ADDRESSING TEMPERATURE RATINGS AND SAFETY AGENCY REGULATIONS IN MAGNETICS DESIGN

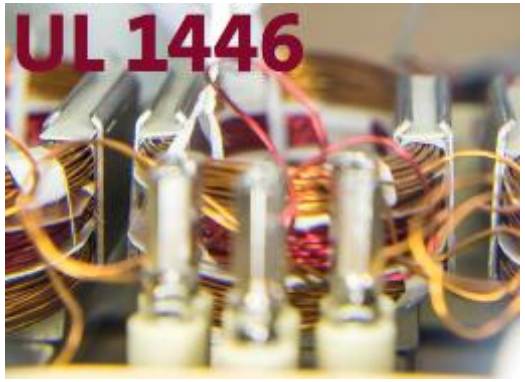
Doug Eaton

Mfg. & Design Engineer

AGENDA

UL vs. UL

- UL Listed VS. UL Recognized
- UL Insulation Systems
- Transformer Temperature Considerations
- Conclusion
- Questions



UL LISTED VS. UL RECOGNIZED

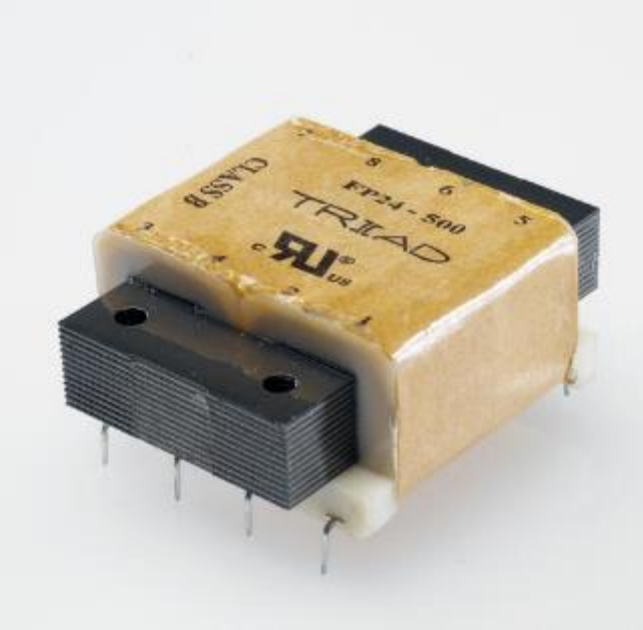
UL LISTED

What Does "UL Listed" Mean?
UL Listed Product Fundamentally, UL Listed products are fully functional, stand-alone products or equipment that fit within a specific category or function as defined by Underwriters Laboratories. If a product is labeled as "UL Listed", it has been thoroughly tested to UL industry and safety standards, which can include everything from fire and flame resistance, mechanical function, and potential electrical hazards.

UL LISTED

UL Listed goods are labeled with a distinctive seal that indicates that the product has met stringent national safety and sustainability requirements as published by Underwriter Laboratories. Having your product UL listed indicates superior quality and enhances your brand's reputation for safety and accountability. UL Listed products require more rigorous testing.

WHAT DOES "UL RECOGNIZE" MEAN?



UL Recognized products are typically parts or components that are manufactured to meet particular industry specifications. These components may be partially complete or have limited operation, as they are intended to be incorporated into larger products or systems. UL Recognition is therefore focused on smaller scale parts and components, rather than UL Listed devices and machinery.

