U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: SPECIFICATION FOR SERIES TO SERIES ISOLATION TRANSFORMERS FOR AIRPORT LIGHTING SYSTEMS

Date: DRAFT **Initiated by:** AAS-100

AC No: 150/5345-47C **Change**:

1. PURPOSE. This advisory circular (AC) contains the Federal Aviation Administration (FAA) specifications for series to series isolation transformers for use in airport lighting systems.

2. EFFECTIVE DATE. Effective six months after the issue date of this AC, only that equipment qualified in accordance with the specifications herein will be listed in accordance with AC 150/5345-53, *Airport Lighting Equipment Certification Program*.

3. CANCELLATION. AC 150/5345-47B, *Isolation Transformers for Airport Lighting Systems*, dated June 30, 2005, is cancelled.

4. APPLICATION. The Federal Aviation Administration (FAA) recommends the guidance and specifications in this Advisory Circular for isolation transformers. In general, use of this AC is not mandatory. However, use of this AC is mandatory for all projects funded with federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charges (PFC) Program. See Grant Assistance No. 34, "Policies, Standards, and Specifications," and PFC Assurance No.9, "Standards and Specifications." All transformer designs contained in this standard are the only means acceptable to the Administrator to meet the lighting requirements of Title 14 CFR Part 139, Certification of Airports, Section 139.311, Marking, Signs and Lighting.

5. PRINCIPAL CHANGES. The following principal changes are incorporated:

a. Paragraph 2.3, ASTM Specification D4247 is withdrawn with no replacement.

Withdrawn Rationale:

This specification covers cross-linked polychloroprene compounds suitable for use as outer coverings or jackets on electrical cables for general-purpose, black heavy-duty and black extra-heavy-duty service.

Formerly under the jurisdiction of Committee D09 on Electrical and Electronic Insulating Materials, this specification was withdrawn in January 2006. The Executive Committee felt strongly that Committee D09 could not support the practice of maintaining a standard for which the expertise may not lie within the current committee membership, or for which the utilization of the standard is questionable.

6. METRIC UNITS. To promote an orderly transition to metric units, this specification includes both "English" and "Metric" dimensions. The metric conversions may not be exact equivalents and until there is an official changeover to the metric system the English dimensions will govern.

MICHAEL J. O'DONNELL
Director of Airport Safety and Standards

1.0 Scope and Classification.

1.1 Scope.

This specification details the certification requirements for series to series isolation transformers for use in airport lighting systems.

1.2 Classification.

Transformers are designated as type L-830 for 60 Hz operation and type L-831 for 50 Hz operation. A numerical suffix identifies the wattage and current rating. The following transformers are included in this specification.

Table 1. Transformer Types

TYPE		WATTAGE	PRIMARY	SECONDARY
60 Hz	**50 Hz**	Watts	**AMPS**	**AMPS**
L-830-1	L-831-1	30/45	6.6	6.6
L-830-2	L-831-2	30/45	20.0	6.6
L-830-3	L-831-3	65	6.6	6.6
L-830-4	L-831-4	100	6.6	6.6
L-830-5	L-831-5	100	20.0	6.6
L-830-6	L-831-6	200	6.6	6.6
L-830-7	L-831-7	200	20.0	6.6
L-830-8	L-831-8	300	6.6	20.0
L-830-9	L-831-9	300	20.0	20.0
L-830-10	L-831-10	300	6.6	6.6
L-830-11	L-831-11	300	20.0	6.6
L-830-12	L-831-12	500	6.6	20.0
L-830-13	L-831-13	500	20.0	20.0
L-830-14	L-831-14	500	6.6	6.6
L-830-15	L-831-15	500	20.0	6.6
L-830-16	L-831-16	10/15	6.6	6.6
L-830-17	L-831-17	20/25	6.6	6.6
L-830-18	L-831-18	150	6.6	6.6
L-830-19	L-831-19	150	20.0	6.6

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2.0 Referenced Documents.

