U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: SPECIFICATION FOR CONSTANT CURRENT REGULATORS AND REGULATOR MONITORS

Date: 6/24/05 **AC No:** 150/5345-10F

Initiated by: AAS-100 **Change:**

1. PURPOSE. This advisory circular (AC) contains a specification for constant current regulators (CCR) and a monitor for use with airport lighting circuits.

2. CANCELLATIONS. AC 150/5345-10E, *Specification for Constant Current Regulators and Regulator Monitors, dated 10/16/84,* is cancelled.

3. PRINCIPAL CHANGES. The following principal changes are in this specification:

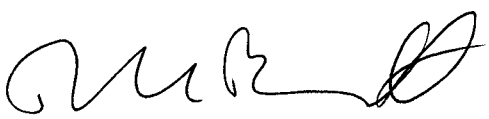
a. The addition of Title 47, Part 15, Subpart B, Incidental Radiator, classification, and testing for conducted and radiated interference.

b. The addition of crest factor limit testing.

c. A change to the output current tolerance of a CCR to ± 0.1 amp (A) for 6.6A and ± 0.3A for 20A.

4. APPLICATION. The specifications contained in this AC are recommended by the Federal Aviation Administration (FAA) in all applications involving development of this nature. For airport projects receiving Federal funds under the airport grant assistance or the passenger facility charge programs, the use of this specification is mandatory.

5. 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.



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CHAPTER 1. SCOPE AND CLASSIFICATION.

1.1 SCOPE.

This specification details the requirements for constant current regulators and a monitor system for use with airport series lighting circuits.

1.2 CLASSIFICATION.

1.2.1 Types.

L-827 – Regulator Monitor.

L-828 - Regulator without monitoring.

L-829 - Regulator with monitoring.

NOTE: *Multiple regulators may be bussed together into switchgear configurations, but each regulator must meet the requirements of this specification. In addition, each regulator must have disconnects to isolate it from primary and control power.*

1.2.2 Classes.

Applicable to regulators only:

Class 1 - 6.6 amperes (A) output current.

Class 2 - 20.0 A output current (see Note 1 in paragraph 1.2.4).

1.2.3 Styles.

Applicable to regulators only:

Style 1 - 3 brightness steps.

Style 2 - 5 brightness steps.

1.2.4 Standard Ratings.

Standard ratings are as follows:

NOTE: *Other voltages, frequencies, or sizes of regulators may be supplied to suit local site conditions, but must meet all the requirements in this specification.*

Standard Sizes (kW out)	Standard Voltages (Volts ac in)	Standard Freq. (Hz)
1, 2, 4, 7.5, 10, 15, 20, 25, 30, 50, 70	208, 220, 240, 480, 2400	60 Hz

NOTES:
1. 50 and 70 kW CCRs are not available for new designs – replacement equipment only.
2. 2400 volt input CCR not available for new designs - replacement equipment only.

CHAPTER 2. REFERENCED DOCUMENTS.

2.1 GENERAL.

The following is a list of documents referenced in this advisory circular.

2.2 FAA ADVISORY CIRCULARS.

AC 150/5345-53 *Airport Lighting Equipment Certification Program*

AC 150/5345-47 *Isolation Transformers for Airport Lighting Systems*

2.3 FAA STANDARDS.

FAA-STD-019d *Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment*

2.4 CODE OF FEDERAL REGULATIONS.

Code of Federal Regulations (CFR) Title 47, *Telecommunications*, Section 15.13, *Incidental Radiators*

2.5 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, AMERICAN NATIONAL STANDARDS INSTITUTE (IEEE/ANSI) PUBLICATIONS.

ANSI/IEEE C57.12.00-2000	*IEEE Standard General Requirements for Liquid Immersed Distribution, Power, Regulating Transformers*
ANSI/IEEE C57.12.01-1998	*IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings*
ANSI/IEEE C57.12.90 01 May 1999	*Standard Test Code for Liquid Immersed Distribution, Power and Regulating Transformers*
ANSI/IEEE C57.12.91 01 May 2001	*Standard Test Code for Dry-Type Distribution and Power Transformers*
IEEE C62.41-1991	*IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits*
IEEE C62.45	*IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits*

2.6 MILITARY STANDARDS.

MIL-STD-810F
1 January 2000 *Department of Defense Test Method Standards for Environmental Engineering Considerations and Laboratory Tests*

2.7 NATIONAL ELECTRIC MANUFACTURERS ASSOCIATION (NEMA).

NEMA 250-1997 *Enclosures for Electrical Equipment*

2.8 INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC).

IEC 60529 *Degrees of Protection Provided by Enclosures (IP Code)*

Copies of FAA ACs may be obtained from:

