Insulation System Testing

IEEE vs. IEC

Insulation System Testing

- Parent Documents for Insulation System Testing
- Insulation System Testing for LV Applications
- Insulation System Testing for MV Dry-Type Transformers
- Insulation System Testing for Liquid-Immersed Transformers

Parent Documents for Insulation System Testing

- IEEE 99 - Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electrical Equipment

5.2 End-point criteria

The TI/RTI of an insulation system is determined by end-point criteria based on the insulation system's capability to withstand stresses, typically from a functional life test, such as a dielectric withstand test. All of the materials within an insulation system will not age at the same rate, but if the functional life test is designed to be consistent with the stresses of the application for which the testing is performed, the failure will typically occur in the area of the insulation system which would cause a failure during long time loading of the electrical equipment. This may be at the "hottest spot" portion of the electrical equipment or it may be at the weakest link electrically within the equipment design. In cases where these two locations overlap, the failures will be the quickest, and if possible, the test model should try to accomplish this.

Parent Documents for Insulation System Testing

- IEC 60505 - Evaluation and qualification of electrical insulation systems

5.1 Elements for preparing an evaluation method

The preparation of methods for EIS evaluation requires careful consideration of the elements shown in Figure 6:

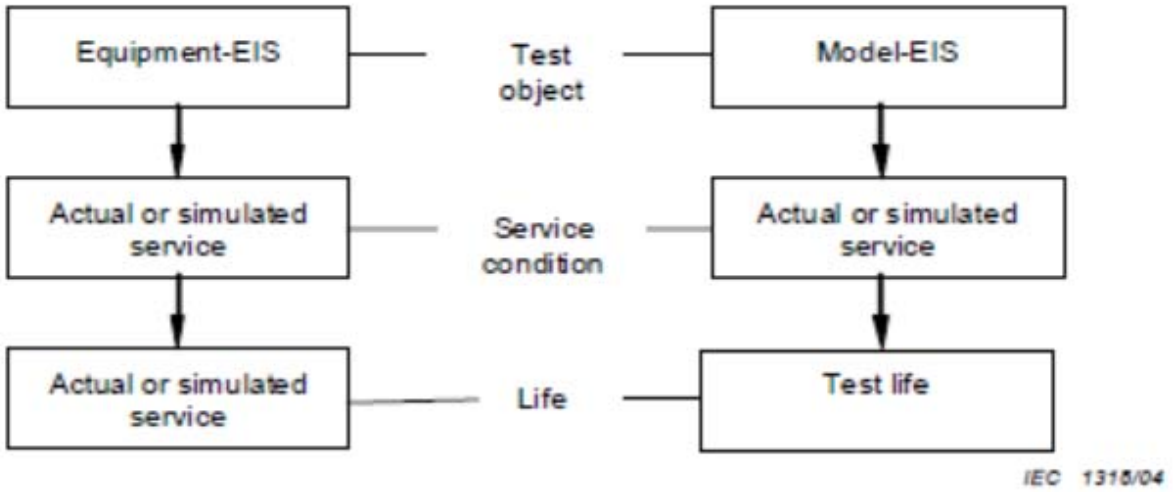

Figure 6 – Elements of evaluation methods

Insulation System Testing for LV Applications

- IEEE 117 - IEEE Standard Test Procedure for Thermal Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery
  - Standardized procedure using motorettes (model designed to simulate insulation system used in a motor)
  - Thermal aging cycles followed by diagnostic procedures to technically evaluate the model after the aging (subject it to environmental stresses followed by dielectric evaluation).
- UL 1446 - Systems of Insulating Materials – General
  - Derived from IEEE 117, provided information on modification of systems, including substitutions and additions.
- IEC 61857-1 - ELECTRICAL INSULATION SYSTEMS – PROCEDURES FOR THERMAL EVALUATION – Part 1: General requirements – Low-voltage
  - Similar in concept to IEEE 117.
  - Many additional parts which provide detail on other types of evaluations (form wound wires, encapsulated systems, etc.). More detail for different types of models than the original motorette.

