US. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: SPECIFICATION FOR CONSTANT CURRENT REGULATORS AND REGULATOR MONITORS

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Change:

1. PURPOSE. This advisory circular (AC) contains a specification for constant current regulators used on airport lighting circuits, and for a monitor that reports on the status of the regulator.

2. CANCELLATION. AC 150/5345-10D, Specification L-828, Constant Current Regulators, dated 3/10/80, is cancelled.

3. PRINCIPAL CHANGES. The following principal changes have been made in this AC:

a. A specification for a constant current circuit monitor has been added. The regulator without monitoring is a type L-828. If monitoring is added, it becomes a type L-829. The monitor also may be a separate module (type L-827) used to monitor existing constant current regulators.

b. The classification system has been relaxed to allow more combinations of features. The purchaser will now be allowed to specify many different parameters, including the input voltage, to suit his particular needs.

4. APPLICATION. The specification contained herein is recommended by the Federal Aviation Administration in all applications involving airport development of this nature. The specification is an acceptable means for compliance with Federal Aviation Regulation (FAR) Part 152 for projects funded under the Airport Improvement Program or with FAR Part 139 where such facilities may be required. Where alternate means are proposed, it must be demonstrated that equivalent levels of performance, safety, and for Federally funded projects, equivalent cost effectiveness, are achieved.

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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FEDERAL AVIATION ADMINISTRATION

4017 2/12

SPECIFICATION FOR

CONSTANT CURRENT REGULATORS AND REGULATOR MONITORS

1. SCOPE AND CLASSIFICATION.

1.1 Scope. This specification covers the requirements for constant current regulators for use in airport series lighting circuits. It also covers a monitor system used to determine and indicate the status of the regulator and series lighting circuit.

1.2 Classification.

1.2.1 Types.

L-827 - Monitor

L-828 - Regulator without monitoring

L-829 - Regulator with'monitoring

1.2.2 Classes. (Applicable to regulators only)

Class 1 - 6.6 amperes output current

Class 2 - 20 amperes output current

1.2.3 Styles. (Applicable to regulators only)

Style 1 - 3 brightness steps

Style 2 - 5 brightness steps

1.2.4 Ratings. Standard ratings are as follows; however, other voltages, frequencies, or sizes may be used to suit local site conditions.

Standard Sizes (kW out)	Standard Voltages (Volts in)	Standard Frequency (Hz)
4, 7½, 10, 15, 20, 25, 30, 50, 70	240, 2400	60

2. APPLICABLE DOCUMENTS.

2.1 General. The following documents, of the issue in effect on the date of application for qualification, are applicable to the extent specified in this AC.

2.2 Federal Aviation Administration (FAA) Advisory Circulars (AC).

AC 150/5345-1 Approved Airport Lighting Equipment

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

2.3 American National Standards Institute (ANSI) publications.

ANSI C57.12.00 General Requirements for Distribution, Power, and Regulating Transformers

ANSI C57.12.90 Test Code for Distribution, Power and Regulating Transformers

ANSI C57.12.91 Standard for Dry-Type Transformers

2.4 Military Standards.

MIL-STD-810 Environmental Test Methods

MIL-STD-462 Electromagnetic Interference Characteristics, Measurement of

(Copies of FAA ACs may be obtained from the Department of Transportation, Subsequent Distribution Unit., M-494.3, Washington, D.C. 20590.)

(Copies of American National Standards Institute publications may be obtained from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.)

(Copies of military standards may be obtained from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120, Attention: Code CDS.)

3. REQUIREMENTS.

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

3.2 Environmental Requirements. The equipment shall be designed for continuous indoor operation under the following conditions:

a. Temperature range of -40 to +55° C (for monitoring circuitry the range is 0 to 55° C).

b. Relative humidity range of 10 percent to 95 percent.

c. Altitude range of zero to 6,600 feet (2 000 m).

3.3 Performance Requirements.

3.3.1 Regulation.

3.3.1.1 Resistive Loading. The regulator shall maintain the output current within the limits of table 1 while powering any load between no load (short circuit) and full load. For regulators 10 kW and larger, the regulation shall be maintained over the full range of environmental conditions specified in 3.2 and the input voltage range specified in 3.3.4. For regulators less than 10 kW, the regulation shall be provided at nominal input voltage for all brightness steps.

