TECHNICAL COMMITTEE ON STATIC ELECTRICITY

AGENDA

Technical Committee on Static Electricity
Fowler Associates
Moore SC
Wednesday, August 3 and Thursday, August 4, 2011

1. Call to Order.

2. Introduction of Attendees. Update of Committee Roster. [Attachment № A1]

3. Approval of Minutes of Last Meeting. [Attachment № A2]

4. Report of Committee Chair.

5. Report of Staff Liaison.
   - Technical Committee Membership.
   - Fall 2012 Document Revision Schedule. [Attachment № A3]


8. Prepare All Technical Committee Proposals for Incorporation into the Fall 2012 Report on Proposals (ROP). [To Be Done at Meeting.]

9. Recent Correspondence. [NONE]

10. Other Old Business.
   - Add information about single-wire spiral hose. [During the February 2010 Web Conference, it was decided to address this issue.]
   - Add precaution about potential for electrostatic discharge during aggressive application of fire-fighting foam. [During the February 2010 Web Conference, it was decided to include a new section at end of Chapter 8 to address this issue and to include use of CO2 extinguishers.]
   - Revise 8.10.2.1 so that it is also applicable to bottom transfer or bottom loading. [During the February 2010 Web Conference, Jim Reppermund and Larry Britton agreed to draft proposed language.]
• Definition of “Breakdown Strength”  
  [Chuck Noll pointed out that this is not a voltage and should be expressed in volts per meter.]
• Definition of “Breakdown Voltage”  
  [Chuck Noll pointed out that this applies to all states of matter.]
• Definition of “Inert Gas”  
  [Chuck Noll pointed out that this does not apply to materials with their own oxygen.]
• Subsection 4.2.4: $t/\tau$ is not a rate, it is dimensionless.  
  [Chuck Noll pointed out that $1/\tau$ is the rate. Review 4.2.4 to see if anything missed.]

11. New Business

• Amendments to NFPA 77, Table 8.6 to Correlate with API RP 2003  
  [The Staff Liaison has secured a copy of the latest edition of API RP 2003.]

12. Schedule Next Meeting(s).

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### Address List

#### Static Electricity

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<td>Gene H. Wolfe</td>
<td>Principal</td>
<td>U 10/1/1996</td>
<td>R. R. Donnelley &amp; Sons</td>
<td>2971 173rd Place, Lansing, IL 60438</td>
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<td>G. Thomas Work II</td>
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<td>Dow Corning Corporation</td>
<td>4770 Highway 42 East, Carrollton, KY 41008</td>
<td>502-732-2626</td>
<td>502-732-2069</td>
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<tr>
<td>C. James Dahn</td>
<td>Alternate</td>
<td>SE 1/1/1992</td>
<td>Safety Consulting Engineers Inc.</td>
<td>2131 Hammond Drive, Schaumburg, IL 60173</td>
<td>847-925-8100</td>
<td>847-925-8120</td>
<td><a href="mailto:sceinc@sceinc.com">sceinc@sceinc.com</a></td>
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<td>U 4/16/1999</td>
<td>Orica Canada Inc.</td>
<td>Maple Avenue, Brownsburg, QC J0V 1A0 Canada</td>
<td>450-533-4201</td>
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<td>Thomas H. Pratt</td>
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<td>Burgoyne Inc.</td>
<td>1020 Finsbury Drive, Roswell, GA 30075-1243</td>
<td>770-552-0064</td>
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<td><a href="mailto:thomaspratt@att.net">thomaspratt@att.net</a></td>
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<td>Robert P. Benedetti</td>
<td>Staff Liaison</td>
<td>U 3/10/2011</td>
<td>National Fire Protection Association</td>
<td>1 Batterymarch Park, Quincy, MA 02169-7471</td>
<td>617-984-7433 617-984-7110</td>
<td>617-984-7494</td>
<td><a href="mailto:bbenedetti@nfpa.org">bbenedetti@nfpa.org</a></td>
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</table>
I. Attendance

L. G. Britton, Charleston, WV  
S. L. Fowler, Fowler Associates, Inc.  
R. L. Gravell, E. I. duPont de Nemours & Company – Chambers Works Site  
S. J. Gunsel, SG Technologies, LLC  
C. G. Noll, Bloomsburg University of Pennsylvania, CHAIR  
J. R. Reppermund, Howell NJ  
D. A. Rivord, Graco, Inc.  
D. Scarbrough, Elyria, OH  

R. P. Benedetti, National Fire Protection Association, STAFF LIAISON  
P. May, National Fire Protection Association, STAFF LIAISON  

GUESTS: D. Kirby, Baker Engineering & Risk Consultants (Oct. 26 only)

I. Minutes

1. The meeting was called to order at 8:00 AM by Technical Committee Chair Charles Noll.

2. Attendees introduced themselves and necessary corrections were made to the Technical Committee roster. Since a number of new members have been appointed to the Technical Committee, each was asked by the Chair to give a brief biographic sketch.

   [See Attachment № M1.]

3. Approval of the Minutes of the previous meetings was deferred, due to loss of record.

   **Action Item:** The Staff Liaison will search the NFPA server for meeting records and will prepare and distribute all Minutes of meetings, etc. to date.  [See Attachment № M2.]

4. Technical Committee Chair Charles Noll reviewed the Agenda. He reported to the Technical Committee on the Technical Committee Chair training session.
On a more technical note, the Chair reported that he had obtained a number of various types and sizes of tubing, including spiral wound types. He will be studying charging currents for tubing up to 2 inches diameter.

5. The Staff Liaison reported on the following:
   
   - **Technical Committee Scope.** The Staff Liaison asked if there were any suggestions to amend the Technical Committee’s Scope State. There were no changes suggested.
   
   - **Technical Committee Membership Status.** The Staff Liaison reported on the balance of interests on the Technical Committee. There are no issues to be addressed.
   
   - **Fall 2012 Master Schedule.** The Staff Liaison reviewed the schedule for the Fall 2012 document revision cycle. [See Attachment № M3.]

6. There were no additional proposals to amend the 2007 edition of NFPA 77 to be reviewed by the Technical Committee, who reviewed and took action on all proposals received to date at the last meeting. The Staff Liaison reported that a new Proposal Closing Date has been established (May 23, 2011), due NFPA 77’s having been moved into the Fall 2012 document revision cycle.

   **Action Item:** Technical Committee members are to inform appropriate trade associations and other groups that the Proposal Closing Date for NFPA 77 has been extended.

7. The Technical Committee discussed a number of source documents that might be helpful in revisions to NFPA 77, including the following:
   - ISGOTT Manual – sections on static electricity.
   - ASTM F150.
   - ACA Static Electricity document.
   - ISO 8330 (terminology)
   - ISO 8031 (electrical resistance & conductivity of hoses)
   - Draft Document 60079-32 (from ISO TC21/JWG29/DTS1)

   **Action Item:** Technical Committee members will secure these references as they can.

The Technical Committee noted the following tasks for the next edition:

   - Revise 1.1.7 of NFPA 77, as noted in CP1.  
     **REASON:** Clean rooms are used in industries other than the semiconductor industry. The text of 1.1.8 is not relevant to damage to circuitry.
   - Replace “antistatic” and its definition with the phrase “static dissipative” 
     Use a suitable definition from IEC.  
     **Action Item:** Steve Fowler is to send a suitable definition.
   - A lead-in sentence to Section 3.3 was suggested: “These definitions only apply within the scope of this Recommended Practice.”  
     **REASON:** Ensure that definitions are understood in context.
   - Definitions need to be reviewed to ensure they match with Table 1 of IEC 60079.  
     **Action Item:** Messrs. Britton, Gravell, Gunsel, and Reppermund agreed to review.
   - **NOTE:** IEC 60079 is still in draft form and has received numerous comments that must be resolved. It may be appropriate to defer rewriting the definitions until the next revision cycle.
   - Subsections 7.6.4, 7.6.6.2, and Section 7.7 need to be rewritten for Zone 0, 1, and 2 industrial application, per IEC.
**Action Item:** Steve Fowler agreed to do this.
- Need recommendations for dispensing from pipes and hoses.

**Action Item:** Messrs. Britton and Noll agreed to do.
- In 8.1.3.4, revise “2mm” to 50 microns (\(\mu\)), per Process Safety Progress of March 2010.
- In Figure 6.7(b), the label should be ohms per square.
- In 8.5.2.1, correct “other gases”.
- In 8.5.2.1(4), change 50m\(^3\) to 50,000 gallons.
- In 8.11.5.2, need to clarify 40m\(^3\) and provide reference.

The Technical Committee established the following Task Groups (*denotes leader):

- Chapters 1 & 2 RPB*
- Chapters 3 & 4 Britton, Gravell, Gursel*, Reppermund
- Chapters 5 — 7 Gursel, Noll*
- Chapter 8 Britton*, Hinske, Noll
- Chapter 9 Gravell*, Noll, Price
- Chapter 10 Fowler, Gravell, Rivord*, Wolfe (web processes)

Members who were not able to attend the meeting are asked to volunteer for at least one Task Group.

8. There was no recent correspondence requiring the Technical Committee’s attention.

9. Under “Other Old Business, the Technical Committee took the following actions:

- Add information about single-wire spiral hose. This has been addressed.
- Inconsistency between NFPA 77 and NFPA 407 regarding grounding of aircraft during fueling. The Technical Committee determined that fueling of aircraft is beyond the scope of NFPA 77.
- Definitions of “nonconductive” and nonconductor”. This has been addressed.
- Definition of “breakdown strength”. This has been addressed.
- Definition of “breakdown voltage”. This has been addressed.
- Definition of “inert gas”. This has been addressed.

10. Under “New Business”, the Technical Committee took the following actions:

- **Control of Static Electric Hazards with Plastic Intermediate Bulk Containers.** During the February 2010 web conference, the Technical Committee concluded there really is no way to accomplish grounding of plastic IBCs reliably. The question to be addressed is: Should nonconductive liquids be limited to metallic IBCs.
  
  **Action Item:** Ask Peter Apostoluk to address this issue.

- **IEC Test Standard for Flexible Intermediate Bulk Containers.**

  **Action Item:** A proposed new section is needed.

- **Ultra-Low Sulfur Diesel Fuel.** During the February 2010 web conference, the Technical Committee concluded that a precautionary statement might be needed.

At this meeting, the Technical Committee discussed two explosions involving transfer of ULSD, one involving a tank truck, the other involving a stationary tank. The Technical Committee now is of the opinion that not enough is known about either incident to draw any specific conclusions. The Technical Committee decided not to add any precautionary language, until the actual causes for both incidents has been
determined.

