ELTEK International Laboratories

EIU Course 101, Class 2: Spectrum of Testing

Section 1 – General

1.1 In line with the T.E.A.M. concept of the multifactor aspect of the real world application requirements, the testing aspect also covers a wide range of performance properties. There are tests for exposure to elevated temperatures over short periods of time and for extended periods of time. There are tests for evaluation to salt spray, humidity, UV, and oils; tests for physical strength or electrical strength; and for retention of property over time at elevated temperatures. There are tests for almost every property and exposure anyone can think of. When viewed without a pattern, the testing and the results of tests can appear to be random or chaotic.

The total range of testing can be presented from a few different points of view. One point is to approach the “big picture” as a Spectrum of Testing. A different approach is to view the big picture from the T.E.A.M. concept in which the various types of real-world stresses are separated into four main categories which can be tested and then merge the results. The T.E.A.M. concept is presented in a separate course.

1.2 This course is focused on the view of testing as a range from the end-product to the testing of individual materials. Because the various tests can be related to different levels of the overall scheme, this approach is referred to as the Spectrum of Testing (as in spectrum of light).

In the spectrum of light, when viewed in a general way, the separate colors are easy to identify. However, the closer one looks to find exactly where one color ends and the next begins, the more difficult it becomes to actually separate the colors. The same is true for testing.

Many properties of performance are the result of more than one material used in manufacturing the end-product. Many aspects of overall performance cannot be properly defined from the values of a material or from the results of a material being tested under one set of conditions. There is a connection to overall performance and the interaction of each material, each design, and each set of application conditions.

1.3 As presented in a separate EIU course titled the Flow of Standard, the concept of the Flow of Testing begins with the end-product and application. The total extends from the long-term performance and continues to the performance of individual materials. This is summarized in the flow of the Spectrum of Testing below:

Spectrum level	Summary of the Level
1	End-Product testing based on application
2	Build and test a prototype
3	Design – including determination of the thermal class
4	Compatibility of the EIS to the application
5	Test the Electrical Insulation System (EIS)
6	Compatibility of the Materials for the application
7	Long-term testing of the Electrical Insulating Material (EIM)
8	Material Property (Short-term) testing of the EIM

Section 2 – Details

2.1 The spectrum of testing starts with the end-product. All of the safety and performance requirements are based on the safety and performance of the end-product. No testing of an EIS or of any individual material or component can totally replace evaluation of the end-product.

End-product evaluations can be reduced by using information about the EIS or EIM. The thermal classification of the end-product can be assigned based on the EIS selected. Characteristics of the other products may be obtainable from the characteristics of individual EIMs.

2.2 **Spectrum Level 1 – End-product**

In earlier times of the electrical industry, all safety and performance testing was conducted only on end-products. Motors, generators, and transformers were designed and prototypes were built and then tested for perhaps years, to determine the long-term life or long-term performance of the end-product.

The ability to afford such commitments of time and money are rare in today's business world. To remain competitive it is essential to be aware of, and to use (when appropriate), any options which can provide information about performance and safe operations.

Technical information about individual materials or insulation systems may, in some cases, reduce or eliminate certain levels of the evaluation of the end-product. Materials can function as Electrical Insulating Materials (EIM) or as physical support or some other benefit that could add to the product. Since safe operation and long-term performance are related to the total application environment (T.E.A.M.), a review of end-product certification programs will always be expected to start with the end-product.

2.3 **Spectrum Level 2 – Prototype**

Building a prototype unit implies that the design of the end-product with the selection of all materials to be used has been completed. The prototype unit is intended to be a pre-production unit used to evaluate production procedures and processes. A prototype of the final product can be evaluated for actual safe performance.

However, due to cost of time and money, prototypes are usually evaluated without long-term aging. As stated above, the time and cost of long-term evaluations of a prototype unit in today's business world can be cost prohibitive.

2.4 **Spectrum Level 3 – Design**

Design of any end-product requires knowledge of the application, performance requirements, safety requirements, operating temperature limits, material capabilities and other aspects of mechanical stresses during operation and ambient conditions (operating environment conditions).

If the design is to replace materials from different vendors, the design process may be simple because details about the original material and the alternate material can be requested and supplied.