Table 1. Output current.
(Amperes rms)

Class	Style	Step	Nominal output	Allowable range
1	1	3	6.6	6.40 - 6.70
		2	5.5	5.33 - 5.67
		1	4.8	4.66 - 4.94
1	2'	5	6.6	6.40 - 6.70
		4	5.2	5.04 - 5.36
		3	4.1	3.98 - 4.22
		2	3.4	3.30 - 3.50
		1	2.8	2.72 - 2.00
'2	2	5	20.0	19.40 - 20.30
		4	lS.8	15.33 - 16.27
		3	12.4	12.03 - 12.77
		2	10.3	9.99 - 10.61
		1	8.5	8.24 - 8.76

3.3.1.2 Reactive Loading. The regulator shall maintain the current within the limits of table 1 for all brightness steps when the load is connected via isolating transformers, and the secondaries of 30 percent of these transformers become open-circuited. The load before opening the isolation transformer secondaries may be any value from half to full load. For regulators less than 10 kW loaded as specified above, 'the current shall remain below 6.8 amperes for the 100 percent brightness step.

3.3.2 Efficiency. The efficiency of the regulator operated with rated input voltage into a full load having unity power factor shall be not less than the value shown in table 2.

Table 2. Regulator efficiency.

Regulator size (kW)	Minimum overall efficiency (percent)
less than 30	90
30	92
SO	93
70	94

3.3.3 Power Factor.- The power factor for regulators 10 kW or less in size shall be not less than 90 percent; for regulators larger than 10 kW, it shall be not less than 95 percent. The power factor shall be measured with the regulator operating on the maximum intensity setting, at rated input voltage, and into a rated load with unity power factor.

3.3.4 Input Voltage. Input voltage shall be single phase, either 50 or 60 Hz ac. Regulators 10 kW and larger shall operate as required in 3.3.1 when the input voltage is anywhere between 95 and 110 percent of the nominal value. For regulators under 10 kW, it is permissible to provide a regulator with several different voltage taps, from which the correct tap may be selected for the supply voltage. The regulator shall be designed to withstand momentary increases of voltage up to 120 percent of nominal input voltage without being shut off or damaged by such overvoltage. The duration of such overvoltage excursions shall be not longer than 50 milliseconds and shall occur no more than once per minute.

3.3.5 Temperature Rise. The temperature rise of the transforming portion of the regulator shall be in accordance with ANSI C57.12.00 (for liquid-cooled regulators) or ANSI C57.12.91 (for air-cooled regulators).

3.3.6 Control System. The control system shall stabilize the output current at any selected intensity within 5 seconds, and shall hold the output current stable within ±0.1 ampere. The control system shall provide both local and remote control. The regulator shall function properly while operated by a circuit with a round-trip length of 10,000 feet (3 000 m) using No. 19 AWG control cable. Voltage for the control system shall not exceed 120 V.

3.3.7 Output Current Surge Limitation. The regulator shall be designed so that switching the regulator on and off, changing brightness steps, or shorting the load will not produce output surges that will damage series incandescent lamps. If time delay is utilized, no more than 2 seconds shall elapse from regulator turn-on to delivery of current to the output terminals.

3.3.8 Circuit Isolation. The power input circuit shall be electrically isolated from the output circuit. With the open circuit protection disabled, the peak output voltage of an open-circuited regulator shall not exceed two times the rated wattage divided by the rated current or 4,250 V peak, whichever is greater.

3.3.9 Protective Devices.

3.3.9.1 Open-Circuit Protection. The regulator shall include an open-circuit protective device to open the primary switch within 2 seconds after an open circuit occurs in the secondary. The device shall reset within 2 seconds after the control switch is turned off and reenergized, and shall not be tripped by switching of load circuits or other transients.

3.3.9.2 Overcurrent Protection. Regulators 10 kW and larger shall include an overcurrent protective device that opens the primary switch when the output current exceeds the 100 percent current (6.6 or 20 A) by 5 percent. The device shall operate within 5 seconds after an overcurrent of 5 percent and within 1 second after an overcurrent of 25 percent. The device shall reset within 2 seconds after the control switch is turned off and reenergized. The overcurrent protection shall not be activated by a momentary (0.25 second) overcurrent caused by switching of load circuits or other transients.

3.3.10 Input Power Loss. In the event of a loss of input power, the regulator shall resume operation on the selected brightness setting within 5 seconds after the restoration of input power.

3.3.11 Electromagnetic Interference. The regulator shall cause minimal radiated or conducted electromagnetic interference to other equipment such as computers, radars, instrument landing systems, radio receivers, very high frequency omnidirectional radio ranges, etc., that may be located on or near an airport, or that may use the same power supply.

3.4 Detail Requirements.

3.4.1 Primary Switch. The regulator shall have a primary switching device which interrupts the input power before it reaches the main transforming device. It shall be operable via remote control and shall not interrupt internal control power.