Department of Transportation
General Services Division
M-45
Washington, DC 20590

Phone: (202)267-3115, 3161, and 8329
Website: www.faa.gov/airports_airtraffic/airports/resources/advisory_circulars/

Copies of FAA Standards may be obtained from:

Federal Aviation Administration
ACM-20 - NAS Documentation Control Center
800 Independence Avenue, SW
Washington, DC 20591

Phone: (202) 548-5502
Fax: (202) 548-5501
Website: www.faa.gov/cm/dcc.htm

Copies of Codes of Federal Regulations (CFRs) may be obtained free of charge from:

Website: www.gpoaccess.gov/cfr/index.html

Copies of American National Standards Institute (ANSI) publications may be obtained from:

American National Standards Institute
W. 42 Street, New York, NY 10036

Phone: (212) 642-4900 and 764-3274
Website: www.ansi.org

Copies of military standards and specifications publications may be obtained from:

DAPS/DODSSP
Building 4, Section D
700 Robins Avenue
Philadelphia, PA 19111-5094

Phone: (215)697-2179
Fax: (215)697-1460

Website: www.dodssp.daps.mil

Copies of NEMA documents may be obtained from:

Internet: www.nema.org

or:

NEMA
1300 North 17th Street
Suite 1847
Rosslyn, VA 22209

Phone: (703) 841-3200

Copies of IEC documents may be obtained from:

Internet: E-standards store - webstore.ansi.org

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CHAPTER 3. EQUIPMENT REQUIREMENTS.

3.1 GENERAL.

The equipment requirements are grouped into four categories: environmental, performance, detail, and monitoring requirements.

3.2 ENVIRONMENTAL REQUIREMENTS.

The equipment must be designed for continuous operation under the following conditions:

a. Temperature range from -40 degrees to 131 degrees Fahrenheit (F) (-40 degrees to 55 degrees Celsius (C)).

b. For monitoring circuitry, the temperature range is from 32 degrees to 131 degrees F (0 degrees to 55 degrees C).

c. Relative humidity range from 10 to 95 percent.

d. Altitude range from zero to 6,600 feet above sea level (2,000 meters).

3.3 PERFORMANCE REQUIREMENTS.

3.3.1 Regulation.

3.3.1.1 Resistive Loading.

The CCR must maintain the output current per Table 1 while powering any load from short circuit to 100 percent load.

a. For all CCRs, regulation must be maintained over the full range of environmental conditions specified in paragraph 3.2 and the input voltage range specified in paragraph 3.3.4.

Table 1. CCR Output Current

Class	Style	Step	Nominal output amperes (A) root mean square (RMS)	Allowable range (A RMS)
1	1	3	6.6	6.5 - 6.70
		2	5.5	5.4 - 5.6
		1	4.8	4.7- 4.9
1	2	5	6.6	6.50 - 6.70
		4	5.2	5.1 - 5.3
		3	4.1	4.0- 4.2
		2	3.4	3.30 – 3.50
		1	2.8	2.7 – 2.9
2	2	5	20.0	19.7 - 20.30
		4	15.8	15.5 - 16.1
		3	12.4	12.1 - 12.7
		2	10.3	10.0 - 10.6
		1	8.5	8.2 - 8.8

3.3.1.2 Reactive Loading.

The CCR output current must be per Table 1 for all current steps when the CCR is connected to series isolation transformers with between 0 and 30 percent of the secondary windings open circuited.

3.3.2 Efficiency.

The efficiency of a CCR operated at its rated input voltage with 100 percent load at unity PF must not be less than the values shown in Table 2.

Table 2. CCR Efficiency

CCR size kilowatts (kW)	Minimum overall Efficiency (percent)
Less than 30	90
30	92
50	93
70	94

3.3.3 Power Factor.

a. The PF for CCRs 10 kW or less, must not be less than 0.90.

b. The PF must not be less than 0.95 for CCRs larger than 10 kW.

c. The PF must be measured with the equipment operating at:

(1) Its maximum intensity setting,

(2) Its rated input voltage,

(3) Its rated load at unity PF.

3.3.4 Standard Input Voltage.

The CCR standard input voltage must be single phase, 60 Hz alternating current (ac).

a. All CCRs must operate per paragraph 3.3.1 when the input voltage is from 95 to 110 percent of its nominal value.

b. CCRs may be provided with different voltage taps from which the correct supply voltage may be selected.

c. The CCR must be designed to withstand momentary increases of voltage up to 120 percent of the nominal input voltage (duration of over-voltage not longer than 50 milliseconds (ms) at no more than once per minute) without shutdown or damage.

