the exposure of conductors (e.g., pins), shall have a discharge time that does not exceed 1 second.

Exception No. 1: Exempted from this requirement are components having a stored charge of 60 microcoulombs or less.

Exception No. 2: Exempted from this requirement are conductors that are protected against direct contact.

[ROP 79-45 (Log 75)]

Chapter 7 Protection of Equipment

7.1 General. Chapter 7 shall detail the measures to be taken to protect equipment against the effects of the following:

(1) Overcurrent arising from a short circuit
(2) Overload currents
(3) Ground faults
(4) Overvoltages due to lightning and switching surges
(5) Abnormal temperatures
(6) Loss of or reduction in the supply voltage
(7) Overspeed of machines/machine elements
(8) Incorrect phase sequence

7.2 Overcurrent Protection.

7.2.1* General. Overcurrent protection shall be provided where the current in a machine circuit can exceed either the rating of any component in the circuit or the current carrying capacity of the conductors in the circuit, whichever is the lesser value.

[ROP 79-46 (Log 75)]

7.2.2* Supply Conductors. Unless otherwise specified by the user, the supplier of the electrical equipment shall not be responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment.

The supplier of the electrical equipment shall state on the installation diagram the data necessary for selecting this overcurrent protective device.

7.2.3 Power Circuits. Devices for detection and interruption of overcurrent, selected in accordance with 7.2.10, shall be applied to each ungrounded phase conductor. Conductors shall be protected against overcurrent in accordance with their ampacities as specified in Section 13.5. [ROP 79-47 (Log 76)]

7.2.4 Control Circuits.

7.2.4.1 General. A control circuit tapped from the load side of the branch-circuit short-circuit and ground-fault protective device(s) and functioning to control the load(s) connected to that branch circuit shall be protected against overcurrent in accordance with 7.2.4.2. Such a tapped control circuit shall not be considered to be a branch circuit and shall be permitted to be protected by either a supplementary or branch-circuit overcurrent protective device(s).

7.2.4.2 Conductor Protection.

7.2.4.2.1 Conductors, other than flexible cords and fixture wires, shall be protected against overcurrent in accordance with their ampacities as specified in Section 13.5, unless otherwise permitted in 7.2.4.2.2 through 7.2.4.2.6.

7.2.4.2.2 Conductors sizes of 18, 16, and 14 AWG shall be considered as protected by an overcurrent device(s) of not more than a 20-ampere rating.

7.2.4.2.3 Conductors that do not extend beyond the control cabinet enclosure shall be considered protected by the load branch-circuit short-circuit and ground-fault protective device(s) where the rating of the protective device(s) is not more than 400 percent of the ampacity of the control circuit conductor for conductors 14 AWG and larger, or not more than 25 amperes for 18 AWG and 40 amperes for 16 AWG.

7.2.4.2.4 Conductors of 14 AWG and larger that extend beyond the enclosure shall be considered protected by the load branch-circuit short-circuit and ground-fault protective device(s) where the rating of the protective device(s) is not more than 300 percent of the ampacity of the control circuit conductors.

7.2.4.2.5 Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary shall be considered protected by overcurrent protection provided on the primary (supply) side of the transformer, if this protection is in accordance with 7.2.7 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary voltage ratio. Transformer secondary conductors (other than 2-wire) are not considered to be protected by the primary overcurrent protection.

7.2.4.2.6 Conductors of control circuits shall be considered protected by the motor branch-circuit short-circuit and ground-fault protective device(s) where the opening of the control circuit would create a hazard (e.g., the control circuit of a magnetic chuck).

7.2.5 Receptacle (Socket) Outlets and Their Associated Conductors.

7.2.5.1 Overcurrent protection shall be provided for the circuits feeding general purpose receptacle (socket) outlets intended primarily for supplying power to maintenance equipment.

7.2.5.2 Overcurrent protective devices shall be provided in the ungrounded phase conductors of each circuit feeding receptacle...
(socket) outlets. Overcurrent protection for these receptacle (socket) outlets shall not exceed 15 amperes.

7.2.6 Lighting Circuits. Overcurrent protection for lighting branch circuits shall not exceed 15 amperes.

7.2.7 Transformers.

7.2.7.1 Transformers for motor control circuits shall be protected in accordance with Article 430, Part VI, of NFPA 70, National Electrical Code. Transformers for other than motor control circuits shall be protected in accordance with of NFPA 70, National Electrical Code, Article 450, Part I.

7.2.8 Location of Overcurrent Protective Devices. An overcurrent protective device shall be located at the point where the conductor to be protected is connected to the supply except as follows:

(1) Overcurrent protection at the supply shall not be required if all of the following conditions are met:
   a. The current carrying capacity of the conductors is at least equal to that required for the load.
   b. Each connecting conductor to the overcurrent protective devices is no longer than 3 m (10 ft).
   c. The conductor is suitably protected from physical damage.
   d. The conductor does not extend beyond the control panel enclosure.
   e. The conductor terminates in a branch circuit rated circuit breaker or set of fuses.

(2) Overcurrent protection at the supply shall not be required if all of the following conditions are met:
   a. The conductor has an ampacity of at least one-third that of the conductor from which it is supplied.
   b. The conductor is suitably protected from physical damage.
   c. The conductor is not over 7.5 m (25 ft) long and the conductor terminates in a single circuit breaker or set of fuses.

7.2.9 Short-Circuit Interrupting Rating. The short-circuit interrupting rating shall be at least equal to the available fault current at the point of application. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (e.g., from motors, from power factor correction capacitors), these shall be taken into consideration.

7.2.10* Rating and Setting of Overcurrent Protective Devices.

7.2.10.1 Each motor controller and its associated wiring shall be protected as an individual branch circuit by a short-circuit protective device (SCPD) as specified by the controller manufacturer. The maximum rating of the designated SCPD shall be as shown in Table 7.2.10.1.

Exception: Table 7.2.10.1 shall not apply to Design E motor circuits. The provisions of NFPA 70, National Electrical Code, shall be observed for Design E motor circuits.

![Table 7.2.10.1 Maximum Rating of Setting of Fuse and Circuit Breakers: Motor, Motor Branch Circuit, and Motor Controller](image)

<table>
<thead>
<tr>
<th>Fuse Class with Non-Time Delay</th>
<th>Full-Load Current (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>300 300 300</td>
</tr>
<tr>
<td>J</td>
<td>300 300 300</td>
</tr>
<tr>
<td>CC</td>
<td>300 300 300</td>
</tr>
<tr>
<td>T</td>
<td>300 300 300</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuse Class with Time Delay Type of Application</th>
<th>Full-Load Current (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RK-51</td>
<td>150 175 175</td>
</tr>
<tr>
<td>RK-1</td>
<td>150 175 175</td>
</tr>
<tr>
<td>J</td>
<td>150 175 225</td>
</tr>
<tr>
<td>CC</td>
<td>150 300 300</td>
</tr>
<tr>
<td>Instantaneous trip circuit breaker</td>
<td>800 800 800</td>
</tr>
<tr>
<td>Inverse trip circuit breaker1</td>
<td>150 250 250</td>
</tr>
<tr>
<td>Inverse trip circuit breaker2</td>
<td>150 250 250</td>
</tr>
</tbody>
</table>

1Where the values determined by Table 7.2.10.1 do not correspond to the standard sizes or ratings, the next higher standard size, rating, or possible setting shall be permitted.

2Where the rating of a time-delay fuse (other than CC type) specified by the table is not sufficient for the starting of the motor, it shall be permitted to be increased but shall in no case be permitted to exceed 225 percent. The rating of a time-delay Class CC fuse and non-time-delay Class CC, J, or T fuse shall be permitted to be increased but shall in no case exceed 400 percent of the full-load current. [ROP 79-52 (Log 161)]

3Types:
   - AC-2: All light-starting duty motors, including slip-rings motors; starting, switching off.
   - AC-3: All medium starting duty motors including squirrel-cage motors; starting, switching off while running, occasional inching, jogging, or plugging but not to exceed 5 operations per minute or 10 operations per 10 minutes and all wye-delta and two-step autotransformer starting motors.
   - AC-4: All heavy starting duty motors including squirrel-cage motors; starting, plugging, inching, jogging.
   - AC-5: All motors with ratings one-third that of the motor full-load current.

4Unless a motor controller is listed for use with RK-5 fuses, Class RK-5 fuses shall be used only with NEMA-rated motor controllers.

5Instantaneous trip circuit breakers shall be permitted to be used only if they comply with all of the following:
   (1) If they are adjustable, and
   (2) If part of a combination controller has motor-running protection and also short-circuit and ground-fault protection in each conductor, and
   (3) If the combination is especially identified for use, and
   (4) It is installed per any instructions included in its labeling and
   (5) If they are limited to single motor applications circuit breakers with adjustable trip settings shall be set at the controller manufacturer’s recommendation, but not greater than 1300 percent of the motor full-load current.

6Where the rating of an inverse time circuit breaker specified in Table 7.2.10.1 is not sufficient for the starting current of the motor, it shall be permitted to be increased but in no case exceed 400 percent for full-load currents of 100 amperes or less or 300 percent for full-load currents greater than 100 amperes. [ROP 79-52 (Log 161)]
7.2.10.2 Several motors each not exceeding 1 hp in rating shall be permitted on a nominal 120-volt branch circuit protected at not over 20 amperes or a 600-volt nominal or less branch circuit, protected at not over 15 amperes, where all of the following conditions are met:

(1) The full-load rating of each motor does not exceed 6 amperes.
(2) The rating of the branch-circuit short-circuit and ground-fault protective device marked on any of the controllers is not exceeded.
(3) Individual overload protection conforms to Section 7.3.

7.2.10.3 Where the branch-circuit, short-circuit, and ground-fault protective device is selected not to exceed that allowed by 7.2.10.1 for the smallest rated motor, two or more motors or one or more motors and other load(s), with each motor having individual overload protection, shall be permitted to be connected to a branch circuit where it can be determined that the branch-circuit short-circuit and ground-fault protective device will not open under the most severe normal conditions of service that might be encountered.

7.2.10.4 Two or more motors and their control equipment shall be permitted to be connected to a single branch circuit where short-circuit and ground-fault protection is provided by a single inverse time circuit breaker or a single set of fuses, provided both of the following conditions are met:

(1) Each motor controller and overload device is listed for group installation with specified short-circuit current ratings.
(2) The rating or setting of the overcurrent device does not exceed the values in Table 7.2.10.4(2) for the smallest conductor in the circuit.

Table 7.2.10.4(2) Relationship Between Conductor Size and Maximum Rating or Setting of Short-Circuit Protective Device for Power Circuits

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Non-Time-delay Fuse or Inverse Time Circuit Breaker (amperes)</th>
<th>Time Delay or Dual Element Fuse (amperes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>12</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>150</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>250</td>
<td>125</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>350</td>
<td>175</td>
</tr>
<tr>
<td>1</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>0</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>2/0</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td>3/0</td>
<td>700</td>
<td>350</td>
</tr>
<tr>
<td>4/0</td>
<td>800</td>
<td>400</td>
</tr>
</tbody>
</table>

7.2.11 Resistance Heating Branch-Circuit Overcurrent Protection.

7.2.11.1 If the branch circuit supplies a single nonmotor-operated load rated at 16.7 amperes or more, the overcurrent device rating shall not exceed 150 percent of the load rating.

7.2.11.2 Equipment employing resistance-type heating elements rated at more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

Exception: A single sheath-type heating element requiring more than 48 amperes shall be protected at not more than 125 percent of the load where the element is integral with and enclosed within the machine housing.

7.2.11.3 The supplementary overcurrent protective devices shall be as follows:

(1) Installed within or on the machinery or provided as a separate assembly
(2) Accessible but need not be readily accessible
(3) Suitable for branch-circuit protection

The main conductors supplying these overcurrent protective devices shall be considered branch-circuit conductors.

7.2.12 Programmable Electronic System Power Supply Input Overcurrent Protection. Programmable electronic system power supply inputs shall be protected by overcurrent protective devices either externally or internally. The overcurrent protection size or rating shall be in accordance with the manufacturer’s instructions.

7.2.13 Control Devices. Pushbuttons, selector switches, sensors, and limit switches shall in no case be connected to a circuit rated larger than 10 amperes.

7.2.14 Common Overcurrent Device. The use of the same overload device to provide the protection called for in 7.2.4, 7.2.6, and 7.2.7 shall be permitted.

7.3 Overload Protection of Motors.

7.3.1 General. Overload devices shall be provided to protect each motor, motor controller, and branch-circuit conductor against excessive heating due to motor overloads or failure to start.

Motor overload protection shall be provided as follows:

(1) Motors in accordance with Article 430, Part III of NFPA 70, National Electrical Code.
(b) Adjustable speed drives (electronic drives) in accordance with Article 430.2 of NFPA 70, National Electrical Code.

7.3.2 Resetting. Resetting of the overload device shall not restart the motor.

Exception: Where the machine has only a single motor of 2 hp or less, an overload reset operator mounted on the motor shall be permitted to restart the motor provided that the distance between the overload reset operator and the machine start pushbutton operator is 300 mm (12 in.) or less, and a suitable warning label is attached on or adjacent to the overload reset operator.

7.3.3 Number of Overloads. The minimum number and location of running overcurrent units shall be determined from Table 7.3.3.

An overload unit in each phase shall not be required where overload protection is provided by other approved means.
Note: For 2-phase power supply systems, see NFPA 70, National Electrical Code, Section 450.37. [ROP 79-44 (Log 45)]

Short-time-rated motors or high-reversing duty motors that cannot be adequately protected by external overload devices shall be protected by a thermal device mounted in the motor and sensitive to the temperature of the motor, or to both motor temperature and current.

Motors that are an integral part of a refrigeration compressor of the hermetic or semihermetic type shall be protected per the compressor manufacturer’s recommendations.

7.4* Abnormal Temperature Protection. Resistance heating or other circuits that are capable of attaining or causing abnormal temperatures and, therefore, can cause a hazardous condition shall be provided with suitable detection to initiate an appropriate control response.

7.5 Protection Against Supply Interruption or Voltage Reduction and Subsequent Restoration.

7.5.1 General. Where a supply interruption or a voltage reduction can cause a hazardous condition or damage to the machine or to the work in progress, undervoltage protection shall be provided (e.g., to switch off the machine) at a predetermined voltage level.

7.5.2 Undervoltage Protection. Where the operation of the machine can allow for an interruption or a reduction of the voltage for a short time period, delayed undervoltage protection shall be permitted to be provided. The operation of the undervoltage device shall not impair the operation of any stopping control of the machine.

7.5.3 Restarting. Upon restoration of the voltage or upon switching on the incoming supply, automatic or unintentional restarting of the machine shall be prevented when such a restart can cause a hazardous condition.

Where only a part of the machine or of the group of machines working together in a coordinated manner is affected by the voltage reduction or supply interruption, the undervoltage protection shall initiate appropriate control responses to ensure coordination.

7.6 Overspeed Protection.

7.6.1* Motor Overspeed Protection. Unless the inherent characteristics of the motor or the controller, or both, are such as to limit the speed adequately, drive systems motors shall include protection against motor overspeed.

7.6.2 Equipment Overspeed Protection. Where the safe operating speed of the equipment is less than that of the drive motor, means shall be provided to limit the speed of the equipment.

7.7 (Reserved.)

7.8* Phase Sequence Protection. Where a phase loss or an incorrect phase sequence of the supply voltage can cause a hazardous condition or damage to the machine, protection shall be provided.

7.9 Protection Against Overvoltages Due to Lightning and Switching Surges.

7.9.1 Protective devices shall be permitted to be provided to protect against the effects of overvoltages due to lightning or switching surges.

7.9.2 Where provided, devices for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the supply disconnecting device.

7.9.3 Where provided, devices for the suppression of overvoltages due to switching surges shall be connected across the terminals of all equipment requiring such protection.

7.10 Power Factor Correction Capacitors.

7.10.1* Overcurrent Protection. Where capacitors are installed for motor power factor correction on circuits of 600 volts, nominal, and under, overcurrent protection for the conductors shall be provided. Each capacitor cell or capacitor bank shall be protected against rupture of the individual cells. Protection included as a part of the capacitor assembly shall be provided.

7.10.2 Discharge of Stored Energy.

Capacitors shall be provided with a means of discharging stored energy. [70:460.6]

7.10.2.1 Time of Discharge. The residual voltage of a capacitor shall be reduced to 50 volts, nominal, or less, within 1 minute after the capacitor is disconnected from the source of supply. [70:460.6]

7.10.2.2 Means of Discharge. The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank upon removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used. [70:460.6]
Chapter 8  Grounding

8.1* General.

8.1.1 Applicability. This chapter shall provide for grounding, bonding requirements, and grounded conductors.

8.1.2 Connections. Grounded conductors shall not be connected to the equipment grounding (protective) circuit, except for separately derived systems.

8.2 Equipment Grounding (Protective Bonding) Circuit.

8.2.1 Grounding System. The equipment grounding (protective bonding) circuit shall consist of the following:

  (1) Equipment grounding (PE) terminal(s)
  (2) Conductive structural parts of the electrical equipment and the machine
  (3) Equipment grounding (protective) conductors and equipment bonding jumpers

All parts of the equipment grounding (protective bonding) circuit shall be capable of withstanding the highest thermal and mechanical stress that can be caused by fault currents flowing in that part of the circuit.

All exposed conductive parts of the electrical equipment and the machine(s) shall be connected to the equipment grounding (protective bonding) circuit.

Exception: Small parts such as screws, rivets, and nameplates that are not likely to become energized shall not be required to be grounded.

8.2.1.1 Equipment Grounding. The machine and all exposed, noncurrent-carrying conductive parts, material, and equipment likely to be energized shall be effectively grounded. Where electrical devices are mounted on metal mounting panels that are located within nonmetallic enclosures, the metal mounting panels shall be effectively grounded.

8.2.1.2* Equipment Grounding Terminal.

8.2.1.2.1 For each incoming supply circuit, an equipment grounding (external protective) conductor terminal shall be provided in the vicinity of the associated phase conductor terminals.

8.2.1.2.2 All of the items in 8.2.1.1 shall be interconnected to the equipment grounding terminal.

8.2.1.2.3 The equipment grounding terminal shall accommodate an equipment grounding conductor sized in accordance with Table 8.2.2.3.

8.2.1.2.4* The equipment grounding terminal shall be identified with the word "GROUND," the letters "GND" or "GRD," the letter "G," the color GREEN, or the symbol in Figure 8.2.1.2.4. In addition to the required marking, the letters PE shall also be permitted to identify this terminal.

Exception: Where an attachment plug and receptacle are used as the disconnecting means, 5.3.3.3 shall apply.

8.2.2 Equipment Grounding (Protective) Conductors and Bonding Jumpers. Equipment grounding (protective) conductors and bonding jumpers shall be identified in accordance with 14.2.2.

8.2.2.1 Conductors used for grounding and bonding purposes shall be copper. Stipulations on stranding and flexing as outlined in this standard shall apply.

8.2.2.2 Equipment grounding conductors and bonding jumpers shall be insulated, covered, or bare and shall be protected against physical damage.

8.2.2.3 Equipment grounding conductors and bonding jumpers of the wire type shall not be smaller than shown in Table 8.2.2.3, but shall not be required to be larger than the circuit conductors supplying the equipment.

8.2.2.3.1 Machine members or structural parts of the electrical equipment shall be permitted to be used in the equipment grounding circuit provided that the cross-sectional area of these parts is at least electrically equivalent to the minimum cross-sectional area of the copper conductor required. [ROP 79-152 (Log 81)]

Table 8.2.2.3 Minimum Size of Equipment Grounding Conductors and Bonding Jumpers

<table>
<thead>
<tr>
<th>Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of the Equipment (Not exceeding Amperes)</th>
<th>Copper Conductor Size (AWG or kcmil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>8</td>
</tr>
<tr>
<td>200</td>
<td>6</td>
</tr>
<tr>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>400</td>
<td>3</td>
</tr>
<tr>
<td>500</td>
<td>2</td>
</tr>
<tr>
<td>600</td>
<td>1</td>
</tr>
<tr>
<td>800</td>
<td>1/0</td>
</tr>
<tr>
<td>1000</td>
<td>2/0</td>
</tr>
<tr>
<td>1200</td>
<td>3/0</td>
</tr>
<tr>
<td>1600</td>
<td>4/0</td>
</tr>
<tr>
<td>2000</td>
<td>250</td>
</tr>
<tr>
<td>2500</td>
<td>350</td>
</tr>
<tr>
<td>3000</td>
<td>400</td>
</tr>
<tr>
<td>4000</td>
<td>500</td>
</tr>
<tr>
<td>5000</td>
<td>700</td>
</tr>
<tr>
<td>6000</td>
<td>800</td>
</tr>
</tbody>
</table>

8.2.3 Continuity of the Equipment Grounding (Protective Bonding) Circuit.
8.2.5.2 The equipment grounding (protective bonding) circuit shall be ensured by effective connections through conductors or structural members.

8.2.5.3 Bonding of equipment with bolts or other identified means shall be permitted where paint and dirt are removed from the joint surfaces or where the bonded members are effectively penetrated.

8.2.5.4 Moving machine parts, other than accessories or attachments, having metal-to-metal bearing surfaces shall be considered as bonded. Sliding parts separated by a nonconductive fluid under pressure shall not be considered as bonded.

8.2.5.5 Raceways, wireways, and cable trays shall not be used as equipment grounding or bonding conductors.

8.2.6 Doors or Covers.

8.2.6.1 Where electrical devices are mounted on conductive doors or covers, an equipment (protective) bonding jumper shall be installed.

8.2.6.2 An equipment (protective) bonding jumper shall connect the conductive door or cover to the equipment enclosure or to an equipment grounding (protective bonding) terminal within the enclosure.

8.2.7 Portable, pendant, and resilient-mounted equipment shall be bonded by separate conductors. Where multiconductor cable is used, the bonding conductor shall be included as one conductor of the cable.

8.2.8 Where equipment grounding conductors are subject to physical damage they shall be protected or monitored to ensure continuity.

8.2.4 Exclusion of Switching Devices. The equipment grounding (protective) circuit shall not contain any switches or overcurrent protective devices. Links or plugs in the grounding circuit shall be permitted if properly labeled or interlocked with the control circuits.

8.2.5 Equipment Grounding (Protective) Conductor Connecting Points.

8.2.5.1 All equipment grounding (protective) conductors shall be terminated in accordance with 14.1.1. The equipment grounding (protective) conductor connecting points shall have no other function.

8.2.5.2 The equipment grounding conductor connecting points, other than the equipment grounding terminal, shall be identified by the color GREEN or by use of the symbol in Figure 8.2.1.2.4.

8.3 Control Circuits. Control circuits shall be permitted to be grounded or ungrounded. Where grounding is provided, that side of the circuit common to the coils shall be grounded at the control transformer if alternating current or at the power supply terminal if direct current.

Ungrounded control circuits shall be provided with an insulation monitoring device that either indicates a ground (earth) fault or interrupts the circuit automatically after a ground (earth) fault.

Exception No. 1: Exposed control circuits as permitted by Section 6.3 shall be grounded.

Exception No. 2: Overload relay contacts shall be permitted to be connected between the coil and the grounded conductor where the conductors between such contacts and coils of magnetic devices do not extend beyond the control enclosure.

Exception No. 3: Class 2 low-voltage circuits in Article 725 of NFPA 70, National Electrical Code shall not require insulation monitoring.

8.5 Lighting Circuits.

8.5.1 One conductor of all machine lighting and maintenance lighting circuits shall be grounded. The grounded conductor(s) shall be identified in accordance with Section 14.2.

8.4.2 Where the lighting circuit is supplied by a separate isolation transformer, the grounding shall occur at the transformer. Where the equipment maintenance lighting circuit is supplied directly from the plant lighting circuit, the grounding shall occur at the grounding terminal.

