



PERFORMANCE MATERIALS

COMPLIANCE OPTIONS FOR UL 1446 ELECTRICAL INSULATION SYSTEMS



FACILITATING CUSTOMER ACCESS TO THE GLOBAL MARKETPLACE

UL Certification of electro-magnetic devices that operate at elevated temperatures, including motors, transformers, generators, and solenoids, often requires a thorough review of the electrical insulation system (EIS). UL 1446 “Systems of Insulating Materials” is the de-facto standard that is referenced in over 150 UL Safety Standards and provides guidance on evaluating EIS for safety and performance.

What is an Electric Insulation System (EIS)?

An EIS is a unique combination of closely packed electrical insulating materials (EIMs). As many devices operate at elevated temperatures, thermal degradation of the EIMs is likely to occur, and performance reliability depends on the compatibility of these materials and how they will react together as a system. UL 1446 covers the guidelines and test methods used to evaluate the thermal performance of insulating materials and their interaction as a complete system.





COMPLIANCE OPTIONS

UL offers users of EIS several ways to demonstrate compliance to UL 1446.

Full Thermal Aging Test:

Full thermal aging (FTA), often referred to as long-term thermal aging (LTTA), is designed to monitor thermal degradation of an EIS over time. This test is performed on non-functioning general purpose models (GPMs) and can also be performed on actual electro-technical device samples. The samples/models are exposed to three or more elevated temperatures with intermittent dielectric proof testing. After each heat cycle, samples/models are also typically subjected to a repeated series of environmental exposures such as cold shock, mechanical stress and humidity.

Thermal Class Ratings	
UL Letter Class	Temperature Rating (°C)
E	120
B	130
F	155
H	180
N	200
R	220
S	240
C	Over 240

At the conclusion of the aging program, test results for the proposed EIS are compared to results from a field-proven control EIS. A thermal class rating is then issued based on the results of the testing and a UL Certification report is issued under Electrical Insulation Systems (OBJY2). A typical full thermal

aging program using GPMs lasts 9-12 months and is able to evaluate up to three different enameled magnet wire types (OBMW2), three stand-alone Single- and Multi-Layer Insulated Winding Wire (OBJT2) and 18 EIM ground and interwinding insulations. Testing of GPMs allows the use of the EIS in any electro-magnetic device (motor, transformer, and coil) that operates at or below the established temperature rating. Reduced test programs of one- or two-temperature thermal agings can be used to evaluate modifications to an established EIS.

System Adoption:

Over 160 material suppliers have established certified EIS under the UL category of System Components, Electrical Insulation (OBJS2). This allows end-users to quickly comply with UL 1446 requirements through a System Adoption project to establish their own EIS Certification.

End-users can easily access UL's iQ™ EIS database (iQ.UL.com/systems) to find over 1,500 UL Certified EIS. A parametric search function, also allows users to research and identify possible systems that will work for a specific device. These EIS often reference over 100 different materials that can be used at or below the temperature class listed for a variety of insulation functions.

Once an EIS is identified as suitable for the application, UL will work with the customer to initiate the system adoption process and establish a UL Report under the Electrical Insulation Systems (OBJY2) category.

The system adoption process is the most popular, cost effective, and fastest option. Projects are typically completed in less than two weeks and provide peace of mind that electro-magnetic devices using materials listed in the EIS will be accepted in the end-use evaluation.