3.3.5 Temperature Rise.

The temperature rise of the transformer portion of the CCR must not exceed the maximum transformer safe operating temperature and the maximum insulation temperature permitted in the hottest spot of the windings when operated at its maximum operating temperature (131 degrees F or 55 degrees C). Temperature rise measurements are performed at room temperature (77 degrees F or 25 degrees C).

3.3.6 Crest Factor.

The crest factor for L-828 and L-829 CCRs must be less than 3.2 with regulator output loading per paragraph 3.3.1.

3.3.7 CCR Control System.

a. The control system must stabilize the CCR output current at any selected intensity within 5.0 seconds, and hold the output current stable within ± 0.1A for 6.6A CCRs and ± 0.3 A for 20A CCRs.

b. The control system must provide both local and remote control.

c. The equipment must function properly when operated by a circuit with a round-trip length of 10,000 feet (3,000 m) using #19 American Wire Gauge (AWG) control cable.

d. The operating voltage for the remote control system must not exceed 120 V ac or +48 V dc.

3.3.8 Output Current Surge Limitation.

a. The equipment must be designed so that switching the equipment on and off, changing brightness steps, or opening/shorting the output will not produce current surges that will damage the CCR or any equipment connected to its output.

b. If a start-up time delay is used, no more than 2.0 seconds must elapse from CCR turn-on to current present at the output terminals.

c. The CCR must not generate a transient of over 120 percent of the nominal current for more than 250 milliseconds at any step or setting after the load is switched with a 50 percent resistive component. The preceding must also be true when the load includes an inductive component at a PF of 0.6.

3.3.9 CCR Circuit Isolation.

a. The input power circuit must be electrically isolated from the output circuit.

b. With open circuit protection disabled, the peak output voltage of an open-circuited CCR must not exceed two times the rated wattage divided by the rated current or 4,250 volts, whichever is greater.

3.3.10 Protective Devices.

3.3.10.1 Open-Circuit Protection.

a. The CCR must include an open-circuit protective device to open the primary switch (see paragraph 3.4.1 for primary switch description) within 2.0 seconds after an open circuit is detected in the regulator output circuit.

b. The protective device must reset within 2.0 seconds after the CCR control switch is turned off and re-energized. Alternatively, if a reset switch is provided, it may be used to reset the protective device and re-energize the regulator.

c. The protective device must not be tripped by load circuit switching or other transients.

3.3.10.2 Over-current Protection.

a. CCRs must include an over-current protective device that opens the primary switch when the output current exceeds 100 percent (6.6 or 20 A) by 5 percent.

b. The protective device must operate within 5.0 seconds after an over-current of 5 percent and within 1.0 second after an over-current of 25 percent.

c. The protective device must reset within 2.0 seconds after the regulator control switch is turned off and re-energized. Alternatively, if a reset switch is provided, it may be used to reset the protective device and re-energize the regulator.

d. The over-current protection must not be activated by momentary (0.25 second) over-current events that are caused by load circuit switching or other transients.

3.3.11 Input Power Loss.

If there is a loss of input power, the CCR must resume operation on its last selected brightness setting within 5.0 seconds after the restoration of input power.

3.3.12 Electromagnetic Interference.

The regulator must cause the minimum possible radiated or conducted electromagnetic interference (EMI) to airport and FAA equipment (e.g., computers, radars, instrument landing systems, radio receivers, VHF Omni-directional Range, etc.) that may be located on or near an airport.

NOTE: *A CCR is classified as an incidental radiator (Title 47, Subpart B, Section 15.13). This applies to equipment that does not intentionally generate any radio frequency energy, but may create such energy as an incidental part of its intended operations. A CCR must employ good engineering practices to minimize the risk of harmful interference.*

3.4 DETAILED REQUIREMENTS.

3.4.1 Primary Switch.

a. The CCR must use a primary switching device that interrupts the input power prior to the current regulating/transformer circuits.

b. The primary switching device must be operable by remote control and must not interrupt the regulator internal control power.

3.4.2 Operator Controls.

a. The CCR must provide, located for ready access on the CCR, without opening doors or removing covers, a means for the operator to select the remote/local modes and the desired current step.

b. If a dedicated control switch (or an assembly of switches) is used, it must be marked:

(1) Remote, Off, 10, 30, 100 for a three step CCR.

(2) Remote, Off, 1, 2, 3, 4, 5 for a five step CCR.

c. If a rotary switch is used, it must not be allowed to rotate beyond an active position.

d. Multi-function keys or discrete switches may be used in place of, or in addition to a dedicated switch.

e. All controls must be designed to clearly reflect the function and status of the dedicated switch, switches, or keypad entries per paragraph 3.4.2b.

f. The manufacturer may provide additional functions and features that enhance the performance or serviceability of the CCR, but they must not cause any confusion with the controls per paragraph 3.4.2b.