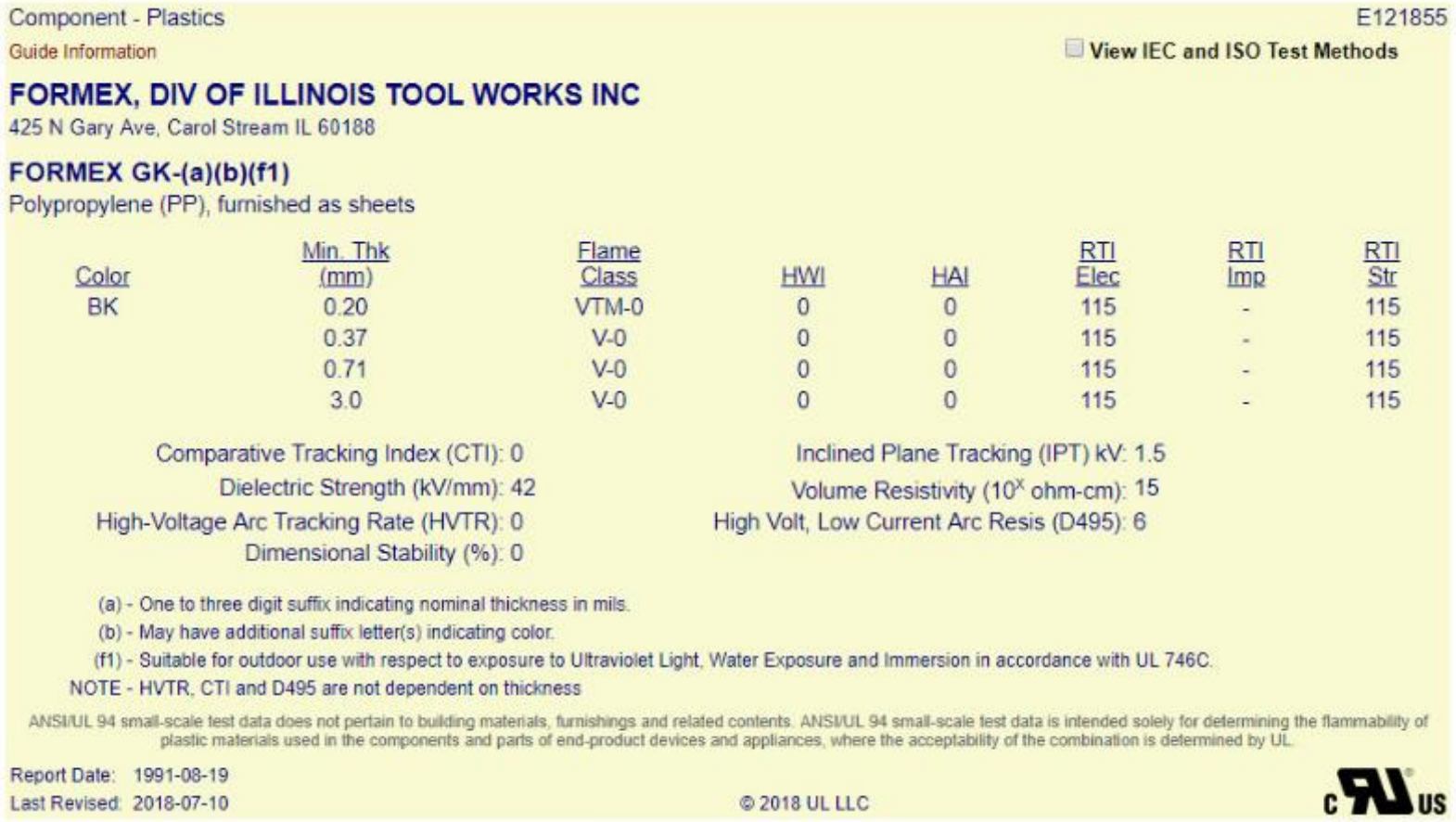
WHAT DOES "UL RECOGNIZE" MEAN?

Many products, such as power supplies, electrical components, and even insulation materials receive UL Recognized certification because they are incorporated into larger systems, but do not have a specified user function on their own. It is important to note, however, that although UL Recognized components have less stringent requirements, they are not of a lower quality. Rather, UL Recognized components and power supplies must still meet certain industry standards to be incorporated into grander designs. This may include appropriate housing for the component or specified installation and manufacturing procedures that protect the device from damage.

UL YELLOW CARD

All materials that are recognized By UL will have a “UL yellow or White card with important electrical and flammability rating.

The UL card with the manufacture's TDS go hand in hand when specifying the right materials.