2.1 General.

The following is a listing of documents applicable to the extent referenced in this advisory circular.

2.2 FAA Advisory Circulars.

AC 150/5345-26	*FAA Specification for L-823 Plug and Receptacle, Cable Connectors*
AC 150/5345-53	*Airport Lighting Equipment Certification Program*

2.3 American Society for Testing Materials (ASTM) Standards.

D2240	*Standard Test Method for Rubber Property - Durometer Hardness*

2.4 Institute of Electrical and Electronic Engineers (IEEE) Standards.

C57.12.91-2001	*IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*

2.5 Joint Insulated Cable Engineers Association (ICEA) and National Electronic Manufacturer's Association (NEMA).

ICEA S-95-658/ NEMA WC 70	*Non-shielded 0-2kV Power Cables*
ICEA S-96-659/NEMA WC 71	*Standard for Non-shielded Cables Rated 2001-5000 Volts for use in the Distribution of Electrical Energy*

FAA Advisory Circulars are available on the FAA Airports web page:

http://www.faa.gov/airports/resources/advisory_circulars/

Copies of ASTM standards may be obtained from:

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

Phone: (215)299-5400
Website: http://webstore.ansi.org

Copies of IEEE Standards may be obtained from:

IEEE Customer Service
445 Hoes Lane
PO Box.1331
Piscataway, NJ 08855-1331

Fax: (732)981-9667

E-mail: onlineproducts@ieee.org
Website: https://webstore.ansi.org

Copies of joint ICEA/NEMA standards may be obtained from:

Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112, USA

Phone: (800) 854-7179 or (303) 397-7956
Fax: (303) 397-2740

Email: global@ihs.com
Website: http://global.ihs.com

3.0 Series to Series Isolation Transformer Equipment Requirements.

3.1 Component Parts.

NOTE: *The series to series isolation transformers will be referred to in all subsequent paragraphs as "transformers."*

The transformers must consist of electrically separate primary and secondary coils wound upon a core and encapsulated in a watertight case with rubber (or an equivalent rubber-like material) connectors molded on the primary and secondary leads.

3.2 Materials.

Materials must be as specified in this document. When materials are not specifically designated, they must be of the best commercial quality and suitable for the design purpose.

3.3 Design and Construction.

a. The transformers must be designed and constructed so that no parts will work loose in service. All transformer electrical connections must be permanent.

b. Transformers must be built to withstand strains, jars, vibrations and any other conditions incident to shipping, storage, installation, and service.

c. Transformers must be designed to operate when immersed in water and buried in the ground (with runway deicing agents present, e.g., sodium formate, potassium acetate, ethylene/propylene glycol, and salt).

d. The shape and design of the transformers is optional provided all the requirements in this specification are met.

e. Transformers must be designed to meet this specification when operated in any orientation.

3.3.1 Windings.

a. The transformer primary and secondary windings must be insulated from each other and the core.

b. Windings on the core assembly must be wound tightly and secured prior to molding to reduce the possibility of loose turns being forced close to the outer surface during pressure-molding operations.

c. Transformers must be designed to operate indefinitely with short or open-circuit loads placed on the secondary winding with the rated current and frequency input applied on the primary winding.

d. The transformers must have sufficient capacity to allow for lamp aging, secondary lead losses, and contact losses.

3.3.2 Operating Conditions.

a. The transformers must be constructed for continuous outdoor service at temperatures from -67 to 149 degrees Fahrenheit (F) (-55 to +65 Celsius (C)).

b. Transformers must operate properly when buried in the ground and submerged in water with up to 5,000 volts between the primary winding and ground.

3.3.3 Frequency.

Transformers must be designed to operate at their rated frequency.

3.3.4 Electrical Characteristics.

Isolation transformers electrical characteristics must be per Table 2.