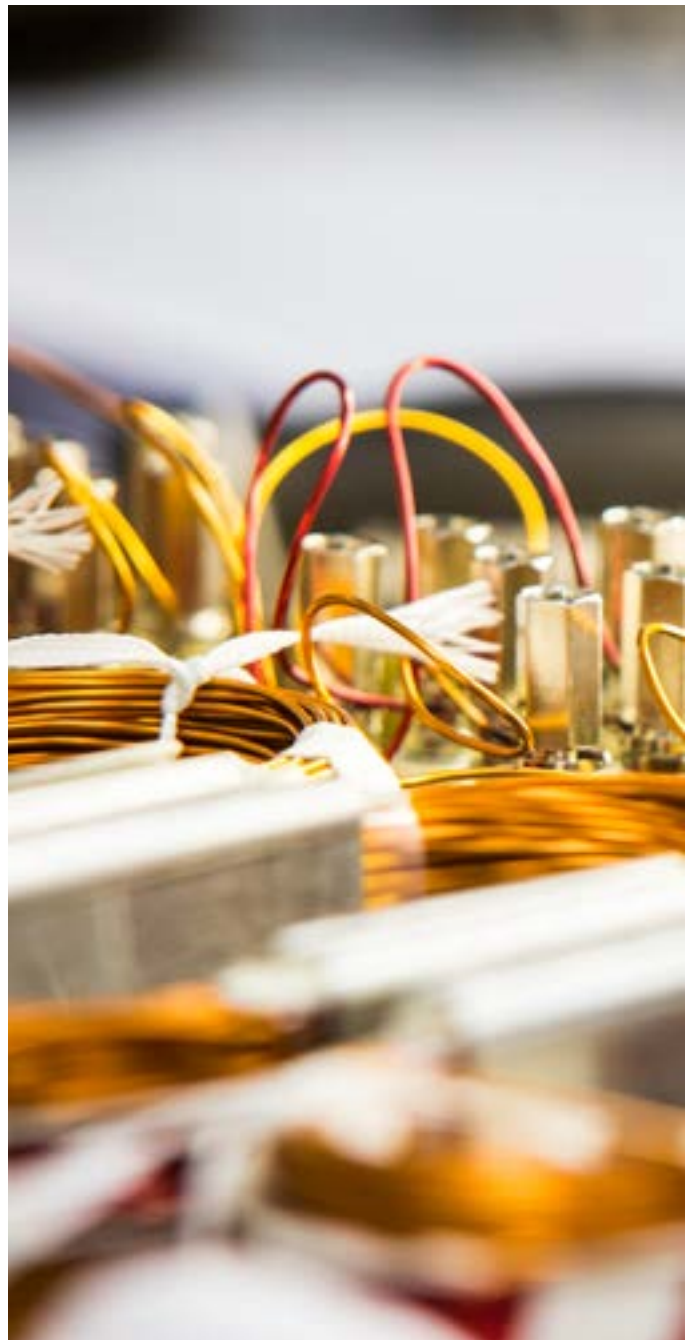
Sealed Tube Chemical Compatibility Test:

After completion of a FTA or system adoption, end users often add new non-electrical insulating materials, including fastening tapes, tie cords, balancing compounds, and tubing and sleeving, through the Sealed Tube Chemical Compatibility Test (CCT).

Designed to address the chemical compatibility of components with the turn insulation of the winding wire, the test is conducted by creating two material samples. The first, a Reference Tube, is a glass test tube containing the applicable materials in the FTA. The second, a Substitute Tube, is a glass tube sealed with the same materials as the Reference and any additional proposed materials. The two sealed tubes are then aged for two weeks at the EIS's established temperature rating, plus 25°C. After aging, the tubes are unsealed and dielectric strength testing is conducted on the magnet wire

from each tube to determine if the additional materials contained in the Substitute Tube have shown any incompatibility with the magnet wire.

A CCT is a great way to expand the list of acceptable materials in a FTA or system adoption without waiting for a complete FTA. This evaluation takes 4-6 weeks to complete.





ALTERNATIVE COMPLIANCE OPTIONS

FTA, System Adoption, and CCTs are the three most common evaluations performed under UL 1446 to demonstrate compliance. However, some additional options may be available depending on the requirements of the governing end-product standard.

High-voltage Full Thermal Aging Test:

UL offers high-voltage (HV) evaluations that are similar to the FTA mentioned above, but are specifically designed to address the performance of high-voltage form-wound rotating machinery and HV power and distribution transformers. The tests are performed on actual form-wound coils or transformer coils to globally recognized IEEE or IEC Standard test methods and a thermal class rating certification is issued by UL based on the test results. Depending on the test methods and governing UL end product standard, various options may be available to make modifications or to evaluate non-electrical insulating materials.

Short-Term Thermal Aging Test for Motors:

The Short-Term Thermal Aging (STTA) Test for Motors is specifically designed to accelerate time to market for clients certifying to the UL 1004-x Series “Rotating Electrical Machines” of standards. The test requirements are covered in ANSI/UL/IEC 60335-1 Annex C and involve cycling six production motors through elevated temperatures and humidity exposures for a total

of 50 days, if the highest aging temperature is chosen. Compliance is determined through an electric strength test and leakage current test.

The results of the STTA evaluation are motor design and type specific, providing limited flexibility of material sourcing and end-use options when compared to the traditional FTA program. Motors that go through this program are re-examined every three years to ensure variances in the motor manufacturing processes have not affected the performance of the EIS.

CCT can be performed after a STTA, but is limited to only non-electrical insulating materials, including tapes, tubing, sleeving, cable ties, lead wire and tie cords. More complex materials (e.g. film laminates, varnishes, encapsulants, and impregnating resins) need to be evaluated through an additional STTA or FTA program.