3.4.3 Output Ammeter.

a. A flush mounted, true root mean square (rms) digital or analog meter to indicate the CCR output current must be positioned on the front of the regulator enclosure so it may be easily read.

b. If analog, the meter must have a scale of sufficient length that allows the operator to easily distinguish 0.1 A for a 6.6 A CCR and 0.3 A for a 20 A CCR.

c. The panel meter accuracy must be at least ± 1.0 percent (at full scale with analog meter) of the CCR maximum output current with non-sinusoidal waveforms.

3.4.4 Output Voltmeter.

a. The manufacturer may offer an optional true rms digital or analog voltmeter that is positioned on the front of the regulator cabinet in reasonable proximity to the output ammeter specified in paragraph 3.4.3.

b. The panel meter accuracy must be ± 1.0 percent (at full scale with analog meter) of the CCR maximum output voltage at the highest current step setting.

3.4.5 Operator Display.

a. A digital multi-functional display may be used by the manufacturer to display CCR parameters, controls, and equipment setting options. Any displayed value must clearly identify the name of the value (for example: volts, watts, amps, or current step).

b. The display must show the CCR output current by default.

c. If an operator uses the display for purposes other than the CCR output current, the display must revert to the output current if no keypad entries are made for more than one minute.

3.4.6 Terminal Block.

a. Pressure type terminal blocks with a suitable voltage and current rating must be installed in the control cabinet for connection to the external wiring associated with monitoring and remote control.

b. Terminal blocks must accommodate #12 to 20 AWG wire with insulation ratings up to 600 V.

c. The following minimum terminal functions must be made available and labeled per the following list:

NOTE: *The manufacturer may provide additional terminal functions and labels for CCR monitoring and a computer interface if connected to a computerized remote control.*

Terminal function	**Label**
(1) Power supply for remote control (control power)	CCI
(2) Return from remote on/off switch	CC
(3) Returns from remote intensity switch (3 or 5 terminals required)	Bl-B2-B3-B4-B5 or Bl-B2-B3

(4) Input for external control power (If required) XCP

(5) Neutral for external control power (If required) N

3.4.7 CCR Enclosure.

a. The reactors and/or transformer components must be housed in an enclosure of sheet steel or other suitable material per NEMA equipment enclosures Type 1 (equivalent to IEC IP20).

b. The enclosure must be equipped with a removable cover that is securely held in place.

c. Feet or channels must be attached that provide no less than 2.0 inches (5.0 cm) of space between the bottom of the enclosure and the floor.

d. Four enclosed terminals (one pair labeled "input" and the other "output") rated for the proper voltage and current must be located on the top, side, or front of the enclosure.

e. Lifting lugs that are properly rated for the CCR cabinet weight must be installed on the enclosure.

f. The overall size of a complete CCR assembly must allow it to pass through an opening 39.0 inches (1.0 meter (m)) wide by 78.0 inches (2.0 m) high.

g. A ground terminal must be provided on the outside of the CCR cabinet.

h. CCR oil immersed transformer enclosures must allow no seepage of oil from welds, gaskets, seals, or vents.

(1) Oil immersed transformer enclosures must be equipped with a sampling/drain valve located not more than 2.0 inches (5.0 cm) above the bottom of the enclosure.

(2) The CCR must have a method or device that indicates the proper transformer oil level.

(3) The CCR must be shipped filled with the proper amount of oil and be ready for service.

3.4.8 Control Cabinet.

a. A control cabinet or a compartment that excludes falling dirt must be provided for housing the relays, control terminal block, remote/local control switch, and other low voltage control components of the CCR.

b. The control cabinet or compartment must be either permanently attached to or an integral part of the CCR enclosure.

c. All low voltage control components must be easily accessible by opening the CCR cabinet and/or control cabinet or compartment panels/doors. No high voltage components may be installed in the low voltage component area or on the CCR front panel door.

3.4.9 Capacitors.

a. If PF correction capacitors are provided, the terminals must be protected from accidental contact.

b. The service life expectancy of the capacitors must not be less than 60,000 hours under rated operating conditions.

3.4.10 Wiring Diagram.

A legible wiring diagram must be permanently mounted in an unobstructed viewing location in the CCR control cabinet.

3.4.11 Painting and Finishing.

a. The inside and outside of the enclosure must be painted with one prime coat and one finish coat of oil resistant and weatherproof paint.

b. Coatings with equivalent oil resistance and weatherproofing properties may be substituted for paint.

c. Damage to the coating on the CCR enclosure must be repaired after assembly and production testing is complete.

