NFPA® 72-Proposed 2016 Edition
National Fire Alarm and Signaling Code
TIA Log No. 1189
Reference: Various Sections on Battery
Comment Closing Date: June 19, 2015
Submitter: Herbert Hurst, Savannah River Nuclear Solutions, LLC

1. Add new IEEE Standards Association publications to Chapter 2, Referenced Publications as 2.3.2 and renumber existing 2.3.2 through 2.3.6 as 2.3.3. through 2.3.7 as follows:

2.3.2 IEEE Standards Association Publications. Institute of Electrical and Electronics Engineers, 3 Park Avenue, New York, NY 10016-5997
IEEE Std™ 485, *Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications*, 2010.
IEEE Std™ 1106, *Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications*, 2005

2. Add the following new definitions to 3.3 General Definitions and renumber 3.3 as required:

3.3.31 Battery. Two or more cells connected together electrically. Cells can be connected in series or parallel, or both, to provide the required operating voltage and current levels. Common usage permits this designation to be applied to a single cell used independently. (SIG-TMS)

3.3.31.1 Battery Capacity. The electrical energy available from a fully charged battery expressed in ampere-hours. (SIG-TMS)

3.3.31.2 Battery Charger. A device used to restore and maintain the charge of a secondary battery in which electrical energy is converted to chemical energy. (SIG-TMS)

3.3.31.2.1 Float-Charge. A constant-voltage charge applied to a battery to maintain it in a fully charged condition. (SIG-TMS)

3.3.31.2.2 Fully Charged. A condition synonymous with 100 percent state of charge. See 3.3.31.2.3, State Of Charge. (SIG-TMS)

3.3.31.2.3 State Of Charge (SOC). The stored or remaining capacity of a battery at a given time expressed as a percentage of its rated capacity. (SIG-TMS)

3.3.31.2.4 Trickle-Charge. A continuous, low rate, constant current charge given to a cell or battery to maintain the unit in a fully charged condition. See 3.3.31.2.1, Float Charge. (SIG-TMS)

3.3.31.3 Battery Load Test. A controlled discharge of a battery at a specified rate for a given period of time until a final voltage is achieved in order to determine battery capacity. (SIG-TMS)

3.3.31.4 Battery Unit (Unit). See 3.3.39.3, Unit (Multi-Cell). (SIG-TMS)

3.3.31.5 Rechargeable Battery. An electrochemical cell that is capable of being discharged and then recharged. (SIG-TMS)

3.3.39 Cell. The basic electrochemical unit, characterized by an anode and a cathode, used to receive, store, and deliver electrical energy. [70, 480] (SIG-TMS)

3.3.39.1 Primary (Dry) Cell. A non-rechargeable electrochemical cell requiring periodic replacement such as a 9-volt alkaline cell. (SIG-FUN)

3.3.39.2 Starved Electrolyte Cell. A cell in which liquid electrolyte is immobilized, also known as Absorbed Glass Mat (AGM) or Gel Cell. (SIG-TMS)

3.3.39.2.1 Absorbed Glass Mat (AGM) Cell. A cell in which the liquid electrolyte is immobilized in fiberglass or polymeric fiber separators. (SIG-TMS)

3.3.39.2.2 Gelled Electrolyte Cell (Gel Cell). A cell in which the electrolyte is immobilized by addition of a gelling agent. (SIG-TMS)

3.3.39.3 Unit (Multi-Cell). Multiple cells in a single container such as a 12-volt unit comprised of six 2-volt cells. (SIG-TMS)

3.3.39.4 Valve-Regulated Lead-Acid (VRLA) Cell. A lead-acid cell that is sealed with the exception of a valve that opens to the atmosphere when the internal pressure in the cell exceeds atmospheric pressure by a pre-selected amount. VRLA cells provide a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption. (SIG-TMS)

3. Delete 3.3.197, Primary Battery in its entirety.

4. Add a new 10.6.7.2.1.2 and renumber existing 10.6.7.2.1.2 thru 10.6.7.2.1.8 as 10.6.7.2.1.3 thru 10.6.7.2.1.9.

10.6.7.2.1.2* For battery operation less than 70°F (21.1°C), battery calculations shall include a temperature correction for the minimum expected design temperature.

5. Add new A.10.6.7.2.1.2 to read as follows:

A.10.6.7.2.1.2 Batteries are sized with a 20-percent safety margin. However, in temperatures less than 70°F (21.1°C), the battery will not be able to provide full rated amperes. IEEE 485 provides guidelines for additional margins based on anticipated minimum design temperatures.

6. Revise 10.6.10.2.3 to read as follows:

10.6.10.2.3 ~~Battery Cells~~ Batteries shall be insulated against ground faults.

7. Revise 10.6.10.2.4 to read as follows:

10.6.10.2.4 ~~Battery Cells~~ Batteries shall be insulated to prevent short circuits between multiple battery units ~~cells~~.

8. Revise 10.6.10.2.5 to read as follows:

10.6.10.2.5 ~~Battery Cells~~ Batteries shall be protected from physical damage.

9. Add the following text to 10.6.11.7 to read as follow:

10.6.11.7 Battery and Charger. A separate storage battery and separate automatic charger shall be provided for starting the engine-driven generator and shall not be used for any other purpose. The battery shall be sized per NFPA 110, Chapter 5.