11. The Technical Committee agreed to hold web conferences on the following dates:

- December 15, 2010, 11:00 AM Eastern Time
- February 16, 2011, 11:00 AM Eastern Time
- Wednesday, April 27, 2011, 11:00 AM Eastern Time

The Technical Committee also agreed to hold the Report on Proposals (ROP) meeting at a date to be determined in the Greenville / Spartanburg SC area, at Steve Fowler’s training facility.

12. The meeting adjourned at 5:10 PM on October 24.
I. Attendance

P. R. Apostoluk, Greif Incorporated
L. G. Britton, Charleston, WV
S. J. Gunsel, SG Technologies, LLC
C. G. Noll, Bloomsburg University of Pennsylvania, CHAIR
M. L. Savage, Middle Department Inspection Agency, Inc.

R. P. Benedetti, National Fire Protection Association, STAFF LIAISON
P. May, National Fire Protection Association, STAFF LIAISON

I. Minutes

1. The conference call was called to order at 11:00 AM by Technical Committee Chair Charles Noll.

2. Technical Committee Chair Chuck Noll stated that he wants each Task Group Chair to have MSWord file of each draft chapter with legislative text amendments to date.

3. Bob Benedetti presented reviews of Chapters 1 and 2 of NFPA 77. Both were accepted.

   **Action Item:** Bob Benedetti to search for bibliography that was put together during the last revision cycle for NFPA 77.

4. The Pratt nomographs were discussed. It is understood that one or more may have been reproduced incorrectly in NFPA 77. Larry Britton suggested deleting Figure 8.1.4.1(b) and replace with the table from API 2003.

   **Action Item:** Bob Benedetti to contact Tom Pratt to ascertain which nomograph is incorrect and what needs to be corrected.

5. Steve Gunsel reported on Chapters 3 and 4 of NFPA 77. It was agreed that 3.3.13 needs numerical values and 3.3.14 should be deleted; it is incorrect.

   **Action Item:** Steve Gunsel to submit proposals.
In Section 4.2, Steve Gunsel suggests the following:

- delete the symbols A and P. A is not used anywhere in the document and P is only used in C.4.2, where it can be defined there.
- $\varepsilon$ should read “permittivity of a material”.
- $\varepsilon_0$ should stay the same
- $\kappa$ should read “dielectric constant, $\varepsilon / \varepsilon_0$”

6. Chuck Noll agreed to define “resistance”, “surface resistivity”, and “volume resistivity”.

7. Chuck Noll reported on Chapter 5. The following issues were identified:

- 5.1.11 needs a better explanation.
- 5.2.2 needs a table of comparative capacitances.
- 5.2.5: delete “through a solid or liquid material”.
  [NOTE: Steve Gunsel needs a graph showing what time constant means.]
- 5.3.2: delete “needle-shaped”.
- 5.3.3.5: insert a reference to Table B.1.
  [NOTE: Larry Britton has prepared a new Table B.1]

8. Chuck Noll reported on Chapter 6.

- Figure 6.1.2, Note 1: add a new bullet to read: “deliberate or intentional generation of electrostatic charge, e.g., electrostatic coating process”.
- Figure 6.1.2, Note 2: add a new bullet to read “isolated conductive liquids, e.g., a conductive liquid in an electrostatic system where the entire system must be isolated from ground”.

9. Chuck Noll reported that there were no issues with Chapter 7.

10. Larry Britton reported on Chapter 8. The only recommendation is to relocate Sections 8.14, 8.15, and 8.16.

  **Action Item:** Need to identify new locations for these sections.

11. In Chapter 10, the proposed new IEC document 61340-4-4 needs to reviewed, when it has been accepted, to properly define Types A, B, C, and D flexible intermediate bulk containers.

    Also in Chapter 10, Subsection 10.4.3 needs a reference to IEC 60079-10.

    Also in Chapter 10, A.10.3.2 should be re-designated A.10.3.

12. The conference call ended at 12:45 PM.
# 2012 Fall Revision Cycle

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* Proposal Closing Dates may vary according to documents and schedules for Revision Cycles may change. Please check the NFPA website (www.nfpa.org) for the most up-to-date information on proposal closing dates and schedules.
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77- Log #CP6 (Figure 5.3.3.3) Final Action: Accept

Submitter: Technical Committee on Static Electricity,
Recommendation: Correct Figure 5.3.3.3 to accurately represent source document.
Substantiation: The Figure was incorrectly reproduced from source document.
Committee Meeting Action: Accept
77- Log #CP4
(Figure 8.4.1.4(a))

Final Action: Accept

Submitter: Technical Committee on Static Electricity,

Recommendation: 1. Correct Figure 8.4.1.4(a) to accurately represent source document.
2. Replace the "S" in the left-most column and in the note below the figure with lower-case Greek letter sigma.

Substantiation: The Figure was incorrectly reproduced from source document. Also, the "S" for volumetric charge density should be designated by lower-case Greek letter sigma. These are corrections of errors.

Committee Meeting Action: Accept
77- Log #CP5
(Table 8.4.1.4(b))

Final Action: Accept

Submitter: Technical Committee on Static Electricity,

Recommendation: Correct Figure 8.4.1.4(b) to accurately represent source document.

Substantiation: The Figure was incorrectly reproduced from source document.

Committee Meeting Action: Accept
77- Log #CP1 (Entire Document) Final Action: Accept

Submitter: Technical Committee on Static Electricity,

Recommendation: Review entire document to: 1) Update any extracted material by preparing separate proposals to do so, and 2) review and update references to other organizations documents, by preparing proposal(s) as required.

Substantiation: To conform to the NFPA Regulations Governing Committee Projects.

Committee Meeting Action: Accept
Log #CP3  
(Entire Document)

Final Action: Accept

Submitter: Technical Committee on Static Electricity,
Recommendation: Review entire document to: 1) Update any extracted material by preparing separate proposals to do so, and 2) review and update references to other organizations documents, by preparing proposal(s) as required.
Substantiation: To conform to the NFPA Regulations Governing Committee Projects.
Committee Meeting Action: Accept
Delete the definition of “bonding” and adopt the preferred definition of “Bonded (Bonding)” from NFPA 70. Move the current definition of “bonding” to become an annex note.

For the purpose of controlling static electric hazards, the process of connecting two or more conductive objects together by means of a conductor so that they are at the same electrical potential, but not necessarily at the same potential as the earth.

Connected to establish electrical continuity and conductivity.

This definition, from NFPA 70, is the preferred definition from the Glossary of Terms. The meaning of the term is very similar. Definitions should be in a single sentence. Changing to this definition complies with the Glossary of Terms Project.

Your technical committee has the following options:

a) Adopt the preferred definition
b) Modify the term to make it unique
c) Request that the Standards Council reassign responsibility for the term
d) Request that the standards council authorize a second preferred definition

Committee Meeting Action: Reject

Committee Statement: our definition is clearer to the user. to move this to annexserves only to confuse the user
Log #13

(3.3.2 Bonding)

Submitters: Glossary of Terms Technical Advisory Committee.

Recommendation: Delete the definition of “bonding” and adopt the preferred definition of “Bonded (Bonding)” from NFPA 70. Move the current definition of “bonding” to become an annex note.

Bonding: For the purpose of controlling static electric hazards, the process of connecting two or more conductive objects together by means of a conductor so that they are at the same electrical potential, but not necessarily at the same potential as the earth.

Bonded (Bonding)*: Connected to establish electrical continuity and conductivity.

A* For the purpose of controlling static electric hazards, the process of connecting two or more conductive objects together by means of a conductor so that they are the same electrical potential, but not necessarily at the same potential as the earth.

Substantiation: This definition, from NFPA 70, is the preferred definition from the Glossary of Terms. The meaning of the term is very similar. Definitions should be in a single sentence. Changing to this definition complies with the Glossary of Terms Project.

Your technical committee has the following options:

a) Adopt the preferred definition
b) Modify the term to make it unique
c) Request that the Standards Council reassign responsibility for the term
d) Request that the standards council authorize a second preferred definition

Committee Meeting Action: Reject

Committee Statement: The current definition serves the purposes of the Recommended Practice. The definition from NFPA 70, National Electrical Code, is specific to their usage.
77- Log #2
(3.3.6 Combustible)

Final Action: Accept

Submitter: Glossary of Terms Technical Advisory Committee,

Recommendation: Revise text to read as follows:

3.3.6 Combustible. Capable of undergoing combustion. Capable of reacting with oxygen and burning if ignited.

Also, add a definition for the term combustion, as follows:

Combustion. A chemical process of oxidation that occurs at a rate fast enough to produce heat and usually light in the form of either a glow or flame.

Substantiation: It is important to have consistent definitions of terms within NFPA. The term combustible at present has 6 definitions, as follows:

A substance that will burn. (430)

A material or structure that will release heat energy on burning. (901)

Capable of burning, generally in air under normal conditions of ambient temperature and pressure, unless otherwise specified; combustion can occur in cases where an oxidizer other than the oxygen in air is present (e.g., chlorine, fluorine, or chemicals containing oxygen in their structure). (921)

Any material that, in the form in which it is used and under the conditions anticipated, will ignite and burn or will add appreciable heat to an ambient fire. (1144)

Capable of undergoing combustion. (69, 82, 99, 120, 122, 214, 502, 804, 805, 820, 851, 853, 1126)

Capable of reacting with oxygen and burning if ignited. (77, 220, 1141)

It is therefore recommended, in order to improve consistency within NFPA documents that a simple definition which is widely used be employed in all documents. The document responsible for this definition is NFPA 220 and the same recommendation will be made to that document. This definition is also used by ASTM E 176 for committee ASTM E05 on Fire Standards.

There are 5 definitions of combustion in NFPA and the one chosen is the most widely used, including NFPA 1. This definition is also used by ASTM E 176 for committee ASTM E05 on Fire Standards.

Committee Meeting Action: Accept
77- Log #10
(3.3.13 Nonconductive)

Submitter: Steven J. Gunsel, SGTechologies, LLC

Recommendation: Revise text to read as follows:

3.3.13 Nonconductive: Possessing the ability to resist the flow of an electric charge. Material with a conductivity less than $10^2$ pS/m or a resistivity greater than $10^{10}$ ohm-m ($10^{12}$ ohm-cm).

Substantiation: The current definition is meaningless. All materials possess the ability to resist the flow of electric charge. Conductive and semiconductive are defined (Sections 3.3.8 and 3.3.15) in terms of conductivity and resistivity. Note that $10^2$ pS/m and $10^{10}$ ohm-m, and $10^{12}$ ohm-cm are equivalent.

Committee Meeting Action: Accept in Principle

Revise text to read as follows:

3.3.13 Nonconductive (Insulating). For the purposes of describing static electric behavior, having the ability to accumulate charge, even when in contact with ground. See Table 5.2.1 for specific applications. Possessing the ability to resist the flow of an electric charge.