8.4.3 The grounded conductor, where run to a screw-shell lampholder, shall be connected to the screw-shell.

Chapter 9 Control Circuits and Control Functions

9.1 Control Circuits.

9.1.1 Control Circuit Supply.

9.1.1.1 Control transformers shall be used for supplying the control circuits. Control circuits shall not be derived from autotransformers.

9.1.1.2 Where dc control circuits are connected to the equipment grounding (protective bonding) circuit, they shall be supplied from a separate winding of the ac control circuit transformer or by another control circuit transformer or a listed dc power supply.

9.1.1.3 Transformers shall not be required if the supply voltage does not exceed 120 volts ac and the available short-circuit current does not exceed 1000 amperes rms.

9.1.1.4 The source of supply for all control circuits shall be taken from the load side of the supply disconnecting means.

Exception: The power supply circuit to memory elements and their support logic requiring power at all times to maintain the storage of information shall be permitted to be taken from the line side of the supply disconnecting means or other power source.

9.1.1.5 The marking requirements of 17.2.4 shall apply.

9.1.2 Control Circuit Voltages.

9.1.2.1 AC Control Circuit Voltages. The ac voltage for control circuits shall not exceed 120 volts, ac single phase.

Exception No 1: Other voltages shall be permitted, where necessary, for the operation of electronic, precision, static, or devices used in the control circuit.

Exception No. 2: Any electromechanical magnetic device having an inrush current exceeding 20 amperes at 120 volts shall be permitted to be energized at
9.2.2 DC Control Circuit Voltages. DC control voltage shall be 250 volts or less.

9.1.3 Protection. Control circuits shall be provided with overcurrent protection in accordance with Chapter 7.

9.1.4 Connection of Control Circuit Devices.

9.1.4.1 All operating coils of electromechanical magnetic devices and indicator lamps (or transformer primary windings for indicator lamps) shall be directly connected to the same side of the control circuit. All control circuit contacts shall be connected between the coil and the other side of the control circuit.

Exception No. 1: Overload relay contacts where the wiring to these contacts does not extend beyond the control enclosure.

Exception No. 2: Contacts of multipole control circuit switching devices that simultaneously open both sides of the control circuit.

Exception No. 3: Ground test switching device contacts in ungrounded control circuits.

Exception No. 4: Solenoid test switching device contacts in ungrounded circuits.

Exception No. 5: Coils or contacts used in electronic control circuits where the wiring to these coils or contacts does not extend beyond the control enclosure.

Exception No. 6: "Run" pushbuttons for two-hand operation, such as for presses having ground detection circuits and overcurrent protection in each conductor.

9.1.4.2 Contacts shall not be connected in parallel where the purpose is to increase ampacity.

9.2 Control Functions.

9.2.1 Start Functions. Start functions shall operate by energizing the relevant circuit.

9.2.2* Stop Functions. The three categories of stop functions shall be as follows:

(1) Category 0 is an uncontrolled stop by immediately removing power to the machine actuators.
(2) Category 1 is a controlled stop with power to the machine actuators available to achieve the stop then remove power when the stop is achieved.
(3) Category 2 is a controlled stop with power left available to the machine actuators.

9.2.3 Operating modes.

9.2.3.1 Each machine shall be permitted to have one or more operating modes (e.g., automatic, manual, normal, and bypass) determined by the type of machine and its application.

9.2.3.2 Where a hazardous condition results from mode selection, inadvertent selection shall be prevented from occurring (e.g., key-operated switch, access code). Mode selection by itself shall not initiate machine operation. A separate action by the operator shall be required. [ROP 79-70 (Log 152)]

9.2.3.3 Safeguarding means shall remain effective for all operating modes.

9.2.3.4 Indication of the selected operating mode shall be provided (e.g., position of mode selector, provision of indicating light, visual display indication).

9.2.4 Overriding Safeguards. Where it is necessary to temporarily override one or more safeguards, a mode selection device or means capable of being secured (e.g., locked) in the desired mode shall be provided to prevent automatic operation. The control circuit for the suspension of a safeguard shall have the same safety requirements as the suspended safeguard itself. In addition, one or more of the following measures shall be permitted to be provided:

(1) Initiation of motion by a hold-to-run or other control device.
(2) A portable control station (e.g., pendant) with an emergency stop device, and where appropriate, an enabling device. Where a portable station is used, motion shall only be initiated from that station.
(3) Limiting the speed or the power of motion.
(4) Limiting the range of motion. [ROP 79-71 (Log 151)]

9.2.5 Operation.

9.2.5.1 General.

9.2.5.1.1 The necessary interlocks shall be provided for safe operation.

9.2.5.1.2 Measures shall be taken to prevent movement of the machine in an unintended manner after any stopping of the machine (e.g., locked-off condition, power supply fault, battery replacement, lost signal condition with cableless control).

9.2.5.2 Start.

9.2.5.2.1 The start of an operation shall be possible only where all of the safeguards are in place and functional except for conditions as described in 9.2.4.

9.2.5.2.2 On those machines where safeguards cannot be applied for certain operations, manual control of such operations shall be by hold-to-run controls together with enabling devices.

9.2.5.2.3 Interlocks shall be provided to ensure correct sequential starting.

9.2.5.2.4 On machines requiring the use of more than one control station to initiate a start, the following criteria shall be met:

(1) Each control station shall have a separate manually actuated start control device.
(2) All required conditions for machine operation shall be met.
(3) All start control devices shall be in the released (off) position before a start operation is permitted.
(4) All start control devices shall be actuated concurrently.

9.2.5.3 Stop.

9.2.5.3.1 Each machine shall be equipped with a category 0 stop.

9.2.5.3.2 Category 0, Category 1, and/or Category 2 stops shall be provided where indicated by an analysis of the risk assessment and
the functional requirements of the machine. Category 0 and Category 1 stops shall be operational regardless of operating modes, and Category 0 shall take priority. Stop function shall operate by de-
energizing that relevant circuit and shall override related start functions.

9.2.5.3 Where required, provisions to connect protective devices and interlocks shall be provided. Where applicable, the stop function shall signal the logic of the control system that such a condition exists. The reset of the stop function shall not initiate any hazardous conditions.

9.2.5.4* Emergency Operations (Emergency Stop, Emergency Switching Off).

9.2.5.4.1 Emergency Stop. Where the emergency stop function is used, it shall be initiated by a single human action.

9.2.5.4.1.1 In addition to the requirements for stop, the emergency stop shall have the following requirements:

(1) It shall override all other functions and operations in all modes.
(2) Power to the machine actuators, which causes a hazardous condition(s), shall be removed as quickly as possible without creating other hazards (e.g., by the provision of mechanical means of stopping requiring no external power, by reverse current braking for a Category 1 stop).
(3) Reset of an emergency stop circuit shall not initiate a restart.

9.2.5.4.1.2 Where required, provisions to connect additional emergency stop devices shall be provided in accordance with Section 10.7.

9.2.5.4.1.3 The emergency stop shall function as either a Category 0 or a Category 1 stop (see 9.2.2). The choice of the category of the emergency stop shall be determined by the risk assessment of the machine.

9.2.5.4.1.4 Where a Category 0 stop is used for the emergency stop function, it shall have only hardwired electromechanical components.

Exception: An electronic logic (hardware or software) system as well as the communication network or link that complies with 11.3.4 and is listed for Category 0 emergency stop function shall be permitted. The final removal of power shall be accomplished by means of electromechanical components. [ROP 79-77 (Log 12)] [ROP 79-72 (Log 150)]

9.2.5.4.2 Emergency Switching Off. Where the emergency switching off function is used, it shall be initiated by a single human action.

9.2.5.4.2.1 Emergency switching off shall be permitted as follows:

(1) Where protection against direct contact (e.g., with collector wires, collector bars, slipping assemblies, control gear in electrical operating areas) is achieved only by placing out of reach or by obstacles.
(2) Where other hazards or damage caused by electricity are possible.

9.2.5.4.2.2 Emergency switching off shall be accomplished by disconnecting the incoming supply circuit of the machine effecting a Category 0 stop. Where the machine cannot tolerate the Category 0 stop, it shall be necessary to provide other protection, (e.g., against direct contact) so that emergency switching off is not necessary.

9.2.5.5 Hold-to-Run Controls.

9.2.5.5.1 Hold-to-run controls (e.g., jog, inch functions) shall require continuous actuation of the control device(s) to achieve operation.

9.2.5.5.2 Jog or inch functions shall operate only in the manual mode. Manual reverse shall be considered a jog function. The prevention of run or automatic operation during jog or inch shall be accomplished by an operator interface and a separate jog or inch selection method.

9.2.5.6* Two-Hand Control. All two-hand controls shall have the following features:

(1) The provision of two control devices shall require the concurrent actuation by both hands.
(2) It shall be necessary to actuate the control devices within a certain time limit of each other.
(3) Where the time limit of less than or equal to 0.5 seconds is exceeded, both control devices shall be released before operation is initiated.
(4) The control devices shall require continuous actuation during the hazardous conditions.
(5) Machine operation shall cease upon the release of either control device when hazardous conditions are still present and
(6) Require of the release of both control devices, before the machine operation is reinitiated.

9.2.5.7 Enabling Device.

9.2.5.7.1 An enabling device as used in this chapter is defined as an additional manually operated control device used in conjunction with a start control and, when continuously actuated, allows a machine to function.

9.2.5.7.2 When an enabling device is provided as a part of a system, it shall be designed to allow motion when actuated in one position only. In any other position motion shall be stopped.

9.2.5.7.3 Enabling devices shall have the following features:

(1) Connect to a Category 0 or a Category 1 stop (see 9.2.2)
(2) Design follows ergonomic principles
(3) For two-position types, the positions are as follows:
   a. Position 1 is the off function of the switch (actuator is not operated)
   b. Position 2 is the enabling function (actuator is operated)
(4) For three-position types, the positions are as follows:
   a. Position 1 is the off function of the switch (actuator is not operated)
   b. Position 2 is the enabling function (actuator is operated in its mid position) c. Position 3 is the off function of the switch (actuator is operated past its mid position)
A three-position enabling device shall require manual operation to reach position 3.
9.2.5.7.4 When returning from position 3 to position 2, the function shall not be enabled.

9.2.5.7.5 An enabling device shall automatically return to its off function when its actuator is not manually held in the enabling position.

9.2.6 Combined Start and Stop Controls. A single pushbutton and other devices that alternately start and stop motion shall only be used for secondary functions where no hazardous condition arises when they are operated.

9.2.7 Cableless Control Functions.

9.2.7.1 General.

9.2.7.1.1 Means shall be provided to remove or disconnect the power supply of the operator control station.

9.2.7.1.2 Means (e.g., key-operated switch, access code) shall be provided, as necessary, to prevent unauthorized use of the operator control station.

9.2.7.1.3 Each operator control station shall carry an unambiguous indication of which machine(s) is intended to be controlled by that operator control station.

9.2.7.2 Control Limitation.

9.2.7.2.1 Measures shall be taken to ensure that control commands affect only the following:

(1) The intended machine
(2) The intended functions

9.2.7.2.2 Measures shall be taken to prevent the machine from responding to signals other than those from the intended operator control station(s).

9.2.7.2.3 Means shall be provided so that the machine shall only be controlled from operator control stations in one or more predetermined zones or locations.

9.2.7.3 Stop Function.

9.2.7.3.1 Operator control stations shall include a separate and clearly identifiable means to initiate the stop function of the machine or of all the motions that cause a hazardous condition. The actuating means to initiate this stop function shall not be marked or labeled as an emergency stop device, even though the stop function initiated on the machine results in an emergency stop function.

9.2.7.3.2 A machine that has safety critical functions that are equipped with cableless control shall have a means of automatically initiating the stopping of the machine and preventing the initiation of potentially hazardous motions in the following situations:

(1) When a stop signal is received
(2) When a fault is detected in the system
(3) When a valid signal has not been detected within a specified period of time

9.2.7.4 Serial Data Communication. In a machine where the control of safety critical functions relies on serial data transfer, correct communications shall be ensured by using an error detection method that is able to cope with up to three error bits in any command sequence. The safety capability of the serial data communication system shall be listed to have the same degree of safety capability as hardware-based components installed in accordance with this standard.

9.2.7.5 Use of More Than One Operator Control Station. Where a machine has more than one operator control station, measures shall be taken to ensure that only one control station shall be enabled at a given time. Indication of which operator control station is in control of the machine shall be provided at locations where necessary for the safety requirements of the machine.

Exception: A stop command from any one of the control stations shall be effective where necessary for the safety requirements of the machine.

9.2.7.6 Battery-Powered Operator Control Stations. A variation in the battery voltage shall not cause a hazardous condition. If one or more potentially hazardous motions are controlled using a battery-powered operator control station, a clear indication shall be given to warn the operator when a variation in battery voltage exceeds specified limits. Under those circumstances, the operator control station shall remain functional long enough to put the machine into a nonhazardous condition.

9.3 Protective Interlocks.

9.3.1 Reclosing or Resetting of an Interlocking Safeguard. The reclosing or resetting of an interlocking safeguard shall not initiate machine motion or operation that results in a hazardous condition.

9.3.2 Overtravel Limits. Where a machine overtravel causes a hazardous condition, a position sensor or limit switch shall be provided to initiate control action.

9.3.3 Operation of Auxiliary Functions.

9.3.3.1 Appropriate devices (e.g., pressure sensors) shall check the correct operation of the auxiliary functions.

9.3.3.2 Where the nonoperation of a motor or device for an auxiliary function (e.g., lubrication, coolant, swarf removal) causes a hazardous condition or causes damage to the machine or to the work in progress, interlocking shall be provided.

9.3.4 Interlocks Between Different Operations and for Contrary Motions.

9.3.4.1 All contactors, relays, and other control devices that control elements of the machine that cause a hazardous condition when actuated at the same time (e.g., those that initiate contrary motion) shall be interlocked against incorrect operation.

9.3.4.2 Motor contactors and starters that initiate opposing motion shall be both mechanically and electrically interlocked to prevent simultaneous operation. Relays and solenoids that are mechanically interlocked shall be electrically interlocked.

[ROP 79-65(Log 84)]

9.3.4.3 Where certain functions on the machine are required to be interrelated for safety or for continuous operation, coordination shall be ensured by interlocks. For a group of machines working together in a coordinated manner and having more than one controller, provision shall be made to coordinate the operations of the controllers as necessary.
9.3.4.4 Where a failure of a mechanical brake actuator results in the brake being applied when the associated machine actuator is energized and a hazardous situation results, interlocks shall be provided to switch off the machine actuator.

9.3.5 Reverse Current Braking.

9.3.5.1 Where reverse current braking is used on a motor, effective measures shall be taken to prevent the motor starting in the opposite direction at the end of braking where this reversal will cause a hazardous condition or damage to the machine or to the work in progress. For this purpose, the use of a device operating exclusively as a function of time shall not be allowed.

9.3.5.2 Control circuits shall be arranged so that rotation of a motor shaft, manually or otherwise, shall not result in a hazardous condition.

9.3.6 Protective Interlock. Where doors are interlocked, the interlocking devices shall be listed safety switches to prevent the operation of the equipment when the doors are open. [ROP 79-79 (Log 116)]

9.4 Control Functions in the Event of Failure.

9.4.1* General Requirements. Where failures or disturbances in the electrical equipment can cause a hazardous condition or damage to the machine or the work in progress, measures shall be taken to minimize the probability of the occurrence of such failures or disturbances. [ROP 79-67 (Log 85)]

9.4.2 Protection Against Unintended Operation Due to Ground (Earth) Faults and Voltage Interruptions.

9.4.2.1 Ground (Earth) Faults. Ground (earth) faults on any control circuit shall not cause unintentional starting or potentially hazardous motions, or prevent stopping of the machine. Grounded control circuits shall be in accordance with Sections 8.2 and 8.3. Ungrounded control circuits shall be provided with an insulation monitoring device that either indicates a ground (earth) fault or interrupts the circuit automatically after a ground (earth) fault. A restart of the machine with a detected ground (earth) fault shall be prevented. [ROP 79-69 (Log 147)]

9.4.2.2 Voltage Interruptions.

9.4.2.2.1 The requirements detailed in Section 7.5 shall apply.

9.4.2.2.2 Where a memory is used, its functioning in the event of power failure shall be ensured (e.g., by using a nonvolatile memory) where such loss of memory can result in a hazardous condition. [ROP 79-62 (Log 46)]

Chapter 10 Operator Interface and Control Devices

10.1 General.

10.1.1* Applicability. This chapter shall contain the requirements for devices mounted outside or partially outside control enclosures.

10.1.2 Location and Mounting.

10.1.2.1 Control Devices. As far as is practicable, control devices shall be as follows:

(1) Readily accessible for service and maintenance
(2) Mounted in such a manner as to minimize the possibility of damage from activities such as material handling

10.1.2.2 Hand-Operated Control Devices. The actuators of hand-operated control devices shall be selected and installed as follows:

(1) They are not less than 0.6 m (2 ft) above the servicing level and are within easy reach of the normal working position of the operator.
(2) The operator is not placed in a hazardous situation when operating them.
(3) The possibility of inadvertent operation is minimized.

10.1.3* Protection. Operator interface, control devices, and enclosures shall be suitable for the environment and shall withstand the stresses of expected use.

10.1.4 Position Sensors.

10.1.4.1 Position sensors (e.g., limit switches, position switches, proximity switches) shall be arranged so that they will not be damaged in the event of overtravel.

10.1.4.2* Position sensors used in circuits with safety-related functions either shall have positive (direct) opening operation or shall provide similar reliability.

10.1.5 Portable and Pendant Control Stations.

10.1.5.1 Portable and pendant operator control stations and their control devices shall be selected and arranged to minimize the possibility of inadvertent machine operations.

10.1.5.2 Pendant control stations that are vertically suspended from overhead shall comply with 14.4.2.4 or 14.5.10.

10.1.6 Operator Interface Devices.

10.1.6.1 Location of Operator Interface Devices.

10.1.6.1.1 Operator interface devices shall be mounted in locations that will minimize exposure to oil, coolant, and other contaminants.

10.1.6.1.2 Operator interface devices shall be within normal reach of the machine operator and shall be placed so that the operator is not exposed to hazards.

10.1.6.1.3 Operator interface devices shall be located so that unintentional operation by normal movement of the machine, operator, or work will be unlikely.

10.1.6.2 Arrangement of Operator Interface Devices. All start pushbuttons shall be mounted above or to the left of their associated stop pushbuttons.

Exception No. 1: Start pushbuttons in series, such as operating pushbuttons on punch presses.

Exception No. 2: Wobble-stick or rod-operated emergency stop pushbuttons mounted in the bottom of pendant stations.

10.1.7 Foot-Operated Switches. Foot-operated switches used for applications where accidental actuation could create a hazardous
situation shall be protected to prevent accidental actuation by falling or moving objects and from unintended operation by accidental stepping onto the switch.

Exception: Foot-operated switches used for emergency stop in accordance with 10.7.2.1 shall not be of the covered or hooded type.

10.2 Pushbutton Actuators and Color Graphic Interface Devices.

10.2.1 Pushbutton Actuators. Pushbutton actuators used to initiate a stop function shall be of the extended operator or mushroom-head types.

10.2.2 Colors. Pushbutton actuators and action initiating icons of color graphic interface devices shall be color coded in accordance with 10.2.2.1 through 10.2.2.6.

10.2.2.1 Start or On. The preferred color of start or on shall be GREEN, except that BLACK, WHITE, or GRAY shall be permitted. RED shall not be used for start or on.

10.2.2.2 Stop or Off. The preferred color of stop or off shall be RED, except that BLACK, WHITE, or GRAY shall be permitted. GREEN shall not be used for stop or off.

Exception: Stop function operators of the wobble-stick or rod-operated types in the bottom of a pendant station need not be colored RED.

10.2.2.3 Emergency Stop. RED shall be used for emergency stop actuators in accordance with 10.7.4.

10.2.2.4 Alternate Action. Pushbuttons that, when pressed, act alternately as start and stop or on and off shall be BLACK, WHITE, or GRAY. RED or GREEN shall not be used.

10.2.2.5 Abnormal Conditions. The color YELLOW shall be used for actuators used to respond to abnormal conditions.

10.2.2.6 Hold to Operate. Pushbuttons that cause movement when pressed and stop movement when they are released (e.g., jogging) shall be BLACK, WHITE, GRAY, or BLUE with a preference for BLACK.

10.2.2.7 Reset. Reset pushbuttons shall be BLUE, BLACK, WHITE, or GRAY except when they also act as a stop or off button, in which case they shall be RED.

10.2.3 Legends.

10.2.3.1 A legend shall be provided for each operator interface device to identify its function and shall be located so that it can be easily read by the machine operator from the normal operator position. The legends shall be durable and suitable for the operating environment.

Exception: Emergency stop devices require no legend if they meet the requirements of 10.7.4. [ROP 79-104 (Log 3)]

10.2.3.2 For illuminated pushbuttons, the function(s) of the light is separated from the function(s) of the button by a virgule (’).

10.3 Indicator Lights and Icons of Color Graphic Interface Devices.

10.3.1 Modes of Use. Indicator lights and icons of color graphic interface devices shall provide the following information:

(1) Indication to attract the operator’s attention or to indicate that a certain task should be performed. The colors RED, YELLOW (AMBER), GREEN, and BLUE are normally used in this mode.

(2) Confirmation of a command or a condition, or the termination of a change or transition period. The colors BLUE and WHITE are normally used in this mode. GREEN shall be permitted to be used in some cases.

10.3.2 Colors. Indicator lights and icons of color graphic interface devices shall be color-coded with respect to the condition (status) of the machine in accordance with Table 10.3.2. Alternate purposes shall be permitted to indicate machine or process status.

Table 10.3.2. Machine Indicator Lights and Icons

<table>
<thead>
<tr>
<th>Color</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>Safety of Persons or Environment</td>
</tr>
<tr>
<td>YELLOW (AMBER)</td>
<td>Warning/Caution</td>
</tr>
<tr>
<td>GREEN</td>
<td>Safe</td>
</tr>
<tr>
<td>BLUE</td>
<td>Mandatory action</td>
</tr>
<tr>
<td>CLEAR</td>
<td></td>
</tr>
<tr>
<td>WHITE</td>
<td></td>
</tr>
<tr>
<td>GRAY</td>
<td></td>
</tr>
<tr>
<td>BLACK</td>
<td></td>
</tr>
</tbody>
</table>

10.3.3 Flashing Lights. Flashing lights shall be permitted to be used for any of the following purposes:

(1) Attract attention
(2) Request immediate action
(3) Indicate a discrepancy between the command and actual states
(4) Indicate a change in process (flashing during transition)

10.4 Illuminated Pushbuttons. Illuminated pushbutton actuators shall be color-coded in accordance with Table 10.3.2. The color RED for the emergency stop actuator shall not depend on the illumination source.

10.5 Rotary Control Devices. Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be relied upon to prevent rotation.

10.6 Start Devices. Actuators used to initiate a start function or the movement of machine elements (e.g., slides, spindles, carriers) shall be constructed and mounted to minimize inadvertent operation. Mushroom-type actuators for two-hand control initiation shall conform to 9.2.5.6.

10.7 Devices for Stop and Emergency Stop.

10.7.1 Location and Operation.

10.7.1.1 Stop and emergency stop pushbuttons shall be continuously operable and readily accessible.

10.7.1.2 Stop and emergency stop pushbuttons shall be located at each operator control station and at other locations where emergency stop is required.
10.8.3 Restoration of Normal Function After Emergency Switching Off. It shall not be possible to restore an emergency switching off circuit until the emergency switching off circuit has been manually reset.

10.8.4 Actuators.

10.8.4.1 Actuators of emergency switching off devices shall be colored RED. The background immediately around the device actuator shall be permitted to be colored YELLOW.