Getting Started

UL's global sales and engineering teams are available to assist customers looking to comply with the requirements of UL 1446. UL recommends involving the EIS team early in the design process, to better understand test options and reduce the risks. Please contact your local Customer Service Professional at [UL.com/contactus](https://www.ul.com/contactus) or refer to the contact information below:

Sales – US and General: PMSales@ul.com

Sales – Europe: PerformanceMaterials.eu@ul.com



FREQUENTLY ASKED QUESTIONS

What standards and test methods are used for evaluation?

The primary standard used to evaluate electrical insulation systems is UL 1446 “Systems of Insulating Materials.” In this standard, test methods from IEC, ASTM, and IEEE are often referenced depending on the product and intended end-application.

How can I learn more about UL 1446?

UL global sales and engineers are available to answer questions. UL also offers both private and public UL 1446 workshops to accelerate learning and understanding. Contact UL today by visiting UL.com/contactus to find a local representative. Learn more by visiting UL online at UL.com/EIS, UL Performance Materials Public Workshops at: <http://bit.ly/2bDRINr> or by reading UL’s white paper “Reliability of Electrical Insulation Systems”.

How do I know if I need a compliant UL 1446 EIS?

The need to comply with UL 1446 requirements is governed by the end-use product Standard and determined by the UL engineer who investigated the end product. End-product manufacturers should reference the specific requirements written in the applicable end-product standard.

Although requirements vary by standard, most standards require the use of UL 1446 if the EIS hot spot temperature is greater than 105°C, as

thermal degradation of insulating materials is likely to occur at higher temperatures.

Is there a list of common acronyms I can refer to?

Below is a list of common acronyms used in conjunction with UL 1446.

EIS	Electrical Insulation Systems
EIM	Electrical Insulating Materials, commonly referred to as “major components”
NIM	Non-electrical Insulating Materials, commonly referred to as “minor components”
FTA	Full Thermal Aging, also referred to as LTTA
LTTA	Long-Term Thermal Aging
GPM	General Purpose Model, commonly referred to as “motorettes”
CCT	Chemical Compatibility Test, commonly referred to as “sealed tube test (STT)”
STTA	Short-Term Thermal Aging

What Short-Term Thermal Aging Class Rating is needed?

The EIS thermal class rating is determined by the hot-spot temperature measured during the end-product investigation. As an example, an electromagnetic device that has a hot spot temperature of 138°C must have a thermal class rating of at least 155(F) (155°C). In some cases, standards may add an additional safety margin on top of the measured hot-spot temperature.

Is there a list of the different EIS category codes and an explanation of what is covered under each category?

Below is a list of the different EIS categories (often referred to as CCNs) and links to the Guide Information. The Guide Information for each product category provides important information regarding the scope and limitations of UL Certifications and a general description of the products in that category.

OBJ52	Electrical Insulation System Components
OBJY2	Electrical Insulation Systems
OBJY8	Electrical Insulation Systems Certified for Canada
ODCA2	Electrical Insulation Systems Certified to IEC
OBFQ2	Laminate Construction Details for Insulation Systems
OBJT2	Single- and Multi-layer Insulated Winding Wire
OBMW2	Magnet Wire
OBNT2	Magnet Wire Coatings
OBOR2	Varnishes

What steps should I follow to find a compliant EIS?

UL often recommends to first use the iQ™ Electrical Insulation System database (iQ.UL.com/systems) to identify potential insulation systems that will meet your needs. A system adoption project can then be requested if an EIS is identified. This is the fastest and most cost effective way to establish your own EIS certification. In addition, a Sealed Tube Chemical Compatibility Test can be conducted to evaluate additional non-electrical insulating materials that may be required but are not

listed in the adopted EIS.

If no existing insulations system in the iQ database meets your specific needs, a Full Thermal Aging (FTA) project will be conducted. In some cases, the end-product standard may offer alternative certification paths, such as the STTA test for motors.

UL engineers are available to help review specific cases to determine which approach is appropriate

How much does it cost and how long does it take to have an evaluation?

Cost varies depending on the scope of the certification. Once UL has determined the full scope of the investigation, UL will work to determine the estimated cost and time frame. For budgetary estimates, please contact UL sales.

Where will my project be handled and tested?

UL has knowledgeable experts globally and labs in both the US and China to assist clients with EIS certification.

How do I get started on a submittal?

The first step in submitting a product to UL is to contact UL's global sales team. UL's sales team will provide guidance regarding the specific information needed to prepare a quote. After the quote is accepted, a UL engineer will contact the client to discuss the scope of the project, finalize the test scope and sample requirements, review other important matters such as estimated test time and client production dates. In some cases, such as FTA and CCT requests, UL may require a preliminary investigation project to be completed prior to submitting samples to UL for evaluation.

**Learn more at UL.com/EIS or
Contact UL directly at UL.com/contactus**

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