Committee Statement:
77- Log #9
(3.3.14 Nonconductor)

Final Action: Accept

Submitter: Steven J. Gunsel, SGTechnologies, LLC

Recommendation: Delete text to read as follows:

3.3.14 Nonconductor: A material or object that resists the flow of an electric charge.

Substantiation: Definition is meaningless. All materials possess the ability to resist the flow of electric charge.

Committee Meeting Action: Accept
77- Log #3
(7.4.1.3.1 and 7.4.1.3.2)

Final Action: Accept

Submitter: Graham Tyers, Newson Gale Inc.

Recommendation: Revise text to read as follows:

7.4.1.3.1 (third sentence): A permanent/fixed grounding system that is acceptable for power circuits or for lightning protection is more than adequate for a static electricity grounding system.

Suggested added sentence or new paragraph, in between Sections 7.4.1.3.1 and 7.4.1.3.2: In field based situations such as "HAZMAT" hazardous response operations of flammable/combustible materials spill control and transfer, it may be necessary to establish a temporary or emergency grounding system in a remote location in order to dissipate static charges. In these situations, various types of conductive grounding electrodes may be used, such as rods, plates and wires which are sometimes used in combination to increase surface area contact with the earth. If the purpose of the temporary grounding system is to dissipate static electricity, a total resistance of up to 1 k ohm (1,000 Ohms) in the ground path to earth is considered adequate. This may be measured using standard ground resistance testing instruments, and is realistically and quickly achievable in most types of terrain and weather conditions.

7.4.1.3.2: (additional diagram illustrating typical temporary grounding system devices is available to add to Annex G if required)

Substantiation: The need for effective and safe grounding and bonding techniques and equipment for mobile/field use is absolutely vital for Hazardous Materials/Emergency Response Teams and Vacuum Truck - Environmental/Clean-up operations involving flammable or combustible materials. NFPA and other safety codes all point to ensuring proper bonding and grounding as the prime way to avoid static sparks in hazardous areas. While attending an incident involving flammable or combustible liquids, gases or bulk powders, it is necessary to ensure all potentially isolated transfer equipment, vehicles, tanks, containers and other items are bonded and grounded to prevent accumulation of dangerous levels of static charge. However, the technical standards and guidelines for rendering an operation safe can be confusing, difficult to achieve and verify extremely time consuming to set up in a situation where time is of the essence.

One very real and specific problem area is setting up and testing a satisfactory "ground" point in a remote location where a permanent grounding system is not available. In different types of terrain and climatic conditions it can be impossible to verify a proper ground according to the most commonly referenced standard (NEC Article 250) which is written to meet the requirements of electrical fault current grounding and lightning protection, both of which require a much lower "ground resistance" (<25 Ohms).

NFPA 77 (7.4.1.3.1) states that in order to dissipate static charges a "resistance of 1 Meg Ohm (10^6 Ohms) or less generally is considered adequate", however with a standard instruments typically used to verify a satisfactory ground, like Clamp-on Ground Resistance Meters, an elevated resistance at this level is impossible to measure – more specialised and costly equipment is required.

The proposed maximum of 1,000 Ohms (i.e. 1,000 times less than the maximum previously stated) is therefore seen as a realistic level which 1) can be achieved in most soil and weather conditions and 2) can quickly and easily tested and verified. Our own research in various types of terrain confirms that this level of ground resistance can be rapidly achieved and confirmed using commercially available test instruments, leaving the HazMat responders or Environmental Contractors to get on with the urgent matters in hand.

We believe this addition to NFPA 77 will provide people in these positions to carry out their urgent tasks in a timely manner, while still continuing to work within extremely safe parameters with a wide margin of safety.

Committee Meeting Action: Accept
Collecting liquids and solids in an ignitable atmosphere using a vacuum cleaner can create a significant hazard due to ignition from static electric discharge. If it is necessary to use such equipment in a process area, the hazards and the procedures for safe use should be carefully reviewed and clearly communicated to the potential users. If electrically powered, the vacuum cleaner should be listed for use in the applicable hazardous location, as defined in Article 500 of NFPA 70, National Electrical Code. Air-operated vacuum cleaners are available for this application. Special consideration should be given to grounding the vacuum hose and the nozzle per manufacturers recommendations, regardless of the type of vacuum used.

Committee Statement: proposed text does is acceptable, but needs to be expanded to cover air-operated vats.
Submitter: Cash Mason, Teck Cominco

Recommendation: Revise text as follows:
... and toluene generates its lowest-MIE vapor air-mixture at about \(26^\circ C\) (4.1 percent).  

Substantiation: Wrong data – please get your expert to check this out.

Committee Meeting Action: Accept
The unit of conductivity is ohms per meter (Ωm). [note basis in reciprocal of resistivity with units of ohm-meters; mhos per meter is the same as siemens per meter (S/m)]. Some authors express volume resistivity data in terms of ohm-m (100 ohm-cm = 1 ohm-m).

Conductivity is the reciprocal of resistivity. Resistivity is usually stated in ohm-cm or ohm-m. The reciprocal of ohm-m is NOT ohm/m, but 1/(ohm-m). Mho is the symbol for 1/ohm. Note: 1 mho = 1 siemen = 1/ohm; therefore mho/m = siemens per meter.

Revise text to read as follows:

**Committee Meeting Action:** Accept in Principle

Conductivity is the reciprocal of resistivity, expressed as 1/ohm-m, also referred to as mho per meter, ohms per meter (Ωm). 1 mho/m is the same as siemens per meter (S/m). Some authors express volume resistivity data in terms of ohm-m (100 ohm-cm = 1 ohm-m).
The resistance of a circuit through which a current of 1 ampere will flow when a potential difference of 1 volt is applied across the current circuit.

OR

The unit of electrical resistance (R), which measures the resistance between two points of a conductor when a constant difference of potential of one volt between these two points produces in this conductor a current of one ampere.

Substantiation: The electrical potential across the resistance causes current to flow. An electrical potential of one volt causes a current of 1 ampere to flow through a resistance of 1 ohm. The first definition above corrects a mistake in terminology, the second definition is the preferred definition in NFPA Glossary of Terms.

This is not original material; its reference/source is as follows:

NFPA Glossary of Terms.

Committee Meeting Action: Accept in Principle

Delete the definition of "ohm". The concept is explained in the definition of "resistance".
H.2.50 Resistance (R). The opposition that a device or material offers to the flow of direct current. The resistance in ohms is equal to the voltage drop, in volts, across the material element divided by the current, in amperes, through the material element for a purely resistive circuit, also known as electrical resistance.

Substantiation: Resistance applies equally to both alternating and direct currents. The use of Ohm’s law for calculating the value of a resistance in ohms applies to purely resistive loads only. When alternating currents are present, special precautions must be taken to allow for inductive and capacitive circuit elements to assure an accurate measurement.
Resistivity. The intrinsic property of all materials that opposes the flow of electric current. A low resistivity (high conductivity) indicates a material that readily allows the movement of electrical charge. The resistivity on the surface of a material often differs from the resistivity through a volume of the same material. The resistance of a material depends on its resistivity and geometry. Resistivity is the reciprocal of conductivity.

Substantiation: Resistivity is a fundamental property that is critical to defining and understanding resistance. “Resistance” is used repeatedly throughout this document and proper understanding of the term is important to assure correct implementation. The definitions for surface resistivity and volume resistivity should also be improved.
77- Log #5
(H.2.51.1)

Submitter: Steven J. Gunsel, SGTechnologies, LLC

Recommendation: Revise text to read as follows:

H.2.51.1 Surface Resistivity. The resistivity resistance of the surface of a material an insulator, in ohms per square, as measured between the opposite sides of a square on the surface reported in units of ohms or in ohms per square and whose value in ohms is independent of the size of the square or the thickness of the surface film. The resistivity of a surface can differ from the volume resistivity of a material due to surface contamination, chemical reactivity, and atmospheric moisture. Common electrode arrangements for measuring surface resistivity of a solid material include: parallel electrodes, coaxial electrodes, a four point probe, and the van der Paaw method.

Alternate: surface resistivity, resistance across opposite sides of a surface of unit length and unit width commonly expressed in ohms (or ohms/square). Measurement of surface resistivity depends upon selection of the appropriate test procedure.

Substantiation: The existing definition of surface resistivity is incomplete and does not include common measurement techniques.
The intrinsic property resistance of a sample of material that opposes the flow of electric current through the material, expressed in ohm-meters or ohm-cm, having unit length and unit cross-sectional area.

The resistance of an object is a function of its resistivity and geometry.

Substantiation: The existing definition of volume resistivity is incomplete.

Committee Meeting Action: Accept in Principle

Revise text to read as follows:

H.2.51.2 Volume resistivity. The intrinsic property resistance of a sample of material that offers resistance to the flow of electric current through the material, expressed in ohm-meters or ohm-cm, having unit length and unit cross-sectional area. The resistance of an object is a function of its resistivity and geometry. Typical test procedures include ASTM D991, (title), and D257, (title).
8.1 General.

This chapter discusses the assessment and control of static electricity hazards involved with the storage, handling, and use of flammable and combustible liquids and their vapors and mists. While focused on flammable and combustible liquids, the principles of this chapter also apply to noncombustible liquids and vapors (e.g., wet steam) where their storage, use, and handling can cause a static electricity ignition hazard. The chapter begins with a discussion of the combustion characteristics of liquids and their vapors and mists, followed by a discussion of charge generation and dissipation in liquids. Emphasis is then given to processes involving the following:

1. Flow in pipe, hose, and tubing
2. Storage tanks
3. Loading and unloading of tank vehicles
4. Vacuum trucks
5. Railroad tank cars
6. Marine vessel and barge cargo tanks
7. Process vessels
8. Gauging and sampling
9. Tank cleaning
10. Portable tanks and containers
11. Vacuum cleaning

8.1.1 Static control measures need to be taken whenever ignitable mixtures may be present. Conversely, if ignitable mixtures can be ruled out, these measures are not required. However, it requires careful evaluation to rule out the possibility of ignitable mixtures under all conditions (see 8.2). Also, some operations may pose a risk of shocks to people (see 7.8) and, in such cases, bonding and grounding will usually correct the problem.

Comment: All sections will be editorially renumbered as necessary per NFPA guidelines

8.2 Combustion Characteristics of Liquids, Vapors, and Mists.

The following combustion properties of liquids need to be understood to properly assess the static electricity ignition hazard:

1. Flash point
2. Flammable limit and vapor pressure
3. Ignition energy
4. Oxidant concentration

8.2.1 Flash Point.

8.2.1.1 Flash point is the minimum temperature at which a liquid gives off sufficient vapor to form an ignitable mixture with air near the surface of the liquid as determined using standard flash point apparatus described in ASTM E 502. The standard “closed cup” flash point is generally higher than true flash point known as the “lower temperature limit of flammability” or LTLF. This is the temperature at which the vapor...
at thermal equilibrium with the liquid achieves a concentration equal to the lower flammable limit (LFL). For single component liquids it is found that the standard flash point can be 4-6°C higher than the true flash point (LTLF). For complex fuel mixtures such as Jet-A the difference can be 10-15°C.

