IEEE 383-2003 to 2015 Changes

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***Abstract*—IEEE 383 latest revision was approved in September of 2015. This is a revision to the 2003 edition. This paper reviews the major changes and provides some insight as to why the changes were made.**

***Index Terms*—Cable, Class 1E, IEEE 383, LOCA qualification, nuclear facility, qualified life, splice, wire.**

I. INTRODUCTION

IEEE 383 was first published in 1974. The first revision was in 2003. The current revision is 2015. Many changes were made to update IEEE 383 considering life extension from 40 years 60 years, new plant designs with cables and splices starting at 60 year qualified life, subsequent life extension from 60 years to 80 years and beyond. There were many items considered and the items where consensus was established were added. Some items were discussed, but not added. The following are some items discussed that will be considered for the next revision:

1. Information on condition monitoring.
2. How to handle high beta radiation
3. Jacket sump issues as they pertain to qualification
4. Splices and cables being qualified together as a system

II. TITLE

IEEE 383-2015 title is *IEEE Standard for Qualifying Electric Cables and Splices for Nuclear Facilities*. Class 1E was deleted from the title. Deleting Class 1E is consistent with changes in IEC/IEEE 60780-323 that use the "term important to safety". This also recognizes that this standard has also been used for cables that are not safety related. "Field Splices" was changed to splices in the title and throughout the document. There is a caveat on qualification of cables and splices within equipment that allows them to be qualified with equipment. The title was changed from nuclear power generating stations to nuclear facilities. This is consistent with IEEE 627 *IEEE Standard for Qualification of Equipment Used in Nuclear Facilities* which is the parent document to IEC/IEEE 60780-323 that has also been changed to use nuclear facilities in the title.

III. SCOPE

The scope was simplified. This includes changes to be consistent with title, simplifying what is included and adding a note on qualification of fiber optic cable being to IEEE 1682.

A. Direction

The word "direction" was deleted in the scope and a similar change in the purpose changing "direction" to "standard methodology". This recognizes that IEEE 383 is over 40 years old now and provides more than direction for qualifying cable. It should be noted though that this does not mean that it is a cookbook and additional testing may not be required in special cases.

B. Class 1E

Class 1E was deleted to be consistent with the title.

C. Splice

The word "field" before splice, factory splices and factory rework was deleted as no longer being required as these are covered by the more generic term of splice and cable. These all still require qualification as noted in the body of the document if they are used.

D. Nuclear Facility

Power generating stations was changed to facilities to be consistent with the title.

E. Simplified Scope

The sentences "Categories of cables covered are those used for power, control, and instrumentation services, including signal and communication cables. Field cables, wires, and splices are within the scope of this standard." were deleted as this was considered not to be required.

F. Editorial

"Cables, wires" was changed to "Cable, wire" as strictly an editorial change.

G. IEEE 323 Date

The date was updated on IEEE 323 to the latest date of the standard at the time IEEE 383 was being written. A new version (IEC/IEEE 60780-323:2016) is out and this will be reviewed for changes in the next version. Note, this was done throughout the document.

H. As appropriate

In the scope, the term "as appropriate" was deleted as an editorial change. This is implied, and it is noted in the next sentence that this standard may be used for those cases. In most cases cable is qualified to IEEE 383 as an example in IEEE 572, it states that qualification of cable with connectors to this standard does not replace qualification to IEEE 383. It further states that the cable part of the Connection Assembly shall be qualified in accordance to IEEE 383.

I. Splices

Splices was added to the allowance for this document to cover splices within equipment. Splices are now handled the same as cables.

J. Fiber Optic Cables

IEEE 383 is to qualify electric cables, but to be clear it was added that: "For qualification of fiber optic cable refer to IEEE Std 1682." This is to cite the document for fiber optic qualification.

IV. Purpose

Purpose was modified in a similar manner as scope to changing "specific direction" to "standardized methodology" for the same reason as noted above.

1. IEEE 323 was updated to the latest dated as noted with change in scope.
2. Field was deleted before splices for the reason as noted previously. This was also done throughout the document.

V. References

References were changed to normative references as per the style manual with the required text. Documents were limited to those used as requirements in the body of the document. Other documents were moved to the Bibliography. IEEE 627 is not listed as a normative reference since this is an upper tier to IEEE 323. IEEE 627 was added a reference in the bibliography.

1. Titles and dates were updated to the latest published standard.
2. ICEA T-27-581 was added as this was added in the document.
3. ICEA T-22-294 was added as this was added in the document, but without a date. Note, it was known that a revision was in process as this standard was being written, but had not been published before this document was finalized, so the date was left off to refer to the latest version. Note the document has since been issued.
4. ICEA S-97-682 was added as this was added in the document.
5. NFPA 262 was deleted as this is no longer referenced in the document.
6. UL 44 and UL 2556 were added as these were added in the document.