Insulation System Testing for MV Dry-Type Transformers

- IEEE C57.12.56-1986 - IEEE Standard Test Procedure for Thermal Evaluation of Insulation Systems for Ventilated Dry-Type Power and Distribution Transformers
- IEEE C57.12.60-1998 - IEEE Guide for Test Procedures for Thermal Evaluation of Insulation Systems for Solid-Cast and Resin Encapsulated Power and Distribution Transformers
- Merged into one document – IEEE C57.12.60 – IEEE Standard for Thermal Evaluation of Insulation Systems for Dry-Type Power and Distribution Transformers
  - Just completed revision of this document – submitted to REVCOM for review.
  - Significant revision incorporating a number of changes first proposed within IEC TC112 technical Committee

Insulation System Testing for MV Dry-Type Transformers

- IEC 61857-41 - Electrical insulation systems - Procedures for thermal evaluation - Part 41: Specific requirements for electrical insulation systems for use in dry-type high-voltage transformers with operating voltages of 1kV and above
  - Document current at the CDV stage (document still open for voting) after a number of rounds of drafts and CD's.
  - A number of innovations proposed to "improve upon" what was done in IEEE C57.12.60-2009. Initial draft was quite vague, and this caused concerns over the suitability of this method.
  - Innovations included screening tests, more realistic aging conditions, change procedures (such as are common within IEC).
  - A Voting block of countries has been holding up the completion of this test method. The best of the document has been used to update our IEEE C57.12.60 document.

Insulation System Testing for Liquid-Immersed Transformers

- IEEE C57.100-2011 – Standard Test Procedure for Thermal Evaluation of Insulation Systems for Liquid-Immersed Distribution and Power Transformers
- IEC 62332-1 – Electrical insulation systems (EIS) – Thermal evaluation of combined liquid and solid components – Part 1: General requirements
- IEC 62332-2 – Electrical insulation systems (EIS) – Thermal evaluation of combined liquid and solid components – Part 2: Simplified Test

Insulation System Testing for Liquid-Immersed Transformers

- IEEE C57.100-2011
  - Distribution transformer model test (Lockie test) – primary method
  - Power transformer model test – described. Not aware of any successful evaluation using this methodology
  - Materials testing – sealed tube test
  - Materials testing – dual temperature test
- To coordinate with our loading information from IEEE C57.91, the method requires aging the industry proven system first to develop end-of-life criteria for the aging.
- Aging requires at least three temperatures, 15C apart (span of at least 30C). Extrapolation no more than 40C from lowest aging temperature to resulted temperature index. Detailed discussion in current draft (2nd recirculation) of IEEE 1276 on how to conduct such aging.

Insulation System Testing for Liquid-Immersed Transformers

- IEC 62332-1
  - Dual Temperature Test
- This document is a revision from the original IEC 62332 test originally developed. Aging times/conditions modified based on aging experience from the dual temperature test conducted by Roger Wicks/Tom Prevost in support of our work on IEEE C57.100
- Aging criteria developed are broader than considered in the current version of IEEE C57.100

Solid Insulation Criteria

Characteristics	*Test specification*
Moisture content:	IEC 60554-2 (ISO 287)
Dielectric strength in oil:	IEC 60243-1
Tan δ and permittivity ε in oil:	IEC 60250
Tensile strength:	IEC 60554-2 (ISO 1924)
Compression strength:	IEC 60763-2
Degree of polymerization (cellulose):	IEC 60450

Insulation System Testing for Liquid-Immersed Transformers

Solid Insulation Criteria

Characteristic	*Test specification*
Colour and appearance:	ISO 2049
Breakdown voltage:	IEC 60156
Interfacial tension:	ASTM D971
Acidity:	IEC 62021-1
Dielectric dissipation factor (DDF) at 90 °C	IEC 60247 or IEC 61620
Water content :	IEC 60814
Dissolved gas :	IEC 60567 and IEC 60599
2-furfural content :	IEC 61198

Insulation System Testing for Liquid-Immersed Transformers

- IEC 62332-2
  - Sealed Tube Test
- This document was developed after the completion of IEEE C57.100-2011, and took into account issues found from initial work following this method.
  - Added a requirement to evaluate enamel wire as part of the control and candidate system.
  - Ratio of materials based on weight rather than volume, and an additional ratio for shell-form power transformers was added.
  - Modified the control based on typical insulation systems used in IEC transformers environment (Kraft paper in mineral oil).
  - Aging times/temperatures based on expected life from IEC loading guide (not our IEEE equations).
  - Time frame for the rating based on 20,000 hours rather than 180,000 hours.
- Seems that there have been issues using this method, but the detail of these issues has not been provided to the relevant technical committee, just that there is an issue.

Comparison IEEE - IEC

- In many cases the learnings from implementation of one standard is used to improve the modification/development of the related standard.
- In some cases the differences between IEEE and IEC require different methods (dielectric test methods are different, “controls” are different, etc.).
- The people developing the standards are different. There is some overlap between the groups, but this overlap is very thin (typically the working group chair/convenor and a few more.