8.2.1.2 If the flash point of a liquid is at or below typical ambient temperatures, it is likely to evolve an ignitable vapor. The lower the flash point, the higher the vapor pressure and the more likely that an ignitable vapor concentration will be present. Because of the inherent errors in standard flash point measurements, an allowance of at least 5°C to 11°C below the published flash point should be made in the evaluation of an ignition hazard. A minimum safety factor of 5°C is appropriate for single component liquids having a well-defined flash point. The higher minimum safety factor of 11°C is appropriate for mixed liquids of less certain composition such as fuels. In either case, operations at high elevations such as in mining operations require an additional safety factor depending on the elevation. The recommended “additional” safety factor for each 1000 meters above sea level is 2.6°C for complex fuels such as diesel oils and 1.9°C for pure liquids such as toluene and ethanol [Britton, L.G., Unpublished]. Elevations below 1000 meters can be neglected because the additional correction factor is no greater than the typical reproducibility error for flash point measurement of a given sample.

8.2.1.3 In addition to the conditions described in 8.2.1.2, the following effects also can generate an ignitable vapor:

(1) Off-gassing of flammable vapors from solids or low-volatility liquids
(2) Switch loading and/or common vapor headers
(3) Processing at pressures below atmospheric pressure
(4) Nonhomogeneity of the vapors above the liquid
(5) Mist, droplets, or foam on the surface of a liquid

8.2.1.3.1 Many fires have been caused by switch loading, which is the practice of switching between tank loads of different liquids (see 8.6.3). In some cases, fires have been caused by transfer of ignitable vapors via vent collection headers connecting tanks containing high flash point liquids, such as diesel oil, with tanks containing low flash point liquids, such as gasoline.

Comment: We decided last week to reference NFPA 30 for these hazards. Subsection 8.6.3 should be moved here because switch loading hazards are part of “avoiding ignitable mixtures”.

8.2.2* Flammable Limits and Vapor Pressure. Vapors or gases in air are flammable only between certain concentrations — the lower flammable limit (LFL) and the upper flammable limit (UFL). The concentrations between these limits constitute the flammable range. Below the LFL, vapors are too lean to burn; above the UFL, they are too rich to burn. Both increased pressure (above atmospheric pressure) and increased temperature widen the flammability range of typical hydrocarbons.

8.2.3 Ignition Energy. The energy needed to ignite a vapor–air mixture varies with the concentration. For most materials, the lowest ignition energy value occurs at a concentration near the midpoint between those for the LFL and UFL. The lowest value is referred to as the minimum ignition energy (MIE). Some MIEs are given in Section B.1. Figure 8.2.3 illustrates a typical relationship between ignition energy and concentration.
8.2.4* Oxidant Concentration. Combustibility is normally determined for atmospheric air, which contains 21 percent oxygen. With an oxygen-enriched atmosphere, the flammable range expands; that is, the LFL decreases and the UFL increases. If the oxygen concentration is sufficiently reduced by inerting, however, an oxygen concentration below which no ignition is possible is reached. This concentration is referred to as the limiting oxygen concentration (LOC). By effectively inerting to below the LOC, the hazard of ignition can be eliminated, as explained in NFPA 69, Standard on Explosion Prevention Systems. Other oxidants, if present in the mixture, can be addressed similarly. Laboratory testing might be required to evaluate the hazard.

8.3 Generation and Dissipation of Charge in Liquids.

8.3.1* Charge Generation. Charge separation occurs where liquids flow through pipes, hose, and filters; where splashing occurs during transfer operations; or where liquids are stirred or agitated. The greater the area of the interface between the liquid and the surfaces and the higher the flow velocity, the greater is the rate of charging. The charges become mixed with the liquid and are carried to receiving vessels, where they can accumulate. The charge is often characterized by its bulk charge density and its flow as a streaming current to the vessel. (See Figure 8.3.1.)
8.3.2* **Charge Relaxation.** Static electric charge on a liquid in a grounded conductive container will dissipate at a rate that depends on the conductivity of the liquid.

8.3.2.1 For liquids with conductivity of 1 picosiemens per meter (1 pS/m) or greater, charge relaxation proceeds by exponential, or ohmic, decay, as described for semiconductive materials in 5.2.5. For liquids with conductivity less than 1 pS/m, relaxation occurs more rapidly than would be predicted by the exponential decay model. *(See 5.2.8.)*

8.3.2.2 According to the Bustin relationship *(see Annex E)*, where low viscosity liquids (less than $30 \times 10^{-6}$ m²/sec) are charged, relaxation proceeds by hyperbolic decay. However, for those same liquids, the exponential decay constant gives a conservative estimate for the relaxation time.

8.3.3 **Factors That Affect Liquid Charging.**

8.3.3.1* In grounded systems, the conductivity of the liquid phase has the most effect on the accumulation of charge in the liquid or on materials suspended in it. A liquid is considered nonconductive (charge accumulating) if its conductivity is below 50 pS/m, assuming a dielectric constant of 2. Table B.2 lists values of conductivity for typical liquids. What is important is that the charge decays from the liquid fast enough to avoid ignition hazards. The acceptable conductivity in any particular application can be larger or smaller, depending on flow rate and processing conditions.

8.3.3.2 Conductive liquids, defined as having conductivities greater than $10^4$ pS/m, do not pose a hazard due to static electric charge accumulation in typical hydrocarbon and chemical processing and handling operations **provided that equipment is conductive (or static dissipative) and grounded.** In this recommended practice, liquids having conductivities of 50 pS/m to $10^4$ pS/m are considered semiconductive.

8.3.3.3 The charging characteristics of many industrial liquids, particularly nonpolar hydrocarbons, are the result of trace contaminants in the liquid, sometimes in concentrations of less than 1 ppm. Thus, industrial liquids can become more or less conductive by orders of magnitude, depending on the concentration of contaminants that results from process, storage, and handling practices.

8.3.3.4 Conductive liquids that at first could appear to be safe can present a significant hazard if isolated from ground by an insulating container or if suspended in air. Where isolated, essentially all charge on the conductive liquid can be released as an incendive spark. Where suspended as a mist, significant static electric fields can lead to incendive brush discharge.
8.3.3.5 In the petroleum industry, for tank-loading and distribution operations involving petroleum middle distillates, liquids in the semiconductive category are handled as conductive liquids. The use of such procedures is possible because regulations prohibit the use of nonconductive plastic hose and tanks, and multiphase mixtures and end-of-line polishing filters are not involved.

8.3.3.6 In general chemical operations, semiconductive liquids represent a distinct category in which the tendency to accumulate charge varies greatly with the operation and with liquid conductivity. These operations can involve multiphase mixtures, nonconductive tank linings, and microfilters, all of which promote charge accumulation in equipment.

8.4 Flow in Pipe, Hose, and Tubing.

8.4.1* Metal Piping Systems.

8.4.1.1 All parts of continuous all-metal piping systems should have a resistance to ground that does not exceed 10 ohms. A significantly higher resistance could indicate poor electrical contact, although this will depend on the overall system. For flanged couplings, neither paint on the flange faces nor thin plastic coatings used on nuts and bolts will normally prevent bonding across the coupling after proper torque has been applied. However, care should be taken to avoid accumulation of excessive paint thicknesses caused by repainting. Jumper cables and star washers are not usually needed at flanges. Star washers could even interfere with proper torquing. Electrical continuity of the ground path should be confirmed after assembly and periodically thereafter.

8.4.1.2 Bonding wires might be needed around flexible, swivel, or sliding joints. Tests and experience have shown that resistance in these joints is normally below 10 ohms, which is low enough to prevent accumulation of static charges. However, the manufacturer’s specifications should be checked or the joints should be inspected, because a few are fabricated with insulating surfaces. Where painted, slip flanges (lap joints) using nonconductive gaskets can cause loss of continuity in the grounding path. This loss of continuity can be remedied by using a conductive gasket, such as a flexible, graphite-filled, spiral-wound gasket, or by installing a jumper wire across the joint.

8.4.1.3 Bonding and grounding should not compromise sections of pipe that are supposed to be isolated. For example, insulating flanges could have been installed to avoid arcs from stray current or from cathodic protection systems, which provide a separate ground path.

8.4.1.4 Figure 8.4.1.4(a) and Figure 8.4.1.4(b) provide guidance in estimating the charge on a nonconductive liquid flowing through a smooth pipe.
FIGURE 8.4.1.4(a) Nomograph for Estimating Charge on Nonconductive Liquid Flowing Through a Smooth Pipe. (Source: T. H. Pratt, Electrostatic Ignitions of Fires and Explosions, p. 112.)

Notes:
(1) One straight line through the scales simultaneously solves the following:

\[ I_s = 2.5 \times 10^{-5} v^2 d^2 \quad S = 3.18 \times 10^{-5} v \quad F = \frac{\pi}{4} v d^2 \]

(2) To convert from ft/sec to m/sec, multiply by 3.28; to convert from bbl/hr to m³/hr, multiply by 0.159.
8.4.2* Nonconductive Pipe and Lined Pipe. Nonconductive surfaces affect the rates of charge generation and charge dissipation during flow through a pipe. The rate of charge generation is similar in conductive and nonconductive pipes, while the rate of charge loss can be significantly slower in nonconductive pipes. For charged, nonconductive liquids, insulation by the pipe wall can result in charge accumulation of the opposite polarity on the outer surface of the insulating liner or pipe. Charge accumulation can eventually lead to electrical breakdown and pinhole punctures of either the liner or, in the case of nonconductive pipe, the entire wall thickness.

8.4.3* Flexible Hose and Tubing. Flexible hose and flexible tubing are available in metal, lined metal, nonconductive plastic, reinforced rubber and plastic, and composite-ply types.

8.4.3.1 Where nonconductive hose or tubing must be used because of process conditions, the hazards of static electric charge generation should be thoroughly investigated.

8.4.3.2 As a minimum, all conductive couplings (e.g., end fittings) and components should be bonded and grounded. Other measures may be necessary.

8.4.3.3 If hoses are used immediately downstream of filters in nonconductive liquid service, they should be of metal or other conductive material. Semiconductive liners might be necessary to prevent charge accumulation and pinhole damage to the hose.

