EIU Course 106: Thermal Classifications General

Section 1 – General

1.1 Thermal classifications refer to the T portion of the T.E.A.M. concept. Electrical Insulation Materials can be assigned a thermal classification based on either the generic chemical composition or on actual long-term thermal aging. Electrical Insulation Systems are assigned a thermal classification based on long-term thermal aging projects only.

Thermal classifications can easily become confusing or be misunderstood since the industry uses thermal classifications for all types of Electrical Insulation Materials, Electrical Insulation Systems, and also end-products. However, the type of testing and thermal classification assigned use different test methods and criteria mean thermal classifications are not uniform.

1.2 Letters or numbers?

The International Standards committees have tried to implement a pattern of assigning thermal classifications to end-products, Electrical Insulation Materials, and Electrical Insulation Systems. End products are assigned ratings using a scale of letters; Electrical Insulation Materials and Electrical Insulation Systems are assigned ratings using numerical values.

The reason for the distinction is that end products must be designed for applications and the design must consider some aspects of all of the expected factors (this reflects to the TEAM concept) while Electrical Insulation Materials and Electrical Insulation Systems can only address one or a limited amount of the T.E.A.M. requirements.

1.2.1 For example, motors or generators may be used as part of earth moving equipment which encounters severe mechanical stress levels, rapid temperature rises and extreme changes in weather conditions. To incorporate the total stresses which go into the design and use of a motor or generator for this application more than thermal factors are involved.

1.2.2 Electrical Insulation Materials are assigned thermal classifications based on thermal (T) stress only. The Electrical Insulation Material level of testing is intended to have only one material involved. The assigned rating for each property evaluated does not include stresses other than thermal during the aging process.

1.2.3 Electrical Insulation System testing does include some level of electrical (E) stress during evaluation plus some exposure to ambient (A) stresses by means of exposure to humidity and/or condensation and mechanical (M) stresses by means of physical vibration during conditioning, but all of

the stresses and conditioning are of a low level.

Based on the different levels of actual stress, the assignment of thermal classifications for end products are expected to be designated by letters.

Based on the more limited levels of actual stress in Electrical Insulation Materials and Electrical Insulation Systems testing, the thermal classification is expected to be designated by numbers.

There is an intended correlation between the letters and numbers used. However, it is essential to realize that the rating assigned to an Electrical Insulation Material or Electrical Insulation System may not transfer directly or equally to all end products. End product total stress levels may be approximately similar to or greatly exceed the stress levels encountered during Electrical Insulation Material or Electrical Insulation System evaluations.

It is expected that design engineers for the end-product are aware of and can interpret the correlation between Electrical Insulation Materials and Electrical Insulation Systems and end-product match-ups.

1.3 When the end-product requirements match with the values of the Electrical Insulation Materials and Electrical Insulation System, the following pattern is correct:

Number	Letter
90º C	
105º C	A
120º C	E
130º C	B
155º C	F
180º C	H
200º C	N
220º C	R
240º C	S

Polymeric materials have a different rating scale. For polymeric materials, the ratings are in 5-degree increments for ratings up to and including 130º C. For temperatures above 130 º C, the rating increment is a 10-degree step.

90 º / 95 º / 100 º / 105 º / 110 º / 115 º / 120 º / 125 º / 130 º / 140 º / 150 º / 160 º / etc.

Some categories of end-products do have additional designations.

1.4 Are all 130 ratings equal?

It is very important to realize that each category of material has a different test program and different categories do not always match with other categories.

Long-Term Thermal Aging can also be referred to as Long-Term Heat Aging (LTHA).

1.5 Magnet wire – Magnet wire has only one property which is evaluated by Long Term Thermal Aging. That property is the retention of electrical insulation. The test is conducted using test specimens made by twisting a pair of wire strands together. This specimen is called a Twisted Pair (TP).

The full details are presented in a 300 level EIU course. The following is a summary:

Sets of 10 or more TP specimens are aged at three or more elevated temperatures. The test voltage applied at the end of each aging cycle is related to insulation thickness of the insulation coating on the conductor. The test is a “Proof” test, meaning a pre-selected voltage is applied across the two legs of each TP specimen for a time of 1 second. If there is no current flow, the insulation is said to be good and the TP specimens are returned to the thermal exposure cycle. This cycle of thermal exposure and electrical stress for evaluation continues until the insulation fails. The life of each TP specimen is recorded and averaged for each temperature.

For magnet wire, the thermal class rating is assigned by projecting the pattern of actual test life at elevated temperature to a pre-selected time coordinate of 20,000-hours. This actual value is called the Thermal Index Value. The thermal index value is then placed into a temperature class by rounding down to the temperature class which is the first one lower than the thermal index value.

For example: if the pattern of the life at elevated temperatures projects to a temperature value at 20,000-hours of 186 °C the thermal class is 180 class. If the projected temperature at 20,000 hours is 206 °C the thermal class is 200 class.

For magnet wire, no reference or “control” material is included into the project. The time coordinate is pre-selected at 20,000 hours. The rating of one wire size is applied to all sizes of wire and all constructions.

1.6 Polymeric Materials – Polymeric materials have a distinctively different program. There are three possible properties which could be evaluated: retained mechanical strength, retained impact strength, and retained dielectric strength.

The thermal index ratings are based on the retention of 50% of the initial value for each property evaluated. Each property which is defined as a fully tested (Primary Property) is assigned the rating by comparing the performance of the new or candidate material against the performance of a known or reference material.

The comparison of properties of an unknown against the performance of a known material means the properties is properly called a Relative Thermal Index.

To compare:

- The magnet wire rating is a Thermal Index value determined without reference to any known reference.
- The magnet wire rating is assigned by projecting to a pre-selected time coordinate.
- The polymeric material's electrical rating is determined by comparing performance against that of a known material.
- The correlation time needed to assign the thermal index (thermal class) rating is determined by the performance of the known reference material; there is no preset correlation time.
- The end of test (end of life) is usually defined as the time at aging temperature at which the measured property is reduced to 50% of the initial value. For a polymeric material the initial break down voltage value could be 30 kV or higher. With this example the end of test would be determined at 15 kV. However, for the magnet wire, if the insulated wire is of the preferred construction of 1 mm diameter bare copper with standard insulation thickness of type 2 (heavy) insulation thickness, the proof test voltage would be 1 kV.

If both materials were to be assigned a rating of 180 °C, the criteria would be unrelated in terms of voltage stress levels.

1.7 The above example is intended to illustrate the fact that each type of Electrical Insulation Material has an established test program; however, different types of Electrical Insulation Materials have different criteria within each test method. The original purpose of most test methods is to provide a program that could be used to generate data for comparison of materials of the same category. The error in usage occurs when a material from one category is directly compared to a rating of a material which is in a different product category. The comparisons must be limited to comparisons within a single product category.

More details of test programs are provided in other EIU courses.