3.4.12 Lightning/Surge Arresters.

a. Arresters of the proper rating to protect the CCR from lightning induced voltage and current surges must be installed at both the input and output terminals of the CCR.

b. The CCR input lightning arresters must be rated for pulses per IEEE C62.41-1991, paragraph 4.2.17b, Table 6, Category B2, Medium.

c. The CCR output lightning arrestors must be rated for Location Category C3 in IEEE 62.41-1991, per Table 4 (A 1.2/50 microsecond (μs) 8/20 μs combination wave at 20 kilovolts and 10 kiloamperes peak - the nominal ratio of peak open circuit voltage to peak short circuit current is 2 ohms).

d. The ground side of the arresters must be connected to the cabinet grounding lug or other electrically equivalent ground location. If a bonding jumper wire is used, it must not be smaller than 14 AWG.

3.4.13 Transient Voltage and Current Protection.

a. Transient protection that does not degrade signal quality must also be provided for all signal, data, and control lines that enter the monitor and/or CCR per IEEE C62.41-1991, Table 3, Category A2.

NOTE: *See IEEE C62.41- 1991, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits, Section 9, Definition of Standard Surge Testing Waveforms, for detailed explanations of surge/transient waveforms.*

3.4.14 Warning.

A plate or decal must be affixed to the front of the CCR control cabinet door warning the maintenance technician to remove input and control power before opening the cabinet or interrupting the output series circuit.

3.4.15 Components.

All CCR components must be suitable for their function and not operated in excess of the component manufacturer's recommended rating.

3.4.16 Nameplate.

a. A nameplate with the following information must be securely attached to the front of the CCR enclosure.

(1) Constant current regulator, single phase.

(2) Input: ____Volts ____Hertz ____Amperes.

(3) Control: ____Volts ____Hertz.

(4) Output: ____kW at ____Amperes.

(5) Output Current: ____Amperes ____Gallons of oil

(6) Identification: FAA-L-828, or L-829 ____Serial No.

b. If the nameplate is attached to a removable enclosure surface (a cover), the serial number must be duplicated in a permanent conspicuous location elsewhere on the CCR.

3.4.17 Instruction Book.

An instruction book with at least the following information must be furnished with each CCR:

a. Schematic and wiring diagrams showing all components for user serviceable parts.

b. Parts list with applicable rating and characteristics of each part and with the component manufacturer's name and part number.

c. Installation instructions.

d. Maintenance instructions.

e. Troubleshooting charts.

f. Theory of operation.

3.5 MONITOR.

The monitor must detect the status of the CCR and the series lighting circuit.

a. Type L-829 CCRs must use integral monitoring.

(1) A CCR without monitoring is designated Type L-828.

(2) A monitor may be offered as a separate module designated type L-827.

(3) If monitoring is added to a Type L-828 regulator, it becomes a Type L-829.

b. The monitor must be matched with the CCR so it will function when the CCR is powering a load with a nominal value that is between 50 and 100 percent of its rated capacity. The load must be a constant current loop that energizes the primary of isolating transformers that are specified in AC 150/5345-47, *Isolation Transformers for Airport Lighting Systems.* The secondary winding of the transformers will power airport lighting fixtures.

c. At a minimum, the monitor must operate on the top two steps of Style 1 (3 brightness steps) and Style 2 (5 brightness steps) regulators.

d. The monitor must detect the following fault conditions:

Table 3. CCR Fault Conditions

Fault Letter	Fault Condition
a	Loss of ac input power to the CCR
b	Shutdown of the regulator due to operation of protective circuits described in paragraph 3.3.10
c	A 10 percent or greater drop in the volt-amperes (VA) delivered to the series circuit.
d	Failure of the regulator to deliver the output current that corresponds to the brightness step selected (see Table 1).
e	Failure of a preset number of lamps in the series circuit.

e. See Table 3. Faults a, b, and d must be detected at all brightness levels.

f. The monitor must function when the regulator is in the remote or local control modes (fault "d" must be detected in the remote mode, but need not be detected in the local mode).

g. The monitor must operate in a fail-safe manner and not cause the regulator to be inoperable or output incorrect currents.

h. If it is required by the application, the output of the monitor must energize the coil of a single pole double throw (SPDT) relay when the regulator is operating properly.

(1) The relay contacts must be rated for a 2 amp resistive load at 120 Volts ac, 60 Hz.