10.8.4.2 Where the emergency switching off initiating device is separate from the emergency stop device, the emergency switching off initiating device shall be functionally identified.

10.8.5 Local Operation of the Supply Disconnecting Means to Effect Emergency Switching Off. Where the supply disconnecting means is to be locally operated for emergency switching off, it shall be readily accessible and shall meet the color requirements of 10.8.4.1.

10.9* Displays. Displays [e.g., visual display units, alarm annunciators, indicator lights and the action-initiating icons of human-machine interface (HMI) devices] shall be selected and installed in such a manner as to be visible from the normal position of the operator. [ROP 79-99 (Log 24)]

Chapter 11 Electronic Equipment [ROP 79-155 (Log 25)]

11.1 General.

11.1.1 This chapter shall apply to all types of electronic equipment including programmable electronic systems, subassemblies, printed circuit boards, electronic components, and other miscellaneous solid state equipment.

11.1.2 Electronic equipment used as part of an industrial machine, including subassemblies, printed circuit boards, devices, internal wiring, and components, shall not be required to be inspected at the time of installation of the industrial machine, except to detect alterations or damage, if the equipment has been listed by a qualified electrical testing laboratory.

11.1.3 Listed or labeled electronic equipment shall be permitted to be used without modifications, on or with industrial machines, where approved for the location and use.

11.2 Basic Requirements.

11.2.1 Equipment Grounding (Equipotential Bonding).

11.2.1.1 All input/output racks (remote or local), processor racks, and conductive enclosures of power supplies shall be electrically bonded together in accordance with the supplier’s specifications and connected to the equipment grounding (protective bonding) circuit.

11.2.1.2 Where specified by the manufacturer, components and subassemblies shall be effectively bonded to the equipment grounding (protective bonding) circuit in accordance with the manufacturer’s recommendations.

11.2.2 Subassemblies. Subassemblies shall be readily removable for inspection or replacement.

11.2.3 Electrical Noise and Transient Suppression. Transient suppression, isolation, or other appropriate means shall be provided.
where the electronic equipment generates electrical noise or transients, which can affect the operation of equipment.

12.2.4 Output Protection. Outputs controlled by programmable electronic systems shall be protected from overload and short-circuit conditions.

11.3 Programmable Equipment.

11.3.1 Software Modification. Programmable electronic systems shall be designed and constructed so that the ability to modify the application program shall be limited to authorized personnel and shall require special equipment or other means to access the program (e.g., access code, key-operated switch).

Exception: For safety reasons, the manufacturer or supplier shall be permitted to retain the right not to allow the user to alter the program.

11.3.2 Memory Retention and Protection.

11.3.2.1 Means shall be provided to prevent memory alteration by unauthorized persons.

11.3.2.2 Loss of memory shall not result in a hazardous condition.

11.3.2.3 Power supplies for electronic units that require memory retention shall have battery backup of sufficient capacity to prevent memory loss for a period of at least 72 hours.

11.3.3 Software Verification. Equipment using reprogrammable logic shall have means for verifying that the software is in accordance with the relevant program documentation.

11.3.4 Use in Safety-Related Functions. Software and firmware-based controllers used in place of hardware-based components with safety-related devices shall meet the following requirements:

(1) Be designed so that any single safety-related component or firmware failure shall operate as follows:
   a. Lead to the shutdown of the system in a safe state
   b. Prevent subsequent operation until the component failure has been corrected
   c. Prevent unintended start-up of equipment upon correction of the failure

(2) Provide protection equivalent to that of hardwired/hardware components

(3) Incorporate at least one passive, self-monitored electromechanical device as backup to ensure a line disconnect in case of a failure of the solid state components

(4) Be listed to an approved standard for safety-related functions such as UL 991 or UL 1998 [ROP 79-74 (Log 88)]  [ROP 79-73 (Log 155)]

11.4 Adjustable Speed Drives. Where load conditions or reduced speeds can cause motor overheating, embedded motor thermal protection (effective over the motor speed range) shall be provided and interlocked with the adjustable speed drive system.

[ROP 79-155 (Log 25)]

Chapter 12 Control Equipment: Location, Mounting, and Enclosures [ROP 79-84 (Log 54)]

12.1 General Requirements.

12.1.1 All control equipment shall be located and mounted so as to facilitate the following:

(1) Accessibility and maintenance of the equipment
(2) Protection against the external influences or conditions under which the equipment is intended to operate
(3) Operation and maintenance of the machine and its associated equipment

12.1.2 Minimum construction requirements shall comply with UL 508 and UL 50 for metallic and nonmetallic enclosures.  [ROP 79-87 (Log 131)]

12.1.3 The depth of the enclosure or compartment including doors or covers shall not be less than the maximum depth of the enclosed equipment plus the required electrical clearances.

12.1.4 Any door(s) that permits access to live parts shall comply with 6.3.2.5.

12.2 Location and Mounting.

12.2.1 Accessibility and Maintenance.

12.2.1.1 All items of control equipment shall be placed and oriented so that they can be identified without moving them or the wiring. Where practicable, items that require checking or adjustment for correct operation or that are liable to need replacement, those actions shall be possible without dismantling other equipment or parts of the machine (except opening doors or removing covers). Terminals not associated with control equipment shall also conform to these requirements.

12.2.1.2 Terminal blocks shall be mounted to provide unobstructed access to the terminals and their conductors.

12.2.1.3 Exposed, nonarcing, bare, live parts within an enclosure or compartment shall have an air space of not less than 13 mm (1/2 in.) between them and the uninsulated walls of the enclosure or compartment, including conduit fittings. The air space for uninsulated doors of the enclosure shall be not less than 25 mm (1 in.). Where barriers between metal enclosures or compartments and arcing parts are required, they shall be of flame-retardant, noncarbonizing insulating materials.  [ROP 79-98 (Log 133)]

12.2.1.4* All control equipment shall be mounted so as to facilitate its operation and maintenance. Where a special tool is necessary to remove a device, the tool shall be supplied.

12.2.1.5 Threaded fasteners with machine threads shall be used to attach components to a subplate and shall provide sufficient thread engagement to maintain secure mounting.

12.2.1.5.1 Steel subplate thickness shall provide engagement of at least 2 full threads.

12.2.1.5.2 Aluminum subplate thickness shall provide engagement of at least 3 full threads.

12.2.1.5.3 Thread cutting or thread forming screws shall be permitted if the thread engagement requirements of 12.2.1.5.1 and 12.2.1.5.2 are met.

12.2.1.5.4 Sheet metal screws, rivets, welds, solders, or bonding materials shall not be used to mount components to a subplate.
12.2.1.6 Swing frames or swing out panels shall be permitted, provided the swing is more than 110 degrees. Wiring shall not inhibit swing. Panel-mounted components behind swing frames shall be accessible when open.

12.2.1.7 Where control devices are connected through plug-in arrangements, their association shall be made clear by type (shape), marking, or reference designation, singly or in combination.

12.2.1.8 Attachment plugs and receptacles (plug/socket) combinations that are handled during normal operation shall be located and mounted as to provide unobstructed access.

12.2.1.9 Test points, where provided, shall be mounted to provide unobstructed access, plainly marked to correspond with markings on the drawings, adequately insulated, and sufficiently spaced for connection of test leads.

12.2.2 Physical Separation or Grouping.

12.2.2.1 Machine compartments containing control equipment (built-in control) shall be completely isolated from coolant and oil reservoirs. The compartment shall be readily accessible and completely enclosed. The compartment shall not be considered enclosed where it is open to the floor, the foundation upon which the machine rests, or other compartments of the machine that are not clean and dry.

12.2.2.2 Pipelines, tubing, or devices (e.g., solenoid valves) for handling air, gases, or liquids shall not be located in enclosures or compartments containing electrical control equipment.

Exception No. 1: Equipment for cooling electronic devices.

Exception No. 2: Pipelines, tubings, or devices that are an integral part of listed equipment and are separated by suitable barriers. [ROP 79-95 (Log 10)]

12.2.2.3 Control devices mounted within the control enclosure and connected to the supply voltage, or to both supply and control voltages, shall be grouped separately from those connected only to the control voltages.

12.2.2.4 Terminals shall be separated into groups for power circuits, associated control circuits, and other control circuits, fed from external sources (e.g., for interlocking).

12.2.2.5 The groups shall be permitted to be mounted adjacent, provided that each group can be readily identified (e.g., by markings, by use of different sizes, by use of barriers, by colors).

12.2.3 Heating Effects. Heat-generating components (e.g., heat sinks, power resistors) shall be located so that the temperature of each component in the vicinity remains within the component manufacturer’s specified limits.

12.3 Degrees of Protection.

12.3.1* The protection of control equipment against ingress of solid foreign objects and of liquids shall be adequate taking into account the external influences under which the machine is intended to operate (i.e., the location and the physical environmental conditions including dust, coolants, and swarf).

12.3.2 Enclosures of control equipment shall provide a degree of protection of at least NEMA Type 1.

Exception: Where removable collectors on collector wire or collector bar systems are used and NEMA Type 1 enclosures are not practicable, suitable protection shall be provided (e.g., elevation, guarding).

12.4 Enclosures, Doors, and Openings.

12.4.1 Enclosures shall be constructed and finished using materials capable of withstanding the mechanical, electrical, and thermal stresses, as well as the effects of humidity and corrosion that are likely to be encountered in normal service.

12.4.2 Where corrosion protection beyond normal requirements is needed, nonmetallic enclosures identified for the purposes shall be permitted if they meet the requirements of UL 508.

12.4.3 Subplates having a surface area of more than 15,484 cm² (2400 in.²) shall have supports provided in addition to the panel mounting means to aid in subplate installation.

12.4.4 Enclosures and subplates shall be free of burrs and sharp edges.

12.4.5 The exterior of the enclosure shall be of a material suitable for the intended environment, or include a protective finish suitable for the intended environment.

12.4.6 Fasteners used to secure doors shall be of the captive type. Windows provided for viewing internally mounted indicating devices should be of a material suitable to withstand mechanical stress and chemical attack [e.g., toughened glass, polycarbonate sheet of 3-mm (1/8-in.) thickness].

12.4.7 Door fasteners on enclosures and compartments with door openings 1016 mm (40 in.) tall shall be designed to seal the door tightly around its perimeter with either captive fasteners or vault-type hardware that latch at the top and bottom.

12.4.8 Door fasteners on enclosures and compartments with door openings 1016 mm (40 in.) tall or more shall be designed to seal the door tightly around its perimeter with either captive fasteners or vault-type hardware that latch at the top, center, and bottom.

12.4.9 A print pocket sized to accommodate electrical diagrams shall be attached to the inside of the door of the control enclosure or compartment. Single-door and multi-door enclosures shall have at least one print pocket.

12.4.10 The joints or gaskets of doors, lids, covers, externally mounted accessories, interconnect panels, and enclosures shall withstand the deleterious effects of liquids, vapors, or gases used on the machine. The means used to maintain the enclosure’s degree of protection on doors, lids, and covers that require opening or removal for operation or maintenance shall be securely attached to either the door/cover or the enclosure and not deteriorate due to removal or replacement of the door or the cover, which would impair the degree of protection.

12.4.11 All openings in the enclosure, including those towards the floor or foundation or to other parts of the machine, shall be closed.
by the supplier(s) in a manner ensuring the protection specified for the equipment. Openings for cable entries shall be easily reopened on site. A suitable opening shall be permitted in the base of enclosures within the machine so that moisture due to condensation is allowed to drain.

12.4.12 Openings shall not be permitted between enclosures containing electrical equipment and compartments containing coolant, lubricating fluids, or hydraulic fluids, or compartments into which oil, other liquids, or dust can penetrate. This requirement shall not apply to electrical devices specifically designed to operate in oil (e.g., electromagnetic clutches) nor to electrical equipment in which coolants are used.

12.4.13 Where there are holes in an enclosure for mounting purposes, care shall be taken so that after mounting, the holes do not impair the required protection.

12.4.14 Equipment that, in normal or abnormal operation, can attain a surface temperature sufficient to cause a risk of fire or harmful effect to an enclosure material shall be as follows:

1. Located within an enclosure that will withstand, without risk of fire or harmful effect, such temperatures as can be generated
2. Mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see also 12.2.3); or otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment

12.5 Spaces Around Control Cabinets and Compartments. Access and working space for control cabinets and compartments operating at 600 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized shall comply with the provisions of Chapter 12.

Sufficient access and working space shall be provided and maintained around all control cabinets and compartments to permit ready and safe operation and maintenance of such control cabinets and compartments.

12.5.1 Working Space. The working space shall permit at least 90-degree opening of control cabinet and compartment doors or hinged panels.

12.5.1.1 The depth of the working space in the direction of access to live parts shall not be less than indicated in Table 12.5.1.1. Distances shall be measured from the control cabinet or compartment front or opening.

<table>
<thead>
<tr>
<th>Nominal Voltage to Ground</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–150</td>
<td>900 mm (3 ft)</td>
<td>900 mm (3 ft)</td>
<td>900 mm (3 ft)</td>
</tr>
<tr>
<td>151–600</td>
<td>900 mm (3 ft)</td>
<td>1 m (3 ⅛ ft)</td>
<td>1.2 m (4 ft)</td>
</tr>
</tbody>
</table>

Note: Where the conditions are as follows:

Condition 1 — Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not over 300 volts to ground shall not be considered live parts.

Condition 2 — Exposed live parts on one side and a grounded surface on the other side. Concrete, brick, or tile walls shall be considered as grounded.

Condition 3 — Exposed live parts on both sides of the working space (not guarded as provided in Condition 1) with the operator between.

12.5.2 Access. At least one entrance of sufficient area shall be provided to give access to the working space around control cabinets or compartments.

12.5.2.1 Working space required by Section 12.5 shall not be used for storage.

Table 12.5.1.1 Working Space Depth

Exception No. 1: Working space shall not be required in back or sides of control cabinets or compartments, where there are no renewable or adjustable parts on the back or sides and where all connections are accessible from locations other than the back or sides. Where rear access is required to work on de-energized parts on the back of enclosed control cabinet and compartment, a minimum working space of 762 mm (2 1/2 ft) horizontally shall be provided.

Exception No. 2: By special permission, working space clearance depth of 762 mm (2 1/2 ft) or less shall be permitted where all uninsulated parts are at a voltage no greater than 50 volts rms ac or 60 volts dc.

Exception No. 3: Condition 2 working clearance depth shall be permitted between control cabinets or compartments located across the aisle from each other or across from nonmachinery associated switchgear, panelboards, or motor control centers where conditions of maintenance and supervision ensure that written procedures have been adopted to prohibit the affected equipment doors on both sides of the aisle from being open at the same time and qualified persons who are authorized will service the installation.

Exception No. 4: Condition 1 working clearance depth shall be permitted where control cabinets or compartments are located across the aisle from each other, or across from a grounded surface, and all associated control cabinet or compartment devices and equipment operating at greater than 50 volts rms ac or 60 volts dc are protected or rated IP20 or greater.

Exception No. 5: A working space clearance depth of 762 mm (2 1/2 ft) shall be permitted where all of the following conditions are met:

(a) The control cabinet or compartment is operating at not over 150 volts line-to-line or line-to-ground.
(b) The conditions of maintenance and supervision ensure that only qualified persons will service the installation.
(c) The door(s) of the control cabinet or compartment open at least 90 degrees or are removable.

Exception No. 6: By special permission, working space clearance depth of less than 762 mm (2 1/2 ft) shall be permitted where all of the following conditions are met:

(a) The control cabinet or compartment is operating at not over 150 volts line-to-line or line-to-ground.
(b) The conditions of maintenance and supervision ensure that only qualified persons will service the installation.
(c) The control cabinet and compartment requires a tool to open.
(d) Where only diagnostic troubleshooting and testing on live parts is involved.
(e) The door(s) of the control cabinet and compartment open at least 90 degrees or are removable.

12.5.2.2 The width of the working space in front of control cabinets and compartments shall be the width of the control cabinet or compartment, or 762 mm (2 1/2 ft), whichever is greater.

12.5.2.3 The working space height shall be clear and extend from the grade, floor, or platform to a height of 1.98 m (6 1/2 ft). Within the height requirements of Section 12.5, other equipment associated with the machine located above or below the control cabinet or compartment shall be permitted to extend not more than 153 mm (6 in.) beyond the front of the electrical control cabinet or compartment.

12.5.2 Access. At least one entrance of sufficient area shall be provided to give access to the working space around control cabinets or compartments.
12.5.2.2 When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be suitably guarded.  
[ROP 79-32 (Log 96)]

12.5.3 Door in gangingways and for access to electrical operating areas shall be at least 0.7 m (2 ft 4 in.) wide and 2.0 m (6 ft 7 in.) high, open outwards, and have a means (e.g., panic bolts or panic bars) to allow opening from the inside without the use of a key or tool.

12.6 Machine-Mounted Control Equipment.

12.6.1 Control equipment (e.g., limit switches, brakes, solenoids, position sensors) shall be mounted rigidly in a reasonably dry and clean location, shall be protected from physical damage, and shall be free from the possibility of accidental operation by normal machine movements or by the operator. Such equipment shall be mounted with sufficient clearance from surrounding surfaces to make its removal and replacement easy and shall have a suitable enclosure for the termination of conduit as well as provisions for making electrical connections.

Exception No. 1: A solenoid sealed in an individual oil-filled container shall be permitted.

Exception No. 2: Prewired devices (e.g., limit switches, proximity switches) provided with an identified cable need not be equipped with provisions for termination of conduit as well as provisions for making electrical connections.

12.6.2 All limit switches or position sensors shall be installed so that accidental overtravel by the machine will not damage the limit switch or sensor.

12.6.3 Solenoids for operating devices shall be mounted so that liquids drain away from the electrical component enclosure.  
[ROP 79-32 (Log 54)]

Chapter 13 Conductors, Cables, and Flexible Cords  
[ROP 79-112 (Log 28)]

13.1 General Requirements.

13.1.1 General. Conductors, cables, and flexible cords shall be selected for the operating conditions (e.g., voltage, current, protection against electric shock, grouping of cables) and external influences (e.g., temperature; presence of water or corrosive substances; mechanical stresses, including stresses during installation, fire hazards) that can exist. Conductors, cables, and flexible cords shall be identified for their intended use.

13.1.2 Wire Insulation. Conductors shall be insulated.

Exception No. 1: Bus bars shall not be required to be insulated.

Exception No. 2: Bare conductors, such as capacitor or resistor leads and jumpers between terminals, shall be permitted where the method of securing provides electrical clearance.

Exception No. 3: Equipment grounding conductors and bonding jumpers shall be permitted to be covered or bare.

13.1.3 Type MI Cable. Mineral-insulated, metal-sheathed cable, Type MI, shall be permitted. Temperature range shall be 85°C (185°F) for dry and wet locations.

13.1.4 Conductors and Static Control. Conductors smaller than 18 AWG used to connect electronic programmable control, input/output and static control shall be listed.

13.2 Conductors.

13.2.1 Conductor Material. Conductors shall be copper.

Exception No. 1: Aluminum alloy busbars, located internal to the enclosure, shall be permitted where suitable for the application.

Exception No. 2: The metal frame of the machine shall be permitted to be used as an equipment grounding (protective bonding) conductor.

13.2.2 Stranded Conductors. Conductors of sizes 22 through 4/0 AWG and sizes 250 through 1000 kcmil shall be only of stranded soft-annealed copper. Requirements for conductor cross-sectional area, dc resistance, and stranding shall be in accordance with Table 13.2.2.

Exception No. 1: Conductors with stranding other than that specified in Table 13.2.2 shall be permitted on individual devices that are purchased completely wired (e.g., motor starters).

Exception No. 2: Conductors subject to temperatures, voltages, environmental conditions, or flexing exceeding the ratings listed in this chapter shall have suitable characteristics.

13.2.3 Constant Flexing. Where constant flexing service is required, conductor stranding shall conform to Table 13.2.2.

13.2.4 Solid Conductors. Solid conductors 24 to 30 AWG of soft-annealed copper shall be permitted for use within control enclosures where not subject to flexing.

13.2.5 Printed Wire Assemblies. Printed wire assemblies of flame-retardant material shall be permitted in place of conductor assemblies provided they are within control enclosures and are mounted in such a way as to minimize flexing or stress.

13.2.6 Shielded Conductors. Where shielding is used around conductors in single or multiconductor cables, a foil shield shall be permitted for nonflexing applications. A continuous drain wire shall be provided for foil shield types. A braid shield shall be used where subject to longitudinal flexing. Torsional flexing applications (e.g., a robot arm) shall require shields designed specifically for their use. The shields and drain wire shall be covered with an outer jacket that is suitable for the environment. In all cases the shield shall provide a continuous conduction surface in the presence of bending and flexing.

13.2.7 Special Cables and Conductors.

13.2.7.1 Other listed conductors and listed cables shall be permitted.

13.2.7.2 Special conductors such as RG-/U transmission cable shall be permitted where necessary for the proper functioning of the equipment.
13.3 Insulation.

13.3.1 The insulation and the finished wires and cables shall have flame-retardant properties and temperature limits and characteristics as follows:

1. MTW - Moisture-, Heat, and Oil-Resistant Thermoplastic 60°C (140°F) Wet Locations
   90°C (194°F) Dry Locations
2. THHN - Heat-Resistant Thermoplastic 90°C (194°F) Dry Locations

3. THW - Moisture- and Heat-Resistant Thermoplastic 75°C (167°F) Dry and Wet Locations
4. THWN - Moisture- and Heat-Resistant Thermoplastic 75°C (167°F) Dry and Wet Locations

13.3.2 The average and the minimum thickness of the insulation in constructions A and B shall be in accordance with Table 13.3.2.

13.3.3 Construction B shall have a nylon jacket applied directly over the insulation. The jacket shall be snug on the insulation and shall be at least as thick as indicated in Table 13.3.2.