Component - Plastics E121855

Guide Information ☐ View IEC and ISO Test Methods

FORMEX, DIV OF ILLINOIS TOOL WORKS INC

425 N Gary Ave, Carol Stream IL 60188

FORMEX GK-(a)(b)(f1)

Polypropylene (PP), furnished as sheets

Color	Min. Thk (mm)	Flame Class	HWI	HAI	RTI Elec	RTI Imp	RTI Str
BK	0.20	VTM-0	0	0	115	-	115
	0.37	V-0	0	0	115	-	115
	0.71	V-0	0	0	115	-	115
	3.0	V-0	0	0	115	-	115

Comparative Tracking Index (CTI): 0

Dielectric Strength (kV/mm): 42

High-Voltage Arc Tracking Rate (HVTR): 0

Dimensional Stability (%): 0

Inclined Plane Tracking (IPT) kV: 1.5

Volume Resistivity (10^X ohm-cm): 15

High Volt, Low Current Arc Resis (D495): 6

(a) - One to three digit suffix indicating nominal thickness in mils.

(b) - May have additional suffix letter(s) indicating color.

(f1) - Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL 746C.

NOTE - HVTR, CTI and D495 are not dependent on thickness

ANSI/UL 94 small-scale test data does not pertain to building materials, furnishings and related contents. ANSI/UL 94 small-scale test data is intended solely for determining the flammability of plastic materials used in the components and parts of end-product devices and appliances, where the acceptability of the combination is determined by UL.

Report Date: 1991-08-19

Last Revised: 2018-07-10

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UL STANDARD 1446

UL Certification for electro-magnetic devises operating at higher temperatures like motors, transformers generators, and solenoids.

UL Standard 1446 covers the electrical Insulation System (EIS) Covering the guidelines, testing Used to evaluate the thermal performance of the insulating materials and their interaction As a complete system

Types of Testing

- Full Thermal Aging Testing (9-12 month typically)
- Sealed Tube Chemical Compatibility Testing (4-6 weeks)
- Defined Life Thermal Aging Testing (less samples than Full Thermal Testing)
- High-voltage Full Thermal Aging Testing. (uses form wound coils and tested to recognized IEEE or IEC standard test methods)
- Short-term Thermal Aging Testing for Motors

UL INSULATION SYSTEMS

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

Electrical Insulation Systems (EIS) categories (often referred to as CCNs). Provide important information regarding the scope and limitations of UL Certifications and a description of the Products in that category.

OBJS2 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

UL INSULATION SYSTEMS ADOPTION

If you have a UL Insulation System an UL Field Inspector will come to your manufacturing location four times a year. They will verify that the materials and label match the file.

If you are using a manufacturer or would like to know if a manufacturer has an UL Insulation System or a UL Listed file, you can check Here: https://productiq.ulprospector.com/en

- There are over 160 material suppliers which have certified EIS under UL category of System Components, (OBJS2).
- Adoption of one or more of these systems is normally very quick.
- The system you adopt will be under UL category of System Components (OBJY2)
- If you are a manufacturer of magnetic devises that fall under the UL 1446, you may want several Insulation Systems to build to. It is helpful to your customer should the finish product be going through UL certification.
- As a magnetics designer for the end user, it is good to know if you manufacture is build your magnetics to an insulation system. If an insulation system is required, it is important to work with your magnetics manufacturer when specifying material.

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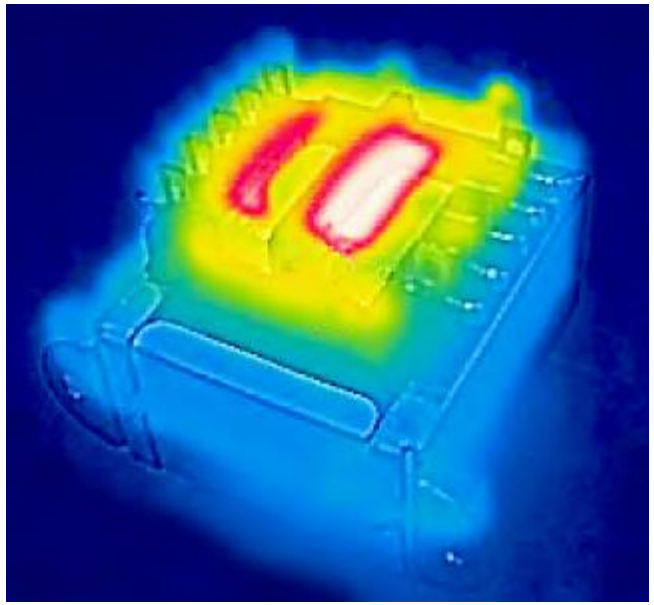
UL INSULATION SYSTEMS



Insulation class. A transformer's insulation system receives a class number according to the highest temperature at which it can operate. Based on NEMA-established standards, this class number is equivalent to the transformer’s maximum full load temperature rise plus its maximum allowable ambient temperature in degrees Celsius. For example, a transformer with a Class B insulation system rated for 130°C would allow for a maximum 40°C temperature rise and 90°C ambient. Insulation system ratings also dictate the transformer's overload capacity. For safety and long-term reliability, it is important to keep the transformer operating below the insulation system's temperature maximum rating.