10. In Table 14.3.1, delete Item 9, and replace with new text to read as follows:

9. Batteries[a]				10.6.10
(a) Valve-Regulated Lead-Acid (VRLA) Batteries	X		Ensure month and year of manufacture is marked in the month/year format on each battery cell/unit.	
		Semiannually	Verify marking of the month/year of manufacture on each battery cell/unit. Replace any cell/unit if alarm equipment manufacturer's replacement date has been exceeded.	
	X	Semiannually	Verify tightness of battery connections. Inspect terminals for corrosion, excessive container/cover distortion, cracks in cell/unit or leakage of electrolyte. Replace any battery cell/unit if corrosion, distortion, or leakage is observed.	
(b) Primary (dry) cell	X	Semiannually	Verify marking of the month/year of manufacture. Replace if alarm equipment/battery manufacturer's replacement date has been exceeded. Replacement date not to exceed 12 months. Verify tightness of connections. Inspect for corrosion or leakage. Replace any battery cell/unit if corrosion or leakage is observed.	

11. Add a new footnote to Table 14.3.1 to read as follows:

[a]For other than VRLA or Primary (dry) cell batteries, refer to the battery manufacturer’s instructions or the appropriate IEEE standard; IEEE 450 for vented lead-acid, IEEE 1106 for Nickel-cadmium.

12. Renumber Table 14.4.3.2 Item 7 as Item 8 and revise to read as follows:

~~7~~8. Secondary (standby) power supply [c]	X	Annually	Disconnect all primary (main) power supplies and verify the occurrence of required trouble indication for loss of primary power. Measure or verify the system’s standby and alarm current demand ~~and verify the ability of batteries to meet standby and alarm requirements~~ using alarm equipment manufacturer’s data and verify that the rated capacity of the battery exceeds the system’s standby and alarm requirements by the applied safety factor.
	X		Operate general alarm systems for a a minimum of 5 minutes and emergency voice communications systems for a minimum of 15 minutes. Reconnect primary (main) power supply at end of test.

13. Renumber Table 14.4.3.2 Item 8 as Item 7 to read as follows:

~~8~~7 Uninterruptable power supply (UPS).	X	Annually	If a UPS system dedicated to the system is used as a required power source, verify by the building owner operation of the UPS system in accordance with NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*.

14. In Table 14.4.3.2, delete Item 9, and replace with new text to read as follows:

9. VRLA Battery and Charger[q]			Prior to conducting any battery testing, verify by the person conducting the test that all system software stored in volatile memory is protected from loss.
(a) Temperature test	X	Semiannually	Upon initially opening the cabinet door, measure and record the temperature of each battery cell/unit at the negative terminal with an infrared thermometer. Replace the battery if the temperature of any cell/unit is greater than 18°F (10°C) above the cabinet internal temperature.
(b) Charger test[r]	X	Semiannually	With the battery fully charged and connected to the charger, measure the voltage across the battery with a voltmeter. Verify the voltage is within the battery/alarm equipment manufacturer’s recommendations. If the voltage is outside of the specified limits, either adjust the charger to within limits or replace the charger.
(c) Cell/Unit voltage test	X	Semiannually	With the battery fully charged and connected to the charger, measure the voltage of each cell/unit with a voltmeter. Replace the battery when any cell/unit measures a voltage less than 13.26 volts.
(d) Ohmic test[s]	X		When the battery is installed, establish a baseline ohmic value for each battery cell/unit or where available use baseline ohmic values provided by the battery or test equipment manufacturer. In either case record the base line ohmic value on each battery cell/unit.

		Semiannually	With the battery fully charged and connected to the charger, measure the internal ohmic value of each battery cell/unit. Record the test date and ohmic value on each cell/unit. Replace the battery when the ohmic measurement of any cell/unit deviates from the established baseline by 30 percent or more for conductance and 40 percent or more for resistance or impedance. Where the battery or test equipment manufacturer's baseline ohmic values are used, replace the battery when any cell/unit has an internal ohmic value outside of the manufacturer's acceptable range.
(e)	Replacement/ Load test[t]	3 years	Replace the battery or conduct a load test of the battery. Load test the battery based on the manufacturer's specifications for a discharge rate of 3 hours or more by applying the current indicated for the selected hourly discharge rate continuously, until the terminal voltage decreases to the end voltage specified by the manufacturer. Record the test duration and calculate the battery capacity including adjustment for ambient temperature. Replace the battery if capacity is less than or equal to 80 percent or at the next scheduled test interval if battery capacity is less than 85 percent.

15. Add new footnotes to Table 14.4.3.2 to read as follows:

[q]The battery tests in Table 14.4.3.2 Item 9 are based on VRLA batteries and it is the intent that the tests specified in (a) thru (d) be performed in order. For other secondary battery types, refer to the battery manufacturer's instructions or the appropriate IEEE standard; IEEE 450 for vented lead-acid, IEEE 1106 for Nickel-cadmium.
[r]If the charger is adjustable, adjust the output voltage to 2.265 volts per cell ±0.015 volts at 77°F (25°C) or as specified by the alarm equipment manufacturer.
[s]See A.14.4.3.2 Item 9 (d). A load test per Item 9(e) is permitted in lieu of an ohmic test.
[t]See A.14.4.3.2 Item 9 (e).

16. Add new A.14.4.3.2.Item 9(d) and associated figure, and A.14.4.3.2 Item 9(e) and associated table to read as follows:

A.14.4.3.2 Table 14.4.3.2 Item 9(d) Ohmic testing is a means to determine the state-of-health of a VRLA battery's cells by measuring some form of a cell's internal resistance. Typically ohmic testing equipment use one of three techniques—conductance, impedance, or resistance—to make these measurements.