---

Table 13.2.2 Single Conductor Characteristics

<table>
<thead>
<tr>
<th>Wire Size or Cross-Sectional area, Nominal (AWG/kcmil)</th>
<th>DC Resistance at 25°C (ohms/1000 ft)</th>
<th>Nonflexing (ASTM Class)</th>
<th>Flexing (ASTM Class)</th>
<th>Constant Flex (ASTM Class/AWG Size)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 AWG 640/0.324</td>
<td>17.2</td>
<td>7(K)</td>
<td>7(K)</td>
<td>19(M/34)</td>
</tr>
<tr>
<td>20 1020/0.519</td>
<td>10.7</td>
<td>10(K)</td>
<td>26(M/34)</td>
<td></td>
</tr>
<tr>
<td>18 1620/0.823</td>
<td>6.77</td>
<td>16(K)</td>
<td>41(M/34)</td>
<td></td>
</tr>
<tr>
<td>16 2580/1.31</td>
<td>4.26</td>
<td>19(C)</td>
<td>26(K)</td>
<td></td>
</tr>
<tr>
<td>14 4110/2.08</td>
<td>2.68</td>
<td>19(C)</td>
<td>41(K)</td>
<td></td>
</tr>
<tr>
<td>12 6530/3.31</td>
<td>1.68</td>
<td>19(C)</td>
<td>65(K)</td>
<td></td>
</tr>
<tr>
<td>10 10380/5.261</td>
<td>1.060</td>
<td>104(K)</td>
<td>65(K/30)</td>
<td></td>
</tr>
<tr>
<td>8 16510/8.367</td>
<td>0.6663</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>6 26240/13.30</td>
<td>0.4192</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>4 41740/21.15</td>
<td>0.2636</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>3 52620/26.67</td>
<td>0.2091</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>2 66360/33.62</td>
<td>0.1659</td>
<td>19(C)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>1 83690/42.41</td>
<td>0.1315</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>1/0 105600/53.49</td>
<td>0.1042</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>2/0 133100/67.43</td>
<td>0.08267</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>5/0 167800/85.01</td>
<td>0.06658</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>4/0 211600/107.2</td>
<td>0.05200</td>
<td>19(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>250 kcmil / .127</td>
<td>0.04401</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>300 / .152</td>
<td>0.03667</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>350 / .177</td>
<td>0.03144</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>400 / .203</td>
<td>0.02751</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>450 / .228</td>
<td>0.02445</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>500 / .252</td>
<td>0.02200</td>
<td>37(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>550 / .279</td>
<td>0.02000</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>600 / .304</td>
<td>0.01834</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>650 / .329</td>
<td>0.01692</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>700 / .355</td>
<td>0.01572</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>750 / .380</td>
<td>0.01467</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>800 / .405</td>
<td>0.01375</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>900 / .456</td>
<td>0.01222</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
<tr>
<td>1000 / .507</td>
<td>0.01101</td>
<td>61(B)</td>
<td>( )</td>
<td></td>
</tr>
</tbody>
</table>

(B), (C), (K) — ASTM Class designation B and C per ASTM B 8-81, Class designation K per ASTM B 174-1971 (R1980).
(') — A class designation has not been assigned to this conductor but is designated as size 22-7 in ASTM B286-1974 (R1979) and is composed of strands 10 mils in diameter (30 AWG).
( ) — Nonflexing construction shall be permitted for flexing service. Per ASTM Class designation B 174-1971 (R1980) Table 3.
(-) — Constant flexing cables are not constructed in these sizes.
Table 13.3.2 – Thickness of Single Conductor Uninsulation (Mils)

<table>
<thead>
<tr>
<th>Wire Size (AWG or kcmil)</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average/Minimum (A)</td>
<td>Average/Minimum (B)</td>
</tr>
<tr>
<td>22 AWG</td>
<td>30/27</td>
<td>15/13(4)</td>
</tr>
<tr>
<td>20</td>
<td>30/27</td>
<td>15/13(4)</td>
</tr>
<tr>
<td>18</td>
<td>30/27</td>
<td>15/13(4)</td>
</tr>
<tr>
<td>16</td>
<td>30/27</td>
<td>15/13(4)</td>
</tr>
<tr>
<td>14</td>
<td>30/27</td>
<td>15/13(4)</td>
</tr>
<tr>
<td>12</td>
<td>30/27</td>
<td>15/13(4)</td>
</tr>
<tr>
<td>10</td>
<td>30/27</td>
<td>20/18(4)</td>
</tr>
<tr>
<td>8</td>
<td>45/40</td>
<td>0/27(5)</td>
</tr>
<tr>
<td>6</td>
<td>60/54</td>
<td>30/27(5)</td>
</tr>
<tr>
<td>4–2</td>
<td>60/54</td>
<td>40/36(6)</td>
</tr>
<tr>
<td>1–4/0</td>
<td>80/72</td>
<td>50/45(7)</td>
</tr>
<tr>
<td>250–500 Kcmil</td>
<td>95/86</td>
<td>60/54(8)</td>
</tr>
<tr>
<td>550–1000</td>
<td>110/99</td>
<td>70/63(9)</td>
</tr>
</tbody>
</table>

*UL 1063 Table 1.1 NEC Construction.
A—no outer covering.
B—nylon covering.

13.4 Wire Markings.

13.4.1 A durable legend printed on the outer surface of the insulation of construction A, on the outer surface of the nylon jacket of construction B, on the outer surface of the insulation under the jacket of construction B (only if clearly legible through the nylon), or on the outer surface of the jacket of a multiconductor cable shall be repeated at intervals of no more than 610 mm (24 in.) throughout the length of the single-conductor or the multiconductor cable.

Exception: Sizes smaller than 16 AWG shall be permitted to be marked on the reel or on the smallest unit of the shipping carton.

13.4.2 The legend shall include the manufacturer's name or trademark, the wire type, voltage rating, and gauge or size.

13.4.3 Where the conductor size is 16 through 10 AWG and the stranding is intended for flexing service, the legend shall include "flexing" or "Class K."

13.4.4 Wire insulation shall be identified and adequate for the voltage on that conductor.

13.5 Conductor Ampacity. The continuous current carried by conductors shall not exceed the values given in Table 13.5. [ROP 79-120 (Log 90)]

Table 13.5 – Conductor Ampacity Based on Copper Conductors with 60°C and 75°C Insulation in an Ambient Temperature of 30°C

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Ampacity 60°C</th>
<th>Ampacity 75°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>–</td>
<td>0.5</td>
</tr>
<tr>
<td>28</td>
<td>–</td>
<td>0.8</td>
</tr>
<tr>
<td>26</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>95</td>
<td>115</td>
</tr>
<tr>
<td>1</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>0</td>
<td>125</td>
<td>150</td>
</tr>
<tr>
<td>2/0</td>
<td>145</td>
<td>175</td>
</tr>
<tr>
<td>3/0</td>
<td>165</td>
<td>200</td>
</tr>
<tr>
<td>4/0</td>
<td>195</td>
<td>230</td>
</tr>
<tr>
<td>250</td>
<td>215</td>
<td>255</td>
</tr>
<tr>
<td>300</td>
<td>240</td>
<td>285</td>
</tr>
<tr>
<td>350</td>
<td>260</td>
<td>310</td>
</tr>
<tr>
<td>400</td>
<td>280</td>
<td>335</td>
</tr>
<tr>
<td>500</td>
<td>320</td>
<td>380</td>
</tr>
<tr>
<td>600</td>
<td>355</td>
<td>420</td>
</tr>
<tr>
<td>700</td>
<td>385</td>
<td>460</td>
</tr>
<tr>
<td>750</td>
<td>400</td>
<td>475</td>
</tr>
<tr>
<td>800</td>
<td>410</td>
<td>490</td>
</tr>
<tr>
<td>900</td>
<td>435</td>
<td>520</td>
</tr>
<tr>
<td>1000</td>
<td>455</td>
<td>545</td>
</tr>
</tbody>
</table>

Notes:
1. Wire types listed in Section 13.3.1 shall be permitted to be used at the ampacities listed in this table.
2. The sources for the ampacities in this table are Table 310-16 of NFPA 70, National Electrical Code.

13.5.1 Motor circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating.

13.5.2 Combined load conductors shall have an ampacity not less than 125 percent of the full-load current rating of all resistance heating loads plus 125 percent of the full-load current rating of the highest rated motor plus the sum of the full-load current ratings of all other connected motors and apparatus in operation at the same time.
13.5.3 Where ampacity derating is required for ambient temperature correction for other than 30°C or adjusted for more than three current-carrying conductors in a raceway or cable, the factor(s) shall be taken from Tables 13.5.3(a) and 13.5.3(b). Sizing of conductors within control enclosures in wiring harnesses or wiring channels shall be based on the ampacity in cable or raceway. [ROP 79-120 (Log 90)] [ROP 79-121 (Log 91)]

Table 13.5.3(a) Correction Factors

<table>
<thead>
<tr>
<th>Ambient Temp. (°C)</th>
<th>Factor</th>
<th>Ambient Temp. (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>1.00</td>
<td>70-77</td>
</tr>
<tr>
<td>21-25</td>
<td>1.05</td>
<td>78-86</td>
</tr>
<tr>
<td>26-30</td>
<td>1.00</td>
<td>78-86</td>
</tr>
<tr>
<td>31-35</td>
<td>.94</td>
<td>87-95</td>
</tr>
<tr>
<td>36-40</td>
<td>.88</td>
<td>96-104</td>
</tr>
<tr>
<td>41-45</td>
<td>.82</td>
<td>105-113</td>
</tr>
<tr>
<td>46-50</td>
<td>.75</td>
<td>114-122</td>
</tr>
<tr>
<td>51-55</td>
<td>.67</td>
<td>123-131</td>
</tr>
<tr>
<td>56-60</td>
<td>.58</td>
<td>132-140</td>
</tr>
<tr>
<td>61-70</td>
<td>.33</td>
<td>141-158</td>
</tr>
</tbody>
</table>

Table 13.5.3(b) Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable

<table>
<thead>
<tr>
<th>Number of Current-Carrying Conductors</th>
<th>Percent of Values in Table 13.5.3(a) as Adjusted for Ambient Temperature if Necessary</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 – 6</td>
<td>80</td>
</tr>
<tr>
<td>7 – 9</td>
<td>70</td>
</tr>
<tr>
<td>10 – 20</td>
<td>50</td>
</tr>
<tr>
<td>21 – 30</td>
<td>45</td>
</tr>
<tr>
<td>31 – 40</td>
<td>40</td>
</tr>
<tr>
<td>41 and above</td>
<td>35</td>
</tr>
</tbody>
</table>

13.5.4 The maximum size of a conductor selected from Table 13.5 and connected to a motor controller shall not exceed the values given in Table 13.5.4.

Exception: Where other motor controllers are used, the maximum conductor size shall not exceed that specified by the manufacturer.

Table 13.5.4 – Maximum Conductor Size for Given Motor Controller Size*

<table>
<thead>
<tr>
<th>Motor Controller Size</th>
<th>Maximum Conductor Size (AWG or Kcmil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14 AWG</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>00</td>
</tr>
<tr>
<td>5</td>
<td>500 Kcmil</td>
</tr>
</tbody>
</table>

*See ANSI/NEMA ICS 2-1993 table 2, 110-1.

13.5.5 Conductor/Terminal Compatibility. The conductor(s) shall be compatible with the device terminal(s), and the conductor size(s) shall not exceed the range recommended by the device manufacturer.

13.6 Conductor Sizing.

13.6.1 Conductors shall not be smaller than the following:

(1) Power circuits 14 AWG

Exception No. 1: 16 AWG shall be permitted where applicable as follows:
   (a) For nonmotor power circuits of 8 amperes or less, where protected in accordance with Chapter 7 using branch-circuit-rated circuit breakers listed for use with 16 AWG wire or Class CC, J, or T fuses rated at not more than 10 amperes or
   (b) For motor loads with a full-load ampacity of 8 amperes or less, where protected in accordance with Chapter 7 using branch-circuit-rated circuit breakers listed for use with 16 AWG wire or Class CC, J, or T fuses and Class 10 overload protection per UL 508, or
   (c) For motor loads with a full-load ampacity of 5.5 amperes or less, where protected in accordance with Chapter 7 using branch-circuit-rated circuit breakers listed for use with 16 AWG wire or Class CC, J, or T fuses and Class 20 overload protection per UL 508, and
   (d) Where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors, where used in a cabinet or enclosure.

Exception No. 2: 18 AWG shall be permitted where applicable as follows:
   (a) For nonmotor power circuits of 5.6 amperes or less, where protected in accordance with Chapter 7 using branch-circuit-rated circuit breakers listed for use with 18 AWG wire or Class CC, J, or T fuses rated at not more than 7 amperes or
   (b) For motor loads with a full-load ampacity of 5 amperes or less, where protected in accordance with Chapter 7 using branch-circuit-rated circuit breakers listed for use with 18 AWG wire or Class CC, J, or T fuses and Class 10 overload protection per UL 508, or
   (c) For motor loads with a full-load ampacity of 3.5 amperes or less, where protected in accordance with Chapter 7 using branch-circuit-rated circuit breakers listed for use with 18 AWG wire or with Class CC, J, or T fuses and Class 20 overload protection per UL 508 and
   (d) Where part of a jacketed multiconductor cable assembly or flexible cord, or as individual conductors, where used in a cabinet or enclosure.

[ROP 79-116 (Log 162)]

(2) Lighting and control circuits conductors on the machine and in raceways shall not be smaller than 16 AWG.

Exception: In a jacketed, multiconductor cable assembly, 18 AWG shall be permitted.

(3) Control circuits within control enclosures or operator stations shall not be smaller than 18 AWG.

(4) Electronic programmable control input/output and static control.
   a. Conductors in raceways shall not be smaller than 24 AWG.
NFPA 79 — May 2002 ROP — DRAFT — Copyright 2001, NFPA

Table 13.7.3 Derating Factors for Cables Wound on Drums

<table>
<thead>
<tr>
<th>Drum Type</th>
<th>Number of Layers of Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any Number</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Cylindrical ventilated</td>
<td>—</td>
</tr>
<tr>
<td>Radial ventilated</td>
<td>0.85</td>
</tr>
<tr>
<td>Radial nonventilated</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Notes:
1. A radial-type drum is one where spiral layers of cable are accommodated between closely spaced flanges; if fitted with solid flanges, the drum is described as nonventilated and if the flanges have suitable apertures, as ventilated.
2. A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and suitable ventilating apertures.
3. It is recommended that the use of derating factors be discussed with the cable and the cable drum manufacturers. This can result in factors being used.

Exception: In a jacketed, multiconductor cable assembly or cord, 30 AWG or larger shall be permitted.

b. Conductors within control enclosures shall not be smaller than 26 AWG.

Exception: For jumpers and special wiring applications (e.g., solderless wrap or wire-clip-type connections or shielded conductors), conductors 30 AWG or larger shall be permitted.

13.6.2 Shielded Conductors. Shielded conductors shall consist of stranded, annealed copper of 25 AWG or larger for single conductors used in subassemblies and 22 AWG or larger for all other uses.

13.7 Conductors and Cables Used for Flexing Applications.

13.7.1 General.

13.7.1.1 Conductors and cables used for flexing applications shall be selected from Table 13.5.

13.7.1.2* Cables that are subjected to severe duties shall be of adequate construction to protect against the following:

(1) Abrasion due to mechanical handling and dragging across rough surfaces
(2) Kinking due to operation without guides
(3) Stress resulting from guide rollers and forced guiding and being wound and rewound on cable drums

13.7.2* Mechanical Rating. The cable handling system of the machine shall be so designed to keep the tensile stress of the conductors as low as practicable during machine operations. Where copper conductors are used, the tensile stress shall not exceed 15 N/mm² (2176 psi) of the copper cross-sectional area.

13.7.3* Current-Carrying Capacity of Cables Wound on Drums. Cables to be wound on drums (see Table 13.7.3) shall be selected with conductors of a cross-sectional area such that, when fully wound on and carrying the normal service load, the maximum allowable operating temperature is not exceeded.

13.8 Flexible Cords.

13.8.1 Multiconductor flexible cords shall be suitable for the intended use.

13.8.2 Ampacity of Flexible Cords. The continuous current by flexible cords shall not exceed the values given in Table 13.8.2.

Table 13.9.1 Allowable Ampacity for Flexible Cords and Cables [Based on Ambient Temperature of 30°C (86°F). See NFPA 70, National Electrical Code, 400.13 and 400.4].

<table>
<thead>
<tr>
<th>Thermoset Type</th>
<th>Thermoset Types</th>
<th>Thermoset Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>C, E, EO, PD, S, SJ, SJOW, SJOO, SJOW, SO, SOW, SOO, SOOW, SP-1, SP-2, SP-3, SRD, SV, SVQ, SVOO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (AWG)</th>
<th>Thermoplastic Types</th>
<th>Thermoplastic Types</th>
<th>Thermoplastic Types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TPT, TST</td>
<td>ET, ETLB, ETP, ETT, SE, SEW, SEO, SEOW, SJE, SJEW, SJO, SJOOW, SJTW, SJOOW, SPE-1, SPE-2, SPE-3, SPT-1, SPT-1W, SPT-2, SPT-2W, SPT-3, ST, SRDE, SRDT, STO, STOW, STOO, STOOO, STOOOW, STPT-1, STPT-1W, STPT-2, STPT-2W, STPT-3, ST, SVE, SVQ, SVT, SVTO, SVTOO</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Types</th>
<th>HPD, HPN, HS, HSJ, HSO, HSJO, HSJO</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>0.5</td>
</tr>
<tr>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>18</td>
<td>—</td>
</tr>
<tr>
<td>17</td>
<td>—</td>
</tr>
<tr>
<td>16</td>
<td>—</td>
</tr>
<tr>
<td>15</td>
<td>—</td>
</tr>
<tr>
<td>14</td>
<td>—</td>
</tr>
<tr>
<td>12</td>
<td>—</td>
</tr>
<tr>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>—</td>
</tr>
<tr>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
</tr>
</tbody>
</table>

*The allowable currents apply to 3-conductor cords and other multiconductor cords connected to utilization equipment so that only 3 conductors are current-carrying.
* The allowable currents apply to 2-conductor cords and other multiconductor cords connected to utilization equipment so that only 2 conductors are current-carrying.
* Tinsel cord.
* Elevator cables only.
* 7 amperes for elevator cables only; 2 amperes for other types.
Source: Table 13.9.1 is based on NFPA 70, National Electrical Code, Table 400.5(A). [ROP 79-112 Log 285]
14.1 Connections and Routing.

14.1.1 General Requirements.
14.1.1.1 All connections shall be secured against accidental loosening and shall ensure a thoroughly good connection.
14.1.1.2 The means of connection shall be identified for the cross-sectional areas and the type of conductors being terminated.
14.1.1.3 Terminals for more than one conductor shall be so identified.
14.1.1.4 A power distribution block designed for multiple tap conductors (e.g., single or multiple conductors “in” and multiple conductors “out”) shall be permitted for additional tap connections and circuit branching.
14.1.1.5 Soldered connections shall only be permitted where terminals are provided that are identified for soldering.
14.1.1.6 Terminals on terminal blocks shall be plainly identified to correspond with markings on the diagrams.
14.1.1.7 The installation of flexible conduits and cables shall be such that liquids drain away from the fittings. Where practicable, raceway connections shall enter the sides or bottom of an enclosure or box.
14.1.1.8 Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals that are not equipped with this facility. Solder shall not be used for that purpose.
14.1.1.9 Shielded conductors shall be terminated so as to prevent fraying of strands and to permit easy disconnection.
14.1.1.10* Identification tags shall be readable, permanent, and identified for use in the physical environment.
14.1.1.11* Terminal blocks shall be mounted and wired so that the internal and external wiring does not cross over the terminals.

14.1.2 Conductor and Cable Runs.

14.1.2.1 Conductors and cables shall be run from terminal to terminal without splices or joints.

Exception No. 1: Splices shall be permitted to leads attached to electrical equipment, such as motors and solenoids. Such splices shall be insulated with oil-resistant electrical tape or insulation equivalent to that of the conductors and installed in a suitable enclosure.

Exception No. 2: Where it is impracticable to provide terminals in a junction box (e.g., on mobile machines, on machines having long flexible cables) the use of splices or joints shall be permitted.

14.1.2.2 Factory-applied connectors molded onto cables shall be permitted. Such connectors shall not be considered as splices or joints.

14.1.2.3 Where it is necessary to connect and disconnect cables and cable assemblies, an additional length shall be provided for that purpose.

14.1.2.4 The terminations of cables shall be supported to prevent mechanical stresses at the termination of the conductors.

14.1.3 Conductors of Different Circuits. Conductors of different circuits shall be permitted to be laid side by side and occupy the same raceway (duct) (e.g., wireway or cable trunking), or be in the same multiconductor cable assembly, provided that the arrangement does not impair the functioning of the respective circuit. Functionally associated circuit conductors including power, control, remote input/output, signaling, and communication cables shall be permitted in the same raceway or cable assembly regardless of voltage, provided all are insulated for the maximum voltage of any circuit within the raceway or cable assembly. Where those circuits operate at different voltages, the conductors shall be separated by barriers or shall be insulated for the highest voltage to which any conductor within the same raceway (duct) or cable assembly is subjected.

Exception: Different voltage insulation levels or conductor properties shall be permitted in the same cable assembly, provided the cable assembly has been designed and tested to the identified application.

14.1.4 Cables.

14.1.4.1 Exposed cables shall be installed along the structure of the equipment or system or in the chases of the machinery shall be permitted. Exposed cables shall be installed to closely follow the surface and structural members of the machinery.

14.1.4.2 Cables shall be supported by the equipment or system structure as follows:

(1) In such a manner that the cable will not be damaged by normal equipment use
(2) Every 305 mm (12 in.) in a nonvertical run

Exception: The supporting distance shall be permitted to be increased up to 914 mm (36 in.) where the structure of the machine or system makes support impractical every 305 mm (12 in.).

(3) Every 914 mm (36 in.) in a vertical run

Exception: Supporting distance shall be permitted to be increased to 2.44 m (96 in.), where the structure of the machine or system makes support impractical every 914 mm (36 in.).

(4) When suspended in air spanning a distance up to 457 mm (18 in.)

Exception: Span distance shall be permitted to be increased up to 914 mm (36 in.), where the structure of the machine or system makes support impractical every 457 mm (18 in.).

14.1.4.3 Cables shall not be supported by machinery guards that are likely to be removed for maintenance access. Exception: Wiring for components that are an integral part of the guard and designed to remain on the guard when the guard is removed for maintenance access shall be permitted to be supported by the guard. [ROP 79-139 (Log 134)]

14.1.4.4 Multiple cables shall be permitted to be supported and fastened together in a bundle, provided the method of support and fastening is sufficient to support the mechanical weight and strain of the bundle.
14.2.2 Identification of the Equipment Grounding (Protective) Conductor.

14.2.2.1* The color GREEN (with or without one or more YELLOW stripes) shall be used to identify the equipment grounding conductor where insulated or covered. This color identification shall be strictly reserved for the equipment grounding (protective bonding) conductor.

Exception No. 1: In multiconductor cable-connected assemblies where equipment grounding is not required, the solid color GREEN shall be permitted for other than equipment grounding.

Exception No. 2: It shall be permitted to use conductors of other colors provided the insulation or cover is appropriately identified at all points of access.

Exception No. 3: For grounded control circuits, use of a GREEN insulated conductor (with or without one or more YELLOW stripes) or a bare conductor from the transformer terminal to a grounding terminal on the control panel shall be permitted.

14.2.2.2 Where the equipment grounding (protective) conductor is identified by its shape, position, or construction (e.g., a braided conductor), or where the insulated conductor is not readily accessible, color coding throughout its length shall not be required. But the ends or accessible positions shall be clearly identified by Figure 8.2.1.2.4. The color GREEN (with or without one or more YELLOW stripes), or the bicolor combination GREEN and YELLOW.

14.2.3 Identification of the Grounded Circuit Conductor.

14.2.3.1* Where an ac circuit includes a grounded conductor, this conductor shall be WHITE, GRAY, or three continuous WHITE stripes on other than GREEN, BLUE, ORANGE, or YELLOW insulation along its entire length.

14.2.3.2 The use of other colors for the following applications shall be as follows:

(1) WHITE with BLUE stripe for grounded (current-carrying) dc circuit conductor.

(2) WHITE with ORANGE stripe or WHITE with YELLOW stripe for grounded (current-carrying) circuit conductor, which remains energized when the main disconnecting means is in the off position.

The color choice of the stripe shall be consistent with the ungrounded conductor of the excepted circuit.

14.2.3.3 Where identification by color is used, bus bars used as grounded conductors shall be either colored by a stripe, 15 mm to 100 mm ((0.6 in. to 3.9 in.) wide in each compartment or unit or at each accessible position, or colored throughout their length.

14.2.4 Identification by Color for Other Conductors.

14.2.4.1* Ungrounded circuit conductors that remain energized when the supply disconnecting means is in the off position shall be consistently applied as either ORANGE or YELLOW. These color identifications shall be strictly reserved for this application only.

Exception No. 1: Internal wiring on individual devices purchased completely wired.
14.3.6 Flexible cords, ac receptacles, ac plugs, appliance couplers and power cord sets shall be permitted inside enclosures for internal wiring and connections between assemblies with ac power where used in accordance with their listing.

14.4 Wiring Outside Enclosures.

14.4.1 General Requirements. The means of introduction of cables or ducts with their individual glands, bushings, and so forth into an enclosure shall ensure that the degree of protection is not reduced.

14.4.2 External Raceways (Ducts).

14.4.2.1 All conductors of the same ac circuit routed to the same location shall be contained in the same raceway (duct).