8.4.3.4 Conductive hose should be electrically continuous and the continuity should be periodically checked.

8.4.4 Fill Pipes. Fill pipes should be conductive and should be bonded to the filling system.

8.4.4.1 Fill pipes should extend to the bottom of the vessel and can be equipped with either a 45-degree cut tip or a tee to divert flow horizontally near the bottom of the vessel being filled.
8.4.4.2 The design should prevent upward spraying during the initial stage of filling. A “slow start” might be necessary, so that the inlet velocity is held to less than 1 m/sec until the outlet of the dip pipe is covered by at least two pipe diameters of liquid.

8.4.5 Filtration.

8.4.5.1 Microfilters.

8.4.5.1.1 Microfilters typically have pore sizes less than 150 μm. These filters generate very large streaming currents with nonconductive liquids, due to their large contact area. (Conductive liquids typically dissipate their charge to ground through the body of the liquid.) Streaming currents frequently are greater than those for the pipe flow entering the microfilter by two orders of magnitude, and the charge density added to the liquid can exceed 2000 μC/m³.

8.4.5.1.2 To prevent the charges described in 8.4.5.1.1 from entering the receiving vessel, the filter should be placed far enough upstream so that the charge can decay to the magnitude it would be in the pipe flow. Common industry practice is to provide 30 sec of residence time in the pipe or conductive hose downstream of the microfilter, especially if the conductivity of the liquid is not known. For nonconductive liquids that have both very low conductivity (i.e., less than 2 ps/m) and high viscosity (i.e., greater than 30 centistokes) at the lowest intended operating temperature, longer residence times might be appropriate. In those cases, a residence time of up to three times the relaxation time constant of the liquid should be considered.

8.4.5.2 Strainers. Mesh strainers finer than 150 μm should be treated as microfilters. Mesh strainers coarser than 150 μm can also generate significant static electric charge where fouled with accumulated debris. If such coarse strainers are used in services where debris can be expected to accumulate, then those strainers should also be treated as microfilters.

8.4.5.3 Polishing Filters. A polishing filter is sometimes placed at the end of a delivery line to remove debris. This filter might be a bag installed on the end of a hose and directly exposed to the vapor in the tank. Filters used in flammable liquid service should be enclosed in grounded metal housings.

8.4.6 Suspended Material. Immiscible and marginally soluble liquids and slow-dissolving solids can disperse as droplets or as an emulsion. Where a nonconductive liquid contains a dispersed phase, such as water in oil, the continuous phase determines the charge relaxation behavior. Charge generation typically is greater for such suspensions than that for a single phase.

8.4.7 Miscellaneous Line Restrictions. Piping system components, such as orifice plates, valves, elbows, and tees, increase turbulence and can increase the rate of charge generation. Brief contact with a plastic component, in particular, can cause significant charge generation both on the liquid and the plastic component. Suspended material such as water (see 8.4.6) also has been found to increase this effect.

8.5 Storage Tanks.

8.5.1 General. Liquid flowing into a tank can carry a static electric charge that will accumulate in the tank. This charge can be detected as a potential above the surface of the liquid in the tank. The maximum surface potential attained depends not only on the charge density of the incoming liquid but also on the dimensions of the tank. For commercial tanks of equal volume, the maximum potential will be greater in tanks having smaller cross-sectional areas, because liquid depth increases faster relative to the rate of charge relaxation. Smaller potentials will therefore be generated in, for example, a near-rectangular barge tank than in a cylindrical vertical tank of the same volume.

8.5.2 Conductive Fixed-Roof Storage Tanks. Charge accumulation in the liquid in a tank can lead to static electric discharge between the liquid surface and the tank shell, roof supports, or tank appurtenances. The charge generation rate is influenced by turbulence in the liquid and by the settling of particulate matter, such as water droplets, iron scale, and sediment.

8.5.2.1 Precautions. If the vapor space in the tank is likely to contain an ignitable mixture (e.g., in cases where intermediate vapor pressure products or low vapor pressure products contaminated with high vapor pressure liquids are stored) or where switch loading is practiced, the following protective measures should be taken:

1. Splash filling and upward spraying should be avoided.
The fill pipe should discharge near the bottom of the tank, with minimum agitation of water and sediment on the tank bottom.

If possible, the inlet flow velocity should be limited during the initial stage of tank filling to reduce agitation and turbulence, and the following also should be applied:

(a) The flow velocity of the incoming liquid should be no greater than 1 m/sec until the fill pipe is submerged either two pipe diameters or 0.6 m, whichever is less.

(b) Because too low a velocity can result in entrained water settling out at low points in the piping, the inlet flow velocity should be kept as close to 1 m/sec as possible during the initial tank filling period to prevent subsequent re-entrainment of water or other contaminants that could significantly increase the product’s charging tendency when the velocity is increased.

The following applies to storage tanks greater than 200 m³ (50,000 gal) containing liquids that are either nonconductive or for which conductivity is unknown:

(a) The inlet flow velocity can be increased to 7 m/sec after the fill pipe is submerged.

(b) Where operating experience has shown that the practice is acceptable, such as in the petroleum industry, the inlet flow velocity can be increased above 7 m/sec, but in no case to a velocity greater than 10 m/sec. [See Figure 8.4.1.4(a) and Figure 8.4.1.4(b) for determining flow rate.]

The following applies to vertical axis storage tanks greater than 75 m³ (20,000 gal) and less than 200 m³ (50,000 gal) containing liquids that are either nonconductive or for which conductivity is unknown:

(a) The product of inlet flow velocity and pipe inside diameter can be increased to 0.50 m²/sec after the fill pipe is submerged.

The following applies to vertical axis storage tanks greater than 1 m³ (250 gal) and less than 75 m³ (20,000 gal) containing liquids that are either nonconductive or for which conductivity is unknown:

(a) The product of inlet flow velocity and pipe inside diameter can be increased to 0.38 m²/sec after the fill pipe is submerged.

(b) If the liquid is nonconductive and contains a dispersed phase, such as entrained water droplets, the flow velocity should be restricted to 1 m/sec throughout the filling operation.

Comment: See Table 8 in IEC doc. In order to address the less usual case of horizontal tanks we’d need to introduce the factor N. Also, I didn’t include a 1 m/s restriction for tanks > 20,000 gal containing water bottoms because it’s restrictive – is there any evidence this is needed?

A 30-sec minimum residence time should be provided for liquid to flow between upstream microfilter screens and the tank. (See 8.4.5.)

Tanks should be inspected for ungrounded conductive objects, such as loose gauge floats and sample cans, because such objects floating on the liquid surface can promote sparks.

Lines should not be blown out with air or other gases if the liquid is a Class I liquid or is handled at or above its flash point, because introducing substantial amounts of air or other gas into a tank through such a liquid can create a hazard due to charge generation, misting of the liquid, and formation of an ignitible atmosphere.

8.5.2.2 Grounding.

8.5.2.2.1 Storage tanks for nonconductive liquids should be grounded. Storage tanks on grade-level foundations are considered inherently grounded, regardless of the type of foundation (e.g., concrete, sand, or asphalt).

8.5.2.2.2 For tanks on elevated foundations or supports, the resistance to ground can be as high as $10^6$
ohms and still be considered adequately grounded for purposes of dissipation of static electric charges, but the resistance should be verified. The addition of grounding rods and similar grounding systems will not reduce the hazard associated with static electric charges in the liquid.

8.5.2.3 Spark Promoters.

8.5.2.3.1 A tank gauging rod, high-level sensor, or other conductive device that projects downward into the vapor space of a tank can provide a location for static electric discharge between the device and the rising liquid; therefore, these devices should meet the following criteria:

(1) They should be bonded securely and directly downward to the bottom of the tank by a conductive cable or rod to eliminate a spark gap or should be installed in a gauging well that is bonded to the tank.

(2) They should be inspected periodically to ensure that the bonding system has not become detached.

8.5.2.3.2 If tank fixtures are nonconductive, the potential for sparking does not exist, and no specific measures are needed. Devices that are mounted to the sidewall of the tank (e.g., level switches or temperature probes) and project a short distance into the tank might not pose a static electric discharge hazard. These situations should be evaluated on an individual basis.

8.5.2.4 Tank Mixers. In-tank jet mixing or high-velocity agitator mixing can stir up water and debris and cause splashing at the surface that can generate static electric charges. If an ignitible mixture exists at the surface, ignition is possible. Surface splashing should be minimized. Gas blanketing or inerting can be employed to eliminate the ignition hazard.

8.5.2.5 Gas Agitation.

8.5.2.5.1 Air, steam, or other gases should not be used for agitation because they can produce high levels of charge in liquids, mists, or foams. In addition, air agitation can create an ignitible atmosphere in the vapor space of the tank. If gas agitation is unavoidable, the vapor space should be purged prior to mixing, and the process should be started slowly to ensure that static electric charge does not accumulate faster than it can dissipate.

8.5.2.5.2 It should be noted that special precautions need to be taken to prevent agitation with air to dilute any initial inerting. Similarly, while agitation with an inert gas can eventually result in an inert vapor space, the electrostatic charge buildup due to the agitation process can result in a spark and ignition before inerting of the tank vapor space is achieved. A waiting time should be observed prior to any gauging or sampling activities.

8.5.3 Conductive Floating Roof Storage Tanks. Floating roof storage tanks are inherently safe, provided that the floating roof is bonded to the tank shell. Bonding typically is achieved by shunts between the floating roof or cover and the wall of the tank. The shunts are installed for lightning protection, but they also provide protection from static electric charges that could be generated. If the floating roof is landed on its supports, charge accumulation in the surface of the liquid can occur, and the precautions for a fixed roof tank should be followed. If an internal floating roof tank is not adequately ventilated, flammable vapor can accumulate between the floating roof and the fixed roof.

8.5.4 Coated and Lined Tanks. The presence of internal coatings or linings in grounded metal tanks can generally be neglected, provided that one of the following criteria applies:

(1) Coating or lining has a volume resistivity equal to or lower than $10^9$ ohm-m;

(2) Thickness of painted coating does not exceed 2 mil (50 microns);

(3) The liquid is conductive and is always in contact with ground (for example, grounded dip pipe or grounded metal valve always in contact with liquid).

Comment: see IEC doc section 7.3.4.2 for additional precautions. I’m not sure how or why to include either a 2 mm or 4 kV restriction. Not sure whether to say anything here about fluorocarbon vs phenolic coatings – most painted coatings are epoxy or phenolic.