3.4.2 Remote/Local Control Switch.. A switch with detents for local regulator control shall be located for ready access without opening doors or removing covers. The switch positions shall be marked "Remote, Off, 10, 30, 100" for a three-step regulator and "Remote, Off, 1, 2, 3, 4, 5" for a five-step regulator. The switch shall not rotate beyond an active position.

3.4.3 Output Ammeter. A flush-mounted, true rms-reading ammeter to indicate output current shall be positioned on the front of the regulator so that it may be easily read. If analog, the meter shall have a scale length equal to that of a 3-inch (75 mm) round meter. The meter accuracy shall be at least +3.0 percent of the maximum output current.

3.4.4 Terminal Block. Pressure-type terminal blocks having a suitable voltage rating shall be installed in the control cabinet for connection of the external wiring associated with monitoring and remote control. Terminal blocks shall accommodate No. 12 to No. 20 AWG wire with an insulation rating up to 600 V. Two spare positions shall be provided.

Terminal function	Label
a. Power supply for remote control (control power)	cc1
b. Return from remote on/off switch	cc
c. Returns from remote intensity switch (3 or 5 terminals required)	B1-B2-B3-B4-B5 or B10-B30-B100
d. Input for external control power (If required)	XCP
e. Neutral for external control power (If required)	N

3.4.5 Regulator Enclosure. The reactors and/or transformer shall be housed in a enclosure of sheet steel or other suitable material. The enclosure shall be equipped with a removable cover that is held securely in place. Feet or channels shall be attached to provide no less than 2 inches (5 cm) of space between the enclosure and the floor. Four enclosed terminals (one pair labeled "input" and the other "output"), suitable for the voltages involved, shall be located on the top, side, or front of the enclosure. Lifting lugs shall be installed on the enclosure. Overallphysical size of the complete regulator assembly shall be such that it will pass through an opening 39 inches wide by 78 inches high (1 m wide by 2 m high). A ground terminal shall be installed on the outside of the regulator enclosure. Oil-cooled regulators shall be designed and fabricated to be oiltight. They shall be equipped with a sampling and drain valve located not more than 2 Inches (5 cm) above the bottom, and shall have a method or device to show the oil level. The regulator shall be shipped with the required amount of oil ready for service.

3.4.6 Control Cabinet. A control cabinet or compartment made of suitable materials shall be provided for housing the relays, the sensing devices, the control terminal block, the remote/local control switch, and other low voltage control components. It shall be either permanently attached to or an integral part of the enclosure. All low voltage control components shall be accessible by opening the cabinet. The cabinet shall close tightly to keep out insects or dust.

3.4.7 Capacitors. If capacitors are provided for power factor correction, their terminals shall be enclosed. After 10 years of operation at 12 hours a day, 90 percent of the capacitors shall still be operational.

3.4.8 Wiring Diagram. A legible wiring diagram shall be permanently mounted in an unobstructed place in the control cabinet.

3.4.9 Painting and Finishing. The inside and outside of the enclosure shall be given one prime coat and one finish coat of oilproof and weatherproof paint. The outside of the enclosure shall be touched up after assembly and testing are complete.

3.4.10 Lightning Arresters. Lightning arresters of the size necessary to protect the regulator shall be installed across the regulator output terminals. The ground side of the arresters shall be connected to the grounding lug of the enclosure or other suitable location. The lightning arresters shall be able to handle the pulse specified in 4.3.13 as a minimum.

3.4.11 Warning. A plate or decal shall be affixed to the front of the control cabinet door warning the maintenance technician to remove input and control power before opening the cabinet.

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

3.4.13 *Nameplate. A nameplate with the information below shall be securely attached to the front of the regulator enclosure. If the nameplate is attached to a readily removable surface, such as a cover, the serial number shall be duplicated in a permanent conspicuous place elsewhere on the regulator.

4017 8/12

a. Constant current regulator, single phase.

b. Input: _____ Volts _____ Hertz _____ Amperes.

c. Control: _____ Volts _____ Hertz.

d. Output: _____ kW at _____ Amperes.

e. Output Current: /_ / _Amperes. Gallons of oil _____.

f. Identification: FALL-828 (or L-829) _ _ Serial No.