14.4.2.2 Conductors external to the electrical equipment enclosure(s) shall be enclosed in raceway (duct) described in Section 14.5.

Exception: Cables and cable connectors need not be enclosed in a raceway where they are otherwise protected and supported.

14.4.2.3 Fittings used with raceways (ducts) or multiconductor cable shall be identified for use in the physical environment.

14.4.2.4 Flexible conduit or multiconductor cable with flexible properties shall be used where it is necessary to employ flexible connections to pendant pushbutton stations. The weight of the pendant stations shall be supported by means other than the flexible conduit or the multiconductor cable with flexible properties, except where the conduit or cable is specifically designed for that purpose.

14.4.2.5 Flexible conduit or multiconductor cable with flexible properties shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to stationary motors, position switches, and other externally mounted devices. Where prewired devices (e.g., position switches, proximity switches) are supplied, the integral cable shall not be required to be enclosed in a raceway (duct).

14.4.3 Connection to Moving Elements of the Machine.

14.4.3.1 Connections to moving parts shall be made using conductors in accordance with Section 13.7. Flexible cable and conduit shall have vertical connections and shall be installed to avoid excessive flexing and straining. Horizontal connections shall be permitted where the flexible cable or conduit is adequately supported. Cable with flexible properties and flexible conduit shall be so installed as to prevent excessive flexing and straining, particularly at the fittings.

14.4.3.2 Cables with flexible properties subject to movement shall be supported in such a way that there is neither mechanical strain on the connection points nor any sharp flexing. When this is achieved by the use of a loop, it shall provide for the cable with a bending radius of at least 10 times the diameter of cable.

14.4.3.3 Cable with flexible properties of machines shall be installed or protected so as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:

(1) Being run over by the machine itself
(2) Being run over by vehicles or other machines
14.4.3.4 The cable sheath shall be resistant to the wear from movement and the effects of atmospheric contaminants (e.g., oil, water, coolants, dust).

14.4.3.5 Where cables subject to movement are close to moving parts, precautions shall be taken to maintain a space of at least 25.4 mm (1 in.) between the moving parts and the cables. Where that distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

14.4.3.6 The cable handling system shall be so designed that lateral cable angles do not exceed 5 degrees, avoiding torsion in the cable when being wound on and off cable-drums and approaching and leaving cable guidance devices.

14.4.3.7 Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

14.4.3.8 Devices serving to guide and carry a cable with flexible properties shall be designed so that the inner bending radius is not less than the values given in Table 14.4.3.8.

Exception: A smaller bending radius shall be permitted if the cable is identified for the purpose.

[ROP 79-135 (Log 136)]

<table>
<thead>
<tr>
<th>Application</th>
<th>Cable Diameter or Thickness of Flat Cable (d) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d \leq 8</td>
</tr>
<tr>
<td>Cable drums</td>
<td>6 d</td>
</tr>
<tr>
<td>Guide rollers</td>
<td>6 d</td>
</tr>
<tr>
<td>Festoon systems</td>
<td>6 d</td>
</tr>
<tr>
<td>All others</td>
<td>6 d</td>
</tr>
</tbody>
</table>

For U.S. customary units, 8 mm = 0.315 in., 20 mm = 0.787 in.

14.4.3.9 The straight section between two bends in an S-shaped length and a bend into another plane shall be at least 20 times the diameter of the cable.

14.4.3.10 Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit under all conditions of operation. Flexible metallic conduit shall not be used for rapid movements except when specifically designed for that purpose.

14.4.4 Interconnection of Devices on the Machine. Where practicable, machine-mounted switching devices (e.g., position sensors, pushbuttons) are connected in series or in parallel, and the connections between those devices shall be made through terminals forming intermediate test points. Such terminals shall be conveniently placed, protected from the environment, and shown on the relevant diagrams.

14.4.5 Attachment Plug and Receptacle (Plug/Socket) Combinations.

14.4.5.1 Where equipment is removable, connections to it through a polarized attachment plug and receptacle (plug/socket) combination shall be permitted. The male plug shall be connected to the load circuit.

14.4.5.2 Attachment plug and receptacle (plug/socket) combinations shall be listed for the intended use and shall be of the locking type where rated greater than 20 amperes. Where used on circuits of more than 300 volts to ground or 300 volts phase-to-phase, they shall be skirted and constructed to contain any arc generated when a connection is made or broken.

14.4.5.3 Attachment plug and receptacle (plug/socket) combinations shall be designed so that both of the following occurs:

   (1) The equipment grounding (protective bonding) circuit connection is made before any current-carrying connections are made.

   (2) The equipment grounding (protective bonding) circuit connection is not disconnected until all current-carrying connections in the plug are disconnected.

Exception: Connections used in PELV circuits or the connectors used only to facilitate assembling and disassembling (multipole connectors) shall not be required to meet these requirements.

[ROP 79-134 (Log 157)]

14.4.5.4 Attachment plug and receptacle (plug/socket) combinations used for carrying motor loads shall meet the conditions of 5.3.3.3 if the circuit is likely to be opened under load.

14.4.5.5 Where more than one attachment plug and receptacle (plug/socket) combination is used at the same location, they shall be mechanically coded to prevent incorrect insertion or be clearly identified.

14.4.5.6 Attachment plug and receptacle (plug/socket) combinations that are used for controlling purposes or of a type used for domestic applications shall not be used for control circuits.

14.4.5.7 Means shall be provided to cover externally mounted receptacles (socket) when the plugs are removed.

14.4.6 Dismantling for Shipment. Where it is necessary that wiring be disconnected for shipment and where practicable, terminals or attachment plug and receptacle (plug/socket) combinations shall be provided at the sectional points. Such terminals shall be suitably enclosed and attachment plug and receptive (plug/socket) combinations shall be protected from the physical environment during transportation and storage. Raceway and enclosure openings shall be sealed prior to shipment.

14.5 Raceways (Ducts), Support Systems (Cable Supports), Connection Boxes, and Other Boxes.

14.5.1 General Requirements.

14.5.1.1 Raceways (ducts) shall be identified for the environment.

14.5.1.2 All sharp edges, flush, burrs, rough surfaces, or threads that the insulation of the conductors can come in contact with shall be...
removed from raceways (ducts) and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation.

14.5.1.3 Drain holes shall not be permitted in raceways (ducts), junction boxes, and pull boxes where the holes would compromise the intended enclosure integrity. Drain holes of 6.4-mm (1/4-in.) diameter shall be permitted in wireways (cable trunking systems), connection boxes, and other boxes used for wiring purposes that are subject to accumulations of oil or moisture.

14.5.2* Percentage Fills of Raceways (Ducts). The combined cross-sectional area of all conductors and cables shall not exceed 50 percent of the interior cross-sectional area of the raceway (duct). The fill provisions shall be based on the actual dimensions of the conductors or cables used.

14.5.3 Rigid Conduit and Fittings.

14.5.3.1 General Requirements.

14.5.3.1.1 The minimum electrical trade size shall be metric designator 16 (trade size ½).

14.5.3.1.2* The maximum electrical trade size shall be metric designator 155 (trade size 6).

14.5.3.1.3 Where conduit enters a box or enclosure, a bushing or fitting providing a smoothly rounded insulating surface shall be installed to protect the conductors from abrasion, unless the design of the box or enclosure is such that it provides the same protection. Where conduit bushings are constructed entirely of insulating material, a locknut shall be provided both inside and outside the enclosure to which the conduit is attached.

Exception: Where threaded hubs or bosses that are an integral part of an enclosure to which the conduit is attached.

14.5.3.1.4 Conduit bends shall be made in such a manner that the conduit shall not be damaged and the internal diameter of the conduit shall not be effectively reduced. The radius of the curve of any field bend shall be not less than shown in Table 14.5.3.1.4.

14.5.3.1.5 A run of conduit shall contain not more than four-quarter bends or a combination of bends totaling 360 degrees between pull points.

14.5.3.2 Metal-Type Nonflexible Conduit.

14.5.3.2.1 General Requirements.

14.5.3.2.1.1 Conduits shall be securely held in place and supported at each end.

14.5.3.2.1.2 Fittings shall be compatible with the conduit and identified for the application. Fittings and conduits shall be threaded using an electrical conduit die unless structural difficulties prevent assembly. Running threads shall not be used on conduit for connection at couplings. Metallic tubing shall not be threaded. Where threadless fittings are used, the conduit shall be securely fastened to the equipment.

14.5.3.2.2* Rigid Metal Conduit and Fittings. Rigid metal conduit and fittings shall be of galvanized steel or of a corrosion-resistant material identified for the conditions of service.

14.5.3.2.3* Intermediate Metal Conduit. Intermediate metal conduit shall be a steel raceway of circular cross section with integral or associated couplings, approved for the installation of electrical conductors and used with approved fittings to provide electrical continuity.

14.5.3.2.4* Electrical Metallic Tubing. Electrical metallic (steel) tubing shall be a metallic tubing of circular cross section approved for the installation of electrical conductors when joined together with approved fittings. The maximum size of tubing shall be the 4-in. electrical trade size.

14.5.3.3 Rigid Nonmetallic Conduit (PVC Schedule 80).

14.5.3.3.1* Rigid nonmetallic conduit (PVC Schedule 80) shall be of suitable nonmetallic material approved for the installation of electrical conductors and identified for use where subject to physical damage.

14.5.3.3.2 Conduit shall be securely held in place and supported as specified in Table 14.5.3.3.2. In addition, conduit shall be securely fastened within 900 mm (3 ft) of each box, enclosure, or other conduit termination.

Table 14.5.3.1.4 Minimum Radii of Conduit Bends

<table>
<thead>
<tr>
<th>Size of Conduit (in.)</th>
<th>Radius of Bend Done by Hand (in.)</th>
<th>Radius of Bend Done by Machine (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3/4</td>
<td>5</td>
<td>4 1/2</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>5 3/4</td>
</tr>
<tr>
<td>1 1/4</td>
<td>8</td>
<td>7 1/4</td>
</tr>
<tr>
<td>1 1/2</td>
<td>10</td>
<td>8 1/4</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>9 1/2</td>
</tr>
<tr>
<td>2 1/2</td>
<td>15</td>
<td>10 1/2</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>3 1/2</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>4 1/2</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>30</td>
</tr>
</tbody>
</table>

For SI units, 25 mm = 1 in.

Notes:
1. For field bends done by hand, the radius is measured to the inner edge of the bend.
2. For a single-operation (one-shot) bending machine designed for the purpose, the radius is measured to the centerline of the conduit.

Table 14.5.3.3.2 Support of Rigid Nonmetallic Conduit (RNC)

<table>
<thead>
<tr>
<th>Conduit Size</th>
<th>Maximum Spacing Between Supports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric Designator</td>
<td>Trade Size</td>
</tr>
<tr>
<td>16 – 27</td>
<td>½ – 1</td>
</tr>
<tr>
<td>35 – 53</td>
<td>1 ¾ – 2</td>
</tr>
<tr>
<td>63 – 78</td>
<td>2 ½ – 3</td>
</tr>
<tr>
<td>91 – 129</td>
<td>3 ¾ – 5</td>
</tr>
<tr>
<td>155</td>
<td>6</td>
</tr>
</tbody>
</table>

14.5.3.3.3* Expansion fittings shall be installed to compensate for thermal expansion and contraction.

14.5.3.3.4 All joints between lengths of conduit and between conduit and couplings, fittings, and boxes shall be made with fittings approved for the purpose.
14.5.4 Flexible Metal Conduit and Fittings.

14.5.4.1 General Requirements.

14.5.4.1.1 Flexible metal conduit and liquidtight flexible metal conduit, minimum electrical trade size shall be metric designator 12 (trade size 3/8).

*Exception: Thermocouples and other sensors.*

14.5.4.1.2 The maximum size of flexible metal conduit and liquidtight flexible metal conduit shall be metric designator 103 (trade size 4).

14.5.4.1.3 Flexible metal conduit and liquidtight flexible metal conduit shall be installed in such a manner that liquids will tend to run off the surface instead of draining toward the fittings.

14.5.4.1.4 Fittings shall be compatible with the conduit and identified for the application. Connectors shall be the "union" types.

14.5.4.2 Flexible Metal Conduit. Flexible metal conduit shall be identified for use in the expected physical environment.

14.5.4.3 Liquidtight Flexible Metal Conduit. Liquidtight flexible metal conduit shall be identified for use in the expected physical environment.

14.5.5 Flexible Nonmetallic Conduit and Fittings.

14.5.5.1 Liquidtight flexible nonmetallic conduit is a raceway of circular cross section of the following types:

(1) A smooth, seamless inner core and cover that is bonded together and has or more reinforcement layers between the core and cover
(2) A smoother inner surface with integral reinforcement within the conduit wall
(3) A corrugated internal and external surface with or without integral reinforcement within the conduit wall

14.5.5.2 A flexible nonmetallic conduit shall be resistant to kinking and shall have physical characteristics of the sheath of multiconductor cables.

14.5.5.3 The conduit shall be identified for use in the expected physical environment.

14.5.5.4 Liquidtight flexible nonmetallic conduit minimum electrical trade size shall be 3/8 in.

14.5.5.5* The maximum size of liquidtight flexible nonmetallic conduit shall be 4-in. trade size.

14.5.5.6 Fittings shall be compatible with the conduit and identified for the application.

14.5.5.7 Flexible conduit shall be installed in such a manner that liquids will tend to run off the surface instead of draining toward the fittings.

14.5.6 Wireways (Cable Trunking Systems).

14.5.6.1 Wireways (cable trunking systems) external to enclosures shall be rigidly supported and clear of all moving or contaminating portions of the machine.

14.5.6.2 Covers shall be shaped to overlap the sides; gaskets shall be permitted. Covers shall be attached to wireways by hinges or chains and held closed by means of captive screws or other suitable fasteners. On horizontal wireway, the cover shall not be on the bottom. Hinged covers shall be capable of opening at least 90 degrees.

14.5.6.3 Where the wireway is furnished in sections, the joints between sections shall fit tightly but shall not be required to be gasketed.

14.5.6.4 The only openings permitted shall be those required for wiring or for drainage.

14.5.6.5 Wireways shall not have opened but unused knockouts.

14.5.6.6 Metal thickness and construction of wireways shall comply with UL 870, Wireways and Auxiliary Gutters. [ROP 79-147 (Log 130)]

14.5.7* Machine Compartments and Wireway. The use of compartments or wireways within the column or base of a machine to enclose conductors shall be permitted provided the compartments or wireways are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments or wireways shall be secured and arranged so that they are not subject to damage.

14.5.8 Connection Boxes and Other Boxes.

14.5.8.1 Connection boxes and other boxes used for wiring purposes shall be readily accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influences under which the machine is intended to operate.

14.5.8.2 Those boxes shall not have opened but unused knockouts or any other openings and shall be constructed so as to exclude materials such as dust, flyings, oil, and coolant.

14.5.9 Motor Connection Boxes.

14.5.9.1 Motor connection boxes shall enclose only connections to the motor and motor-mounted devices (e.g., brakes, temperature sensors, plugging switches, tachometer generators).

14.5.9.2 Electrical connections to motors, solenoids, and other devices with integral leads, sizes 14 AWG through 4 AWG, shall be made with ring-type pressure connectors (pressure-tool applied) and bolted.

14.5.9.3 Connectors shall be insulated with a material that will not support combustion.

14.5.9.4 Soldered or insulation-piercing-type connectors (lugs) shall not be used.

14.5.10 Cord.

14.5.10.1* Manufactured assemblies with factory-applied molded connectors applied to cord shall be permitted.
14.5.10.2 The use of cord shall be limited to individual exposed lengths of 15 m (50 ft) or less.

14.5.10.3 Cord shall be installed in accordance with the provision of 14.1.4.

14.5.10.4 Cord shall be permitted for use with flexible connections to pendant pushbutton stations. Chains or wire rope external to the cord shall support the weight of pendant stations.

Exception: Cords listed for the purpose shall be permitted to be used without an external chain or wire rope. [ROP 79-146 (Log 101)]

14.5.10.5 Cord shall be permitted for use with connections involving small or infrequent movements. Cord shall also be permitted to complete the connection to normally stationary motors, limit switches, and other externally mounted devices.

14.5.10.6 Connections to frequently moving parts shall be made with conductors for flexing service in accordance with Section 13.7. Cord with conductors for flexing service shall have vertical connections and shall be installed to avoid excessive flexing and straining.

Exception: Horizontal connections shall be permitted where the cord is adequately supported.

14.5.11 Cable Trays. Cable trays to be used for cable or raceway support on industrial machines shall be permitted. Cable trays shall be permitted to support single conductors 1/0 or larger that are otherwise permitted on industrial machines, cables that are otherwise permitted on industrial machines, and raceways functionally associated with industrial manufacturing systems. [ROP 79-122 (Log 55)]

Chapter 15 Electric Motors and Associated Equipment [ROP 79-149 (Log 27)]

15.1* General Requirements. Motors shall be suitable for the environment in which they are installed.

15.2 (Reserved)

15.3* Motor Dimensions. As far as is practicable, the dimensions of the motors shall comply with those given in NEMA MG-1, IEC 60072-1, or IEC 60072-2 as appropriate.

15.4 Motor Mounting and Compartments.

15.4.1 Each motor and its associated couplings, belts and pulleys, or chains and sprockets shall be mounted so that they are adequately protected from physical damage and are easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be so that all motor hold-down means can be removed and all terminal boxes are accessible. An adjustable base or other means of adjustment shall be provided when belt or chain drives are used.

15.4.2 Motors shall be mounted so that proper cooling is ensured and the temperature rise remains within the limits of the insulation class.

15.4.3 Motor compartments shall be clean and dry, and when required, shall be ventilated directly to the exterior of the machine. The vents shall be so that ingress of swarf, dust, or water spray is at an acceptable level.

15.4.4 All openings between the motor compartment and any other compartment shall meet the motor compartment requirements. Where a raceway is run into the motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the raceway shall be sealed.

15.5 Criteria for Selection. The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environment conditions. The points that shall be considered include the following:

(1) Type of motor
(2) Type of duty cycle
(3) Fixed speed or variable speed operation (and consequent variable influence of the ventilation)
(4) Mechanical vibration
(5) Type of converter for motor speed control
(6) Influence of the harmonic spectrum of the voltage and/or current feeding the motor (when it is supplied from a converter) on the temperature rise
(7) Method of starting and possible influence of the in-rush current on the operation of other users, taking into account possible special considerations stipulated by the supply authority
(8) Variation of counter torque load with time and speed
(9) Influence of loads with large inertia
(10) Influence of constant torque or constant power operations
(11) Possible need of inductive reactors between motor and converter

15.6* Protective Devices for Mechanical Brakes. Operation of the overload and overcurrent protective devices for mechanical brake actuators shall initiate the simultaneous de-energization (release) of the associated machine actuators.

15.7 Direction Arrow. Where reverse rotation can produce an unsafe condition, a direction arrow shall be installed. The arrow shall be adjacent to the motor and plainly visible.

15.8 Marking on Motors. Motors shall be marked in accordance with Section 430.7 of NFPA 70, National Electrical Code. [ROP 79-149 (Log 27)]

Chapter 16 Accessories and Lighting [ROP 79-105 (Log 26)]

16.1 Accessories.

16.1.1 Where the machine or its associated equipment is provided with receptacle outlets to be used for accessory equipment (e.g., hand-held power tools, test equipment), the following conditions shall apply:

(1) Receptacles shall be of the grounding type, 125-volt, single-phase, 15-ampere configuration and listed for the applied voltage.
(2) Receptacles with their associated attachment plugs (plug/sockets) shall be in accordance with 14.4.5.3.
(3) The continuity of the equipment grounding (protective bonding) circuit to the receptacle outlet shall be verified by Section 19.2.

Exception: Verification is not required for PELV circuits in accordance with Section 19.2.

(4) All ungrounded (unearthed) conductors connected to the receptacle outlet shall be protected against overcurrent in
accordance with the provisions of 7.2.5 and these circuits shall not be connected to other machine circuits.

(5) Where the power supply to the receptacle outlet is not disconnected by the supply disconnecting device for the machine or section of the machine, the warning and marking requirements of 5.3.5-4 shall apply.

(6) Shall be suitable for the environment. Receptacles mounted external to the enclosure shall be provided with a means to cover the receptacle when the plug is removed.

[ROP 79-106 (Log 160)]

16.1.2 Receptacles, which are part of the industrial machine, either internal or external to the control cabinet and intended for use by maintenance personnel, shall have Ground-Fault Circuit-Interrupter (GFCI) protection for personnel.

16.2 Local Lighting of the Machine and Equipment.

16.2.1 General.

16.2.1.1 Lighting circuits shall comply with the provisions of Section 8.3.

16.2.1.2 Machine work lights shall not contain switches or receptacles where exposed to liquids or condensing mists unless identified for the purpose. Lampholders shall not incorporate a switch or receptacle. Work lights used in wet locations shall be provided with ground fault protection.

[ROP 79-110 (Log 124)]

16.2.1.3 The conductors to stationary lights used as an integral part of the machine shall be Type MTW, and the conductors within the fixtures shall be not smaller than 18 AWG.

16.2.1.4 Flexible cords shall be Type SO, STO, or STOW or Type SJ, SJOW, or SJTO and shall not incorporate in-line switches.

16.2.1.5 Stroboscopic effects from lights shall be avoided.

16.2.2 Supply.

16.2.2.1 The lighting circuit voltage shall not exceed 150 volts between conductors.

16.2.2.2 Lighting circuits shall have overcurrent protection in accordance with 7.2.6 and shall be supplied from one of the following sources:

(1) A separate isolating transformer connected to the load side of the supply disconnecting means. Overcurrent protection shall be provided in the secondary circuit.

(2) A separate isolating transformer connected to the line side of the supply disconnecting means shall be permitted for the supply of a maintenance lighting circuit in control enclosures only. Overcurrent protection shall be provided in the secondary circuit.

(3) A grounded machine circuit that has separate overcurrent protection and does not exceed 150 volts to ground shall be permitted.

(4) An isolating transformer connected to the line side of the supply disconnecting device when a separate primary disconnecting means and secondary overcurrent protection are provided and mounted within the control enclosure adjacent to the supply disconnecting device.

(5) An externally supplied lighting circuit (e.g., factory lighting supply). This shall be permitted in control enclosures and for the machine work light(s) where the total power rating does not exceed 3 kW.

16.2.3 Protection. Local lighting circuits shall be separately protected with overcurrent protection and shall not exceed 15 amperes.

16.2.4 Lighting Fixtures.

16.2.4.1 Adjustable lighting fixtures shall be suitable for the physical environment.

16.2.4.2 The lampholders shall be as follows:

(1) Rated for the voltage and wattage of the lamp

(2) Constructed with an insulating material protecting the lamp so as to prevent unintentional contact, except where fixed lighting is out of reach of operators during normal operations, the provisions of this subsection do not apply.

16.2.4.3 Reflectors and protectors shall be supported by a bracket and not the lampholder.

[ROP 79-105 (Log 26)]

Chapter 17 Marking and Safety Signs [ROP 79-18 (Log 23)]

17.1 General.

17.1.1 The electrical equipment shall be marked with the supplier's name, trademark, or other identifying symbol.

17.1.2 Safety signs, nameplates, markings, and identification plates shall be of sufficient durability to withstand the physical environment involved.

17.2 Safety Signs for Electrical Enclosures.

[ROP 79-92 (Log 6)]

17.2.1 Enclosures that do not clearly show that they contain electrical devices shall be marked with a safety sign in accordance with ANSI Z535 series, which deal with product safety signs.