8.5.4.1 Metal tanks with nonconductive coatings or linings that do not meet the criteria of 8.5.4(1), 8.5.4(2) or 8.5.4(3) should be treated as nonconductive tanks. Regardless of the coating or lining thickness or resistivity, the tank should be bonded to the filling system. The coating or lining is not regarded as a barrier to the flow of static electric charges. YES IT IS Its resistivity is of the same order of magnitude NOT NECESSARILY as that of the liquid, or there could be small bare areas (holidays) in the coating. THESE
8.5.4.2 A thin coat of paint, a thin plastic liner, or a layer of metal oxide on the inside of piping, vessels, or equipment does not constitute a static electric hazard. **THIS IS INCONSISTENT WITH 8.5.4 AND NEEDS TO BE MODIFIED – IT’S ONLY TRUE AS REGARDS OXIDE FILMS AND <50 MICRON PAINT – THE WORD “THIN” IS MEANINGLESS – “THIN” TEFLO LININGS CAN BE HAZARDOUS**

8.5.5 Tanks Constructed of Nonconductive Materials. Tanks constructed of nonconductive materials are not permitted for storage of Class I, Class II, and Class IIIA liquids, except under special circumstances, as outlined in Section 4.2 of NFPA 30, *Flammable and Combustible Liquids Code*. (See 8.10.7 for design and use recommendations.)

8.6 Loading and Unloading of Tank Vehicles.

Recommended loading precautions for tank vehicles vary with the characteristics of the liquid being handled and the design of the loading facility. A summary of recommended precautions that should be used where a flammable mixture exists in the tank vehicle compartment, based on API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*, is provided in Table 8.6. These precautions are intended for tank vehicles with conductive (metal) compartments. *(For compartments with nonconductive linings, see 8.10.4. For compartments of nonconductive material, see 8.10.7.)*
### Table 8.6 Summary of Precautions for Loading Tank Vehicles

<table>
<thead>
<tr>
<th>Recommended Loading Precaution&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Liquid Being Loaded</th>
<th>Nonconductive</th>
<th>Low Vapor Pressure</th>
<th>Intermediate Vapor Pressure</th>
<th>High Vapor Pressure&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Conductive&lt;sup&gt;c,d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonding and Grounding. Tank trucks should be bonded to the fill system, and all bonding and grounding should be in place prior to starting operations. Ground indicators, often interlocked with the filling system, frequently are used to ensure bonding is in place. Bonding components, such as clips, and the fill system continuity should be periodically examined and verified. For top loading, the fill pipe should form a continuous conductive path and should be in contact with the bottom of the tank.</td>
<td>Yes&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Optional</td>
<td></td>
</tr>
<tr>
<td>Initial Loading. Top-loading fill pipes and bottom-loading systems should be equipped with spray deflectors, and splash filling should be avoided. A slow start (i.e., velocity less than 1 m/sec) should be employed until the inlet into the compartment is covered by a depth equal to two fill-pipe diameters to prevent spraying and to minimize surface turbulence.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Maximum Loading Rate. The maximum loading rate should be limited so the velocity in the fill pipe or load connection does not exceed 7 m/sec or (0.5/&lt;i&gt;d&lt;/i&gt;) m/sec (where &lt;i&gt;d&lt;/i&gt; = inlet inside diameter in meters), whichever is less. Transition from slow start to normal pumping rate can be achieved automatically using a special loading regulator tip (which shifts the rate when submerged to a safe depth). Excessive flow rates should be avoided, either procedurally or by system design, which is the preferred method. The maximum loading rate for ultra low-sulfur diesel and gas oils (&lt; 50 ppm S) with conductivity less than 10 pS/m (or unknown) should not exceed (0.25/&lt;i&gt;d&lt;/i&gt;) m/s. The loading rate can be increased to (0.38/&lt;i&gt;d&lt;/i&gt;) m/s if S &gt; 50 ppm or if the conductivity exceeds 10 pS/m. If &lt;i&gt;S&lt;/i&gt; &gt; 50 ppm and the conductivity exceeds 10 pS/m the loading rate can be increased to (0.5/&lt;i&gt;d&lt;/i&gt;) m/s. If the conductivity exceeds 50 pS/m the loading rate can be increased to (0.5/&lt;i&gt;d&lt;/i&gt;) m/s in both cases.</td>
<td>Yes&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Yes</td>
<td>Optional&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Optional</td>
<td>Optional</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>See IEC Table 11 – a table would be better. Also, shouldn’t we use <i>v_d</i> product rather than <i>v_d/d</i>?
**Charge Relaxation.** A residence time of at least 30 sec should be provided between any microfilter or strainer and the tank truck inlet. A waiting period of at least 1 minute should be allowed before the loaded tank compartment is gauged or sampled through the dome or hatch. [However, sampling and gauging via a sample well (gauge well) can be done at any time.]

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**Spark Promoters.** A tank gauging rod, high-level sensor, or other conductive device that projects downward into the vapor space of a tank can provide a location for static discharge between the device and the rising liquid and should be avoided. These devices should be bonded securely and directly downward to the bottom of the tank by a conductive cable or rod (to eliminate a spark gap) or should be installed in a gauging well that is bonded to the bottom. Periodic inspection should be conducted to ensure that the bonding system does not become detached and that there are no ungrounded components or foreign objects.

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*Loading precautions vary with the product being handled. In loading operations where a large variety of products are handled and where it is difficult to control loading procedures, such as at self-service loading racks, a single standard procedure that includes all the precautions should be followed.

*If high vapor pressure products are handled at low temperatures (near or slightly below their flash points), all the recommended loading precautions should be followed.

*Where additives are used to increase conductivity, caution should be exercised. (See 8.6.5.)

*Semiconductive liquids can accumulate charge where charging rates are extremely high or where they are effectively isolated from ground. They might need to be handled as nonconductive liquids. (See 8.3.3.6.)

*Recommended loading precautions need not be applied if only low vapor pressure combustible liquids at ambient temperatures are handled at the loading rack and there is no possibility of switch loading or cross contamination of products. All loading precautions should be followed where low vapor pressure products are handled at temperatures near or above their flash points (See 8.2.1 for applicable safety factors)

*Where the product being handled is a nonconductive, single-component liquid (such as toluene or heptane), the maximum fill rate (velocity) should be (0.38/d) m/sec. (why not use vd product?)

*Very low conductivity and high-viscosity products can require additional residence time of up to 100 sec. (See 8.4.5.1.2.)

*If these devices are nonconductive, the potential for sparking does not exist, and no specific measures need be taken. Devices that are mounted to the sidewall of the tank (e.g., level switches and temperature probes), that project a short distance into the tank, and that have no downward projection might not pose an electrostatic hazard. These situations should be evaluated on an individual basis.

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**8.6.1 Top Filling.** Splash filling should be avoided by using a fill pipe that is designed according to the recommendations in 8.4.4.

**8.6.2 Bottom Filling.** The bottom-filling inlet should be designed with a deflector or a diverter to prevent upward spraying and generation of mist. Using a cap or a tee to direct incoming liquid sideways toward the compartment walls, rather than upward, will achieve this objective.

**8.6.3 Switch Loading.** The practice of loading a liquid having a high flash point and low conductivity into a tank that previously contained a low flash point liquid is referred to as switch loading. This practice can result in the ignition of residual flammable vapor as the tank is filled. The methods of hazard prevention are
similar to those specified in 8.5.2.1(1) through 8.5.2.1(3) and 8.5.2.1(5) through 8.5.2.1(8). Flow velocities are found in Table 8.6.

Comment: it would be better to include this section up front in 8.2.1.3.1 as part of the considerations for avoiding ignitable mixtures, and add NFPA 30 reference

8.6.4 Highway Transport. As noted in API RP 2003, Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents, tank vehicles normally do not create a static electricity hazard during transport, provided that they are compartmented or contain baffles. The compartments or baffles minimize sloshing of the liquid in the tank vehicle, which could result in significant charge generation. Clear bore (unbaffled) tank vehicles should not be used for liquids that can generate an ignitable mixture in the vapor space.

8.6.5 Antistatic Additives. Charge accumulation can be reduced by increasing the conductivity of the liquid by adding a conductivity-enhancing agent (antistatic additive).

8.6.5.1 Antistatic additives normally are added in parts-per-million concentrations and should be used in accordance with manufacturer instructions.

8.6.5.2 Where antistatic additives are used as a primary means of minimizing accumulation of static electric charge, the operator should verify the concentration of the additive at critical points in the system.

8.6.6 Unloading

For bulk transfers to fixed tanks see 8.5.

8.6.6.1 Unloading Small Volumes of Liquid (less than 125 gallons)

Static control measures should always be taken when handling Class I flammable liquids. The measures are not required for small volume deliveries of diesel oil (such as to tractors, refrigeration units and other small equipment), nor for similar dispensing of other Class II and Class III liquids into small tanks and containers, provided that:

1. Ignitable mixtures cannot be formed during the transfer (see 8.2.1), and
2. There is no ignitable atmosphere outside the liquid transfer system, and
3. The practice does not violate the governing Fire Code or Regulation.

Example: transfer of diesel oil from a tank vehicle to a tractor via a hose and flow-control nozzle. In this case the safety considerations are: (a) the flow rate must be controlled so that no ignitable mist is produced; (b) the diesel oil must be uncontaminated in both the tank vehicle and the tractor; and (c) the temperature must be measured to ensure a flash point safety factor of at least 11ºC (corrected for elevation as necessary). Maybe delete this example per teleconference – Bob B said T isn’t usually measured. However, if T isn’t measured how can we say flash point safety factor must be applied? This is important for light diesel oils where MSDS could say FP > 38C or >41C (etc) but not important where MSDS says FP > 52C (etc)

8.7 Vacuum Trucks.

8.7.1 For control of static electricity, hose should be conductive or semiconductive.

8.7.2 As an alternative to the recommendation of 8.7.1, all conductive components should be bonded, and the truck should be grounded.

8.7.3 In no case should plastic dip pipes or plastic intermediate collection pans or drums be used.

8.8 Railroad Tank Cars.

8.8.1 In general, the precautions for railroad tank cars are similar to those for tank vehicles specified in Section 8.6. The major exception is the larger volume typical of railroad tank cars (e.g., greater than 87 m³) compared with that of tank vehicles (e.g., about 50 m³). The greater volume allows greater maximum filling rates (should say “velocities” not “rates” – why not use vd product instead?) to be used, up to a maximum of (0.8/d) m/sec, where d is the inside diameter of the inlet in meters.
8.8.2 Many tank cars are equipped with nonconductive bearings and nonconductive wear pads located between the car itself and the trucks (wheel assemblies). Consequently, resistance to ground through the rails might not be low enough to prevent accumulation of a static electric charge on the tank car body. Therefore, bonding of the tank car body to the fill system piping is necessary to protect against charge accumulation. In addition, because of the possibility of stray currents, loading lines should be bonded to the rails.

8.9 Marine Vessel and Barge Cargo Tanks.
Marine vessel and barge cargo tanks are beyond the scope of this recommended practice. The recommendations given in the International Safety Guide for Oil Tankers and Terminals (ISGOTT) should be followed.

8.10 Process Vessels.
8.10.1 Means of Static Electric Charge Accumulation. Accumulation of static electricity in process vessels occurs by the same methods as described in Section 8.5 for storage tanks.