(2) The monitor outputs must be connected to a terminal block to allow external connections and operate with control lines similar to those described in paragraph 3.4.6.

i. Upon the initial detection of a fault, the monitor must delay 5.0 seconds (except for fault "a" and "b" in Table 3) before the fault is displayed. If the fault still exists after 5 seconds, the monitor must indicate an alarm.

j. A visual indication must be provided on the monitor to indicate which monitored parameter caused the fault indication (except for fault "a").

k. A regulator "on" light must be provided on the monitor.

l. The load of each monitored airfield lighting system lamp and its associated isolation transformer may vary between 10 and 200 watts within the following:

(1) All fixture loads and transformers must be the same.

(2) There cannot be devices on the series circuit which will cause the load to vary greatly (signs with fluorescent ballasts/lamps, power adapters, signs with printed circuit board assemblies, etc.).

(3) Film disc cutouts must not be used since they will cause a load different than an open circuit series to series transformer.

m. The monitor must be adjustable so the number of failed lamps required to cause a failure indication may be from 4 to 10 when the series loop is loaded with identical wattage lamps. For mixed wattage bulbs on the same series loop, a loss of 10% or more CCR load must be detected.

n. After the preset number of monitored lamps fail, it must be possible to switch the monitor into a degraded operation mode.

o. When in the degraded operation mode, the monitor must deactivate the fault indication and reactivate it upon the failure of an additional preset number of lamps (1 to 5).

p. Additional monitor warnings or alarm levels may be optionally provided by the manufacturer, but are not required.

Note: *When a CCR is connected to a computerized airfield lighting control monitoring system (ALCMS), the optional monitoring points may be required for reporting Remote/Local Status and Primary Power (ac power loss to the CCR). See AC 150/5345-56, Specification for L-890 Airport Lighting Control and Monitoring System (ALCMS), for additional information.*

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CHAPTER 4. EQUIPMENT CERTIFICATION REQUIREMENTS.

4.1 CERTIFICATION PROCEDURES.

Procedures for certifying equipment to be furnished under the Federal grant assistance program for airports are contained in Advisory Circular 150/5345-53, Airport Lighting Equipment Certification Program, current edition.

4.2 CERTIFICATION TESTING.

Testing must be performed on each unit submitted for certification to demonstrate compliance with the requirements of this specification.

4.2.1 Regulation Test.

a. The following tests must be performed to demonstrate compliance with paragraph 3.3.1 and Table 1.

b. Where isolation transformers and lamps are not specifically required, a resistive load may be used.

4.2.1.1 Input Voltage Tests.

a. For each CCR, load the output to 100 percent resistive, short circuit, and 50 percent resistive load connected to nominal voltage, 110 percent of nominal voltage, and 95 percent of nominal voltage.

b. Verify the CCR output current is per Table 1 for all brightness steps.

4.2.1.2 Reactive Load Tests.

a. An equivalent of a 100 and 50 percent reactive load (30 percent of the isolating transformers secondary windings open-circuited) must be placed on the CCR output.

b. The CCR input voltages must be: nominal, 110 percent of nominal, and 95 percent of nominal.

c. The CCR output current must be checked at all brightness settings and be within the limits per Table 1 for all voltages in paragraph 4.2.1.2b above.

4.2.2 Remote Control Test.

Check the output current at all brightness steps for the following remote control circuits (an equivalent resistive load may be used to simulate the full cable lengths specified) and rated output load:

a. Connect the remote switch via simulated 100-foot (30 m) lengths of 12 AWG wire (a resistance equal to 0.16 ohms per wire).

b. Operate the CCR remotely on all brightness steps to determine compliance with paragraph 3.3.7.

c. Connect the remote switch via simulated 10,000-foot (3,000 m) lengths (total round-trip distance) of 19 AWG control wire (a resistance equal to 87 ohms per 10,000 feet of wire and a capacitance between conductors of 0.16 microfarads).

d. Operate the CCR remotely on all brightness steps to determine compliance with paragraph 3.3.7.

4.2.3 Temperature Rise.

a. For the equipment under test, determine that the temperature rise of the CCR transforming device will not exceed its maximum operating or insulation temperature rating.

b. Use the resistance method at ambient room temperature (77 degrees F or 25 degrees C) for testing the transformer temperature rise for both immersion and dry type regulating transformers per:

(1) For guidance in determining and testing the temperature rise of liquid immersed transformers, see ANSI/IEEE C57-12.90 - 1999, *IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers*, Section 11, Temperature rise.

(2) For guidance in determining and testing the temperature rise of dry-type transformers, see ANSI/IEEE C57.12.91-2001, *IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*, Section 11, Temperature Test.

4.2.4 Efficiency.

Power the equipment under test with nominal input voltage with a 100 percent load at unity power factor. Determine the CCR efficiency at its maximum current step setting is not less than the values per Table 2.