[ROP 79-93 (Log 20)]

17.2.2 Safety signs shall be plainly visible on the enclosure door or cover.

[ROP 79-92 (Log 6)]

17.2.3 It shall be permitted to omit safety signs on the following:

(1) An enclosure equipped with a supply disconnecting device

(2) An operator-machine interface or control station

(3) A single device with its own enclosure (e.g., position sensor)

[ROP 79-92 (Log 6)]

17.2.4 A safety sign shall be provided adjacent to the disconnecting operating handle(s) where the disconnect(s) that is interlocked with the enclosure door does not de-energize all exposed live parts when the disconnect(s) is in the open (off) position.

17.2.5 Where an attachment plug is used as the disconnecting means, a safety sign shall be attached to the control enclosure door or cover indicating that power shall be disconnected from the equipment before the enclosure is opened.

17.2.6 Where the disconnecting means is remote from the control enclosure, a safety sign shall be attached to the enclosure door or
cover indicating that the power shall be disconnected from the equipment before the enclosure is opened and that the enclosure shall be closed before the power is restored.

17.3* Function Identification. Control devices, visual indicators, and displays used in the operator-machine interface shall be clearly and durably marked with regard to their functions either on or adjacent to the unit.

17.4 Machine Nameplate Data.

17.4.1 Control equipment shall be legibly and durably marked in a way that it is plainly visible after the equipment is installed. A nameplate giving the following information shall be attached to the enclosure:

1. Name or trademark of supplier
2. Serial number, where applicable
3. Rated voltage, number of phases and frequency (if ac), and full-load current for each supply
4. Ampere rating of the largest motor or load
5. Maximum ampere rating of the short-circuit and ground-fault protective device, where provided
6. Electrical diagram number(s) or the number of the index to the electrical drawings

17.4.2 The full-load current shown on the nameplate shall not be less than the full-load currents for all motors and other equipment that can be in operation at the same time under normal conditions of use. Where unusual loads or duty cycles require oversized conductors, the required capacity shall be included in the full-load current specified on the nameplate.

17.4.3 Where more than one incoming supply circuit is to be provided, the nameplate shall state the information in 17.4.1 for each circuit.

17.4.4 Where only a single motor or motor controller is used, the motor nameplate shall be permitted to serve as the electrical equipment nameplate where it is plainly visible.

17.4.5 Where overcurrent protection is provided in accordance with 7.2.3, the machine shall be marked “overcurrent protection provided at machine supply terminals.” A separate nameplate shall be permitted to be used for this purpose.

17.5 Equipment Marking and Identification.

17.5.1 Where equipment is removed from its original enclosure or is placed so that the manufacturer’s identification plate is not easily read, an additional identification plate shall be attached to the machine or enclosure.

17.5.2 Where a motor nameplate or connection diagram plate is not visible, additional identification shall be provided where it can be easily read.

17.5.3 Nameplates, identification plates, or safety signs shall not be removed from the equipment.

17.5.4 All control panel devices and components shall be plainly identified with the same designation as shown on the diagram(s). This identification shall be adjacent to (not on) the device or component.

Exception No. 1: Where the size or location of the devices makes individual identification impractical, group identification shall be used.

Exception No. 2: This requirement shall not apply to machines on which the equipment consists only of a single motor, motor controller, pushbutton station(s), and work light(s).

17.5.5 All devices external to the control panel(s) shall be identified by a nameplate with the same designation as shown on the diagram(s) and mounted adjacent to (not on) the device.

Exception: Devices covered by Section 17.3.

17.5.6 Terminations on multiconductor plugs and receptacles shall be plainly marked. The markings on the plug and receptacles and on drawings shall correspond.

17.5.7 Where group protection as provided for in 7.2.10 is used, information specifying the short-circuit protective device for each group protected motor branch circuit shall be included with the equipment.

Chapter 18 Technical Documentation [ROP 79-19 (Log 53)]

18.1 General.

18.1.1 The information necessary for installation, operation, and maintenance of the electrical equipment of a machine shall be supplied in the form of drawings, diagrams, charts, tables, and instructions as appropriate.

The information provided shall be permitted to vary with the complexity of the electrical equipment. For very simple equipment, the relevant information shall be permitted to be contained in one document provided this document shows all the devices of the electrical equipment and enables the connections to the supply network to be made.

18.1.2 The machinery supplier shall ensure that the technical documentation specified in this chapter is provided with each machine.

18.1.3 Technical documentation shall be permitted to be supplied in an agreed upon format.

18.2 Information to Be Provided. The following information shall be provided with the electrical equipment:

1. Clear, comprehensive description of the equipment, installation and mounting, and the connection to the electrical supply(ies)
2. Electrical supply circuit(s) requirements
3. Overview (block) diagram(s) where appropriate
4. Schematic diagram(s)
5. Information (where appropriate) on the following:
   a. Programming
   b. Sequence of operation(s)
   c. Frequency of inspection
   d. Frequency and method of functional testing
   e. Adjustment, maintenance, and repair
   f. Interconnection diagram
   g. Panel layouts
   h. Instruction and service manuals
   i. Physical environment (e.g., lighting, vibration, noise levels, atmospheric contaminants)
(6) A description (including interconnection diagrams) of the safeguards, interacting functions, and interlocking of guards with potentially hazardous motions.

(7) A description of the safeguarding means and methods provided where the primary safeguards are overridden (e.g., manual programming, program verification).

(8) Information for safety lockout procedure

(9) Explanation of unique terms

(10) Part’s list and recommended spare part’s list

(11) Maintenance instructions and adjustment procedures

(12) Reference information (where appropriate) on the following:
   a. Lubrication diagram
   b. Pneumatic diagram
   c. Hydraulic diagram
   d. Miscellaneous system diagrams (e.g., coolant, refrigerant)

18.3 Requirements Applicable to All Documentation.

18.3.1 The documents shall be prepared in accordance with the requirements of Sections 18.4 through 18.10.

18.3.2 For referencing of the different documents, the supplier shall select one of the following methods:

   (1) Each of the documents shall carry as a cross-reference the document numbers of all other documents belonging to the electrical equipment.

   (2) All documents shall be listed with document numbers and titles in a drawing or document list.

   The first method shall be used only where the documentation consists of four or less documents.

18.3.3 Where appropriate, a table of contents shall appear prominently on the first sheet and shall refer to all major sections of the electrical drawings.

18.4* Basic Information. The technical documentation shall contain, as a minimum, information on the following:

   (1) Normal operating conditions of the electrical equipment including the expected conditions of the electrical supply, and where appropriate, the physical environment

   (2) Handling, transportation, and storage

   (3) Inappropriate use(s) of the equipment

   The technical documentation shall be permitted to be presented as a separate document or as part of the installation or operation documentation.

18.5 Installation Diagram.

18.5.1* The installation diagram shall provide all information necessary for the preliminary work of setting up the machine.

18.5.2 The specified position of the electrical supply to be installed on site shall be clearly indicated.

18.5.3* The data necessary for choosing the type, characteristics, rated currents, and setting of the overcurrent protective device(s) for the supply circuit conductors to the electrical equipment of the machine shall be stated.

18.5.4* Where necessary, the size, purpose, and location of any raceways (ducts) in the foundation that are to be provided by the user shall be detailed.

18.5.5* The size, type, and purpose of raceways (ducts), cable trays, or cable supports between the machine and the associated equipment that are to be provided by the user shall be detailed.

18.5.6* Where necessary, the diagram shall indicate where space is required for the removal or servicing of the electrical equipment.

18.5.7* Where it is appropriate, an interconnection diagram or table shall be provided. That diagram or table shall give full information about all external connections. Where the electrical equipment is intended to be operated from more than one source of electrical supply, the interconnection diagram or table shall indicate the modifications or interconnections required for the use of each supply.

18.6* Block (System) Diagrams and Function Diagrams. Where it is necessary to facilitate the understanding of the principles of operation, a system diagram shall be provided. For the purposes of this chapter, a block diagram shall symbolically represent the electrical equipment together with its functional interrelationships without necessarily showing all of the interconnections.

18.7 Circuit Diagrams.

18.7.1* Diagrams, including machine schematics, of the electrical system shall be provided and shall show the electrical circuits on the machine and its associated electrical equipment. Electrical symbols shall be in accordance with IEEE 315 where included therein. Any electrical symbols not included in IEEE 315 shall be separately shown and described on the diagrams. The symbols and identification of components and devices shall be consistent throughout all documents and on the machine.

   Exception: Wiring schematics shall not be required for commercially available or field replaceable components.

18.7.2* Pertinent information such as motor horsepower, frame size, and speed shall be listed adjacent to its symbol.

18.7.3* Where appropriate, a diagram showing the terminals for interface connections shall be provided. Switch symbols shall be shown on the electromechanical diagrams with all supplies turned off (e.g., electricity, air, water, lubricant) and with the machine and its electrical equipment in the normal starting condition and at 20°C (68°F) ambient. Control settings shall be shown on the diagram.

18.7.4 Conductors shall be identified in logical order in accordance with Section 14.2.

18.7.5* Circuit Characteristics. [ROP 79-21 (Log 118)]

18.7.5.1 Circuits shall be shown in a way so as to facilitate the understanding of their function as well as maintenance and fault location.

18.7.5.2 A cross-referencing scheme shall be used in conjunction with each relay, output device, limit switch, and pressure switch so that any contact associated with the device can be readily located on the diagrams.

18.7.6 Control circuit devices shall be shown between vertical lines that represent control power wiring. The left vertical line shall be the control circuit’s common and the right line shall be the operating coil’s common, except where permitted by Chapter 9 design requirements. Control devices shall be shown on horizontal lines.
(rungs) between the vertical lines. Parallel circuits shall be shown on separate horizontal lines directly adjacent to (above or below) the original circuit.

18.7.7 An interconnection diagram shall be provided on large systems having a number of separate enclosures or control stations. It shall provide full information about the external connections of all of the electrical equipment on the machine.

18.7.8 Interlock wiring diagrams shall include devices, functions, and conductors in the circuit where used.

18.7.9 Plug/receptacle pin identification shall be shown on the diagram(s).

18.8 Operating Manual.

18.8.1* The technical documentation shall contain an operating manual detailing proper procedures for set-up and equipment use.

18.8.2 Where the operation of the equipment can be programmed, detailed information on methods of programming, equipment required, program verification, and additional safety procedures (where required) shall be provided.

18.9 Maintenance Manual.

18.9.1* The technical documentation shall contain a maintenance manual detailing proper procedures for adjustment, servicing and preventive inspection, and repair.

18.9.2 Where methods for the verification of proper operation are provided (e.g., software testing programs), the use of those methods shall be detailed.

18.10 Part’s List.

18.10.1 The part’s list shall comprise, as a minimum, information necessary for ordering spare or replacement parts (e.g., components, devices, software, test equipment, technical documentation) required for preventive or corrective maintenance including those that are recommended to be carried in stock by the equipment user.

18.10.2 The part’s list shall show the following for each item:

- (1) Reference designation used in the documentation
- (2) Its type designation
- (3) Supplier and alternative sources where available
- (4) Its general characteristics where appropriate
- (5) Quantity of items with the same reference designation

[ROP 79-19 (Log 53)]

Chapter 19 Testing and Verification [ROP 79-159 (Log 61)]

19.1* General. The verification of the continuity of the equipment grounding (protective bonding) circuit shall be conducted and documented.

When the electrical equipment is modified, the requirements in Section 19.7 shall apply.

Applicable tests shall be performed where deemed necessary in accordance with the references in the following list:

(1) Verification that the electrical equipment is in compliance with the technical documentation (see Chapter 18)
(2) Insulation resistance test (see Section 19.3)
(3) Voltage test (see Section 19.4)
(4) Protection against residual voltages test (see Section 19.5)
(5) Functional test (see Section 19.6)

19.2* Continuity of the Equipment Grounding (Protective Bonding) Circuit. One of the following methods shall be used to verify the continuity of the equipment grounding circuit:

(1) Use an impedance measuring device, take into account any impedance in the measuring circuit. The measured impedance shall be 0.1 ohms or less.
(2) Apply a current of at least 10 amperes, 50 Hz or 60 Hz, derived from a SELV source. The tests are to be made between the equipment grounding (PE) terminal and relevant points that are part of the equipment grounding (protective bonding) circuit; the measured voltage between the equipment grounding (PE) terminal and the points of test is not to exceed the values given in Table 19.2.

<table>
<thead>
<tr>
<th>Minimum Equipment Grounding (Protective Bonding) Conductor Cross-sectional Area of the Branch Under Test (AWG)</th>
<th>Maximum Measured Voltage Drop* (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>3.3</td>
</tr>
<tr>
<td>16</td>
<td>2.6</td>
</tr>
<tr>
<td>14</td>
<td>1.9</td>
</tr>
<tr>
<td>10</td>
<td>1.4</td>
</tr>
<tr>
<td>&gt;8</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*Values are given for a test current of 10 amperes.

Exception: For certain parts of electrical equipment, incorporating busbars, collector wire or collector bar systems, or slip-ring assemblies, a lower minimum value of 50,000 ohms shall be permitted.

19.4* Voltage Tests. The machine shall withstand without breakdown a test voltage gradually applied from 0 to 1500 volts ac or 2121 volts dc and held at the maximum value for a period of at least 1 second between the conductors of all primary circuits and the equipment grounding (protective bonding) circuit. The test voltage shall be supplied from an isolated power supply with a minimum rating of 500 volt amperes. Components that are not rated to withstand the test voltage shall be disconnected during testing.

[ROP 79-161 (Log 140)]

19.5 Protection Against Residual Voltages. Residual voltage tests shall be performed to ensure compliance with 6.2.4.

19.6 Functional Tests. The functions of electrical equipment, particularly those related to safety and safeguarding, shall be tested.

19.7 Retesting. Where a portion of the machine and its associated equipment is changed or modified, that portion shall be reverified and retested as appropriate.

[ROP 79-159 (Log 61)]
Annex A Explanatory Material [ROP 79-162 (Log 38)]

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 In this standard, the term electrical includes both electrical and electronic equipment. Requirements that apply only to electronic equipment shall be so identified. [ROP 79-8 (Log 35)]

The general terms machine and machinery as used throughout this standard mean industrial machinery. [ROP 79-8 (Log 35)] See Annex C for examples of industrial machines covered by this standard. [ROP 79-8 (Log 35)]

A.1.5 Motor design letter designations are found in ANSI/NEMA MG 1 and ANSI/IEEE 100. [ROP 79-8 (Log 35)]

[ROP 79-10 (Log 36)]

A.3.1 Chapter 3 contains only those definitions essential to the proper application of this standard. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. In general, only those terms that are used in two or more places are defined. Spelling and definitions of general words and terms follow Webster’s Collegiate Dictionary, 10th edition. The terms in parenthesis used throughout this standard are from the English version of IEC 60204-1 and are based on the Oxford English dictionary. [ROP 79-11 (Log 37)]

A.3.2.1 Approved: The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment, or materials, the “authority having jurisdiction” may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The “authority having jurisdiction” may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction: The phrase “authority having jurisdiction” is used in NFPA documents in a broad manner because jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction. [ROP 79-11 (Log 37)]

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product. [ROP 79-11 (Log 37)]

A.3.3.3 Actuator. The actuator can take the form of a handle, knob, pushbutton, roller, plunger, and so forth. There are some actuating means that do not require an external actuating force but only an action. See also 3.3.3.1 Machine Actuator. [ROP 79-11 (Log 37)]

A.3.3.4 Adjustable Speed Drives. This includes ac and dc voltage modes and frequency mode controls. Belt, chain, or roller shifting controllers are not included. [ROP 79-14 (Log 49)]

A.3.3.5 Ambient Temperature. Ambient air temperature as applied to an enclosure or housing is the average temperature of the surrounding air that comes in contact with the enclosure or housing. Ambient air temperature as applied to a component or device within the enclosure is the average temperature of the surrounding air that comes in contact with the component. [ROP 79-11 (Log 37)]

A.3.3.9 Bonding (Bonded). See 3.3.81, Protective Bonding Circuit. [ROP 79-11 (Log 37)]

A.3.3.12 Cable Trunking System. See 3.3.112, Wireway. [ROP 79-11 (Log 37)]

A.3.3.17 Control Circuit (of a machine). Power circuit protection can be provided by control shunt-tripping.

A.3.3.27 Duct. Conduits, cable trunking systems (see 3.3.12) and underfloor channels are types of duct. See 3.3.84, raceway. [ROP 79-11 (Log 37)]

A.3.3.41 Failure (of Equipment). After failure the item has a fault. “Failure” is an event, as distinguished from “fault,” which is a state. This concept as defined does not apply to items consisting of software only. [ROP 79-11 (Log 37)]

A.3.3.42 Fault. A fault is often the result of a failure of the item itself, but can exist without prior failure. [ROP 79-11 (Log 37)]

A.3.3.52 Guard. Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard.

A.3.3.55 Identified (as applied to equipment). Suitability of equipment for a specific purpose, environment, or application can be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification can include labeling or listing. [ROP 79-11 (Log 37)]

A.3.3.63 Interrupting Rating. Equipment intended to interrupt current at other than fault levels can have its interrupting rating implied in other ratings, such as horsepower or locked motor current. [ROP 79-11 (Log 37)]

A.3.3.67.1 Dry Location. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction. [ROP 79-11 (Log 37)]

A.3.3.74 Overload. Overload should not be used as a synonym for overcurrent. [ROP 79-11 (Log 37)]

A.3.3.80 Programmable Electronic System. This term includes all elements in the system extending from sensors to other input devices via data highways or other communication paths to the actuators or other output devices. [ROP 79-11 (Log 37)]
A.3.3.81 Protective Bonding Circuit. See 3.3.9, Bonding.  [ROP 79-11(Log 37)]

A.3.3.83 Qualified Person. See 3.3.30, (Electrically) Instructed Person and 3.3.31, (Electrically) Skilled Person.  [ROP 79-11(Log 37)]

A.3.3.85 Receptacle. See 3.3.98, Socket.  [ROP 79-11(Log 37)]

A.3.3.102 Supplementary Overcurrent Protective Device. The device cannot be used as a substitute for power circuit overcurrent devices in place of the power circuit protection.

A.3.3.103 Supplier. The user can also act in the capacity of a supplier to him or herself.  [ROP 79-11(Log 37)]

A.3.3.108 Undervoltage Protection. The principal objective of this device is to prevent automatic restarting of the equipment. Standard undervoltage or low-voltage protection devices are not designed to become effective at any specific degree of voltage reduction.  [ROP 79-11(Log 37)]

A.4.1 A sample inquiry form is provided in Annex B for use in facilitating an agreement between the supplier and the user.

Hazards can include, but are not limited to, the following:

1. Failures or faults in the electrical equipment resulting in the possibility of electrical shock or electrical fire
2. Failures or faults in control circuits (or components and devices associated with these circuits) resulting in malfunctioning of the machine
3. Disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine
4. Loss of continuity of circuits that depend upon sliding or rolling contacts resulting in a failure of a safety function
5. Electrical disturbances (e.g., electromagnetic, electrostatic, or radio interference) either from outside the electrical equipment or internally generated
6. Stored energy (either electrical or mechanical)
7. Audible noise at levels that cause health problems to persons

Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user.

Design and development should be the first consideration in the reduction of risks. Where this is not possible, safeguarding should be considered. Safeguarding includes the use of safeguards, awareness means, and safe working procedures.

A.4.3.1 See Annex B.  [ROP 79-24 (Log 60)]

A.4.3.2 The short time value for the frequency can be specified by the user (see Annex B).  [ROP 79-24 (Log 60)]

A.4.4 In addition, refer to Annex B for 4.4.3 through 4.4.6.

A.4.4.1 See Annex B for a sample inquiry form that will facilitate an agreement between the user and the supplier.

A.4.4.2 The electrical interferences generated by the equipment itself should not exceed levels specified in the relevant equipment standards and others dealing with electromagnetic compatibility (EMC) levels. The levels allowed should be determined for the specific application.

Generated interference signals can be kept to a minimum by the following:

1. Suppression at the source by using capacitors, inductors, diodes, Zener diodes, varistors, or active devices, or a combination of these
2. Equipment screening in a bonded electrically conductive enclosure to provide segregation from other equipment

Undesirable effects of electrostatic discharge, radiated electromagnetic energy, and supply conductor (mains borne) interference should be avoided (e.g., use of appropriate filters and time delays, choice of certain power levels, suitable wiring types and practices).

The effects of interference on equipment can be reduced by the following:

1. Reference potential circuit or common connections. Each common connection treated as a single circuit and connected to one of several central reference points that are connected to ground (wired to earth) by insulated conductors of large cross-sectional area
2. Frame Connections. In each piece of equipment all frame connections are to be taken to a common point with a conductor of large cross-sectional area (e.g., braided conductors, foil strips having a width much greater than the thickness) used between slides and enclosures.

The connections to the frame are to be as short as possible

3. Transmission of signals. Electrostatic screens, electromagnetic shields, twisted conductors, and orientation (i.e., crossing cable runs at an angle of approximately 90 degrees to each other) is necessary to ensure that the low level signal wiring is not affected by interference from control or power cables, or running the connections parallel to the ground plane as necessary

4. Separation of equipment. Separating and/or shielding sensitive equipment (e.g., units working with pulses and/or at low signal levels) from switching equipment (e.g., electromagnetic relays, thyristors). Separation of low level signal wiring from control and power cables

A.4.4.3 See Annex B.

A.4.4.4 For extremely dry or moist environments, extra requirements may be necessary to prevent static discharge.

A.4.4.5 See Annex B.

A.4.4.6 See Annex B.

A.4.4.7 Where equipment is subject to radiation (e.g., microwave, ultraviolet, lasers, x-rays), additional measures should be taken to avoid malfunctioning and accelerated deterioration of the insulation.  [ROP 79-24 (Log 60)]

A.5.1.1 For large complex machinery comprising of a number of widely spaced machines working together in a coordinated manner, more than one incoming supply circuit might be needed depending upon the site supply circuit arrangements (see 5.3.1).  [ROP 79-35 (Log 59)]

A.5.1.3 See question 14 in Annex B.  [ROP 79-35 (Log 59)]

A.5.2 For additional information on the grounding terminal, see 8.2.1.2.  [ROP 79-35 (Log 59)]

A.5.3.5.4(3) For additional information on color identification for other conductors, see 14.2.4.  [ROP 79-35 (Log 59)]

A.6.3.1(1) Ripple-free is conventionally defined for a sinusoidal ripple voltage as a ripple content of not more than 10 percent rms.

A.6.3.1(2) For additional information on isolating transformers, refer to IEC 60742 and IEC 61558-1.  [ROP 79-25 (Log 68)]

A.7.2.1 General. Figures A.7.2.1(a) and A.7.2.1(b) show typical circuits acceptable for the protection of current-carrying and current-consuming electrical machine components. Protective interlocks are not shown.
See Figure 2
See Figure 2
See Figure 2
See Figure 2
A.7.2.2 See 7.2.10 and 18.5. [ROP 79-44 (Log 45)] The size and overcurrent protection of the supply conductors to a machine are covered by Article 670 of NFPA 70, National Electrical Code®. [ROP 79-44 (Log 45)]

A.7.2.10.1, Table 1, Note 6. IEC 947-4 defines the terms Type 1 and Type 2 coordinated protection as follows.

Type 1 Protection: Under short-circuit conditions the contactor or starter may not be suitable for further use without repair or replacement.

Type 2 Protection: Under short-circuit conditions the contactor or starter shall be suitable for further use.

The maximum allowable values in Table 7.2.10.1 do not guarantee Type 2 protection. Type 2 protection is recommended for use in applications where enhanced performance and reliability are required. [ROP 79-44 (Log 45)]

A.7.2.10.4(1) The short-circuit current rating includes the following:

1. The class and rating of the short-circuit protective device
2. The maximum nominal application voltage
3. The maximum available fault current [ROP 79-44 (Log 45)]

A.7.4 An example could be a resistance heating circuit that is short-time rated or that loses its cooling medium.