VI. Definitions

The text under definitions was updated based on the style manual. Note, reference is made to IEEE 100 online now, so the bibliography reference was deleted.

1. A definition of nuclear facilities was added since there is not one in IEEE. This is adapted from the IAEA safety glossary 2007 edition.
2. Definition of representative cable was revised to change "same or higher service rating" to "the same voltage class". Also "same or higher volts per mil operating level" is changed to "same or higher operating electrical stress level". This is consistent with original intent, but does change this section.
3. The same changes were made to the definition of representative splice.
4. A definition of "wire" was added since this is listed in the scope. This definition was the consensus of the group for use in this document.

VII. Type Test Selection

There were a variety of changes regarding type test selection.

In 6.2.2 the following was added: "When the insulation and jacket are thermoset, the qualification shall proceed as outlined in this subclause. If one or more of the materials are thermoplastic, or if radiation can improve the performance of the materials, additional samples that have not been thermally aged or irradiated shall also be included in DBE testing." Generally thermoset materials have been used for nuclear applications in the US. This section was added based on some experience with using a thermoplastic material that was crosslinked by irradiating the cable first, but without this the material would have melted in the high temperature part of the test and failed.

In 6.2.2 the following was added: "Reasoning for choice of colors tested shall be documented." This was brought up that generally in the US testing would be done by the manufacturer to ensure proper choice of colorant but this may not be true in other parts of the world.

In 6.2.2 the following was added: "Separate power cable sample(s) may be needed because power cable shall be at rated voltage and rated current when tested. Determination of rated current should consider the cable test configuration and design ambient temperature." This was brought up since in the 1974 version there were specific cables called out that included power cables. In the 2003 version it could be interpreted that a small gauge cable with little current flow could qualify a power cable.

In 6.2.2 the following was modified: "Qualification of a type test sample cable shall qualify cable with the same insulation thickness and with heavier thickness without regard to voltage rating, but within the same voltage class (e.g., 5 kV qualifies 15 kV, and 600 V wall thickness qualifies 1000 V walls) if and only if the same or higher operating voltage stress level is maintained. For low voltage cables, the same or higher average voltage stress (e.g. V/mil or kV/mm) at the operating level voltage is required. For medium-voltage cables and coaxial cables, the applied peak voltage stress (e.g. V/mil or kV/mm) during the test shall be equal to or greater than the peak voltage stress that a test sample of the higher voltage rating would require." This is consistent with the changes in the definitions.

In 6.2.4 the wording was added to clarify splice sample selection that includes representative number of conductors, functional configurations and components shall be used. "To qualify a multiconductor splice (i.e., electrically interconnecting three or more conductors)~~ shall qualify splices with)~~, similar design characteristics., including a representative number of conductors, functional configurations, and components, shall be used.

VIII. Additional Information

Additional information for documentation was added. It was not considered that all the information was significant, but it was considered that additional information may be useful in the future.

1. In 6.3.2.1 the following was added: "and the stranding configuration (i.e., round, compressed or compact)." This is to get more detail on the conductor used.
2. In 6.3.2.2 semiconducting was changed to "stress control layers/". This is because not all stress control layers are semiconducting per ICEA.
3. In 6.3.2.4 "and percent coverage for braided shields, percent overlap and lay of tape shields, and information on other shields such as insulation or overall static shield" was added. This is to get more detail on the shielding used.
4. In 6.3.2.5, modified wording editorially to be clear on information needed to identify fillers and binders.
5. In 6.3.2.8," the date of applicable manufacturing standards, and the date of manufacture" was added. This is to get more detail.
6. In 6.3.3.4 "shields (e.g., in medium-voltage splices)," was added. This is to get more detail.
7. In 6.3.3.5 "Other examples of pertinent service requirements include, but are not limited to, voltage, current, frequency, conductor temperature, and ambient conditions." was added to get more detail as with cables.
8. In 6.3.3.6, "the date of applicable manufacturing standards and the date of manufacture" was added. This is to get more detail.

IV. Aging

A lot of information on aging is contained in IEEE 98, but many people have missed some of the information contained in this standard. Critical information was put in IEEE 383.

1. In 6.4, Arrhenius method was changed to just method and shall conform to IEEE 98 and 101 plus the guidance in IEEE 1 are required. This is to note that any method chosen shall be to these standards.
2. In 6.5.1, "The lowest exposure temperature shall give a life of more than 5000 hours." was added. This has always been in IEEE 98 but is repeated to emphasize this point.
3. In 6.5.1, "Sample form, size and shape shall be considered. The sample thickness shall be representative of what will be used in service." was added. This is also from IEEE 98 but is repeated to emphasize this point.
4. In the footnote it was noted that IEEE 1064 and 775 are withdrawn.
5. In 6.5.2, "if the orientation of compound, crystallinity, and thickness is representative of what will be used in service" was added. This was added based on previous experience with high temperature

thermoplastics where extrusion can orient the polymer and how it is cooled can affect the crystallinity of the cable. Additionally, some of these designs may be used with thin insulation and if so should be tested that way.

