SPECIFICATION L-828, CONSTANT CURRENT REGULATORS

1. SCOPE AND CLASSIFICATION.

1.1 Scope. - This specification sets forth the requirements for constant current regulators for use in airport series lighting circuits.

1.2 Classification. - Two types, two classes, two styles, and eight sizes of constant current regulators are covered by this specification. The various combinations are shown in table I below:

TABLE I. REGULATOR CLASSIFICATION

Size (kW Rating)	Type (Output current)		Class (Input voltage)		Style (Brightness steps)	
	I	II	I	II	I	II
kW	6.6 A	20 A	240 V	2400 V	3 Step	5 Step
4	X		X		X	
7½	X		X		X	
10	X		X	X	X	X
15	X		X	X	X	X
20	X	X	X	X		X
30		X		X		X
50		X		X		X
70		X		X		X

2. APPLICABLE DOCUMENTS.

2.1 General. - The following documents, of the issue in effect on the date of application for qualification, form part of this specification and are applicable to the extent specified herein.

2.2 Federal Aviation Administration publications. -

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

FAA-STD-013 Quality Control Program Requirements

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

2.4 Military standards. -

MIL-STD-810 Environmental Test Methods

MIL-STD-462 Electromagnetic Interference Characteristics, Measurement of

(Copies of FAA advisory circulars may be obtained from the Department of Transportation, Publications Section, M-443.1, Washington, D.C. 20590.)

(Copies of FAA standards may be obtained from the Federal Aviation Administration, Airway Facilities Service, Washington, D.C. 20591.)

(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 1052.)

3. REQUIREMENTS.

3.1 General. - The constant current regulators described herein are intended to be power sources for series lighting circuits on airports.

3.2 Environmental requirements. - The constant current regulators shall be designed for continuous indoor operation under the following conditions:

(a) Temperature range of -40°C to +55°C.

(b) Relative humidity range of 10 percent to 100 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 load requirements. - The regulator shall maintain the output current within the limits of table II at 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 3.4.1. For regulators less than 10 kW, the regulation shall be provided at nominal input voltage for all brightness steps.

TABLE II. OUTPUT CURRENT

Brightness step	Nominal rms output current (amperes)	Output current limits (amperes)
	(Style I)	
3	6.6	6.40-6.70
2	5.5	5.33-5.67
1	4.8	4.66-4.94
	(Style II)	
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	2.72-2.88
	(Style II)	
5	20.0	19.40-20.30
4	15.8	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 load requirements. - When the regulator is loaded with isolation transformers as described in AC 150/5345-47 and suitable lamps and the secondaries of 30 percent of the transformers are open-circuited, the output current shall remain within the limits given in table II. The load before opening the isolation transformer secondaries shall be any value from half to full load. For regulators 10 kW or greater, the output current shall remain within the limits given in table II for all brightness steps. For regulators less than 10 kW, 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 100 percent power factor shall be not less than the value shown in table III.

TABLE III. REGULATOR INPUT EFFICIENCY

Regulator size (kW)	Minimum overall efficiency (percent)
4	90
7½	90
10	90
15	90
20	90
30	92
50	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 resistive load.

3.3.4 Temperature rise. - The temperature rise of the regulator shall be in accordance with ANSI C57.12.00.

3.3.5 Control system. - The control system shall stabilize at any intensity setting within 5 seconds and shall hold the output current stable within ±0.1 ampere at any output setting. The control system shall be designed for both local and remote control. Circuit lengths of 10,000 feet (3 000 m) using No. 19 AWG control cable are required. Remote control shall not affect the regulator performance characteristics. Voltage for the control system shall not exceed 120 V.

3.4 Detail requirements. -

3.4.1 Input voltage. - Input voltage shall be single phase, 60 Hz ac as follows:

(a) For regulators 20 kW and smaller - 240 V, +10%, -5%.

(b) For regulators 10 kW and larger - 2400 V, +10%, -5%.

Regulators of 10 kW, 15 kW, and 20 kW may comply with either criteria. As an alternative to the requirements of item (a) above, resonant-type regulators smaller than 10 kW may be supplied with taps for 250, 240, 230, 220, and 208 V from which the proper tap may be selected for various supply voltages. 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 in a 1-minute interval. External control power may be utilized if desired.

3.4.2 Circuit isolation. - The power input circuit shall be electrically isolated from the output circuit. 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. These measurements shall be made with an oscilloscope or high voltage peak reading meter.

3.4.3 Primary switch. - The regulator shall have an integral remotely controlled primary switching device operated by control voltage. The opening of this device shall not interrupt the power to the remote control.

3.4.4 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.

3.4.5 Overcurrent protection. - Regulators 10 kW and larger shall include an overcurrent protective device that opens the primary switch when the output current exceeds the nominal output current 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.

3.4.6 Input power loss. - In the event of a loss of input power long enough to affect regulator output current, the regulator shall resume operation on the selected brightness setting within 5 seconds after the restoration of input power.

3.4.7 Electromagnetic interference. - The regulator shall cause minimal 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 be supplied from the same power supply.