Table 2. Isolation Transformer Electrical Characteristics

Type	Wattage (Watts)	Primary Amps	Min. Power Factor	Min. Efficiency (Percent)	Secondary Full Load Amperes	Secondary Short Circuited Amperes	Load Ohms	Secondary Maximum Open Circuit Voltage - RMS
L-830-1	30/45	6.6	0.95	80	6.53 - 6.67	6.6 - 7.1	1.15	25
L-830-2	30/45	20.0	0.95	80	6.53 - 6.67	6.6 - 7.1	1.15	25
L-830-3	65	6.6	0.95	80	6.53 - 6.67	6.6 - 7.1	1.60	30
L-830-4	100	6.6	0.95	85	6.53 - 6.67	6.6 - 7.1	2.44	70
L-830-5	100	20.0	0.95	85	6.53 - 6.67	6.6 - 7.1	2.44	70
L-830-6	200	6.6	0.95	90	6.53 - 6.67	6.6 - 7.1	4.82	100
L-830-7	200	20.0	0.95	90	6.53 - 6.67	6.6 - 7.1	4.82	100
L-830-8	300	6.6	0.95	90	19.8 - 20.2	20.0 - 22.0	0.90	70
L-830-9	300	20.0	0.95	90	19.8 - 20.2	20.0 - 22.0	0.90	70
L-830-10	300	6.6	0.95	90	6.53 - 6.67	6.6 - 7.1	8.25	135
L-830-11	300	20.0	0.95	90	6.53 - 6.67	6.6 - 7.1	8.25	135
L-830-12	500	6.6	0.95	90	19.8 - 20.2	20.0 - 22.0	1.35	70
L-830-13	500	20.0	0.95	90	19.8 - 20.2	20.0 - 22.0	1.35	70
L-830-14	500	6.6	0.95	90	6.53 - 6.67	6.6 - 7.1	12.0	230
L-830-15	500	20.0	0.95	90	6.53 -6.67	6.6 - 7.1	12.0	230
L-830-16	10/15	6.6	0.95	70	6.53 - 6.67	6.6 - 7.1	0.34	8.0
L-830-17	20/25	6.6	0.95	70	6.53 - 6.67	6.6 - 7.1	0.57	8.0
L-830-18	150	6.6	0.95	85	6.53 - 6.67	6.6 - 7.1	3.58	70
L-830-19	150	20.0	0.95	85	19.8 - 20.2	6.6 - 7.1	3.58	70

NOTE 1: *Voltage ratings must be: primary winding - 5,000 Volts; secondary winding- 600 Volts.*
NOTE 2: *Table also applies to type L-831 Transformers.*

3.4 Component Details.

3.4.1 Case.

a. Transformers must be encapsulated in a permanently sealed watertight case.

b. No portion of the transformer case may be less than 0.25 inch (6.35 mm) thick.

c. The transformer case must be free of any cracks, blisters, and holes.

d. Sharp corners and edges of the core and coil assembly must not cut or penetrate the sealed case if the transformer is dropped or handled roughly.

e. The transformer case must be constructed so that moisture penetrating the leads or connectors cannot be conducted along the lead length and enter the transformer windings.

f. The transformer case must be fabricated with material formed directly on the core/coil assembly or pre-formed and compound filled.

g. The case material used must meet the requirements of ASTM D2240.

h. The case minimum strength requirements must be at least the following:

(1) Tensile strength must be 1200 pounds per square inch (psi) or 84 kilograms (kg)/square centimeter (cm^2).

(2) Tensile strength after 96 hours oxygen bomb test must be 1000 psi or 70 kg/cm^2.

(3) Tensile strength after 168 hours in an oven at 157° - 159° F (69°C - 71°C) must be 1000 psi (70 kg/cm^2).