In simplest technical terms, ohmic technology is based on Ohm's Law, which expresses the relationship between volts, amperes, and ohms in an electrical circuit. Ohmic testing attempts to use voltage and current to determine the resistive characteristic of a battery's cells. As the cells in a battery age and start to lose capacity, the internal components of the battery are undergoing a degradation process. The degradation of these components (plates, grids, internal connection straps) within the battery's cells cause an increased resistance in the conduction paths of the cell, which in turn cause a change in the internal ohmic values. A measured increase in impedance or resistance, or a decrease in conductance, indicates the battery is losing its ability to produce the energy it was designed to deliver when called upon to support the connected loads.

The key to effective application of ohmic testing is the appropriate trending of test results over time compared to a baseline or reference value. Studies have demonstrated that an individual battery produces a unique ohmic "signature" and the use of ohmic testing equipment to trend changes in this signature from installation through the life of the battery is the most effective use of the technology. A program that involves ohmic testing on a regular interval to note changes in the battery is a good maintenance practice.

An ohmic baseline reference value is a benchmark value based on data collected from known good batteries. Reference values can be determined from site-specific measurement, or from testing a sample of new healthy batteries, or by using a generic baseline value to get started.

(1) The best baseline is one established on the installed battery within three to six months after installation and trend accordingly using good record keeping. Ideally the individual ohmic value should be measured at installation and again after the battery has been on float charge for at least 72 hours in order for it to reach a high state of stabilization. These initial "site-specific" values should be recorded and permanently affixed to the battery as a baseline for subsequent tests over the life of the battery. The ohmic value will typically increase for conductance and decrease for resistance and impedance between the initial installation and after being on float-charge for 90 to 180 days (10 percent to 15 percent depending on battery type and size). Six months after

installation measure and compare the ohmic readings to the readings taken at installation. Use whichever value is greater for conductance or lower for resistance and impedance, as the baseline for that particular battery at that site going forward.

(2) A sample of new healthy batteries in a fully charged state can be tested to obtain a baseline value representative of a new battery. A sample size of at least 30 batteries from one manufacturer with the same make, model, amp-hour rating, age (within 6 months), and manufacturing lot is recommended. Record the following information for the batteries:

(a) Battery manufacturer
(b) Model number
(c) Date of manufacture
(d) Manufacturing lot number (if available)
(e) Battery temperature
(f) Has the battery had a freshening charge or not
(g) Battery voltage
(h) Ohmic test value

Calculate the average ohmic value of the batteries. Do not include batteries that deviate more than 30 percent from the average because they could be outside of an acceptable range. Use the average value as a baseline starting point for this model battery.

(3) A generic baseline value for a specific battery model can often be found by contacting the ohmic test equipment manufacturer or from the battery manufacturer. While it is important to note that the use of generic reference values might not be as accurate, it is still possible to identify grossly failed batteries and significant changes in battery condition by applying this method. Generic baseline values are typical averages to be used as general guidelines and should only be used when no other data is available. When testing older batteries for which no initial site-specific ohmic value is available reference values can be obtained in the following ways:

(a) Contact the equipment or battery manufacturer for assistance
(b) Consult your company documentation to see if reference values were created for the battery you are testing
(c) Using ohmic readings of recently installed batteries of the same:
  (i) Manufacturer and model of the battery
  (ii) Manufacturer and model of the alarm panel/system
  (iii) Charging circuit
  (iv) Temperature at time of measurements
  calculate the average ohmic value of the best 8 - 10 batteries and use this value as a baseline reference

As a battery ages and loses capacity, the internal ohmic values change. Although the change might not be perfectly consistent over all battery models and sizes, experience and extensive test data shows that a deviation of ohmic values from the established baseline by 30 percent or more for conductance and 40 percent or more for resistance or impedance indicates that the actual battery capacity has dropped to 80 percent or lower. (For lead-acid batteries, capacity drops off rapidly once the 80-percent capacity point is reached in the lifetime curve, so this is known as the “knee” of the capacity vs. lifetime curve). This 80-percent capacity is the level at which battery manufacturers recommend battery replacement. Figure A.14.4.3.2 item 9(d) illustrates an ohmic trend of a 5-year design life battery with an actual expected service life of 3 years. Note that while battery Unit #1 still has good ohmic readings, semiannual measurements show Unit #2 failing prematurely. For this case, it is desirable to replace both units at the same time. If one unit fails at 1-1/2 years, it is likely the second unit will fail in one of the next semiannual tests. Full replacement ensures that all units will “float” together. One exception would be in the case of “infant mortality” in which one of the units fails in the first year.

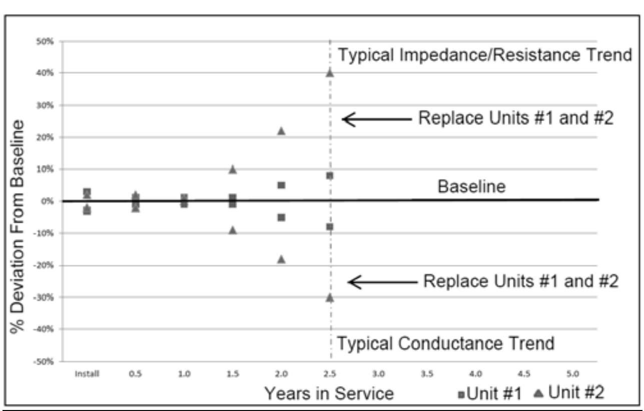

FIGURE A.14.4.3.2 Item 9(d) Example Ohmic Trend Analysis for a 24 Volt Battery Made Up of Two 12 Volt Units.