When the design project is to develop a new end-product or to expand the operating range of an existing version of the end-product, the amount of information needed may be much greater.

What options are available to obtain the needed long-term and safety performance? One approach is to build prototype units and test them under application conditions. Another approach is to utilize programs where EIS or EIM information is available. When the EIS or EIM data is not available, it may be necessary to conduct testing at the EIS or EIM level before moving to the prototype level of expense.

For the Design level of activity, most manufacturers require significant information from vendors. Testing conducted by vendors can be provided to any number of manufacturers which can add to cost effectiveness.

2.5 **Spectrum Level 4 – Compatibility at the EIS Level**

Compatibility relates to the evaluation of the end-product in application environments. When an EIS is evaluated for compatibility in the application environment, the information can greatly reduce the testing and evaluation needed of the end-product.

Compatibility testing of an EIS can be conducted in environments related to oils, refrigerants, soaps, detergents, bleaches, or almost any potential environment.

The combination of Compatibility and EIS testing provides the evaluation of the electrical insulation portion of the end-product. This may be sufficient for many end-products.

2.6 **Spectrum Level 5 – Electrical Insulation System (EIS)**

The entire EIS concept was developed and implemented as the result of a major research and development program initiated by the United States military and a small group of commercial manufacturing companies. The program began around 1950 and continued throughout that decade. The results of this program can be found in a report available from:

> U.S. Department of Commerce
> National Technical Information Services
> ADA-044156
> Title: *Reliability Prediction Studies on Electrical Insulation: Navy Summary Report*
> Issued by: Naval Research Laboratories, Washington D.C.
> Issue date: July 1977
> Key researchers: E. Brancato / L. Johnson / F. Campbell / H. Walker

The research summarized in this publication was the original background testing conducted on actual end-products (motors) and the laboratory models which lead to a major part of the IEEE series of test methods for evaluation of EIS.

This research program became the source for most EIS-level programs in our industry today.

An EIS is defined in International Standards such as the International Electrotechnical Commission (IEC) 61857 series as two or more materials, one of which is a conductor and one of which is an insulator. In UL 1446, an EIS is defined as “a unique, intimate combination of two or more insulating materials used in electrical equipment.” The common aspect is as follows: an EIS evaluates the interaction between two or more materials in contact with each other.

EIS testing can be viewed as a long-term compatibility program. The rating of the EIS is based on the performance of the combined group (system) of materials composing the EIS. EIS testing is a Relative Thermal Index (RTI) level of test. RTI testing is covered in a separate course.

EIS testing can provide the thermal rating of the end-product because of the level of conditioning and electrical stresses involved.

2.7 **Spectrum Level 6 – Compatibility at the Material Level**

Compatibility of materials can reduce, or in some cases, eliminate the need for compatibility testing of end-products. Compatibility testing at the material level is of the same nature as the EIS level: to evaluate ambient conditions and performance of the individual material.

If a material cannot show performance in an environment, it is assumed that it cannot perform when used as an EIS or in an end-product.

Manufacturers often need or require material compatibility test results before considering the material for use. The more common applications are oil-filled transformers, refrigerant units, clothes or dish-washing machines, home appliances and similar applications.

2.8 **Spectrum Level 7 – Long-term Performance of Materials**

Long-term performance refers to the concept of evaluating the potential life of a material in an application. The best approach to this type of testing is to compare a potential alternate material's performance to the performance of the original material.

Most of the long-term evaluations are limited to thermal stresses because heat is more controllable making the ratings more reliable. For thermal ratings, the values are called Relative Thermal Index ratings (RTI) when compared to another material's performance, or Thermal Index (TI), when the rating is established by projecting life to a pre-selected time, but the rating is not established by comparison to another material.

2.9 **Spectrum Level 8 – Material Properties**

This level of the spectrum refers to the performance and safety requirements of a material as manufactured or "new". This is the type of information commonly found on material information sheets. This is the material that the vendor wishes to sell and the user is interested in purchasing.

This level of testing is not focused on long-term performance, only the as-received performance.

2.10 The above spectrum of tests is intended to show that there is a relationship between the wide range of tests and the connection between material, systems and production.