(4) Durometer hardness must be 65 ± 10 measured per ASTM D 2240.

i. The transformer assembly must have no internal air pockets.

j. The transformer must withstand exposure to sunlight, oil, gasoline, water, runway deicing fluids, and acid/alkaline soils for the 10-year service life of the transformer.

k. The transformer must be designed so it may be installed upright or lying on any side.

l. The transformer must easily fit into a cylinder 8 inches (in.) (20.3 centimeters (cm)) diameter by 10 in. (25.4 cm) height.

m. The junction of the case and lead sheath must not crack or be damaged when the transformer is carried by one lead or when the leads are bent or twisted during testing and installation.

(1) The case must provide both a watertight junction and reinforcing area for the leads.

(2) The transformer case lead reinforcing area must be at least 25 percent greater than the outside diameter of the connecting leads.

(3) The reinforcing area may be a cone shape around individual leads or a continuous ridge enclosing all three leads.

(4) The transformer case reinforced area must form an integral bond with the cable sheath inside the cone or ridge.

n. The case of the completed transformer must be firm to the touch at all points and show no permanent indentation marks when subjected to finger pressure.

3.4.2 Transformer Leads.

a. The transformer must be provided with a two conductor secondary lead and two single conductor primary leads.

b. Lead connections may be of the solder or solderless crimp type.

c. If solderless connectors are used in joining leads to the transformer windings, they must be designed for the application and properly installed per the manufacturer's instructions.

d. Care must be exercised during and after molding operations to ensure sufficient clearance exists between the transformer winding connections.

e. All three leads must emerge from one end of the transformer - spacing and arrangement are optional, provided all other specifications are met.

f. The leads must be fastened to the transformer so that carrying or lifting it by a single lead will not loosen the electrical connections or adversely affect its watertight properties.

g. The length of all transformer leads must be measured from the connector face to the junction at the transformer case.

3.4.2.1 Primary Leads.

a. Equip one primary lead (H1) with a Style 2 plug type connector certified to AC 150/5345-26.

b. Equip the other primary lead (H2) with a Style 9 receptacle certified to AC 150/5345-26.

c. Use No. 8 American Wire Gauge (AWG) wire (minimum 6 millimeters squared (mm^2)), 19 strand minimum cable insulated for not less than 5,000 volts and conforming to:

(1). ICEA S-96-659/NEMA WC 71, *Standard for Non-shielded Cables Rated 2001-5000 Volts for use in the Distribution of Electrical Energy.*

(2). Other insulation materials may be used provided that they meet or exceed the physical and electrical requirements in 3.4.2.1c(1).

d. Extend each primary winding lead, including the connector, 24.0 inches ± 3.0 inches (60 cm ± 7.5 cm) beyond the transformer housing.

3.4.2.2 Secondary Leads.

a. The transformer secondary lead must be equipped with a Style 7 or 8 receptacle per AC 150/5345-26.

b. The transformer secondary leads must be two conductor No. 12 or 14 AWG (minimum 2 mm^2) 600 volt rated cable meeting the requirements of ICEA S-95-658/NEMA WC-70. Other insulation materials may be used provided that they meet or exceed the physical and electrical requirements in the ICEA specification.

c. The secondary lead receptacle must be wired so the large contact will connect to the X1 lead of the transformer secondary and the smaller contact will connect to the X2 lead.

d. The secondary lead cable, including the cable connector, must be extended 48.0 in. ± 3.0 in. (120 cm ± 7.5 cm) from the transformer housing.

3.4.2.3 Protective Caps.

a. A water resistant cap must be supplied that protects the transformer lead connectors mating parts from both moisture and dirt during shipping and handling.

b. Caps must be securely held in place by cap friction fit, heat shrink tubing, or electrical tape.

c. If electrical tape is used to secure a cap, the tape adhesive must not leave residues that collect dirt or inhibit the adhesion of cable wraps.

3.5 Weight.

The transformer weight must be the minimum possible and consistent with good design practices.