Ohmic testing can be a safe, simple, accurate, and reliable means of determining the state of health of VRLA batteries. It is important however to understand some basic guidelines in order to maximize the benefits and avoid possible misleading test results.

(1) Follow safety regulations: wear eye protection, remove metal jewelry, etc. prior to working with batteries.
(2) Conduct a visual inspection prior to testing. A cracked case, leaking terminal or post, or bulging battery should be replaced, not tested.
(3) Temperature changes affect measured ohmic values and battery capacity. Ohmic measurements should be taken at 77°F (25°C), +/- 13°F (7°C).
(4) For maximum accuracy and consistency, batteries should be tested when in a fully charged state.
(5) Check the battery charging current prior to test. The charging current should be stable and be within the normal float current recommendations of the battery manufacturer for the battery model. If it is not, it is likely that the batteries have recently been discharged and a test is not appropriate until this float current stabilizes.
(6) Whenever possible, ohmic readings should be taken each time with the same instrument, but as a minimum with the same model. Changing models will skew the data and require re-establishing the base line.
(7) When test equipment is provided with an alert, set the ohmic baseline and/or thresholds prior to beginning the test to provide an indication of any deviations from baseline.
(8) It is essential to take ohmic measurements at the battery terminal or post. For consistency and accuracy subsequent tests should always have probes or clamps placed at the same point while avoiding battery hardware such as bolt heads or washers. Connecting on the hardware will influence the readings and could cause replacement of a healthy battery.
(9) Maintain good contact at the test point for the duration of the test. If the probe or clamp slips off during the test an incorrect reading will result.
(10) For batteries with fully insulated quick disconnect connectors, the battery should be taken offline by removing the quick disconnects from the battery terminals and then measuring and recording the internal ohmic value of the battery.
(11) Do not condemn a battery based upon results of a single test without any trending data or an established baseline for that specific battery.
(12) When one or more units in a battery fall outside the acceptable range from base line, replace the entire string.
(13) A battery tested online can display a different value than when tested offline due to the charger circuit and load being across the battery. Always test the same way, either online or offline, to have consistent and meaningful results. When ohmic testing is performed online, a change in current occurs due to the ohmic test set signal that could impact battery voltage readings. Because battery float voltage is directly tied to float current the sum of the voltages of each battery cell/unit have to equal the charger float voltage of the battery string. If a load is applied from the ohmic test set that depresses one cell/unit, then the others have to rise somewhat to offset it. As ohmic testing progresses through the battery string, each cell/unit gets pulled down by the ohmic test set somewhat and the charger must boost the string current to maintain the voltage, raising the voltage of the cells/units that have not yet been tested. For this reason voltage readings should be taken with a voltmeter prior to performing ohmic testing online.

A.14.4.3.2 Table 14.4.3.2 Item 9(e) Battery capacity is determined by the mass of active material contained in the battery and is a measure of the battery's stored energy. The rated capacity of small VRLA batteries used in fire alarm and signaling system applications is typically measured in ampere-hours (Ah) where the ampere-hour rating is based on the battery's capability to provide a constant current at the nominal battery voltage for twenty hours. The rated capacity might vary from manufacturer to manufacturer.

The *actual* battery capacity during service life, often referred to as the State Of Charge (SOC), can vary significantly from *rated* capacity due to aging, charging and discharge cycles, temperature, and other factors. The unique failure modes of VRLA batteries due to aging and internal degradation are attributed for a high failure rate where the *actual* battery capacity has degraded to 80 percent of the manufacturer's *rated* capacity. As a result, battery manufacturers often recommend replacement much sooner than the rated design life for critical systems.

A test of battery capacity is designed to determine if the battery is capable of continuing to deliver the voltage level specified by the manufacturer. The results of a capacity test can also be used to estimate where the battery is in its service life. A test of capacity is performed by applying a constant load to the battery based on the manufacturer's published discharge rates until voltage falls to specified levels. Although discharging the battery for capacity testing concerns some, VRLA batteries are designed to handle numerous discharges within the limits established by the battery manufacturer.

The discharge rate selected for testing should be representative of the battery duty cycle. At shorter test times the test duration has a greater effect on the capacity calculation. For example, a one-minute difference in actual test time for a 5-minute discharge rate compared to a 3-hour discharge rate will result in a greater deviation of the calculated capacity. The battery is also operating less efficiently at shorter discharge rates and the effects of aging and degradation might not be as prevalent during shorter discharges.

Fire alarm and signaling system loading is typically insufficient for the practical application of a battery load test because the system load cannot be varied to maintain a constant current equal to the battery manufacturer's published discharge rates. The fixed load applied by the system will result in final voltage levels that are deceptively high. Battery sizing is also a factor. The calculated system loads for the battery duty cycle (e.g., 24 hours standby followed by 5 minutes in an alarm) will rarely align with published discharge rates necessary for load testing. In many applications where the battery size is large in comparison to the required system current, the system loading could be too small to accurately determine battery capacity. In these cases, a battery near failure could conceivably satisfy the low discharge rate applied by the fire alarm or signaling system.