6. In 6.5.2, the additional information on inert atmospheres was deleted since it may be misinterpreted to think aging was not required.
7. In 6.5.2 d), it was clarified that coiling was to be done around a mandrel.
8. In 6.5.2 d), changed as follows "80 Vac/mil (3.15 kVac/mm) of insulation thickness at a nominal line frequency of 50 Hz or 60 Hz or 240 Vdc/mil (9.45 kVdc/mm) of insulation thickness." This is to highlight that it based on insulation thickness at a nominal frequency of 50 or 60 Hz. Metric equivalents were also added.

V. RADIATION

In 6.5.3 additional information was added for additional samples per 6.2.2. "If the materials are thermoplastic or radiation can improve the performance of the materials, additional sample(s) that have not been thermally aged or irradiated shall also be included."

VI. DBE

In 6.5.4.1 "The qualification type tests for coaxial, triaxial, twinaxial and data/communication cables should include sufficient testing of cable's critical electrical performance characteristics to permit an adequate analysis of the compatibility of the cables for the specific application, as appropriate." was added. This was adopted from RG 1.211.

VII. NORMAL AND MILD QUALIFICATION

In section 7, "and section 6.5.2." was added after - Qualification for cables and splices located in mild environments shall be demonstrated by providing certified evidence that the cables meet or exceed the specified requirements, including those of recognized industry associations. This was added to emphasize that thermal and radiation exposure for normal service testing to section 6.5.2 is required.

In section 7, "Qualification of low voltages cables shall include long term water immersion testing to ICEA T-22-294 at 90°C with both ac and dc voltage at the cable's rated voltage for at least one year without failure of the sample and with insulation resistance meeting the requirements of ICEA T-27-581/NEMA WC53-2008, section 2.15." was added. This was added as a consensus minimum test to address cable in a wet or submerged environment and is considered a minimum for all cables.

In section 7, "Qualification for submergence of medium voltage cables shall be ICEA S-97-682 for at least one year in the accelerated water treeing test" was added. This was added as a consensus minimum test to address MV cable in a wet or submerged environment and is considered a minimum for all MV cables. Note ICEA is currently being updated to add this as an appendix.

VIII. FLAME TESTING

Section 8 was rewritten as follows: "All cables shall not propagate flame and shall be rated as such by passing the vertical tray flame propagation test requirements of IEEE Std 1202 and UL VW-1 as noted below. In addition the testing shall include samples which have been aged and irradiated to the normal thermal and radiation levels of the plant environment per 6.5.2. Change in jacket color is considered a new design and shall be tested. Switchboard cables, coaxial, twinaxial, and triaxial cables not installed in tray may only be required to pass the UL VW-1 flame test. Single conductors going into multiconductor cables rated 2000 volts or less shall pass the UL VW-1 test. UL VW-1flame test shall be per UL 2556-2013 with the criteria in UL 44-2014 except that for coaxial, triaxial and twinaxial cables, the size tested shall be the actual cable size." This was to clarify the intention that singles (alone or within a cable) be flame retardant as well as the cable. Information on jacket color effecting flame testing was added since this has been an issue on some low smoke zero halogen materials in the past. Aged flame test was added since some issues were brought up with low smoke zero halogen cables after aging.

In section 8, "For cables that need to a fire rating IEEE P1844 may be used." was added. This is to highlight this new standard that was being completed at the time that covers this area. Note, this standard was published in 2015 after IEEE 383.

IX. DOCUMENTATION

In 9.1, "Documentation should also include manufacturer's inspection and maintenance requirements" was added. This provides addition documentation.

X. MODIFICATIONS

In 10, "Generally a change in a large portion of compound such as the base resin will require new qualification, but also small changes such as those of an antioxidant (which may only be 1% of the formulation) may also require new Arrhenius aging as well as DBE testing. Ingredient name changes will require a review, but may or may not require new testing depending upon the circumstance. Changes should always be documented, but effect on qualification is sometimes hard to judge. In this case it is conservative to requalify." was added. This was added to provide some additional normative guidance on modifications.

XI. BIBLIOGRAPHY

References were moved to the bibliography.

1. Reference to IEEE 100 is no longer required by the style manual as this is an electronic dictionary.
2. IEEE 627 was added as an upper tier document to IEEE 323.
3. IEEE 1205, 1682 and P1844 were all added and are referenced in the text, but not as mandatory requirements.
4. NFPA 262 was deleted as it is no longer used.
5. IEC/IEEE 62582 will be considered to be added in the next revision.

XII. ANNEX AND EDITORIAL

Annex B on additional information on modifications was added. This was added to provide some additional information on modifications.

Editorial changes were made in many areas. Changing singular to plural was done in some areas, but unless noted were only meant to be editorial.

ACKNOWLEDGMENT

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