NOTE: $\eta = P_2/P_1$

where:

η = efficiency

P_2 = active output power
P_1 = active input power

4.2.5 Power Factor.

For the equipment under test, apply power at the nominal input voltage with a 100 percent load at unity power factor. Determine that the CCR power factor at the maximum current step setting is not less than specified in paragraph 3.3.3.

NOTE: $PF = \frac{P}{S}$

where:

PF = power factor
P = total input power expressed in watts (W)
S = apparent input power expressed in volt-amps (VA)

4.2.6 Crest Factor.

For the equipment under test, determine the crest factor for L-828 and L-829 CCRs using the loading per paragraph 3.3.1.

a. The maximum crest factor must not exceed 3.2 at nominal input voltage for all current step settings.

b. Crest Factor = $\frac{I_{OUT}\ PK}{I_{OUT}\ RMS}$

c. An oscilloscope with a suitable current probe may be required to measure the CCR peak output current (I_{OUT}).

4.2.7 Altitude.

a. Each design of CCR must be tested for low pressure (altitude) in accordance with MIL-STD-810F, Method 500.4, Paragraph 4.5.3, Procedure II.

b. The maximum altitude must be 6,600 feet (2,000 meters).

c. The maximum chamber ambient air temperature must be 131 degrees F (55 degrees C).

d. The CCR must be operated at its rated voltage, load, and maximum brightness for 1 hour.

e. Perform CCR testing per paragraph 4.2.1.1 immediately after the 1-hour run-in period.

f. Any test failures will be cause for rejection of the equipment.

4.2.8 Low Temperature.

a. Each type of CCR must be tested by placing it in a test chamber and maintaining the temperature at -40 degrees F ± 9 degrees (-40 degrees C, ±5 degrees) for 12 hours with the unit under test off.

b. Perform CCR input voltage tests per paragraph 4.2.1.1 while maintaining low temperature. Remote control may be used.

c. The low temperature test must be run at 32 degrees F (0°C) for L-827 Monitors.

d. Verify all visual displays are functioning properly at the end of the test.

e. The failure of tests will be cause for disapproval of the regulator.

4.2.9 Humidity.

a. Each design of CCR must be tested for resistance to humidity per MIL-STD-810F, Method 507.4, Paragraph 4.5.2, Procedure

b. The regulator must be exposed to a minimum of 5 48 hour cycles.

NOTE: *Limit the maximum chamber temperature to 131 degrees F (55 degrees C) during humidity cycling.*

c. After humidity cycling, perform the CCR input voltage tests per paragraph 4.2.1.1

d. Failure of tests or evidence of corrosion or deterioration, will be cause for disapproval of the regulator.

4.2.10 Electromagnetic Interference Tests.

All tests must be conducted with the CCR set to its highest output current setting at full load.

a. CCRs must be tested for and not exceed the conducted power line emissions per Title 47, Subpart B, Section 15.107b, using a 50 microhenry (μH)/50 ohm line impedance stabilization network (LISN) to the following limits:

Table 4. CCR Conducted Emission Limits

Frequency of Emission (MHz)	Quasi-peak Emissions Decibels per microvolt dB/μV	Average Emissions dB/μV
0.15 – 0.5	79	66
0.5 -30.0	73	60

b. CCRs must be subjected to the tests in paragraph 4.2.10a and not exceed additional testing to radiated emission limits per Title 47, Subpart B, Section 15.109b for the following limits at 33 feet (10 meters):

Table 5. CCR Radiated Emission Limits

Frequency of Emission (MHz)	Field Strength (microvolts per meter)
30-88	90
88-216	150
216-960	210
Above 960	300

4.2.11 Basic Impulse Insulation Level (BIL) Tests.

NOTE: *See ANSI/IEEE C57.12.00 (liquid immersed type transformers) and C57.12.01 (dry type transformers) for BILs that may be specified for a given system voltage.*

a. Testing must be performed with a 1.2 microsecond rise to crest by 50 microsecond decay to half crest waveshape.

NOTE: *Waveforms of positive polarity must be used for dry type transformers. Negative polarity must be used for liquid immersed transformers.*

b. BIL testing must be performed on both the primary and secondary windings of the transformer.

c. The terminals of each winding must be connected together at the input to the impulse generator prior to testing.

d. All other transformer terminals not under test, including the core must be grounded.

e. Use ANSI/IEEE C57.12.90-1999, Section 10.3, for guidance about methods for performing the BIL tests specified in ANSI/IEEE C57.12.00.

f. Use ANSI/IEEE C57.12.91-2001, Section 10.5, for guidance about methods for performing the BIL tests specified in ANSI/IEEE C57.12.01

4.2.12 Dielectric Tests.

Test the circuits of all CCR sizes to determine the equipment capability to withstand the following 60 hz alternating current rms test voltages referenced to ground for one minute without failure:

a. Lightning arresters must be disconnected for the test.

b. Both the control terminals and low voltage circuitry must be grounded for the test.