In order to satisfy the load test requirements of Table 14.4.3.2 Item 9(e), battery capacity testing can be performed in the following manner or in accordance with other methods such as those identified in IEEE Standard 1188:

(1) Referring to the battery manufacturer's specifications, determine the load current for the 3-hour battery rating to the selected end voltage, typically 1.67 volts per cell (10.2 volts for 12-volt system or 20.4 volts for 24-volt system).
(2) Record the battery temperature at the negative terminal.
(3) Disconnect the charger and connect a load bank to the battery terminals.
(4) Apply the constant current specified for the 3-hour rate to the battery. Once the constant current is applied continue the test until the battery terminal voltage decreases to the specified end voltage.
(5) Stop the test when the selected end voltage is reached
(6) Record the actual test duration in minutes
(7) Disconnect the load bank and reconnect the charger
(8) Calculate percent battery capacity as follows:

$\%Capacity = (T_{actual}/180 \times K_T) \times 100$

where:

T_{actual} = the test duration in minutes

K_T = the temperature correction factor for the actual battery temperature at the start of the test from Table A.14.4.3.2 Item 9(e). Additional Temperature Correction Factors can be obtained from IEEE 1188.

(9) Replace the battery if the battery capacity is less than or equal to 80 percent. Replace the battery at the next scheduled test interval if the battery capacity is less than 85 percent.

Temperature		K_T
°F	(°C)	
65	18.3	0.920
66	18.9	0.927
67	19.4	0.935
68	20.0	0.942
69	20.6	0.948
70	21.1	0.955
71	21.7	0.960
72	22.2	0.970
73	22.8	0.975
74	23.4	0.980
75	23.9	0.985
76	24.5	0.990
77	25.0	1.000
78	25.6	1.002
79	26.1	1.007
80	26.7	1.011
81	27.2	1.017
82	27.8	1.023
83	28.3	1.030
84	28.9	1.035
85	29.4	1.040
86	30.0	1.045
87	30.6	1.050
88	31.1	1.055
89	31.6	1.060
90	32.2	1.065

95	35.0	1.090
100	37.8	1.112

Table A.14.4.3.2 Item 9(e) Temperature Correction Factors.

As a good practice, a new battery should be fully charged and then load tested following the battery manufacturer's recommendations prior to installation. A new battery should have a capacity of at least 90 percent.

17. Revise subsection 27.5.2.8.1 to read as follows:

27.5.2.8.1 Float-charged batteries shall be of the storage type. Primary batteries (dry cells) shall not be used. Vented lead-acid batteries shall be in ~~jars of glass or other identified or~~ approved transparent materials; other types of batteries shall be in containers identified or approved for the purpose.

18. Revise A.10.6.7.2.1.1 to read as follows:

A.10.6.7.2.1.1 Battery calculations take into account standby and alarm discharge rates. The 20-percent ~~minimum reserve capacity~~ safety margin is intended to address both normal aging ~~and~~ effects ~~of~~ on battery ~~loading.~~ capacity and initial battery capacity that may be less than rated capacity. As a battery ages, rated capacity will decrease to 80 percent; therefore, the rated battery capacity should be 20 percent more than the load at the end of battery service life. At initial installation battery capacity may be as low as 90 percent until after several discharge-charging cycles or several weeks of float charge. For additional information on battery sizing considerations, refer to IEEE 485. ~~Some systems with a high rate of alarm signaling battery discharge might require a greater safety margin. Battery calculations should take into account a discharge factor resulting from the discharge of batteries at a greater rate than the one specified in the battery data provided by the manufacturer. For example, valve-regulated lead acid (VRLA) batteries are typically assigned a 20-hour discharge rate(C/20). Any rate greater than C/20 requires using the manufacturer's formula or discharge factor table.~~

19. Delete A.10.6.10 and replace with new text to read as follows:

A.10.6.10 The following type of rechargeable battery is currently used in protected premises applications:

Valve-Regulated Lead-Acid (VRLA) Battery. This rechargeable type battery is generally used in place of primary batteries in applications that have a relatively high current drain or that require the extended standby capability of much lower currents. The nominal voltage of a single starved electrolyte cell is 2 volts, and the battery is available in multiples of 2 volts (e.g., 2, 4, 6, 12). Batteries should be stored according to the battery manufacturer's published instructions. These batteries are often incorrectly referred to as: "sealed lead-acid", "Gel" or "maintenance-free batteries".

There are two technologies available. The most common type is referred to as "absorbed glass mat" or AGM. In this technology, the electrolyte is immobilized by being absorbed into fiberglass mats that surround the plates. Nearly all VRLA batteries in use in U.S. fire protection applications are AGM.

The second technology is referred to as gelled electrolyte. In this technology the electrolyte is immobilized in a silica gel. This technology is predominately seen in European applications. While some manufacturers refer to the battery as a Gel battery in the literature, this needs to be confirmed by the technician. Gel batteries require higher float voltages than AGM and floating an AGM battery at Gel voltages will shorten the battery life.

20. Delete Annex F.4 Batteries and associated Tables in their entirety:

21. Add new IEEE Standards Association publications to Annex H.1.2, Other Publications. Insert as new H.1.2.6 and renumber existing Annex H.1.2.6 through H.1.2.15 as H.1.2.7 through H.1.2.16:

H.1.2.6 IEEE Standards Association Publications. Institute of Electrical and Electronics Engineers, 3 Park Avenue, New York, NY 10016-5997

IEEE Std™ 450, *Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications, 2010.*
IEEE Std™ 485, *Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications, 2010.*
IEEE Std™ 1106, *Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications, 2005*
IEEE Std™ 1188, *Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications, 2005.*

22. Add new EPRI publications to Annex H.2, Informational References as H.2.1 and renumber existing UL Publications section H.2.1 as H.2.2.