3.4.8 Remote/local control switch. - A multiposition selector switch to select remote, off, and local brightness control shall be located for ready access by an operator without opening doors or removing covers. The switch shall have detents, and the 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.

3.4.9 Output ammeter. - A flush-mounted, true rms-indicating 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 (7.5 cm) round meter. The meter accuracy shall be at least ±3.0 percent of the maximum output current.

3.4.10 Terminal block and wiring. - A pressure-type terminal block having suitable voltage rating shall be installed in the control cabinet. Label the terminals as shown below. This terminal block shall accommodate No. 12 to No. 20 AWG wire with an insulation rating up to 600 V. At least two spare terminal block positions shall be provided in addition to those listed below. Terminals XCP and N need be supplied only if external control voltage is used.

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

3.4.11 Regulator enclosure. - The reactors and/or transformer shall be housed in a sheet steel enclosure. The enclosure shall be equipped with a removable cover that is held securely in place by capscrews or clamps. Feet or channels shall be attached to the bottom of the enclosure so there will be no less than 2 inches (5 cm) of space between the bottom of the enclosure and the floor below it. Four enclosed terminations (two input and two output), suitable for the voltages involved, shall be located on the side or front of the enclosure with each pair labeled "input" or "output" as applicable. If the enclosure is an oil-filled tank, it shall be designed and fabricated to be oiltight, 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. Lifting lugs shall be installed on the enclosure. Overall physical 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. The regulator shall be shipped with the required amount of oil ready for service.

3.4.11.1 Control cabinet. - A suitable steel control cabinet or compartment for housing the relays, the sensing devices, the control terminal block, the remote/local control switch, and other low voltage control components 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 in order to minimize entrance of insects and airborne foreign material.

3.4.12 Capacitors. - Capacitors shall be provided for power factor correction if required. After 10 years of operation at 12 hours a day, 90 percent of the capacitors shall still be operational. Capacitors may be connected externally provided the terminals are enclosed when the equipment is installed.

3.4.13 Output current surge limitation. - The regulator shall be designed so that any output surges caused by switching the regulator on and off, changing brightness steps, or shorting the load will not damage series incandescent lamps. If time delay is utilized, no more than 2 seconds shall elapse from when the regulator is turned on to when the current is delivered to the load terminals. Pulsation or hunting of output current shall be limited to 5 seconds or less under all conditions of switching.

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

3.4.15 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.

3.4.16 Nameplate. - A nameplate with at least the following information shall be securely attached to the front of the regulator enclosure:

(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: FAA-L-828_____ Serial No.

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.

3.4.17 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 part number.

(c) Installation instructions.

(d) Maintenance instructions.

(e) Troubleshooting charts.

(f) Theory of operation.

3.4.18 Special provisions. - In exceptional cases, special modifications to this specification may be required to meet local conditions. Modifications permitted are listed below:

(a) Input voltage and frequency may be specified other than normal. In this event, adjust the performance and testing requirements proportionately.

(b) The regulator may be furnished with an external instead of an integral primary switch. The protective functions specified in 3.4.4 through 3.4.6 shall not be affected. All connections for an external primary switch or control power shall be made through the terminal block.

(c) Regulators smaller than 10 kW may be provided without local control provision. All tests requiring local control shall be conducted with remote control.

3.4.19 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. The lightning arresters shall be able to handle the pulse specified in 4.2.13.1 as a minimum.

3.4.20 Warning. - A plate or decal with the following warning shall be affixed to the front of the regulator control cabinet door:

WARNING
REMOVE MAIN INPUT AND CONTROL POWER BEFORE OPENING COMPARTMENT

4. QUALITY ASSURANCE PROVISIONS.

4.1 Qualification requirements. -

4.1.1 Qualification request. - Requests for qualification approval must be submitted in writing to the Office of Airport Standards, Attention: AAS-200, Federal Aviation Administration, Washington, D.C. 20591. This request must include:

(a) A list of the types, classes, styles, and sizes of equipment, along with the manufacturer's catalog numbers, for which qualification approval is requested. A list of equipment options should also be included when specified in individual equipment specifications.

(b) A copy of proposed test procedures and test data sheets and a statement as to whether the manufacturer proposes to conduct tests or name and location of the independent testing laboratory where the tests are to be conducted (4.1.2).

(c) A copy of the manufacturer's proposed guarantee for the equipment (4.1.4).

(d) A copy of the manufacturer's quality control plan (4.1.3).

(e) A preliminary copy of the equipment instruction manual (3.4.17).

(f) A copy of the output waveform photographs (4.1.8).

4.1.2 Qualification testing. - The equipment must pass all tests in 4.2. The manufacturer shall supply all test equipment and bear all testing costs. Tests may be conducted at the manufacturer's plant, if facilities are available, or at an independent test laboratory acceptable to the FAA. The FAA reserves the right to witness any or all tests and shall be provided with 14 days advance notification of testing. Where the FAA waives the option to witness tests, the manufacturer must submit a certified copy of all test reports.