(1) 240-volt input circuit to ground - 2,000 V.

(2) 480 volt input circuit to ground - 2,000 V.

(3) 2,400-volt input circuit to ground - 4,900 V (replacement equipment only).

(4) 120-volt control circuits to ground - 1,000 V.

(5) 48-volt control circuits to ground - 500 V.

(6) Output circuit to ground - 5 times the 100 percent load rms voltage.

4.2.13 Protective Device Tests.

a. Test all protective devices for proper operation per paragraph 3.3.10.

b. Test the CCR open-circuit voltage per paragraph 3.3.10 using an oscilloscope or high voltage peak reading voltmeter.

c. On each brightness step, interrupt the input voltage until the CCR ceases operation, then reconnect the power to demonstrate resumed operation on the same step per paragraph 3.3.11.

4.2.14 Leakage Test.

a. Test each oil-filled regulator assembly to ensure that there is no leakage from welds, gaskets, o-rings, or other types of seals.

b. Pressurize the unit under test with dry air to an internal air pressure of 10 ±2 pounds per square inch gauge (psig) for 5 minutes - no loss of pressure is allowed for the test duration.

4.2.15 Output Current Surge.

Check for the compliance of the CCR output current during turn-on and switching per paragraph 3.3.8.

4.2.16 Monitor Test.

a. The manufacturer must develop a test plan and procedures for submission to the FAA, Office of Airport Safety and Standards, Airport Engineering Division, AAS-100 , or an FAA approved third party certification body, that demonstrates compliance with paragraphs 4.2.7 through 4.2.10 and 4.2.17.

b. The test procedure must exercise and test the monitoring functions and meet the sensitivity requirements per paragraph 3.5.

c. The test setup must use a constant current loop with isolating transformers and lamp loads that are at least 50 percent of the CCR's rated capacity.

d. Monitor operation must be demonstrated with each type of CCR with which it will be mated.

4.2.17 Surge Suppression.

NOTE: *The equipment might be damaged by the following tests; perform them only after all other testing is complete.*

a. To demonstrate the effectiveness of the lightning arrestors, they must safely suppress a test pulse of 10 by 20 microsecond current surge of 15,000 A with the subsequent power-follow current and a voltage surge of 10kV per microsecond maximum.

b. Subject the ac power input of the CCR and/or monitor to the combination (1.2 microsecond /50 microsecond and 8 microsecond/20 microsecond) test pulses per the descriptions per Table 4 below:

Table 6. Test Waveform Amplitudes

Location Category	System Exposure	Voltage kilovolts (kV)	Current (kiloamps) (kA)	Effective Impendance (ohms)
0.5 microsecond – 100 kilohertz Ring Wave				
B2	Medium	4	0.33	12
1.2/50 microsecond – 8/20 microsecond Combination Wave				
B2	Medium	4	2	2

c. See IEEE C62.41-1991 Section 9.3 for test condition and test generator information.

d. See IEEE C62.41-1991 Section 9.4 for a detailed combination and ring wave generation and parameters discussion.

e. See also IEEE C62.45, *IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits* for guidance about equipment test methods.

4.3 OUTPUT WAVEFORMS.

a. The manufacturer must supply oscilloscope screen capture data of the CCR output current and voltage waveforms at nominal line voltage for all intensity steps at short circuit, 50 percent load, and 100 percent load with the qualification documents.

NOTE: *Oscilloscope screen capture data may be a photograph or digital file such as: bit map (BMP), Joint Photographic Experts Group (JPEG), or Tagged Image File Format (TIFF).*

b. The 100 percent load and 50 percent half-load waveforms must be recorded with a purely resistive load, then repeated with 30 percent of the isolation transformers open-circuited per paragraph 4.2.1.2.

c. All waveform capture data must include the amplitudes of voltages/currents and their duration.

d. The waveforms will be used by lighting equipment manufacturers to ensure compatibility with all approved CCRs.

e. The waveforms must also be made available in either a manual or a standard electronic format for a nominal fee.

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CHAPTER 5. PRODUCTION TEST REQUIREMENTS.

5.1 PRODUCTION TESTING.

a. Each CCR must be tested per the requirements in paragraphs 4.2.2, 4.2.12, 4.2.13 (only protective devices test), and 4.2.14.

b. The manufacturer must exercise and test each monitor alarm function per Table 3.

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