H.2.1 EPRI Publications. Electric Power Research Institute, 3420 Hillview Avenue, Palo Alto, CA 94304
Technical Report 1002925, Stationary Battery Monitoring by Internal Ohmic Measurement, 2002
Technical Report TR-10067577, Stationary Battery Guide; Design, Application, and Maintenance, 2002

Submitter's Substantiation: The test methods currently listed in Table 14.4.3.2 Item 9, Battery Tests, do not reflect the testing requirements of battery manufacturers or the Institute of Electrical and Electronics Engineers (IEEE) standards, necessary to support an effective battery replacement program that ensures a reliable secondary power source. This TIA addresses the SIG-TMS Battery Task Group recommendations concerning the battery test methods of Item 9 and other necessary changes within NFPA 72 in support of these recommendations. The recommendations are made with support from the IEEE Stationary Battery Committee project team dedicated to this effort and are based on battery manufacturer's specifications, IEEE standards, and studies performed by various entities including the Electric Power Research Institute (EPRI), North American Electric Research Corporation (NERC), and Albercorp. The recommendations were presented during the Second Draft Meeting held June 23rd and 24th, 2014 where this TIA drew support from the (SIG-TMS) Committee. The SIG-TMS Battery Task Group focused on three primary areas; battery replacement, capacity (load) testing, and alternative test methods.

Replacement: The most prevalent type of battery used as a source of secondary power in fire alarm and signaling system applications is the Valve Regulated Lead Acid (VRLA) battery commonly referred to as a sealed lead or gel-cell battery. Studies show that the service life of a VRLA battery can often be significantly shorter than the design life stated by the manufacturer. An example of the extensive research in this area can be found in EPRI technical reports 1006757, 2002. The shorter service life can be attributed to several inherent factors unique to the design of a VRLA battery such as aging, charging and discharge cycles, temperature, and other factors. Therefore replacement will likely need to occur much sooner than the advertised rated design life, when the actual battery capacity has degraded to 80 percent of the manufacturer's rated capacity. Some manufacturers of small VRLA batteries like those used in fire alarm applications recommend replacement after only three years in standby service. Certain industries where VRLA batteries are widely used in critical applications often implement battery replacement at intervals less than three years.

Due to less common use and inaccuracy of the test methods for lead-acid and nickel-cadmium type batteries given in Table 14.4.3.2 Item 9.(a) and (b), these battery types are deleted and referral to the battery manufacturer or appropriate IEEE standard for testing these types is footnoted in Table 14.4.3.2.

Load Test: The anticipated shorter service life of a VRLA battery requires test methods that support an effective monitoring program capable of predicting battery capacity, thereby assuring replacement occurs before the end of service life. A test of battery capacity is designed to determine if the battery is capable of continuing to deliver the voltage level specified by the battery manufacturer. The results of a capacity test can also be used to estimate where the battery is in its service life. A test of capacity is performed by applying a constant load to the battery based on the manufacturer's published discharge rates until voltage falls to specified levels.

The system loading currently described in Table 14.4.3.2 Item 9(c) is inadequate for the practical application of a battery load test to determine actual battery capacity. This occurs because fire and signaling system loads will not align with battery manufacturers published discharge rates and the load cannot be varied during the test so as to maintain a constant current required for determining actual capacity. The fixed load applied by a fire or signaling system will cause a decrease in current during the load test resulting in final voltage levels that are deceptively high. Additionally discharge rates that simulate the evacuation period are typically short discharges and the effects of aging and degradation may not be as prevalent during because the battery operates less efficiently at shorter discharges.

Alternative Methods: Advancements in certain battery testing technologies have made it possible to determine when a battery has degraded near 80 percent of rated capacity without performing a load test. Various documented studies from within the battery industry demonstrate a consistent correlation of battery ohmic values to battery capacity consistent with EPRI technical report 1002925 as an example. As a result, specific ohmic values of impedance, resistance and conductance have been shown to correspond to 80 percent remaining capacity. Ohmic measurements are relatively simple to perform once a baseline ohmic value has been obtained for the battery under test, eliminating the need for frequent load testing to determine available capacity. Ohmic testing is widely used to monitor battery performance in critical applications such as the power and telecommunications industries and has drawn the support of battery manufacturers and has become an accepted test method of the IEEE Stationary Battery Committee (IEEE-1188).

Additional substantiations for the different sections:

1. Add new IEEE Standards Association publications to Chapter 2, Referenced Publications as 2.3.2 and renumber existing 2.3.2 through 2.3.6 as 2.3.3. through 2.3.7 as follows:
(Basis: Added references to IEEE standards for stationary battery applications that appear in body of the Code.)
2. Add the following new definitions to 3.3 General Definitions and renumber 3.3 as required:
(Basis: Added per the recommendations of IEEE Stationary Battery Committee and NFPA Battery Task Group to introduce correct battery terminology. The new definitions are based on definitions found in published IEEE battery standards, EPRI technical reports, and battery manufacturer's, technical manuals, that have been adapted for the intended use within NFPA 72 by the SIG-TMS Battery Task Group. Refer to: IEEE standards 450 and 1188, EPRI technical reports 1002925 and 1006757, Power-Sonic's SLA technical manual and Enersys Battery Application Manual US-NP-AM-003.)
3. Delete 3.3.198, Primary Battery, as a modified definition is added at 3.3.ii.1:
(Basis: Revised per the recommendations of IEEE Stationary Battery Committee and NFPA Battery Task Group to introduce correct battery terminology. The new definitions are based on definitions found in published IEEE battery standards, EPRI technical reports, and battery manufacturer's, technical manuals, that have been adapted for the intended use within NFPA 72 by the Battery Task Group. Refer to: IEEE standards 450 and 1188, EPRI technical reports 1002925 and 1006757, Power-Sonic's SLA technical manual and Enersys Application Manual US-NP-AM-003.)
4. Add the following text to section 10.6.7.2.1 as 10.6.7.2.1.2 and renumber existing text 10.6.7.2.1.2 thru 10.6.7.2.1.8 as 10.6.7.2.1.3 thru 10.6.7.2.1.9.
(Basis: Added requirement to include additional safety factor necessary for cooler environments to coincide with IEEE 485. because cooler temperatures affect available battery capacity and adjustments to battery calculations are needed to ensure adequate battery sizing.)
5. Add the following text to Annex A as A.10.6.7.2.1.2:
(Basis: Added to include additional safety factor necessary for cooler environments per IEEE Stationary Battery Committee, to coincide with IEEE 485 because cooler temperatures affect available battery capacity and adjustments to battery calculations are needed to ensure adequate battery sizing.)
6. Edit 10.6.10.2.3 to read as follows:
(Basis: Correction of terminology to coincide with definitions provided in change 15 below. Suitable ground fault insulation of cells cannot be verified within a multi-cell battery. The connections of each battery unit should be insulated.)
7. Edit 10.6.10.2.4 to read as follows:
(Basis: Correction of terminology to coincide with definitions provided in change 15 below. Suitable short circuits insulation of cells cannot be verified within a multi-cell battery. The connections of each battery unit should be insulated.)
8. Edit 10.6.10.2.5 to read as follows:
(Basis: Correction of terminology to coincide with definitions provided in change 15 below.
9. Add the following text to 10.6.11.7 to read as follow:
(Basis: Added requirement to ensure storage battery is correctly sized per NFPA 110 for engine-driven generators.
10. In Table 14.3.1, Item 9, delete existing text in its entirety and replace with new text to read as follows:
(Basis: This change is in direct support of the changes to Table 14.4.3.2 recommended by the IEEE Stationary Battery Committee and SIG-TMS Battery Task Group. The recommendation is to introduce correct battery terminology and delete battery types not used, i.e., vented lead-acid and Nickel-cadmium as the test methods for these types contain inconsistencies and errors compared to IEEE standards or battery manufacturers recommendations. The change adds specific requirements for initial/acceptance and semiannual inspections based on published IEEE battery standard and EPRI technical reports. Adjustment to recommended inspection frequency of VRLA batteries found in published IEEE standards and EPRI technical reports is made based on fire alarm and signaling system applications compared to the substantial needs of other more complex configurations in other applications i.e., telephone switch rooms, power generation facilities. In establishing a semiannual frequency the IEEE Stationary Battery Committee and SIG-TMS Battery Task Group considered several factors including; small simple battery configurations, battery design, supervision, battery service life, maintenance cost analysis, and previous NFPA 72 inspection results. The frequency change for Primary (Dry) cell is made based on manufacturer's published test requirements for these disposable

batteries, other Table 14.3.1 inspection frequencies, NFPA recommended practices for smoke alarms, and an unsubstantiated current monthly frequency. Refer to: IEEE standards 450 and 1188, EPRI technical reports 1002925 and 1006757 for VRLA and ANSI C18.1M Part 1 for primary.)

11. *Following Table 14.3.1, add the following footnote to read as follows:*
    (Basis: Footnote "a" added to provide a reference for guidance to the inspection requirements of other battery types previously included in Table 14.3.1.)
12. *Revise Table 14.4.3.2 Item 7. text as follows and renumber as Item 8:*