A.7.6.1 Overspeed protection means include, but are not necessarily limited to, the following:

1. A mechanical overspeed device incorporated in the drive to remove armature voltage upon motor overspeed.
2. An electrical overspeed detector that will remove armature voltage upon motor overspeed.
3. Field loss detection to remove armature voltage upon the loss of field current.
4. Voltage-limiting speed-regulated drives that operate with constant full field. In this case, protection is obtained individually for the loss of field or tachometer feedback; however, protection against simultaneous loss of field and tachometer is not provided.

[ROP 79-44 (Log 45)]

A.7.8 Conditions of use that can lead to an incorrect phase sequence include the following:

1. A machine transferred from one supply to another
2. A mobile machine with a facility for connection to an external power supply

[ROP 79-44 (Log 45)]

A.7.10.1 See 7.2.1 and 7.2.10. [ROP 79-44 (Log 45)]

A.8.1 The terms protective earthing conductor, protective bonding conductor, protective conductor, neutral, and earth are used in other countries. [ROP 79-151 (Log 52)]

A.8.2.1.2 The minimum cross-sectional area of the external protective copper conductor can be required to be larger for IEC applications. See Table 1 in IEC 60204-1 for these requirements. [ROP 79-151 (Log 52)]

A.8.2.1.2.4 Some other standards require the letters PE for the connection to the external protective earthing system.

A.8.2.5.2 The letters PE or the bicolor GREEN and YELLOW is used in some countries. [ROP 79-151 (Log 52)]

A.9.2.2 With the exception of emergency stop and depending upon the risk assessment, removal of power can be accomplished by the use of either electromechanical or solid-state components. [ROP 79-62 (Log 46)]

A.9.2.3 See 9.2.4 for overriding of safeguards under special conditions. [ROP 79-62 (Log 46)]

A.9.2.5.4.1 For other safety-related stop functions, see 11.3.4.

A.9.2.5.6 See Annex B.

A.9.2.7.4 One way to determine applicable error detection methods is to refer to IEC 60870-5-1, "Telecontrol equipment and systems." [ROP 79-62 (Log 46)]

A.9.4.1 The measures and the extent to which they are implemented, either individually or in combination, depend on the safety requirements associated with the respective application. [ROP 79-67 (Log 85)]

Measures to reduce these risks include but are not limited to the following:

1. Protective devices on the machine (e.g., interlock guards, trip devices)
2. Protective interlocking of the electrical circuit
3. Use of proven circuit techniques and components (see 9.4.2.1)
4. Provisions of partial or complete redundancy (see 9.4.2.2) or diversity (see 9.4.2.3)
5. Provision for functional tests (see 9.4.2.4)

In general, only single failures are to be regarded. In the event of higher levels of risk, it can be necessary to ensure that more than one failure cannot result in a hazardous condition.

Measures to minimize risk in the event of failure include the use of proven circuit techniques and components.

These measures include but are not limited to the following:

1. Bonding of control circuits for operational purposes (see 9.4.2.1)
2. One terminal of the control device (i.e., the operating coil) connected to the bonded conductor and all switching elements (e.g., contacts) connected to the nonearthed (grounded) side of the control supply (see 9.1.4)
3. Stopping by de-energizing (see 9.2.2)
4. Switching of all live conductors to the device being controlled (see 9.4.2.1)
5. Use of switching devices having positive opening operation (see IEC 60947-5-1)
6. Circuit design to reduce the possibility of failures causing undesirable operations

By providing partial or complete redundancy it is possible to minimize the probability that one single failure in the electrical circuit can result in a hazardous condition. Redundancy can be effective in normal operation (i.e., on-line redundancy) or designed as special circuits that take over the protective function (i.e., off-line redundancy) only where the operating function fails.

Where off-line redundancy that is not active during normal operation is used, suitable measures should be taken to ensure that these control circuits are available when required. [ROP 79-66 (Log 86)]
The use of control circuits having different principles of operation or differing types of devices can reduce the probability of faults and failures giving rise to hazards. Examples include the following:

(1) The combination of normally open and normally closed contacts operated by interlocking guards.
(2) The use of different types of control circuit components in the circuit.
(3) The combination of electromechanical and electronic circuits in redundant configurations.
(4) The combination of electrical and nonelectrical systems (e.g., mechanical, hydraulic, pneumatic) can perform the redundant function and provide the diversity.

Functional tests can be carried out automatically by the control system, or manually by inspection or tests at start-up and at predetermined intervals, or a combination as appropriate (see also Sections 18.2 and 19.9).

A.10.1.1 For further information on device selection, mounting, identification, and coding, see IEC 60073 and IEC 60447. [ROP 79-99 (Log 24)]

A.10.1.3 For further information on degrees of protection, see UL 50, UL 508, Annex F and IEC 60529. [ROP 79-99 (Log 24)]

A.10.1.4 For further information on positive (direct) opening operation, see IEC 60947-5-1.

A.10.7.2.1 For further information on positive (direct) opening operation, see IEC 60947-5-1. [ROP 79-99 (Log 24)]

A.10.9 Displays intended to be warning devices are recommended to be of the flashing or rotary type and be provided with an audible warning device. [ROP 79-99 (Log 24)]

A.11.3.4(b) Firmware is an executive control program in a nonvolatile internal storage mode and is not changeable by the user. [ROP 79-155 (Log 25)]

A.11.3.4(2) For example, equivalency can be achieved by using microprocessor redundancy, microprocessor diversity, and self-checking. [ROP 79-155 (Log 25)]

A.11.4 See Section 7.3 for requirements regarding automatic restarting of motors. [ROP 79-155 (Log 25)]

A.12.2.1.4 Where access is required for regular maintenance or adjustment, the location of relevant devices is recommended to be between 0.4 m (15.75 in.) and 2.0 m (78.75 in.) above the servicing level to facilitate maintenance. The location of the terminals is recommended to be at least 0.2 m (7.88 in.) above the servicing level and be so placed that conductors and cables can be easily connected to them. [ROP 79-84 (Log 54)]

A.12.2.1.7 For additional information on attachment plug and receptacle (plug/socket) combinations, see 14.4.5. [ROP 79-84 (Log 54)]

A.12.3.1 The degrees of protection against ingress of water and other liquids are covered by NEMA 250. See also Annex H. [ROP 79-84 (Log 54)]

A.13.7.1.2 Cables for such conditions are specified in relevant national standards.

The operational life of the cable will be reduced where unfavorable operating conditions such as high tensile stress, small radii, bending into another plane, and/or where frequent duty cycles coincide. [ROP 79-112 (Log 28)]

A.13.7.2 Where the demands of the application exceed the tensile stress limit of 15 N/mm², cables with special construction features should be used. The allowed maximal tensile strength should be agreed upon with the cable manufacturer. The allowed maximum stress of conductors of flexible cables with material other than copper should be agreed upon with the cable manufacturer.

The following conditions affect the tensile stress of the conductors:
(1) Acceleration forces
(2) Speed of motion
(3) Dead (hanging) weight of the cables
(4) Method of guiding
(5) Design of cable drum system [ROP 79-112 (Log 28)]

A.13.7.3 Where cables of circular cross-sectional area are installed on drums, the maximum current-carrying capacity in free air should be derated in accordance with Table 13.7.3. For additional information, also refer to clause 44 of IEC 60621-3. [ROP 79-112 (Log 28)]

A.14.1.1.10 A single tag bearing the complete identification is preferred. [ROP 79-122 (Log 55)]

A.14.1.1.11 For additional information on terminal blocks, refer to IEC 60947-7-1, “Low-voltage switchgear and control gear.” [ROP 79-122 (Log 55)]

A.14.2.2.1 The international standards reserve the use of bicolor combination GREEN and YELLOW for this purpose. The bicolor combination is such that on any 15-mm (0.6-in.) length, one of the colors covers at least 30 percent and not more than 70 percent of the surface of the conductor, and the other color covers the remainder of the surface. [ROP 79-122 (Log 55)]

A.14.2.3.1 IEC 60920-1 reserves the use of the color LIGHT BLUE for the neutral conductor and requires its use when identification is by color. [ROP 79-122 (Log 55)]

A.14.2.4.1 IEC 60920-1 recommends the use of the color ORANGE for this purpose where identification is by color. For further information on excepted circuits, see 5.3.5. [ROP 79-130 (Log 67)] [ROP 79-131 (Log 16)]

A.14.3.1 For additional information on flame-retardant materials, refer to IEC 60332-1, “Tests on electric cables under fire conditions.” [ROP 79-122 (Log 55)]

A.14.5.2 It should be recognized that, for certain conditions, a larger size raceway or a lesser raceway fill should be considered.

A.14.5.3.1.2 Metric trade numerical designations for rigid metal conduit are the same as those found in IEC 981-1989 Extra-heavy duty rigid steel conduits for electrical installations, namely: ½ = 16, ¾ = 21, 1 = 27, 1¼ = 35, 1½ = 41, 2 = 53, 2¼ = 63, 3 = 78, 3½ = 91, 4 = 105, 5 = 129, and 6 = 155. [ROP 79-122 (Log 55)]

A.14.5.3.2.2 The use of dissimilar metals in contact that can cause galvanic action should be avoided. [ROP 79-122 (Log 55)]

A.14.5.3.2.3 The use of dissimilar metals in contact that can cause galvanic action should be avoided. [ROP 79-122 (Log 55)]

A.14.5.3.2.4 The use of dissimilar metals in contact that can cause galvanic action should be avoided. [ROP 79-122 (Log 55)]

A.14.5.3.3.1 For additional information about rigid nonmetallic conduit, refer to UL 651. [ROP 79-122 (Log 55)]
A.14.5.3.3 For additional information see Table 347-9(A). of NFPA 70, National Electrical Code, 1999, Expansion Characteristics of PVC Rigid Nonmetallic Conduit Coefficient of Thermal Expansion = 3.38 \times 10^{-5} \text{ in./in.} / \text{º F}.

A.14.5.4.1.2 Metric trade numerical designations for flexible metal conduit and liquidtight flexible metal conduit are 3/8 = 12, ½ = 16, ¾ = 21, 1 = 27, 1¼ = 35, 1½ = 41, 2 = 53, 2½ = 63, 3 = 78, 3½ = 91, and 4 = 103. [ROP 79-122 (Log 55)]

A.14.5.5.5 Metric trade numerical designations for liquidtight flexible nonmetallic conduit are 3/8 = 12, ½ = 16, ¾ = 21, 1 = 27, 1¼ = 35, 1½ = 41, 2 = 53, 2½ = 63, 3 = 78, 3½ = 91, and 4 = 103. [ROP 79-122 (Log 55)]

A.14.5.7 See Section 17.2 for information on warning marking and signs. [ROP 79-122 (Log 55)]

A.14.5.10.1 For additional information on flexible cords, refer to ANSI/UL 62, Flexible Cord and Fixture Wire. [ROP 79-122 (Log 55)]

A.15.1 For additional information related to motor standards, refer to UL 1004, NEMA MG-1, IEEE 841, or IEC 60034-1.

The protection requirements for motors and associated equipment are given in Section 7.2 for overcurrent protection, in Section 7.3 for overload protection, and in Section 7.6 for overspeed protection. [ROP 79-149(Log 27)]

A.15.3 For a comparison between kilowatt and horsepower size, see Annex G Tables G.1 and G.2. [ROP 79-149(Log 27)]

A.15.6 Associated machine actuators are those associated with the same motion (e.g., cable drums and long-travel drives). [ROP 79-149(Log 27)]

A.17.3 Such markings can be as agreed between the user and the supplier of the equipment. See Annex B for additional information.

For further information on symbols, see IEC 60417 and ISO 7000.

Consideration should be given to the use of IEC symbols for pushbuttons.

A.18.4 The technical documentation should also contain, where appropriate, information regarding load currents, peak starting currents, and permitted voltage drops. That information should be contained in either the system or circuit diagram(s). [ROP 79-19 (Log 53)]

A.18.5.1 In complex cases, it can be necessary to refer to the assembly drawings for details. [ROP 79-19 (Log 53)]

A.18.5.3 For further information regarding supply circuit conductors, see 7.2.2. [ROP 79-19 (Log 53)]

A.18.5.4 For recommendations concerning supplier agreements, see Annex B. [ROP 79-19 (Log 53)]

A.18.5.5 For recommendations concerning supplier agreements, see Annex B. [ROP 79-19 (Log 53)]

A.18.5.6 Examples of installation diagrams can be found in IEC 61082-4. [ROP 79-19 (Log 55)]

A.18.5.7 Examples of interconnection diagrams/tables can be found in IEC 61082-3. [ROP 79-19 (Log 53)]

A.18.6 Examples of block diagrams can be found in IEC 61082-1-2. Further rules and examples can be found in IEC 61082-2-3. [ROP 79-19 (Log 53)]

Function diagrams can be used as either part of, or in addition to, the block diagram. Examples of function diagrams can be found in IEC 61082-1-2 and in IEC 61082-2-4. [ROP 79-19 (Log 53)]

A.18.7.1 See Annex D for examples of electrical diagrams. [ROP 79-20 (Log 119)]

A.18.7.2 Examples of circuit diagrams can be found in IEC 61082-1 and in IEC 61082-2-5. [ROP 79-19 (Log 53)]

A.18.7.3 The diagram showing the terminals for interface connections can be used in conjunction with the circuit diagram(s) for simplification. The diagram should contain a reference to the detailed circuit diagram of each unit shown. [ROP 79-19 (Log 53)]

A.18.7.5 See Annex E for examples of devices and component designations. [ROP 79-21 (Log 118)]

A.18.8.1 Particular attention should be given to the safety measures provided and to the improper methods of operation that are anticipated.
A.18.9.1 Recommendations on maintenance/service records should be part of that manual. Troubleshooting information and suggestions for locating and replacing faulty components, suggested preventative maintenance schedules, and related data should be included. [ROP 79-19 (Log 53)]

Name of manufacturer/supplier
Name of end user
Tender/Order No. __ Date
Type of Machine/Serial Number

1. Are there to be modifications as allowed for within this standard? YES ____ NO _____

Operating Conditions - Special requirements (see Section 4.4)
2. Ambient temperature range
3. Humidity range
4. Altitude
5. Environmental (e.g., corrosive atmospheres, particulate matter, EMC)
6. Radiation
7. Vibration, shock
8. Special installation and operation requirements (e.g., flame-retardant requirements for cables and conductors)

Power supply(ies) and related conditions (see Section 4.3)
9. Anticipated voltage fluctuations (if more than ±10 %)
10. Anticipated frequency fluctuations (if more than in 4.3.2)
   Specification of short-term value
11. Indicate possible future changes in electrical equipment that will require an increase in the electrical supply requirements
12. Indicate for each source of electrical supply required:
   Nominal Voltage (V) _______ ac _____ dc _____
   If ac, number of phases _____ frequency _____ Hz Prospective short-circuit current at the point of supply to the machine ______ kA rms (see also question 15)
   Fluctuations outside values given in 4.3.2 _________________________________________
13. Type of power supply earthing (see IEC 364-3-31):
   - TN [System with one point directly earthed, with a protective conductor (PE) connected directly to that point] ____
   - TT [System with one point directly earthed but the protective conductor (PE) not connected to that earth point of the system] ____
   - IT (System that is not directly earthed) ____
14. Is the electrical equipment to be connected to a neutral (N) supply conductor? (see Section 5.1)
   YES ____ NO _____
15. Does the user or the supplier provide the overcurrent protection of the supply conductors? (see 7.2.2)
   Type and rating of overcurrent protective devices
16. Supply disconnecting device
   - Is the disconnection of the neutral (N) conductor required? YES ____ NO _____
   - Is a link for the neutral (N) conductor permissible? YES ____ NO _____
17. Type of disconnecting device to be provided

1882
18. Limit of power up to which three-phase ac motors can be started directly across the incoming supply lines? ___ HP ___ KW
19. Can the number of motor overload detection devices be reduced? (see Section 7.3) YES ___ NO ___
20. Where the machine is equipped with local lighting:
   - Highest permissible voltage __V
   - If lighting circuit voltage is not obtained directly from the power supply, state preferred voltage __V

Other Considerations
21. Functional identification (see Section 17.3)
22. Inscriptions/special markings
23. Mark of certification YES ___ NO ___ If YES, which one?
   - On electrical equipment? ___ In which language?
24. Technical documentation (see Section 18.1)
   - On what media? ________ In which language?
25. Size, location, and purpose of ducts, open cable trays, or cable supports to be provided by the user (see Section 18.5) (additional sheets to be provided where necessary)
26. For which of the following classes of persons is access to the interior of enclosures required during normal operation of the equipment?
   - Skilled persons
   - Instructed persons
27. Are locks with removable keys to be provided for fastening doors or covers? (see Section 6.2.2)
28. Indicate if special limitations on the size or weight affect the transport of a particular machine or control equipment to the installation site:
   - Maximum dimensions
   - Maximum weight
29. In the case of machines with frequent repetitive cycles of operation dependent on manual control, how frequently will cycles of operation be repeated?
   ___ per hour
30. For what length of time is it expected that the machine will be operated at this rate without subsequent pause?
   ___ minutes
31. In the case of specially built machines, is a certificate of operating tests with the loaded machine to be supplied? YES ___ NO ___
32. In the case of other machines, is a certificate of operating-type tests on a loaded prototype machine to be supplied? YES ___ NO ___
33. For cableless control systems, specify the time delay before automatic machine shutdown is initiated in the absence of a valid signal (see 9.2.7.3). _____ seconds.
34. Do you need a specific method of conductor identification to be used for the conductors referred to in 14.2.4?
   - Yes______ No_____

A.19.1 It is recommended that the sequence listed is followed.
Following this order will help ensure the accuracy of the tests results and the safety of personnel. Refer to SEMI S9 for additional information on performing the testing described in Section 19.1.

A.19.2 The concepts of SELV are further explained in UL 1950, UL 3101-1, and IEC 60364-4-11.1.

A.19.4 Refer to SEMI S9 for additional information on performing this dielectric withstand (hypot) test. [ROP 79-161 (Log 140)]

Annex A Inquiry Form for the Electrical Equipment of Machines
[ROP 79-163 (Log 39)]

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Machine Tools. Examples of machine tools are as follows:
(1) Metal cutting
(2) Metal forming

C.2 Plastics Machinery. Examples of plastics machinery are as follows:
(1) Injection molding machines
(2) Extrusion machinery
(3) Blow molding machines
(4) Specialized processing machines
(5) Thermoset molding machines
(6) Size reduction equipment

C.3 Wood Machinery. Examples of wood machinery are as follows:
(1) Woodworking machinery
(2) Laminating machinery
(3) Sawmill machines
C.4 Assembly Machines.

C.5 Material-Handling Machines. Examples of material-handling machines are as follows:

1. Industrial robots
2. Transfer machines

C.6 Inspection/Testing Machines. Examples of inspection/testing machines are as follows:

1. Coordinate measuring machines
2. In-process gauging machines

Annex D Technical Documentation [ROP 79-164 (Log 40)]

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

Figures D.1 (a) through D.1 (q) are not intended to be (design) guidelines. They are included only to illustrate documentation methods.

Annex E Device and Component Designations [ROP 79-167 (Log 42)]

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

Table E.1 Device and Component Designations

<table>
<thead>
<tr>
<th>Designation</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE</td>
<td>Alarm or Annunciator Bell</td>
</tr>
<tr>
<td>ABU</td>
<td>Alarm or Annunciator Buzzer</td>
</tr>
<tr>
<td>AH</td>
<td>Alarm or Annunciator Horn</td>
</tr>
<tr>
<td>AM</td>
<td>Ammeter</td>
</tr>
<tr>
<td>AT</td>
<td>Autotransformer</td>
</tr>
<tr>
<td>CAP</td>
<td>Capacitor</td>
</tr>
<tr>
<td>CB</td>
<td>Circuit Breaker</td>
</tr>
<tr>
<td>CI</td>
<td>Circuit Interrupter</td>
</tr>
<tr>
<td>CNC</td>
<td>Computerized Numerical Controller</td>
</tr>
<tr>
<td>CON</td>
<td>Contractor</td>
</tr>
<tr>
<td>COS</td>
<td>Cable-Operated (Emergency) Switch</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>CR</td>
<td>Control Relay</td>
</tr>
<tr>
<td>CRA</td>
<td>Control Relay, Automatic</td>
</tr>
<tr>
<td>CRH</td>
<td>Control Relay, Manual</td>
</tr>
<tr>
<td>CRL</td>
<td>Control Relay, Latch</td>
</tr>
<tr>
<td>CRM</td>
<td>Control Relay, Master</td>
</tr>
<tr>
<td>CRT</td>
<td>Cathode Ray Tube, Monitor or Video Display Unit</td>
</tr>
<tr>
<td>CRU</td>
<td>Control Relay, Unlatch</td>
</tr>
<tr>
<td>CS</td>
<td>Cam Switch</td>
</tr>
<tr>
<td>CT</td>
<td>Current Transformer</td>
</tr>
<tr>
<td>CTR</td>
<td>Counter</td>
</tr>
<tr>
<td>D</td>
<td>Diode</td>
</tr>
<tr>
<td>DISC</td>
<td>Disconnect Switch</td>
</tr>
<tr>
<td>DISP</td>
<td>Display</td>
</tr>
<tr>
<td>DR</td>
<td>Drive</td>
</tr>
<tr>
<td>EMO</td>
<td>Emergency (Machine) Off Device</td>
</tr>
<tr>
<td>END</td>
<td>Encoder</td>
</tr>
<tr>
<td>ESTOP</td>
<td>Emergency Stop</td>
</tr>
<tr>
<td>FLD</td>
<td>Field</td>
</tr>
<tr>
<td>FLS</td>
<td>Flow Switch</td>
</tr>
<tr>
<td>FS</td>
<td>Float Switch</td>
</tr>
<tr>
<td>FTS</td>
<td>Foot Switch</td>
</tr>
<tr>
<td>FU</td>
<td>Fuse</td>
</tr>
<tr>
<td>GEN</td>
<td>Generator</td>
</tr>
<tr>
<td>GRD</td>
<td>Ground</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HM</td>
<td>Hour Meter</td>
</tr>
<tr>
<td>HTR</td>
<td>Heating Element</td>
</tr>
<tr>
<td>ICG</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>INST</td>
<td>Instrument</td>
</tr>
<tr>
<td>IOL</td>
<td>Instantaneous Overload</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/Output Device</td>
</tr>
<tr>
<td>L</td>
<td>Inductor</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>LS</td>
<td>Limit Switch</td>
</tr>
<tr>
<td>LT</td>
<td>Pilot Light</td>
</tr>
<tr>
<td>LVDT</td>
<td>Linear Variable Differential Transformer</td>
</tr>
<tr>
<td>M</td>
<td>Motor Starter</td>
</tr>
<tr>
<td>MD</td>
<td>Motion Detector</td>
</tr>
<tr>
<td>MF</td>
<td>Motor Starter - Forward</td>
</tr>
<tr>
<td>MG</td>
<td>Motor - Generator</td>
</tr>
<tr>
<td>MR</td>
<td>Motor Starter - Reverse</td>
</tr>
<tr>
<td>MTR</td>
<td>Motor</td>
</tr>
<tr>
<td>OIT</td>
<td>Operator Interface Terminal</td>
</tr>
<tr>
<td>OL</td>
<td>Overload Relay</td>
</tr>
<tr>
<td>PB</td>
<td>Pushbutton</td>
</tr>
<tr>
<td>PBL</td>
<td>Pushbutton, Illuminated</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>PEC</td>
<td>Photoelectric Device</td>
</tr>
<tr>
<td>PL</td>
<td>Plug</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>POT</td>
<td>Potentiometer</td>
</tr>
<tr>
<td>PRS</td>
<td>Proximity Switch</td>
</tr>
<tr>
<td>PS</td>
<td>Pressure Switch</td>
</tr>
<tr>
<td>PWS</td>
<td>Power Supply</td>
</tr>
<tr>
<td>Q</td>
<td>Transistor</td>
</tr>
<tr>
<td>QTM</td>
<td>Thermistor</td>
</tr>
<tr>
<td>REC</td>
<td>Rectifier</td>
</tr>
<tr>
<td>RECP</td>
<td>Receptacle</td>
</tr>
<tr>
<td>RES</td>
<td>Resistor</td>
</tr>
<tr>
<td>RH</td>
<td>Rheostat</td>
</tr>
<tr>
<td>S</td>
<td>Switch</td>
</tr>
<tr>
<td>SCR</td>
<td>Silicon Controlled Rectifier</td>
</tr>
<tr>
<td>SOL</td>
<td>Solenoid</td>
</tr>
<tr>
<td>SNSR</td>
<td>Sensor</td>
</tr>
<tr>
<td>SS</td>
<td>Selector Switch</td>
</tr>
<tr>
<td>SSL</td>
<td>Selector Switch, Illuminated</td>
</tr>
<tr>
<td>SSR</td>
<td>Solid State Relay</td>
</tr>
<tr>
<td>ST</td>
<td>Saturable Transformer</td>
</tr>
<tr>
<td>SUP</td>
<td>Suppressor</td>
</tr>
<tr>
<td>SYN</td>
<td>Synchro or Resolver</td>
</tr>
<tr>
<td>T</td>
<td>Transformer</td>
</tr>
<tr>
<td>TACH</td>
<td>Tachometer Generator</td>
</tr>
<tr>
<td>TAS</td>
<td>Temperature-Actuated Switch</td>
</tr>
<tr>
<td>TB</td>
<td>Terminal Block</td>
</tr>
<tr>
<td>T/C</td>
<td>Thermocouple</td>
</tr>
<tr>
<td>TR</td>
<td>Timer Relay</td>
</tr>
<tr>
<td>TSDFR</td>
<td>Transducer</td>
</tr>
<tr>
<td>TWS</td>
<td>Thumbwheel Switch</td>
</tr>
<tr>
<td>V</td>
<td>Electronic Tube</td>
</tr>
<tr>
<td>VAR</td>
<td>Varistor</td>
</tr>
<tr>
<td>VM</td>
<td>Voltmeter</td>
</tr>
<tr>
<td>VR</td>
<td>Voltage Regulator</td>
</tr>
<tr>
<td>VS</td>
<td>Vacuum Switch</td>
</tr>
<tr>
<td>WLT</td>
<td>Worklight</td>
</tr>
<tr>
<td>WM</td>
<td>Wattmeter</td>
</tr>
<tr>
<td>X</td>
<td>Reactor</td>
</tr>
<tr>
<td>ZSS</td>
<td>Zero Speed Switch</td>
</tr>
</tbody>
</table>