8.10.1.1 Where a conductive and a nonconductive liquid are to be blended, the conductive liquid should be added to the vessel first, if possible, so that the conductivity of the mixture is as high as possible throughout the mixing process.

8.10.1.2 Re-entry of recirculation loops should be designed to minimize splashing and surface disruption, for example, by use of subsurface jets that do not break the liquid's surface.

8.10.2* Procedures for Transfer to Tanks.
8.10.2.1 When two or more nonconductive liquids are introduced into a blending tank, the less dense liquid should be loaded first to avoid a surface layer comprising the lighter, more highly charged component.

8.10.2.2 Splash recirculation normally should be done only if the vessel is inerted or vapor enriched.

8.10.3 Agitation. Agitators should be covered with sufficient depth of liquid before being operated, to minimize splashing, or should be operated at reduced speed until sufficient depth has been achieved. In cases where hazardous charge accumulation cannot be avoided using the measures discussed in Section 8.10, the vessel can be inerted.

8.10.4 Vessels with Nonconductive Linings. The accumulation of static electric charge can result in pinhole damage to equipment such as enamel- or glass-lined reactors. Because static electric discharges often occur at the liquid interface as liquid drains from the wetted wall, a vapor ignition hazard could also exist. In some cases, it is possible to specify static dissipative coatings for the vessel or agitator. Conductive vessels and appurtenances should be bonded and grounded. In some cases, inerting might be necessary.

8.10.5 Adding Solids. The most frequent cause of static electric ignitions in process vessels is the addition of solids to flammable liquids in the vessels. Even where the vessel is inerted, large additions of solids will introduce air into the vessel while expelling flammable vapor from the vessel. The sudden addition of a large volume of solids can also result in static discharge from a floating pile of charged powder.

8.10.5.1 Manual addition of solids through an open port or manway should be done only in 25 kg batches.

8.10.5.2 Batch additions larger than 25 kg [e.g., from flexible intermediate bulk containers (see 10.1.6)] should be done through an intermediate hopper with a rotary valve or an equivalent arrangement. The hopper can be inerted separately to reduce air entrainment into the mixing vessel, while expulsion of vapor into the operating area can be avoided by venting the vessel to a safe location. The addition of solids from nonconductive plastic bags can be hazardous, even if the solids are noncombustible (e.g., silica).

8.10.5.3 Bags should be constructed of paper, plies of paper and plastic in which the nonconductive plastic film is covered by paper on both sides, or antistatic plastic. Because grounding clips can be impractical, such bags can be effectively grounded by contact with a grounded conductive vessel or skin contact with a grounded operator.

8.10.5.4 Fiber drums or packages should not have a loose plastic liner that can leave the package and behave like a plastic bag.

8.10.5.5 Metal chimes should be grounded.

8.10.5.6 Personnel in the vicinity of openings of vessels that contain flammable liquids should be grounded,
8.10.6 Mixing Solids. Where solids are dissolved or dispersed into nonconductive liquids, the rate of charge generation can be large, depending on factors such as solids loading, particle size, and agitation rate. Dissipation of the charge frequently is achieved by raising the conductivity of the continuous phase by reformulation with conductive solvents or by the addition of antistatic additives. Alternatively, ignition hazards can be controlled by inerting.

8.10.7 Nonconductive Process Vessels.

8.10.7.1 In general, nonconductive process vessels should not be used with flammable liquids, which present external ignition risks if their outer surfaces become charged.

8.10.7.2 If a nonconductive tank is to be used and the possibility exists that the atmosphere around the tank or in the vapor space is ignitible, the following criteria should be met to ensure the safe dissipation of charge and to prevent discharges:

(1) All conductive components (e.g., a metal rim and hatch cover) should be bonded together and grounded.

(2) Where the tank is used to store nonconductive liquids, the following criteria should be met:
   (a) An enclosing, grounded conductive shield should be provided to prevent external discharges.
   (b) The shield should be a grounded wire mesh buried in the tank wall and should enclose all external surfaces.

(3) Where used to store nonconductive liquids, the tank should have a metal plate to provide a path through which charge can flow from the liquid contents to ground, and the following criteria also should be met:
   (a) The plate should have a surface area not less than 500 cm²/m³ of tank volume.
   (b) The plate should be located at the bottom of the tank and bonded to ground.

(4) Where the tank is used to store conductive liquids, an internal grounding cable extending from the top to the bottom of the tank and connected to ground or a grounded fill line meeting the following criteria and extending to the bottom of the tank should be provided:
   (a) The grounded fill line enters at the bottom of the tank.
   (b) The grounded fill line does not introduce a spark promoter.

8.11 Gauging and Sampling.

Gauging and sampling operations, including temperature measurement, can introduce spark promoters into a storage tank or compartment. A conductive gauging well for manual sampling and gauging should be used.

8.11.1 Precautions. The precautions given in Section 8.11 should be taken where use of a gauging well is not possible, where the material stored is a nonconductor, or where the vapor space of the container could be ignitable.

8.11.2 Manual Operations. Where gauging and sampling operations are conducted manually, the personnel grounding recommendations in Section 7.6 should be considered.

8.11.3 Materials. Gauging and sampling systems should be either completely conductive or completely nonconductive. For example, conductive sampling and gauging devices should be used with a conductive lowering device, such as a steel tape or cable.

8.11.3.1 Chains are not electrically continuous and should not be used in flammable atmospheres.

8.11.3.2 Conductive sampling and gauging devices, including the sampling container and the lowering device, should be properly bonded to the tank or compartment.

8.11.3.3 The bonding specified in 8.11.3.2 should be accomplished by use of a bonding cable or by maintaining continuous metal-to-metal contact between the lowering device and the tank hatch.

8.11.3.4 Ideally, if nonconductive hand gauging or sampling devices are used, no waiting period is needed.
after loading or filling; however, it should be noted that these devices might not retain the necessary level of nonconductivity due to environmental factors such as moisture or contamination. Therefore, an appropriate waiting period should be allowed where nonconductive devices are used.

8.11.3.5 Cord made from synthetic material such as nylon should not be used due to possible charging if it slips rapidly through gloved hands. Although natural cellulosic fiber cord can, in principle, be used, such cord is frequently composed of a natural–synthetic blend, with corresponding charge-generating ability.

8.11.4 Gauging. Where possible, gauging should be carried out using automatic gauging systems. These systems can be used safely in tanks, provided that the gauge floats and similar devices are electrically bonded to the tank shell through a conductive lead-in tape or conductive guide wires. Free-floating, unbonded floats can be effective spark promoters and should be avoided. Noncontact gauging devices, such as radar and ultrasonic gauges, are also satisfactory, provided that electrical continuity is ensured. Isolated conductive components must not be used.

8.11.5 Waiting Period.

8.11.5.1 Depending on the size of the compartment and the conductivity of the product being loaded, a sufficient waiting period should be allowed for accumulated charge to dissipate.

8.11.5.2 A 30-minute waiting period should be allowed before the gauging or sampling of storage tanks greater than 40 m$^3$, unless a gauging well is used. The waiting period before the gauging or sampling of smaller vessels can be reduced to 5 minutes for tanks between 20 m$^3$ and 40 m$^3$ and to 1 minute for tanks less than 20 m$^3$. Longer waiting periods might be appropriate for very low conductivity liquids (\(K < 2\) pS/m) or nonconductive liquids that contain a second dispersed phase [such as a Class I liquid with more than 0.5 percent water (weight basis)]. If a gauging well is used, a waiting period is unnecessary.

8.12 Tank Cleaning.

8.12.1 Water Washing.

8.12.1.1 The mist created in a tank by water spraying can be highly charged. This is a particular problem with tanks larger than 100 m$^3$, due to the size of the mist cloud that can form. Water washing using sprays should be done only in an inerted or nonflammable atmosphere.

8.12.1.2 Although specifically written for marine cargo tanks, the *International Safety Guide for Oil Tankers and Terminals* (ISGOTT) presents a comprehensive discussion of tank cleaning. Tanks less than 100 m$^3$ and with all conductive components grounded have a negligible discharge hazard. Where a possibility of steam entering the tank during the water-washing process exists, the precautions in 8.12.3 should be followed.

8.12.2 Solvent Washing. Mist charge densities created by flammable solvents are similar to those from water washing, and similar precautions should be taken regarding grounding of conductive components.

8.12.2.1 Where an ignitable atmosphere or mist cannot be avoided because of the type of solvent or cleaning process used, the tank or vessel being cleaned should be inerted or enriched to reduce the likelihood of ignition during the cleaning process.

8.12.2.2 Where the vessel is not inerted or enriched and an ignitable atmosphere is present, the following precautions should be considered where solvent is used as a cleaning agent:

1. The solvent should be conductive.
2. Where a solvent blend, such as reclaimed solvent, is used, the conductivity should be checked periodically.
3. High flash point materials (at least 9°C above the maximum operating temperature during cleaning) should be used, and the flash point should be confirmed on a daily basis.
4. The cleaning system should be conductive and bonded to the tank, and continuity tests of all bonded equipment should be done periodically.
5. Ungrounded conductive objects should be treated in accordance with the following:
   a. They should not be introduced into the tank during the cleaning process.
   b. They should not be introduced into the tank for a sufficient period of time after the cleaning...
process, which might take several hours due to the generation of mist.

**8.12.3 Steam Cleaning.** Steam cleaning can create very large charge densities with correspondingly large space charge potentials that increase with the size of the tank. Therefore, the following precautions should be taken:

1. Tanks larger than 4 m$^3$ should be inerted before steam cleaning.
2. All components of the steaming system should be conductive and grounded.
3. All conductive components of the tank should be bonded and grounded.

**8.12.4 Internal Grit Blasting.**

**8.12.4.1** Where possible, tanks and process vessels should be clean and free of ignitable materials (no more than 10 percent of the LFL).

**8.12.4.2** Hose used for grit blasting should be grounded, and the resistance to ground from any part of the hose assembly, especially the nozzle, should not exceed $10^6$ ohms. (See A.8.4.3.)

**8.13 Portable Tanks, Intermediate Bulk Containers (IBCs), and Non–Bulk Containers.** The practices specified in this section should be followed to reduce static electricity hazards during filling and emptying of portable tanks, IBCs, and containers.

**8.13.1 Metal Portable Tanks and IBCs.**

**8.13.1.1** Metal portable tanks and IBCs should be bottom-filled, if possible.

**8.13.1.2** Where used for nonconductive flammable liquids, filters should be placed at least 30 sec upstream, as recommended in 8.4.5.1.2.

**8.13.1.3** The portable tank or IBC should be bonded to the fill system prior to opening and should be closed before being disconnected from the bond.

**8.13.1.4** Filling rates should be similar to those normally used for drum filling, about 225 L/min or less, unless the container is inerted.