UL INSULATION SYSTEM

UL iQ for Electrical Insulation Systems
https://iq.ul.com/systems/

This is where you can search for Manufacturer's UL Insulation Systems By:
Manufacturer's Ground Insulations
Manufacturer's Insulating Tapes
Manufacturer's Varnish
Manufacturer's Potting compound
"Encapsulated" System
Class
Wire Type

UL Thermal Class Ratings, Adoptable Systems			
UL Letter Class	Temp. Rating (°C)	Lower Voltage	>1000 VAC
E	120	5	0
B	130	942	0
F	155	909	2
H	180	588	13
N	200	161	0
R	220	178	48
S	240	13	0
C	Over 240	2798	

TEMPERATURE RISE VS. INSULATION CLASS

When selecting a transformer for an application, consider temperature rise and insulation class.

- **Temperature rise.** Temperature rise refers to the average temperature increase of the transformer above ambient temperature when the device is fully loaded according to the rating. This self-heating occurs due to conductor and core power losses. The transformer's capacity or rating is limited by the maximum temperature tolerated by the insulation system.

TEMPERATURE RISE AND EFFICIENCY

- One of the main factors influencing a transformer's efficiency and lifespan is temperature. While most transformers are designed to operate for a few decades, regular exposure to temperatures above the device's tolerable limit can lead to rapid degradation of insulating materials and a reduced lifespan. Transformers with low efficiencies tend to generate more waste heat, which results in a higher temperature rise. In general, the more efficient the transformer is, the lower its temperature rise.

ESTIMATING THE TEMPERATURE RISE OF A TRANSFORMER

- A transformer's acceptable temperature rise depends on several factors including cost, physical space limitations, types of materials used in the device, relevant safety regulations, and temperature tolerances of other components near the device. Most of a transformer's temperature rise is attributable to power losses in the core and the windings, which are dissipated in the form of heat.

ESTIMATING THE TEMPERATURE RISE OF A TRANSFORMER (LOSSES)

- **Core Losses.** Energy loss from the transformer's electromagnetic core has a substantial impact on the device's temperature rise. Core losses mainly occur in the form of hysteresis loss and eddy current loss, with a small amount of residual loss.
- **Hysteresis loss.** Hysteresis loss occurs as a result of a lag or delay of the magnetic molecules within the core. During operation, the flow of current in forward and reverse directions causes magnetization and demagnetization in the transformer's core. This creates friction in the core's molecules, which results in heat generation and an undesirable increase in temperature.
- **Eddy current loss.** Eddy currents are induced within conductors as a result of a changing magnetic field. These currents circulate within the magnetic core, dissipating energy as heat.

ESTIMATING THE TEMPERATURE RISE OF A TRANSFORMER (WINDING LOSSES)

- **Winding Conductor Losses**

Losses from the transformer's primary and secondary windings also contribute to total energy loss and temperature rise. Winding losses are influenced by a combination of factors, including:

- Skin effects
- Proximity effects
- Edge effects
- Conductor effects
- Eddy currents in the windings
- Fringing flux intersecting with the windings close to the core gap

OTHER ASPECTS THAT AFFECT TEMPERATURE

- **Installation space.** The space in which the transformer will be installed should be kept in mind during the selection process, since proper transformer specifications are often highly dependent on the conditions of their surrounding environment. How close is the transformer to components that give off heat or our heat sensitive.
- **Ambient temperature and cooling.** Where is the transformer going to be mounted? Inside or out and in what environment? Will it be passively cooled or have a fan or other active methods of cooling.

THANK YOU

Doug Eaton

deaton@triadmagnetics.com

www.TRIADMAGNETICS.com