3.6 Nameplate.

a. Transformer markings must be molded on the surface of the transformer case.

b. Transformer identification markings must be permanent and withstand environmental tests and normal use.

c. The recommended and minimum text character heights must be:

Character Height (Centimeters)		Character Height (Inches)	Character Height (Points)
Recommended:	0.2	0.08	5.76
Minimum:	0.125	0.05	3.6

d. The transformer must be marked with the following (serial numbers need not be included):

Specification _____ (L-830 or L-831)
Transformer Rating _____ (Watts - Frequency)
Federal Stock Number _____ (Optional)
Manufacturer's Part No. _____
Manufacturer's Name or Trademark _____
Made in _____ (Country of origin)
Transformer, Series-to-Series Primary amperes _____
Volts 5000 _____ Hz Secondary amperes _____
(Optional) Order/Contract No. _____

3.7 Workmanship

a. The transformer, including all parts and accessories, must be constructed and finished to the highest standards of workmanship.

b. Particular attention must be given to the quality of soldering, wiring, impregnation of coils, freedom of the transformer case and leads from burrs and sharp edges, open pores in the transformer case molding material, and the integrity of the case molding to transformer lead sheath.

4.0 Equipment Qualification Requirements.

4.1 Qualification Procedures.

Procedures for qualifying equipment to be furnished under the Federal grant assistance program for airports are contained in AC 150/5345-53, *Airport Lighting Equipment Certification Program*.

4.2 Qualification Tests.

a. The following tests must be performed on 3 samples of each unit submitted for qualification to demonstrate compliance with the specifications.

b. Unless otherwise specified, all tests must be made at room temperature (approximately 68 to 86 degrees F (20 to 30 degrees C) using a suitable 50 or 60 Hz sine wave power source that provides a transformer primary winding current per Table 2.

c. If it is necessary for the water bath temperature to be substantially different from room temperature, the proper temperature coefficient for the transformer insulating material used must be applied when measuring and computing insulation resistance values.

d. See paragraph 4.2c above. It must be the manufacturer's responsibility to furnish proof, via a certified test report from the insulating material supplier or manufacturer, that the insulating material temperature coefficient is correct.

e. Joints between transformer and test leads must not be taped or otherwise insulated during any of the insulation resistance tests required by paragraphs 4.2.4 and 5.1.3.

f. All transformer leads and test harness connectors must be checked with a "go" and "no go" gauge prior to use to ensure a good fit and watertight seal.

4.2.1 Characteristics Test.

a. The samples must be tested to demonstrate their electrical characteristics are per Table 2.

b. Any corrections necessary to compensate for meter-power consumption must be applied.

c. The transformers must be operated at room temperature (in an area as draft free as possible) with their rated load (see Table 2) connected to the secondary winding.

d. Measurements must be taken only when the transformer windings have reached their normal operating temperature.

NOTE: *See IEEE Standard C57.12.91-2001, Section 11, Temperature test, for additional guidance on conducting transformer temperature measurements.*

4.2.2 Shock Test.

a. The sample isolation transformers must be dropped twice from a height of 6 feet (2 meters) onto a smooth hardwood floor.

b. The first drop must orient the transformer so it strikes on a bottom corner or location where damage from the core cutting into the case is most likely.

c. The second drop must orient the transformer so it impacts on a side or location where damage to the windings is most likely to occur.

4.2.2.1 Transformer Lead Rigidity Test

All transformers leads must also be tested for lead rigidity after the shock test.

a. Sequentially secure each transformer lead just below the connector in a clamp fastened to a vertical support.

NOTE: *The lead clamp used must not cause damage to the lead at the point of attachment.*

b. The clamp must be elevated to a height longer than the lead length so the transformer body will not strike the bench top.

c. The transformer body must be released and allowed to free fall from the clamp height.

d. Repeat the test for each transformer lead.

4.2.3 Post Shock/Rigidity Test

a. After the completion of tests in paragraphs 4.2.2 and 4.2.2.1, the transformers must be tested to ensure they meet the secondary current requirements at full load (see Table 2).

b. A change of more than one percent from the test per paragraph 4.2.1 or evidence of damage to the case and attaching leads must be cause for rejection.