**8.13.1.5** If the fill pipe does not extend close to the bottom and the vessel is not inerted, a slow start velocity of 1 m/sec or less should be used until the fill pipe is submerged to about 150 mm.

**8.13.1.6** Portable tanks and IBCs with nonconductive linings present hazards somewhat more severe than with drums, due to the larger capacity and the greater energy that can be stored for equal charge densities.

**8.13.2 Nonconductive Portable Tanks and IBCs.**

**8.13.2.1** Filling nonconductive portable tanks or IBCs with combustible liquids at temperatures below their flash points presents no significant static electric ignition hazard. Filling such a vessel with a combustible liquid above or within 9°C of its flash point should be done as if the liquid were flammable.

**8.13.2.2** Refilling a vessel that could contain flammable vapors from a previous product should not be permitted. Additionally, the routine handling of nonconductive vessels filled with any type of liquid can generate a charge on the outside surface of the vessel.

**8.13.2.3** Nonconductive portable tanks and IBCs should not be used where ignitable ambient vapors are present.

**8.13.2.4** Portable tanks and IBCs constructed of nonconductive materials are prohibited for use with Class I liquids by NFPA 30, *Flammable and Combustible Liquids Code*. Where such containers are used for Class II and Class III liquids, the precautions for filling depend on the size of the container, the container design, and the conductivity of the liquid.

**8.13.3 Metal Non–Bulk Containers.**

**8.13.3.1** Where being filled, metal containers and associated fill equipment should be bonded together and grounded.

**8.13.3.2** Bonding should be done with a clamp that has hardened steel points that will penetrate paint, corrosion products, and accumulated material using either screw force or a strong spring. (See Annex G for recommendations.)
8.13.3.3 The clamp should be applied prior to removal of the container bungs and at a point on the top chime that is located away from the bung openings.

8.13.3.4 The grounded fill pipe should be cut at approximately 45 degrees and be left relatively sharp to inhibit brush discharges from the liquid surface.

8.13.3.5 The tip of the fill pipe should extend to within 25 mm of the bottom of the drum and remain beneath the liquid surface until the drum is filled. Viscous liquids that flow without splashing can be deflected by a short fill nozzle to flow down the inside wall of the drum. Inerting of the drum is seldom necessary.

8.13.3.6 Where liquid is dispensed from a metal container, the container should be grounded.

8.13.3.7 Self-closing, metal dispensing valves should be used.

8.13.3.8 Where liquid is dispensed from an upright drum, the dip pipe, conductive hose, and pump should be bonded to the drum and grounded. (For funnels and receiving containers, see 8.13.6.)

8.13.4 Plastic-Lined Metal Non–Bulk Containers.

8.13.4.1 The effects of static electricity from thin, internal coatings, such as phenolic or epoxy paints, can be ignored, provided that the thickness of the coating does not exceed 2 mil (50 microns). The hazards of special coatings such as fluoropolymers have not been fully evaluated and it is advised that at a minimum, liquid is not directly sprayed at such coatings above the liquid level, such as via a hand-held wand.

8.13.4.2 Where the drum has a lining thicker than 2 mil (50 microns), it should be treated as a nonconductive container, unless the lining is either conductive (volume resistivity < $10^5$ ohm-m) or static dissipative (volume resistivity < $10^9$ ohm-m). Conductive and static dissipative linings are adequately conductive to safely dissipate charge provided the lining is not isolated from ground by a nonconductive coating beneath it (see 8.13.4.2.1). Owing to the common use of "surface resistivity" to describe linings, it is recommended that "conductive" types be used where the volume resistivity is in doubt. To avoid spark hazards due to batch defects of "conductive" linings, a simple performance test can be used. For example, megger or tera-ohmmeter measurements can be made between the top and bottom of several lining samples to confirm the resistance is within the range provided by the lining supplier.

8.13.4.2.1 Removable Conductive and Static Dissipative Linings. Drums and pails usually have internal nonconductive phenolic or epoxy internal painted coatings less than 2 mil (50 microns) thick. These coatings can isolate the removable lining plus any liquid contents from ground. No special measures are needed for grounded, lined pails during ordinary liquid transfer and stirring operations, although open pails should be grounded using a clamp at the upper rim that also grounds the removable lining. The following measures should be considered for drums. Open head drums should be grounded using a clamp connected across the upper chime, so that both the drum and removable lining are bonded and grounded. Closed head drums can in many cases be filled via a grounded dip pipe that is fully inserted before the drum is filled. Where these measures are impractical, a helpful measure is to select drums that have coating thicknesses in the range 0.5-1 mil (12-25 microns) so that the breakdown voltage between the lining and the drum is minimized. A pragmatic solution is simply to remove part of the drum coating at the chime so that the lining contacts bare metal.

8.13.4.2.2 Removal linings that are wet with flammable material pose ignition hazards during handling and storage. Conductive and static dissipative linings should be handled by a grounded person (see XXX) and stored outside the operating area in a well-ventilated location. Nonconductive linings pose special hazards if they are stacked and then unstacked, creating static via rubbing. A hazard review should be considered to determine the safest way to handle and store removable linings.

See IEC Section 7.3.5 – my proposed changes are somewhat different (NFPA user level) and address feedback from a paint company

8.13.5 Plastic Non–Bulk Containers. The use of plastic containers for Class I liquids is limited by NFPA 30, Flammable and Combustible Liquids Code. Where such containers are used for Class II and Class III liquids, the precautions for filling depend on the size of the container, the container design, and the conductivity of the liquid.

8.13.5.1 Because plastic containers cannot be grounded, they should not be used for Class I liquids or handled in flammable atmospheres without expert review of the hazards.

8.13.5.2 For Class II liquids, hazards of static electricity should be addressed as follows:
(1) Where the liquid might exceed its flash point during filling or emptying

(2) Where the container might be stored or handled in an ignitible ambient atmosphere

**8.13.5.3** The options that can be used to address the situation specified in 8.13.5.2(1) include bottom filling and cooling of the liquid prior to unloading, especially if the container has been in direct sunlight or in a hot storage area. Continuous inerting during unloading can also be considered.

**8.13.5.4** For the situation specified in 8.13.5.2(2), plastic containers should be stored away from containers of flammable liquids so that the hazard of static electric discharge from the external surface of the plastic container is avoided.

**8.13.6 Hand-Held Containers Up to 20 L Capacity.** The fire risk from static electricity increases with the volume of the container and the volatility of the liquid handled. Thus, the smallest-volume container capable of effectively fulfilling a particular need should normally be selected and should not exceed 20 L.

**8.13.6.1** Listed safety cans should be used, especially those types equipped with a flexible metal dispensing hose so they can be used without a funnel.

**8.13.6.2** Because nonconductive containers cannot be grounded, they should be limited to 2 L for Class IA liquids and 5 L for Class IB and Class IC liquids. An exception is gasoline, for which approved 20 L plastic cans have been widely used for many years with no reported increase in ignition incidents due to static electricity compared with metal cans. That record is due in part to the rapid establishment of rich (above the UFL) gasoline vapor inside the can.

**8.13.6.3** The plastic containers specified in 8.13.6.2 should not be used for other flammable liquids without review of the hazards. Unlike gasoline, conductive liquids such as alcohols can become inductively charged by a charged plastic container and give rise to sparks. In addition, the container can contain an ignitible atmosphere.

**8.13.7 Nonconductive Containers.** Subject to the volume limitations described in 8.13.6, it is common to handle flammable liquids in small glass or plastic containers of 0.5 L capacity or less.

**8.13.7.1** Where the containers specified in 8.13.7 are involved in frequent transfer operations, such as a small-scale solvent blending operation, a grounded metal funnel with a spout that extends to the bottom of the container should be used for filling the container. This practice ensures that any charge induced on the liquid by the container, as could happen if the plastic container has been charged by rubbing, is dissipated through the grounded funnel.

**8.13.7.2** Plastic or glass funnels should be used only where essential for compatibility reasons.

**8.13.8 Containers for Sampling.**

**8.13.8.1** Ignition risk is greatly increased where an ignitible atmosphere is present outside the container; for example, where sampling is directly from a tank or a sample is transferred near a manway, because such a situation can precipitate a large fire or explosion. A grounded metal sample “thief” or glass bottle in a grounded metal sample cage can be used in such cases.

**8.13.8.2** Because they are more easily charged than glass, nonconductive plastic containers should be avoided except where used in well-ventilated areas. If outdoor sampling is carried out at sample spigots that are located away from tank openings and in freely ventilated areas and if sampled quantities are 1 L or less, the fire risk is, in most cases, insufficient to necessitate any special procedures other than bonding of metal components.

**8.13.9* Cleaning.**

**8.13.9.1** Containers should be bonded and grounded prior to being opened for cleaning operations such as steaming.

**8.13.9.2** Cleaning equipment should be bonded or grounded.

**8.14* Vacuum Cleaning.** Collecting liquids and solids in an ignitible atmosphere using a vacuum cleaner can create a significant hazard due to ignition from static electric discharge. If it is necessary to use such equipment in a process area, the hazards and the procedures for safe use should be carefully reviewed and clearly communicated to the potential users.

**8.15 Clean Gas Flows.**
8.15.1 Usually a negligible generation of static electricity occurs in single-phase gas flow. The presence of solids such as pipe scale or suspended liquids such as water or condensate will create charge, which is carried by the gas phase. The impact of the charged stream on ungrounded objects can then create spark hazards. For example, carbon dioxide discharged under pressure will form charged solid "snow." In an ignitible atmosphere, this phenomenon can create an ignition hazard. For that reason, carbon dioxide from high-pressure cylinders or fire extinguishers should never be used to inert a container or vessel.

8.15.2 Gases with very low ignition energies, such as acetylene and hydrogen, that contain suspended material can be ignited by corona discharge where they are escaping from stacks at high velocity. This phenomenon is associated with electrical breakdown at the periphery of the charged stream being vented. Such discharges can occur even if the equipment is properly grounded.

8.16 Plastic Sheets and Wraps.

8.16.1 Nonconductive plastic sheets and wraps, such as those used to wrap shipping pallets, present hazards similar to those of plastic bags. Such sheets and wraps can generate brush discharges from their surfaces following rubbing or separation of surfaces. Isolated wet patches can also create spark hazards.

8.16.2 An additional problem is charging of personnel as they handle plastic sheets and wrap. Plastic sheets and wrap should not be brought into areas that can contain ignitible atmospheres. Plastic pallet wrap can be removed outside the area and, if necessary, replaced by a suitable tarpaulin or other temporary cover. Antistatic wrap is available. Tear sheets (used outside many clean areas) can generate significant static electric charge when they are pulled from a dispenser, and precautions are similar to those for plastic sheets. (Additional information on handling sheet materials is found in Section 10.2.)