EIU Course 101, Class 1: The T.E.A.M. Concept

Manufacturers of end-products are focused on the application and safety of operation. For companies that manufacture products for households, the applications are expected to be used indoors in a relatively controlled climate. Manufacturers of products for use in heavy-duty earth moving equipment know that the temperature variations and weather conditions, as well as the physical vibrations during operation, will be extreme.

These two markets need and select different groups (systems) of materials for these different applications. In simplified terms, the application determines the selection of (1) materials used, (2) the Electrical Insulation Systems, (3) the design and (4) concerns about compatibility.

The real-world applications require addressing safety and performance requirements from many factors. To evaluate the total application environment requires testing of the multiple factors, commonly referred to as multi-factor testing.

The T.E.A.M concept is related to the multifactor requirements of the real world application of any end-product. The concept is intended to focus on the factors which can lead to aspects, safe operation and safe failure of an E/E (Electrical/Electronic) device. End-products must perform based on the expected environment of the intended use.

By understanding this concept, the overall multi-factor safety and performance requirements can be separated into manageable, smaller tasks. After collecting the technical information as single-factor or simplified factor testing, the results can be integrated to provide more information needed to find solutions.

The T.E.A.M concept works best with the English language because of the meaning of each letter. The word TEAM is formed by using the first letter of four individual words which describe possible sources of stress; therefore, possible areas to evaluate. The four words are:

Without separating the total multifactor stresses into smaller more manageable areas, it is difficult to conduct any test to evaluate the total multifaceted stresses of the real world. Applying the T.E.A.M. concept to the testing of EIMs and EIS makes the process easier because the T.E.A.M. stresses are broken down into four individual areas of testing. The results can be integrated to provide insight to the total T.E.A.M.

THERMAL

One of the leading causes for loss of a property is the decomposition of the molecular structure within the EIM and/or EIS. Decomposition is a *chemical* process. Each chemistry, or molecular structure, will have a decomposition rate based on the specific chemistry. The fact that a molecular structure decomposes does not mean that the properties will be reduced.

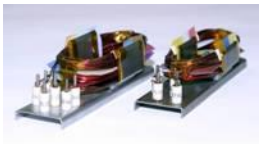
For some molecular structures, the decomposition fragments may still have the ability to provide one property, such as electrical insulation, but not another property, such as physical strength. Hence, each key property must be evaluated for the specific application.

Since decomposition due to thermal stresses can be studied under controlled conditions, it is easy to determine this area of properties.

The most common properties evaluated for retention of performance properties of an EIM are:

- Retention of electrical insulation - measuring insulation breakdown (voltage breakdown).
- Retention of physical properties - measuring tensile strength or flexural strength.
- Retention of impact strength - measuring impact strength.

There are standardized test methods or test procedures for each of these properties. These test methods and specifications are presented separately in other EIU courses. The thermal classifications are also presented as a separate EIU course.



ELECTRICAL

"Electrical" refers to the stresses which may cause failure of the electrical insulation due to the electrical/magnetic forces applied as a result of the energy flow through the conductor or from the environment around the device. These electrical stresses are *not* the same as the electrical stress applied during a thermal aging project to determine if the insulation property has decreased due to decomposition.

These stresses or forces can be the result of:

- Electrical frequency and/or range of frequencies encountered during operation
- Voltage range
- Voltage surges or spikes
- EMI (Electromagnetic Interference)

Measurable properties include:

- Dissipation factor over a range of frequencies at various temperatures
- Dielectric constant over a range of frequencies at various temperatures
- Voltage withstand at various temperatures
- Voltage surges
- Impulse surges

It is difficult to evaluate the long-term retention of these properties since the tests are usually conducted on new material. The initial values for any material will decrease with time (aging). Short-term testing cannot determine any values for materials except for the state of the material under test.

AMBIENT

The term "Ambient" usually relates to the condition of the device due to the environment in which it operates, even when it is not in use.

For example:

- If a device is stored in an unheated warehouse for three months prior to being placed into service, will the device suffer any loss of life after being stored in a freezing temperature exposure?

- Could storage in a hot and dry location affect performance?
- Will moisture accumulate within the insulation that could cause major loss of insulation performance when started?
- Can a dust or salt deposit accumulate during operation which could lead to shortening of operating life?

In order to provide answers to these questions, compatibility tests should be conducted with emphasis on duplicating the ambient environment.

MECHANICAL

The term "Mechanical" usually relates to the condition of the device when it is in use. This relates to physical vibration while operating, movement of coolant and inclusion of dust or moisture. The concern: will there be loss of properties due to exposure of the device to a specific environment?

Testing for environmental factors must be conducted in the appropriate environment in order to relate the information to the application. This means that a wide range of tests may need to be conducted on a single EIM and/or EIS. For this area of concern, it is usually assumed that the device is energized when exposed to the specific environment.

All of the tests evaluating ambient and environmental conditions are commonly identified as "Compatibility Tests". The EIM or EIS is exposed to a specific environment, and the retention of the specific property is measured.

EIM TESTING VS. EIS TESTING

Generally, the thermal classification assigned to an end-product from an EIS level of testing is more reliable at predicting the end-product life because EIS testing includes the materials in direct contact with each other. The EIS conditioning includes thermal exposure, some ambient exposures to cold and moisture, mechanical stress during the vibration cycle and electrical stresses during testing.

The EIM level of testing involves only one material or a simple combination of materials. EIM stress is usually limited to only one type of stress or exposure at a time, such as thermal.

Photos showing decomposition due to heat exposure of EIS test specimens.

Benefit of Utilizing the T.E.A.M. Concept

When the T.E.A.M. approach is understood and utilized, test programs can provide the needed information to solve many problems. One aspect of T.E.A.M. is to also be able to decide when to focus efforts on improvement by redesign and when to focus on selection of new (different) materials.

The table below illustrates the separation of when to redesign and when to search for new materials.

Thermal stresses – long- term performance and some aspects of electrical stresses	Dominated by the material(s) or chemistry, related or limited	The performance cannot exceed the potential of the chemistry. Decomposition is not reversible. To improve performance, select a new EIS or new EIM.
Ambient (Environmental) Mechanical	Design and application related	If the actual performance is not near the potential performance, improvement is within the ability of the existing EIM or EIS. Redesign may provide the improvement needed.

How to determine which to do:

1. Evaluate the end-product using some level of multi-factor stress to find end-of-life under the multi-factor stress level.
2. Compare the actual end-of-life to that projected based on the single-factor evaluations of EIS-level projections.
3. If the actual and projected lives are similar, the solution to improved performance will only be achieved by selecting a new EIM or EIS. A simple guideline: if the life under the real world stress level is within 85% of the projected life based on the EIS level of testing, significant improvement may need to be by selection of a new EIS or EIM.
4. If the actual and projected lives are not similar, redesign is certainly a possible solution. A simple guideline: if the life under the real world stress level is less than 85% of the projected life based on the EIS level of testing, significant improvement may need to be by redesign since the capability is within the EIS or EIM involved.