[ROP 79-166(Log 5)]
Figure D.1(b) System layout and installation diagram.
Figure D.1(c) Block (system) diagram.
Figure D.1(d) Interconnection diagram.
Figure D.1(e) Elementary schematic.
Figure D.1(f) PLC input diagram.
Figure D.1(g) PLC output diagram.
Figure D.1(h) Sample enclosure layout.
Figure D.1(i) Sample enclosure layout.
**Figure D.1(j) Sequence of operations**

<table>
<thead>
<tr>
<th>SOLENOID No.</th>
<th>AIR or HYD</th>
<th>ACTION ENERGIZED</th>
<th>INPUT SENSOR No.</th>
<th>SEQ No.</th>
<th>SEQUENCE DESCRIPTION</th>
<th>CYCLE TIME (SEC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DXXX/XX PRES</td>
<td>1</td>
<td></td>
<td>PART PRESENT ESCAPEMENT DELAY</td>
<td>.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ESCAPEMENT OPENS</td>
<td>.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>PART TRAVEL TO SHUTTLE</td>
<td>.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>PART PRESENT SHUTTLE DELAY</td>
<td>.5</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>5</td>
<td></td>
<td>ESCAPEMENT CLOSES</td>
<td>.75</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>6</td>
<td></td>
<td>SHUTTLE SHIFTS TO TRACK #1</td>
<td>1.0</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>7</td>
<td></td>
<td>PART ACCEL TRACK #1 ENERGIZES</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td></td>
<td>PART PRESENT LOADER #1 DELAY</td>
<td>.5</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>9</td>
<td></td>
<td>SHUTTLE SHIFTS TO CENTER</td>
<td>10</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>10</td>
<td></td>
<td>LOADER TRACK #1 ADVANCES</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td></td>
<td>LOADER TRACK #1 ADVANCED DWELL</td>
<td>.5</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>12</td>
<td></td>
<td>LOADER TRACK #1 RETURNS</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13</td>
<td></td>
<td>PART PRESENT ESCAPEMENT DELAY</td>
<td>.5</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>14</td>
<td></td>
<td>ESCAPEMENT OPENS</td>
<td>.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td>PART TRAVEL TO SHUTTLE</td>
<td>.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td></td>
<td>PART PRESENT SHUTTLE DELAY</td>
<td>.5</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>17</td>
<td></td>
<td>ESCAPEMENT CLOSES</td>
<td>.75</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>18</td>
<td></td>
<td>SHUTTLE SHIFTS TO TRACK #2</td>
<td>1.0</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>19</td>
<td></td>
<td>PART ACCEL TRACK #2 ENERGIZES</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td>PART PRESENT LOADER #2 DELAY</td>
<td>.5</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>21</td>
<td></td>
<td>SHUTTLE SHIFTS TO CENTER</td>
<td>10</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>22</td>
<td></td>
<td>LOADER TRACK #2 ADVANCES</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>23</td>
<td></td>
<td>LOADER TRACK #2 ADVANCED DWELL</td>
<td>.5</td>
</tr>
<tr>
<td>DXXX/XX SOL</td>
<td>AIR</td>
<td>DXXX/XX PRES</td>
<td>24</td>
<td></td>
<td>LOADER TRACK #2 RETURNS</td>
<td>10</td>
</tr>
</tbody>
</table>

**Cycle time for one part/one track = 11.0 sec.**

**Cycle time for one part each track = 19.0 sec.**
Figure D.1(k) Sequence of operations – descriptive graphical.

18.2 f2

SEQUENCE OF OPERATION

A. MACHINE OPERATION. PRESS 'MOTORS START' PUSHBUTTON '2PB'. MOTORS START.
B. SELECT SPINDLE SPEED BY TURNING SELECTOR SWITCH 'ISS' TO 'INC'. ENERGIZING '3SOL', TO INCREASE OR TO 'DEC', ENERGIZING '4SOL', TO DECREASE SETTING.
C. WITH CORRECT SPINDLE DIRECTION SELECTED, LIMIT SWITCH '1LS' IS ACTUATED. PRESS 'SPINDLE START' PUSHBUTTON '4PB', ENERGIZING RELAY '1CR', WHICH ENERGIZES '1SOL'. SPINDLE STARTS AND PRESSURE SWITCH '1PS' IS ACTUATED. '1PS' ENERGIZES '1TR' AND AFTER A TIME DELAY '2SOL' IS ENERGIZED, PERMITTING MOVEMENT OF MACHINE ELEMENTS AT SELECTED FEED RATES.
D. PRESSING 'SPINDLE STOP' PUSHBUTTON '3PB' STOPS SPINDLE AND FEEDS MOVEMENTS SIMULTANEOUSLY.
E. LUBRICATION OPERATION
F. PRESSURE SWITCH '2PS' IS CLOSED
   1. TIMER '2TR' CLUTCH IS ENERGIZED WHEN MOTORS START.
   2. CONTACT '2TR1' CLOSES AND ENERGIZES TIMER MOTOR 'MTR', STARTING LUBE TIMING PERIOD.
   3. CONTACT '2TR3' CLOSES AND ENERGIZES TIMER '3TR'.
G. TIMER '2TR' TIMES OUT
   1. CONTACT '2TR1' OPEN, DEENERGIZING TIMER MOTOR 'MTR'.
   2. CONTACT '2TR2' CLOSES, ENERGIZING '5SO2'.
   3. CONTACT '2TR3' CLOSES, DEENERGIZING TIMER '3TR'.
   4. LUBRICATION PRESSURE ACTUATES PRESSURE SWITCH '2PS', DEENERGIZING AND RESETTING TIMER '2TR'. CONTACTS '2TR1', '2TR2', AND '2TR3' OPEN.
   5. CONTACT '2TR2' OPENING, DEENERGIZING '5SO2'.
H. REDUCED LUBRICATION PRESSURE DEACTUATES PRESSURE SWITCH '2PS' AND SEQUENCE REPEATS.

SWITCH OPERATION

1LS (115) ACTUATED BY SPINDLE DIRECTION LEVER ENGAGED
1PS (118) ACTUATED WHEN SPINDLE CLUTCH ENGAGED
2PS (126) OPERATED BY NORMAL LUBE PRESSURE
1FS (129) OPERATED BY ADEQUATE LUBE SUPPLY

FOR PANELS AND CONTROL STATION LAYOUT SEE SHEET 2
FOR HYDRAULIC DIAGRAM SEE
FOR LUBRICATION DIAGRAM SEE

LAST WIRE NUMBER USED 20
LAST RELAY NUMBER USED 1CR
SUPPLIER'S DWG. NO.
SUPPLIER'S NAME
PURCHASE ORDER NO. P.O. 91011
SERIAL NO. OF MACHINE TYP 13314

THESE DIAGRAMS USED FOR MACHINE NO.
Figure D.1(l) Sample servo diagram.
Figure D.1(m) Sample PLC network — station layout.
Figure D.1(n) Sample operator station.
<table>
<thead>
<tr>
<th>DETAIL</th>
<th>IDENTIFIER</th>
<th>LOCATION</th>
<th>QTY.</th>
<th>PART NUMBER</th>
<th>MANUFACTURER</th>
<th>SUPPLIER NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0001</td>
<td>1</td>
<td>ENCLOSURE</td>
<td>1</td>
<td>A-769738LP</td>
<td>E-TREK ENCLOSURE</td>
<td>---</td>
<td>769738LP</td>
</tr>
<tr>
<td>0002</td>
<td>1</td>
<td>PANEL</td>
<td>1</td>
<td>A-76972</td>
<td>E-TREK PANEL</td>
<td>---</td>
<td>76972</td>
</tr>
<tr>
<td>0003</td>
<td>1</td>
<td>E0754</td>
<td>1</td>
<td>SKESOL31053522</td>
<td>---</td>
<td>76972 SUB-PANEL</td>
<td>76972</td>
</tr>
<tr>
<td>0004</td>
<td>1</td>
<td>T0081P0G</td>
<td>1</td>
<td>GE-0900-50</td>
<td>---</td>
<td>76972 SUB-PANEL</td>
<td>GE-0900-50</td>
</tr>
<tr>
<td>0005</td>
<td>1</td>
<td>2054</td>
<td>1</td>
<td>SELASATND084</td>
<td>---</td>
<td>76972 SUB-PANEL</td>
<td>SELASATND084</td>
</tr>
<tr>
<td>0006</td>
<td>1</td>
<td>E056</td>
<td>1</td>
<td>CL0643151J</td>
<td>---</td>
<td>76972 SUB-PANEL</td>
<td>CL0643151J</td>
</tr>
<tr>
<td>0007</td>
<td>1</td>
<td>R0115</td>
<td>1</td>
<td>TF000-4F3</td>
<td>---</td>
<td>76972 SUB-PANEL</td>
<td>TF000-4F3</td>
</tr>
<tr>
<td>0008</td>
<td>10</td>
<td>X004</td>
<td>1</td>
<td>---</td>
<td>---</td>
<td>76972 SUB-PANEL</td>
<td>---</td>
</tr>
<tr>
<td>0009</td>
<td>2</td>
<td>5432A3,5446E333</td>
<td>1</td>
<td>---</td>
<td>---</td>
<td>76972 SUB-PANEL</td>
<td>---</td>
</tr>
</tbody>
</table>

Figure D.1(o) Sample parts list.
Figure D.1(p) ISO (A2) drawing standard framework.
Annex F Enclosure Type Rating Versus IP Rating

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 Rating for Electrical Enclosures. Electrical enclosures are type rated (NEMA 250 / UL 50 and UL 508) and/or IP rated (IEC 60529) based upon the degree of protection provided.

Type-rated and IP-rated electrical enclosures have only the following in common:

1. A degree of protection for persons from hazardous components inside the enclosure
2. A degree of protection for equipment inside the enclosure from ingress of solid foreign objects, including dust
3. A degree of protection for equipment inside the enclosure from ingress of water
F.1.1 Type Rating System. The type rating system, in a single electrical enclosure document, defines additional requirements that a type-rated enclosure must meet, which include the following:

1) Mechanical impact on enclosure walls
2) Gasket aging and oil resistance
3) Corrosion resistance (indoor and outdoor)
4) Door and cover latching requirements

F.1.2 IP Rating System. The IEC 60529 designation consists of the letters IP followed by two numerals with optional letters (e.g., IP 23CH). The first characteristic numeral indicates the degree of protection provided by the enclosure with respect to persons and solid foreign objects entering the enclosure. The second characteristic numeral indicates the degree of protection provided by the enclosure with respect to the harmful ingress of water. The additional letter indicates the degree of protection for a person against access to hazardous parts. A brief description of the additional letter is in Table F.1.2.

Table F.1.2 Arrangement of the IP Code

<table>
<thead>
<tr>
<th>Code letters</th>
<th>International Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>First characteristic</td>
<td>Numerals 0 to 6, N (or letter X)</td>
</tr>
<tr>
<td>Second characteristic</td>
<td>Numerals 0 to 8, N (or letter X)</td>
</tr>
<tr>
<td>Additional letter</td>
<td>Letters A, B, C, D</td>
</tr>
<tr>
<td>Supplementary letter</td>
<td>Letters H, M, S, W</td>
</tr>
<tr>
<td>Example:</td>
<td>IP 23CH</td>
</tr>
</tbody>
</table>

Where a characteristic numeral is not required to be specified, it shall be replaced by the letter “X” (“XX” if both numerals are omitted). Additional letters and/or supplementary letters may be omitted without replacement.

<table>
<thead>
<tr>
<th>Table F.1 - Degrees of Protection Against Access to Hazardous Parts indicated by the First Characteristic Numeral</th>
</tr>
</thead>
<tbody>
<tr>
<td>First characteristic numeral</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

Note: In the case of the first characteristic numeral 3, 4, 5, and 6, protection against access to hazardous parts is satisfied if adequate clearance is kept. Due to the simultaneous requirement specified in Table II, the definition shall not penetrate is given in Table I.

Table X.X

<table>
<thead>
<tr>
<th>Element</th>
<th>Numerals or letters</th>
<th>Meaning for the protection of equipment</th>
<th>Meaning for the protection of persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code letters</td>
<td>IP</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>First characteristic numerals</td>
<td>0</td>
<td>Against ingress of solid foreign objects (non-protected)</td>
<td>Against access to hazardous parts with: (non-protected) back of hand finger tool wire</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Second characteristic numeral</td>
<td>0</td>
<td>Against ingress of water with harmful effects (non-protected)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>vertically dripping</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>dripping (15° tilted)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>spraying</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>splashing</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>jetting</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>powerful jetting</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>temporary immersion</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>continuous immersion</td>
<td>-</td>
</tr>
<tr>
<td>Additional letter (optional)</td>
<td>A</td>
<td>-</td>
<td>Against access to hazardous parts with: back of hand finger tool wire</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Supplementary letter (optional)</td>
<td>H</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>Supplementary information specific to: High-voltage apparatus Motion during water test Stationary during water test Weather conditions</td>
<td>-</td>
</tr>
</tbody>
</table>

1902
Where more than one supplementary letter is used, the alphabetic sequence shall apply.

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPXXA</td>
<td>Protected against access with the back of hand</td>
</tr>
<tr>
<td>IPXXB</td>
<td>Protected against access with finger</td>
</tr>
<tr>
<td>IPXXC</td>
<td>Protected against access with a tool</td>
</tr>
<tr>
<td>IPXXD</td>
<td>Protected against access with a wire</td>
</tr>
</tbody>
</table>

These letter designations (A, B, C, D) can be used referencing the protection of live parts while the enclosure is accessed. There is not a comparable NEMA 250 rating to this application. Electrical enclosures that carry only an IP rating have not been designed to the above additional type rating requirements. Therefore, a type rating cannot be assigned to an enclosure that has only been IP rated because of the exclusion of the additional requirements of the type rating system.

Because the IP requirements can be interpreted to be inclusive to the type requirements, a conservative IP rating can be assigned to a type-rated enclosure by referencing Table H-1.

As a practical matter thought, many electrical enclosures are tested to both the IP and type requirements and carry both IP and type designations.

### Table F.2 Assignment of IP ratings to type rated enclosures

<table>
<thead>
<tr>
<th>A First Character</th>
<th>B Second Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 3 3R 3S 4 4X 5 6 6P 12 12K 13</td>
</tr>
<tr>
<td>IP0_</td>
<td>AB AB AB AB AB AB AB AB AB AB AB AB</td>
</tr>
<tr>
<td>IP1_</td>
<td>4 4X 5 6 6P 12 12K 13</td>
</tr>
<tr>
<td>IP2_</td>
<td>AB AB AB AB AB AB AB AB AB AB AB</td>
</tr>
<tr>
<td>IP3_</td>
<td>AB AB AB AB AB AB AB AB AB AB AB</td>
</tr>
<tr>
<td>IP4_</td>
<td>AB AB AB AB AB AB AB AB AB AB AB</td>
</tr>
<tr>
<td>IP5_</td>
<td>AB AB AB AB AB AB AB AB AB AB AB</td>
</tr>
<tr>
<td>IP6_</td>
<td>AB AB AB AB AB AB AB AB AB AB AB</td>
</tr>
</tbody>
</table>

A. The first character designation is the protection against access to hazardous parts and solid foreign objects. The respective NEMA enclosure type meets the requirements for the IEC 520 IP first character designation.

B. The IP second character designation is the protection against ingress of water. The respective NEMA enclosure type meets the requirements for the IEC 529 IP second character designation.

**Notes:**

1. Type-rated enclosures for hazardous locations and potentially explosive areas have been excluded from the table. The additional and supplementary letters for IP ratings have also been excluded from the table. (See NEMA 250 / UL 50 and UL 508 and IEC 529 / IEC 60529.)

2. Table H-1 shall only be used to assign an IP rating to a Type rated enclosure, and not to assign a Type rating to an IP rated enclosure. Table H-1 assists in specifying enclosure ratings and shall not be used as a definitive guide.

Example: If the conditions of installation require an IP 55, Table H-1 indicates that a Type 3, 3S, 4, 4X, 6, or 6P enclosure can be utilized. If the conditions of installation require a NEMA Type 4, an enclosure that is only IP rated cannot be used as a substitute.

Although the corresponding NEMA type ratings meet or exceed the corresponding IP rating as indicated in Table H-1, IEC does not currently accept these ratings without further IEC testing.
This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

**G.1 Preferred Kilowatt Outputs with Horsepower Equivalents.** The kilowatt and horsepower values shown in Tables G.1 and G.2 are not exact conversion values. They give the approximate relationships between countries employing the two different systems of units.

### Table G.1 Preferred kW Outputs with HP Equivalents

<table>
<thead>
<tr>
<th>kW</th>
<th>hp(746W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06</td>
<td>1/12</td>
</tr>
<tr>
<td>0.09</td>
<td>1/8</td>
</tr>
<tr>
<td>0.12</td>
<td>1/6</td>
</tr>
<tr>
<td>0.18</td>
<td>1/4</td>
</tr>
<tr>
<td>0.25</td>
<td>1/3</td>
</tr>
<tr>
<td>0.37</td>
<td>1/2</td>
</tr>
<tr>
<td>0.55</td>
<td>3/4</td>
</tr>
<tr>
<td>0.75</td>
<td>1</td>
</tr>
<tr>
<td>1.1</td>
<td>1.5</td>
</tr>
<tr>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td>2.2</td>
<td>3</td>
</tr>
<tr>
<td>3.7</td>
<td>5</td>
</tr>
<tr>
<td>5.5</td>
<td>7.5</td>
</tr>
<tr>
<td>7.5</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>18.5</td>
<td>25</td>
</tr>
<tr>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>37</td>
<td>75</td>
</tr>
<tr>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>50</td>
<td>125</td>
</tr>
<tr>
<td>55</td>
<td>150</td>
</tr>
<tr>
<td>63</td>
<td>175</td>
</tr>
<tr>
<td>75</td>
<td>200</td>
</tr>
<tr>
<td>80</td>
<td>220</td>
</tr>
<tr>
<td>90</td>
<td>250</td>
</tr>
<tr>
<td>100</td>
<td>270</td>
</tr>
<tr>
<td>110</td>
<td>300</td>
</tr>
<tr>
<td>125</td>
<td>335</td>
</tr>
<tr>
<td>132</td>
<td>350</td>
</tr>
<tr>
<td>150</td>
<td>375</td>
</tr>
<tr>
<td>160</td>
<td>402</td>
</tr>
<tr>
<td>185</td>
<td>422</td>
</tr>
<tr>
<td>200</td>
<td>449</td>
</tr>
<tr>
<td>220</td>
<td>476</td>
</tr>
<tr>
<td>250</td>
<td>503</td>
</tr>
<tr>
<td>280</td>
<td>536</td>
</tr>
<tr>
<td>300</td>
<td>570</td>
</tr>
</tbody>
</table>

Source: IEC 60072-1 Annex D Tables D.5.1 and D.5.2, Sixth Edition 1991-2, are provided to assist with hp and kW. Note: The kW-hp conversions are approximately 1 hp = 720 W, not the stated 746 W nor even the rounded off metric units which result in 736 W.

### Table G.2 Preferred Horsepower Outputs with Kilowatt Equivalents.

<table>
<thead>
<tr>
<th>hp (746W)</th>
<th>kW</th>
<th>hp (746W)</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>375</td>
<td>280</td>
<td>710</td>
<td>530</td>
</tr>
<tr>
<td>400</td>
<td>298</td>
<td>750</td>
<td>560</td>
</tr>
<tr>
<td>425</td>
<td>317</td>
<td>800</td>
<td>597</td>
</tr>
<tr>
<td>450</td>
<td>336</td>
<td>850</td>
<td>634</td>
</tr>
<tr>
<td>475</td>
<td>354</td>
<td>900</td>
<td>671</td>
</tr>
<tr>
<td>500</td>
<td>373</td>
<td>950</td>
<td>709</td>
</tr>
<tr>
<td>530</td>
<td>395</td>
<td>1000</td>
<td>746</td>
</tr>
<tr>
<td>560</td>
<td>418</td>
<td>1060</td>
<td>791</td>
</tr>
<tr>
<td>600</td>
<td>448</td>
<td>1120</td>
<td>836</td>
</tr>
<tr>
<td>630</td>
<td>470</td>
<td>1180</td>
<td>880</td>
</tr>
<tr>
<td>670</td>
<td>500</td>
<td>1250</td>
<td>930</td>
</tr>
<tr>
<td>700*</td>
<td>522</td>
<td>1320</td>
<td>985</td>
</tr>
</tbody>
</table>

This value is introduced for use in certain countries that prefer rounded off horsepower values. Note: The kW-hp conversions are approximately 1 hp = 720 W, not the stated 746 W nor even the rounded off metric units which result in 736 W. Source: IEC 60072-1 Annex D tables D.5.1 and D.5.2, Sixth Edition 1991-2, are provided to assist with hp and kW.

The notes are to inform the user that additional information is necessary in order to properly exchange motors.
Annex H  NFPA 79-1997 Cross Reference [ROP 79-172 (Log CP5)]

H.1 NFPA 79-1997 Cross Referenced to NFPA 79-2002

Text to follow


Text to follow