    (Basis: This change is made to require the functional operation of the secondary power supply at initial acceptance only. The secondary supply (battery) is tested semiannually per the requirements of Item 9. Conversely Item 9 does not provide precise operability requirements for initial/acceptance because the battery has yet to "fully form". In addition, the safety factor required by Chapter 10 needed to be added in the verification of the battery rated capacity. Renumbering places the Secondary (standby) power supply requirement adjacent to the battery test methods of Item 9 and places the Item 8 UPS adjacent to Item 6 Engine-driven generator.)
13. *Renumber Table 14.4.3.2 Item 8. as Item 7.*
    (Basis: Renumbering places the Secondary (standby) power supply requirement adjacent to the battery test methods of Item 9 and places the Item 8 UPS adjacent to Item 6 Engine-driven generator.).
14. *In Table 14.4.3.2, Item 9, delete existing text of item 9 in its entirety and replace with new text to read as follows:*
    (Basis: This change is recommended by the IEEE Stationary Battery Committee and SIG-TMS Battery Task Group to provide a practical test method to monitor battery performance in fire alarm and signaling systems. The recommendation introduces correct battery terminology and deletes battery types not used as the test methods for these types contains inconsistencies and errors compared to IEEE standards or battery manufacturer's recommendations, i.e., vented lead-acid and Nickel-cadmium. The change adds specific test methods for initial/acceptance and semiannual battery tests based on published IEEE battery standards and EPRI technical reports. Adjustment to recommended test frequencies of VRLA batteries found in published IEEE standards and EPRI technical reports is made based on fire alarm and signaling system applications compared to the substantial needs of other more complex configurations in other applications i.e., telephone switch rooms, power generation facilities. In establishing a semiannual frequency the IEEE Stationary Battery Committee and SIG-TMS Battery Task Group considered several factors including; small simple battery configurations, battery design, supervision, battery service life, and maintenance cost analysis to support a semiannual frequency. Refer to: IEEE standards 450 and 1188, EPRI technical reports 1002925 and 1006757, Enersys NP battery application manual.)
15. *Following Table 14.4.3.2, add the following footnotes to read as follows:*
    (Basis for adding the footnote "q" is to clarify that tests in Item 9 should be performed in order due to draw down of ohmic meter affecting battery and charger voltage, footnote "r" provides charging range based on VRLA battery manufacturer's normal charging ranges, footnote "s" is used to reference new Annex A material concerning ohmic testing and allow load testing as an alternative to ohmic measurement, and footnote "t" is used to reference new Annex A material concerning load testing.)
16. *Add the following text, associated figure, and table to Annex A as A.14.4.3.2.Item 9 (d) and A.14.4.3.2 Item 9 (e) as follows:*
    (Basis: Annex material added to provide the user of this Code adequate explanatory information of newly introduced ohmic testing technology and corrected load test methods, providing user's guidance to ensure these tests are conducting properly. These annex additions are in direct support of the changes to Table 14.4.3.2 recommended by the IEEE Stationary Battery Committee and SIG-TMS Battery Task Group based on published IEEE battery standards and EPRI technical reports. Refer to: IEEE standards 450 and 1188, EPRI technical reports 1002925 and 1006757.)
17. *Edit 27.5.2.8.1 to read as follows:*
    (Change to 27.5.2.8.1 is made to clarify that the installation requirement for public alarm reporting system float charged batteries applies to vented lead-acid batteries, not VRLA batteries and that "approved transparent container" should be terminology used as newer technologies are more often used than glass jars. This change is a recommendation of the IEEE stationary battery committee.)
18. *In Annex A revise A.10.6.7.2.1.1 to read as follows:*
    (Basis: This change is recommended by the IEEE Stationary Battery Committee and SIG-TMS Battery Task Group due to inconsistencies with IEEE 485 for battery sizing and incorrect terminology in reference to Chapter 10 and battery manufacturer's discharge tables and their use.)
19. *In Annex A, delete existing text of A.10.6.10 in its entirety and replace it with new text to read as follows:*
    (Basis: Correction of terminology per definitions provided in item 1. above. Correction of technical errors throughout the Annex section i.e., (1) gelled, starved electrolyte, and (3) sealed lead-acid are the same type battery but vented lead-acid is not, although in same paragraph (1). Removal of references to battery types not currently used. Refer to: IEEE standards 450 and 1188, and EPRI technical reports 1002925 and 1006757.)
20. *Delete Annex F.4 in its entirety:*

(Basis: This change is recommended by the IEEE Stationary Battery Committee and SIG-TMS Battery Task Group to delete battery types not used as the test methods do not align with IEEE standards and contains technical errors, i.e., vented lead-acid and Nickel-cadmium and referring to IEEE standard 1106 in Table 14.4.3.2 footnote q).

21. *Add new IEEE Standards Association publications to Annex G.1.2, Other Publications. Insert as new G.1.2.6 and renumber existing Annex G.1.2.6 through G.1.2.15 as G.1.2.7 through G.1.2.16:*
    (Basis: Added references to non-mandatory IEEE standards for stationary battery applications that appear in informational sections.)
22. *Add the EPRI publications to Annex G.2, Informational References as G.2.1 and renumber existing UL Publications section G.2.1 as G.2.2.*
    (Basis: Added EPRI additional informational references to technical reports that include studies of battery design, application, maintenance and monitoring used as supporting information in development of the battery test methods included in Table 14.4.3.2, Item 9.)

Emergency Nature: The battery test methods in Table 14.4.3.2 Item 9 do not currently recognize battery replacement or test requirements recommended by battery manufactures, nationally recognized standards, and independent agencies necessary for an effective battery replacement program that ensures availability of a reliable secondary power source. As currently written, these methods cannot be relied upon to ensure a battery with low capacity will be removed from service before its incapable of satisfying the system current demand.

The SIG-TMS Technical Committee recognized during the last cycle that the inspection and test methods contained in the Code for batteries is outdated and is contains technically errors. The committee sought assistance from those with expertise in current battery technology and recommended means of testing. The IEEE Stationary Battery Committee offered their expertise in support of the SIG-TMS Battery Task Group objectives. This group, working with the SIG-TMS Battery Task Group, developed the information contained in this TIA, but due to the availability and time constraints of the IEEE committee members, the fully developed information was not available until after the First Draft meeting of the SIG-TMS Committee. The fully developed information was provided to the SIG-TMS Committee members prior to the Second Draft meeting for the 2016 Edition of NFPA 72, but it was deemed new material that could not be introduced at that point in the process and yet comply with the NFPA rules and regulations governing Technical Committees. The SIG-TMS Technical Committee decided that since the current material in the 2013 edition of the Code is out-of-date and in contains technical errors, that users of the Code needed to have this information available and the best path to take would be to introduce the material to the Code as a TIA for processing concurrently with a separate TIA for the 2016 edition.

Anyone may submit a comment by the closing date indicated above. To submit a comment, please identify the number of the TIA and forward to the Secretary, Standards Council, 1 Batterymarch Park, Quincy, MA 02169-7471.