3.4.14 Instruction Book. An instruction book containing at least the following information shall be furnished with each regulator:

a. Complete schematic and wiring diagrams showing all components cross-indexed to the parts list.

b. Complete 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 Monitoring. The monitor shall detect the status of the regulator and the constant current circuit that it powers. Type L-829 regulators have integral monitoring; the monitor may be offered as a separate module designated type L-827. The monitor shall be matched with the regulator so that it will function when the regulator is powering a load whose nominal value is between 50 and 100 percent of the regulator's rated capacity. The load shall consist of a constant current loop that energizes the primary of several isolating transformers (specified in AC 150/5345-47). The secondary of these transformers will power an airport lighting fixture. As a minimum, the monitor shall operate on the top two steps of both regulator styles; faults (a), (b), and (d) shall be detected at all brightness levels. The monitor shall function when the regulator is in the remote or local control mode (fault (d) must be detected in the remote mode, but need not be detected in the local mode). The monitor shall operate in a fail-safe manner. The output of the monitor shall energize the coil of a SPDT relay when the regulator is operating properly. Upon initial detection of a fault, the monitor shall wait 5 seconds (except for fault (a) and (b)); if the fault still exists, the monitor shall indicate an alarm. The relay contacts shall be rated for a 2 amp resistive load at 120 Volts ac, 60 Hz. The monitor outputs shall be connected to a terminal block to facilitate external connections, and shall operate with control lines similar to those described in 3.3.6. A visual indication shall be provided on the monitor to indicate which monitored parameter caused the fault Indication (except for fault (a)), and a regulator-on light shall be provided. The following fault conditions shall be detected:

a. Loss of input power to the regulator;

b. Shutdown of the regulator due to operation of any of the protective circuits specified in 3.3.9;

c. A 10 percent or greater drop in the volt-amperes being delivered to the circuit;

d. Failure of the regulator to deliver the output current corresponding to the brightness step selected;

e. A failure of a preset number of lamps in the series circuit. The load of each lamp and associated isolation transformer may vary between 80 and 200 Watts; the monitor shall be adjustable so that the number of failed lamps required to cause a failure indication may be varied from 4 to 10. After the preset number of lamps fail, it shall be possible to switch the monitor into a degraded operation mode. This mode will deactivate the fault indication, and reenergize it upon failure of an additional preset number of lamps (1 to 5). Additional warning or alarm levels may be provided, but are not required.

4. QUALIFICATION REQUIREMENTS.

4.1 Qualification Request. Procedures for obtaining qualification approval are contained in the latest edition of AC 150/5345-1, Approved Airport Lighting Equipment.

4.2 Output Waveforms. To ensure compatibility between regulators and auxiliary equipment which may be powered by the regulator output, the manufacturer shall supply with the qualification documents oscilloscope photographs of the output current and voltage waveforms at nominal line voltage for all intensity steps at short circuit, half load, and full load. The full-load and half-load waveforms shall be photographed with a purely resistive load, then repeated with 30 percent of the isolation transformers open-circuited as specified in 4.3.1.2. These photographs will be used by the auxiliary equipment manufacturers to ensure compatibility with all approved regulators. These photographs shall also be available in a manual to any interested auxiliary equipment manufacturers for a nominal fee.

4.3 Qualification Testing.

4.3.1 Regulation Test. The following tests shall be performed to demonstrate compliance with 3.3.1 and table 1. Where isolation transformers and lamps are not specifically required, a lumped resistive load may be used.

4.3.1.1 Input Voltage Tests. For regulators 10 kW and larger, load the regulator to full load and energize it with nominal input voltage, 110 percent of nominal voltage, and 95 percent of nominal voltage and verify that the output current falls within the limits of table 1 for all brightness steps. Repeat this test at half load and short circuit. For resonant regulators under 10 kW, energize the regulator with 250, 240, 230, 220, and 208 V and verify that the output current is within the limits of table 1. This test shall be conducted at short circuit, half load, and full load and at all brightness settings. Nonresonant regulators under 10 kW may meet either criteria.

4.3.1.2 Reactive Load Tests. For regulators 10 kW and larger, an equivalent of full load and half load shall be placed on the regulator, but with 30 percent of the isolating transformers open-circuited. The input voltages shall be nominal, 110 percent of nominal, and 95 percent of nominal. The output current shall be checked at all brightness settings and shall be within the limits of table 1. For regulators under 10 kW, the regulator shall be energized with 240 V under full load and half load at the 100 percent brightness step. The secondaries of 30 percent of the isolating transformers shall be open-circuited, and the output current shall not rise above 6.8 amperes.

4.3.2 Remote Control Test. Check the output current at all brightness steps using the following remote control circuits (a resistance load may be used in lieu of the full length specified) and rated output load:

a. Connect the remote switch by simulated 100-foot (30 m) lengths of No. 12 AWG wire (a resistance equal to 0.16 ohms per wire). Operate the regulator remotely on all brightness steps to determine compliance with 3.3.6.

b. Connect the remote switch by simulated 10,000-foot (3 000 m) lengths (total round-trip distance) of No.19 AWG control wire (a resistance equal to 87 ohms per 10,000 feet of wire and a capacitance between any two wires of 0.16 microfarads). Operate the regulator remotely on all brightness steps to determine compliance with 3.3.6.