4.1.3 Quality control provisions. - The manufacturer shall provide and maintain a quality control program in accordance with FAA-STD-013 except that facilities for an FAA Quality Assurance Representative are not required.

4.1.4 Guarantee. - The manufacturer shall provide the following minimum guarantee for each equipment: That the equipment has been manufactured and will perform in accordance with this specification and that any defect in material or workmanship which may occur during proper and normal use during a period of 1 year from the date of initial operation or a maximum of 2 years from the date of shipment will be corrected by repair or replacement by the manufacturer f.o.b. factory.

4.1.5 Instruction manual. - The preliminary instruction manual will be reviewed to assure compliance with 3.4.17 and recommended changes, if any, will be forwarded to the manufacturer. The manufacturer shall incorporate recommended changes and submit 13 copies of the final instruction manual to the FAA prior to receiving qualification approval. These instruction manuals will be used by FAA personnel to monitor the equipment as delivered to prevent nonapproved modifications.

4.1.6 Qualification approval. - Manufacturers who have met all requirements specified herein will be listed as approved suppliers in AC 150/5345-1, Approved Airport Lighting Equipment. Once approval has been granted, the manufacturer may not make any changes in the equipment without prior FAA approval. Requests for design or component changes must be submitted to the office listed in 4.1.1 and must be accompanied by supporting documentation for the change plus 13 copies of revised instruction manual pages which reflect the proposed change. Substitution of components which are identical in rating and size and equal or better in quality does not require prior FAA approval.

4.1.7 Post qualification requirement. - Production test reports on all regulator assemblies shall be retained on file by the manufacturer for a period of not less than 2 years from the date of shipment to the user. Certified copies of production test reports shall be made available upon written request by the Federal Aviation Administration, Engineering and Specifications Division, AAS-200.

4.1.8 Output waveforms. - To insure 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 4.2.1. These photographs will be used by the auxiliary equipment manufacturers to insure compatibility with all approved regulators. These photographs shall also be available in a manual to all interested auxiliary equipment manufacturers for a nominal fee.

4.2 Qualification testing. -

4.2.1 Regulation test. - The following tests shall be performed to demonstrate compliance with the requirements specified in 3.3.1 and table II. Where isolation transformers and lamps are not specifically required, a resistive load may be used.

4.2.1.1 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 II. Repeat this test at half load and short circuit. These tests shall be repeated at all brightness settings. 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 II. 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.

4.2.1.2 Inductive 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 voltage. The output current shall be checked at all brightness settings and shall be within the limits of table II. For regulators under 10 kW, the regulator shall be energized with 240 V and an equivalent of full load and half load on the secondary 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.

4.2.2 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 3.3.5.

(b) Connect the remote switch by simulated 10,000-foot (3 000 m) lengths of No. 19 AWG control wire (a resistance equal to 87 ohms per wire and a capacitance between any two wires of 0.16 microfarads). Operate the regulator remotely on all brightness steps to determine compliance with 3.3.5.

4.2.3 Temperature rise. - Determine the regulator temperature rise in accordance with ANSI C57.12.90.

4.2.4 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 III.

4.2.5 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.

4.2.6 High temperature. - Place the regulator in a test chamber and maintain the ambient temperature at 55°C ±2°. After the temperature of the regulator components has stabilized, operate the regulator for 4 hours at full rated input and output values. Perform the tests in 4.2.1.1 to demonstrate high temperature operation.

4.2.7 Low temperature. - Place the regulator in a test chamber and maintain the ambient temperature at -40°C ±2° for 12 hours. Perform the tests in 4.2.1.1 while maintaining a temperature of -40°C to demonstrate low temperature operation (remote control may be used).

4.2.8 Humidity. - Each design of regulator shall be tested for resistance to humidity according to MIL-STD-810, Method 507.1, Procedure II, except that the maximum temperature shall be +55°C. Failure of tests in 4.2.1.1 after humidity cycling will be cause for disapproval of the regulator.

4.2.9 Altitude. - Each design of regulator shall be tested for low pressure (altitude) according to MIL-STD-810, Method 500.1, except that 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 4.2.1.1 immediately after the 4-hour run-in period will be cause for rejection of the equipment.

4.2.10 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.

4.2.11 Basic impulse insulation level (BIL) tests. - Subject the primary and secondary of the regulator to BIL tests in accordance with ANSI C57.12.90. Dry-type regulators shall meet the BIL requirements for dry-type regulators.

4.2.12 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:

(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.

Lightning arresters shall be disconnected during this test.

4.2.13 Protective device tests. - Test all protective devices for proper operation as specified in 3.4.4 and 3.4.5. Also test to determine the open-circuit voltage as specified in 3.4.2. Disconnect the open-circuit protection for this test.

4.2.13.1 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.

4.2.14 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.

4.2.15 Output current surge. - Check the regulator to determine compliance with 3.4.13.

4.2.16 Production testing. - Subject each regulator to the tests specified in 4.2.2 and 4.2.12 through 4.2.14, except 4.2.13.1.

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