4.2.4 Insulation Resistance.

The sample transformers must be subjected to a 20-cycle insulation test.

NOTE: *One cycle is the sequence of tests per paragraphs 4.2.4.1 through 4.2.4.5.*

4.2.4.1 Mating Connectors.

a. Mating test harness connectors that were previously subjected to "go" and "no go" gauges must be installed in the transformer lead connectors.

b. The mating connectors must not be removed before completion of the 20 cycle testing. If the connectors are removed for any reason, tests must be repeated so both the transformers and connectors satisfactorily pass 20 continuous cycles.

4.2.4.2 Transformer Heating Cycle.

Transformers must be operated, with mating connectors installed, for a minimum of 6 hours at room temperature with the rated current in primary winding (see Table 2). The secondary windings of the transformers must be open-circuited.

4.2.4.3 Water Immersion Test.

a. As soon as possible following the heating cycle, the transformers, with leads and connectors, must be completely submerged in water that is grounded at room temperature.

b. Ensure that all molded connections on the transformer leads and test harness are completely immersed in water during this test.

c. The insulation resistance of each coil and lead assembly must be measured immediately after immersion with voltage applied per Table 3.

4.2.4.4 Soaking.

a. Both transformers and connectors must be soaked in water at room temperature for not less than 12 hours.

b. After 12 hours minimum has elapsed, verify that the transformer/lead insulation resistance is per Table 3.

4.2.4.5 Insulation Resistance Measurements.

a. All measurements of the transformer insulation resistance must be made with direct current.

b. The test voltage must be applied for 1 minute between each transformer winding and ground.

c. The transformer winding not under test must be grounded and its connectors submerged in water.

d. Insulation resistance at the test voltage must equal or exceed the minimum resistance values per Table 3. Alternatively, the leakage current must be less than or equal to the maximum leakage current values per Table 3.

e. The zero and maximum resistance readings of the test instrument must be periodically checked by first touching the high voltage lead to the water surface and then suspending it in air. After the initial current inrush, readings must remain steady without fluctuations.

Table 3. Insulation Resistance

Winding under Test	Voltage Applied (kV DC)	Minimum Insulation Resistance (Megohms)	Maximum Leakage Current (Micro amps)
Hot/Cold Primary for transformers up to 150 W	15.0	7500	2.0
Hot/Cold Secondary for transformers up to 150 W	5.0	2500	2.0
Hot/Cold Primary for transformers over 150 W	15.0	3000	5
Hot/Cold Secondary for transformers over 150W	5.0	1000	5

4.2.5 Temperature Rise.

a. The temperature rise of the sample transformers must be determined by the resistance method.

b. The transformer temperature rise must be kept at least 9 degrees F (5 degrees C) below the maximum continuous duty temperature of the most critical insulating materials used.

c. Transformers are to be operated at room temperature in an area as free from drafts as possible.

d. Transformers must be tested under each of the following conditions with primary current per Table 2.

(1). Rated Load

(2). Short Circuit

(3). Open Circuit

e. IEEE Standard C57.12.91, *IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*, Section 11, Temperature Test, for temperature rise formulas and guidance in the determination of transformer temperature rise.

5.0 Production Test Requirements.

5.1 Production Tests.

Each isolation transformer must be subjected to tests per paragraphs 5.1.2 through 5.1.3.

5.1.2 Ratio Test.

a. Test each transformer for current ratio at rated frequency and current on the primary winding and rated load on the secondary.

b. The secondary current of each transformer must be per Table 2.

5.1.3 Insulation Testing.

a. Subject each transformer to one cycle of the test per paragraph 4.2.4.

b. To shorten test time, transformers may be pre-heated to an internal temperature known to equal or exceed that in 6-hour open circuit conditions in paragraph 4.2.4.2.

5.1.4 Inspect for Voids.

All isolation transformer assemblies must be inspected for voids. Any evidence of voids shall be cause for rejection.

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