4.3.3 Temperature Rise. Determine the temperature rise of the regulator transforming device in accordance with ANSI C57.12.90 for oil-cooled transformers and ANSI C57.12.91 for dry-type transformers.

4.3.4 Efficiency. With nominal input voltage and a full load of unity power factor, determine that the efficiency at maximum brightness is not less than specified in table 2.

4.3.5 Power Factor. With nominal input voltage and a full load of unity power factor, determine that the power factor at maximum brightness is not less than specified in 3.3.3.

4.3.6 Altitude. Each design of regulator shall be tested for low pressure (altitude) according to MIL-STD-810, Method' 500.2, Procedure II. The maximum altitude shall be 6,600 feet (2 000 m) and the ambient temperature shall be 55° C. The regulator shall be operated at rated voltage, load, and maximum brightness for 4 hours. Failure of the tests in 4.3.1.1 immediately after the 4-hour run-in period will be cause for rejection of the equipment.

4.3.7 Low Temperature. Place the regulator in a test chamber and maintain the ambient temperature at -40° C ±5° for 12 hours with the regulator off. Perform the tests in 4.3.1.1 while maintaining the low temperature to demonstrate regulator operation. Remote control may be used. For monitoring circuitry, the test shall be run at 0° C.

4.3.8 Humidity. Each design of regulator shall be tested for resistance to humidity according to MIL-STD-810, Method 507.2, Cyclic High Humidity (Table 507.2-I, Cycle 3). The regulator shall be exposed to 12 cycles. Failure of tests in 4.3.1.1 after humidity cycling, or evidence of corrosion or deterioration, will be cause for disapproval of the regulator.

4.3.9 Electromagnetic Interference Tests. Test for electromagnetic interference by Methods CE 01 and CE 02 of MIL-STD-462, except that the frequencies from 30 hertz to 50 kilohertz shall be covered and that both power and control lines shall be tested.

4.3.10 Basic Impulse Insulation Level (BIL) Tests. Subject the primary and secondary of the regulator to BIL tests in accordance with ANSI C57.12.90 or C57.12.91.

4.3.71 Dielectric Tests. Test the circuits of all regulator sizes to determine the equipment's ability to withstand the following rms 60 Hz test voltages for 1 minute without failure. Lightning arresters shall be disconnected during this test.

a. 240-volt input circuit to ground - 2,000 V.

b. 2,400-volt input circuit to ground - 19,000 V.

c. 120-volt control circuits to ground - 1,000 V.

d. 48-volt control circuits to ground - 500 V.

e. Output circuit to ground - 5 times the full load rms voltage.

4.3.12 Protective Device Tests. Test all protective devices for proper operation as specified in 3.3.9. Test to determine the open-circuit voltage (3.3.8) using an oscilloscope or high voltage peak reading meter. On each brightness step, interrupt the input voltage until the regulator ceases operation; reconnect the power to'demonstrate resumed operation on the same step (3.3.10).

4.3.13 Transient Suppression. To demonstrate the effectiveness of the lightning arresters, they shall suppress a test pulse on the output lines consisting of a 10 by 20 microsecond current surge of 15,000 amperes with the subsequent power-follow current and a voltage surge of 10 kV per microsecond minimum without damage to the regulator.

4.3.14 Leakage Test. Test each oil-filled regulator assembly to determine that all welds and gasketed seals are tight. Utilize an internal air pressure of 10 $\pm$2 psi for 5 minutes.

4.3.15 Output Current Surge. Check the regulator output current during turn-on and switching to determine compliance with 3.3.7.

4.3.16 *Monitoring Test. The manufacturer shall develop a test program for FAA approval that exercises each of the monitoring functions and demonstrates the required sensitivity. The test shall use an actual constant current loop with isolating transformers and lamp loads consisting of at least 50 percent of the

regulator's rated capacity. Monitor operation shall be demonstrated with each type of regulator design with which it will be mated. The test plan shall demonstrate compliance with 4.3.6 through 4.3.9, and 4.3.13.

4.4 Production testing. Subject each regulator to the tests 4.3.2, 4.3.11, 4.3.12 (only protective devices test), and 4.3.14. For the monitor, the manufacturer shall develop a test procedure to exercise and test each of the alarm functions of the monitor.