

Electrical Insulation System Testing

Qualification of an insulation system to either UL 1446 or IEC standards requires testing of complete, assembled insulation systems. Electrical equipment manufacturers are faced therefore with testing the actual equipment; substituting a motorette or transformette that represents their system; or using a recognized EIS through a material supplier like Du Pont; Schenectady; P. Leo; Ripley Resin who have already done the testing. Because final recognition of a system by UL requires that the system go through 5000 hrs of heat aging at the lowest of the three or four temperatures the system is tested at, many manufacturers choose the preapproved system option.

For the insulation systems used in transformers, motors, etc., the EIS test procedures are found in:

UL STANDARD 1446 Test Procedures for Electrical Insulation Systems

- **Construction of Test Rigs (Motorettes)**

UL or a UL-approved test lab constructs the candidate and control test rigs. Ten rigs are constructed for each test temperature, for both the control and candidate systems. After the test rigs are constructed, a UL engineer approves the construction and records the ingredients; this engineer will typically observe the start-up of the first cycle. Test cycles then proceed as follows:

- **Heat Aging**

Highest temperature: 3-day cycle
Next lower temperature: 7-day cycle
Next lower temperature: 14-day cycle
Lowest temperature: 28-day cycle
Test at end of each cycle

- **Cold Shock**

Hold until stabilized at -20°C (-4°F)

- **Mechanical Stress**

Vibration at 60 Hz
1 hr for motorettes
3 min for transformerettes

- **Moisture Exposure**

Hold for 48 hr at 92 to 100% relative humidity at room temperature.

- **End of Lift Test**

Test rigs are dielectric stressed by 600 V applied phase-to-phase and phase-to-ground and 120 V turn-to-turn, each 10 min. (It is required that the lowest test temperature shall result in a geometric mean time to end-of-life of at least (5000 hrs.)



Manufacturers can test their actual equipment or they can substitute a "motorette" or "transformerette" that represents their system. The motorette pictured can be used to simulate the actual component.

This test procedure qualifies the major components of the insulation system. Major components include ground insulation, magnet wire, interwinding insulation, and varnishes. However, the dip varnish can also be considered a minor component if the motorette or transformerette did not use a varnish. The varnish, like other minor components, can be added to insulation systems by sealed-tube testing.

SEALED TUBE TESTING

Sealed tube testing was devised so that additional materials could be added to the original EIS without going through the full, very laborious motorette or transformerette testing discussed above. Tapes, lead wires, sleeving materials, and dip varnishes can be added to various insulation systems using the sealed tube procedure described below.

UL Standard 1446 Sealed Tube Procedure

- **Sample Preparation *Twisted Pairs of Magnet Wire.*** Twisted pairs of magnet wire used in the original insulation system are prepared, five samples for each tube or straight lengths of a wrapped conductor, an optional varnish overcoat on the wire or conductor, the ground insulation used in the original system.

Reference Tube. This tube contains only materials employed in the original insulation system.

Minor Component Tube. This tube contains all new or substitute materials plus all materials and alternates currently used in the approved insulation system.

- **Preparation of Tubes**

Cleaning. Tubes are first cleaned and dried as needed.

Loading. Twisted wire pairs are inserted in tubes, followed by the component materials, avoiding contact with the magnet wire if possible.

Sealing. Filled glass tubes and the sealing materials are dried 1 hr at 105°C.(221°F) Tubes are then sealed immediately and cooled to room temperature.

- **Sample Conditioning**

Sealed tubes are conditioned 336 hr at a temperature equal to the class rating of the system plus 25°C (45 °F); for example, the temperature for Class 155 (F) would be 180°C. (356°F)

- **Dielectric Stress of Twisted Wire Pairs**

Tubes are cooled to room temperature and then opened just prior to evaluation.

Twisted pairs are stressed until breakdown by increasing the test voltage at a maximum rate of 500 V per second. (Results for the original system components and the new components are compared. The dielectric strength of the new samples cannot be less than 50% of the original.)



These materials are then dried at 105°C (221°F), for one hour and loaded into a tube. This tube is then sealed (hence the name sealed tube) and cooled to room temperature and placed into an oven at 25° C above the system rating (for example, 155 ° C for a Class 130 (B) system) for two weeks (336 hours).

The results of these tests are "recognized" EIS, which are listed in the UL "Yellow Cards" in two places: as UL 1446-recognized EIS and again as IEC 850-recognized EIS. For UL 1446 systems, the listing at UL is under "Plastic Materials and Electrical Insulation Systems (OBJS2). " The EIS listed under IEC 85 are found in the UL "Yellow Cards" under "Insulation System Components, Electrical, Evaluated in Accordance with IEC Publications (OCTU2)."