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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: SPECIFICATION FOR L-828 CONSTANT CURRENT REGULATOR WITH STEPLESS BRIGHTNESS CONTROL

1. PURPOSE. This circular describes the subject specification requirements and is published by the Federal Aviation Administration for the guidance of the public.

2. CANCELLATION. AC 150/5345-10A, Specification for L-828 Constant Current Regulator With Stepless Brightness Control, dated December 8, 1965, is cancelled.

3. REFERENCE. The issuance of American Standards Association C57, American Standards for Transformers, Regulators, and Reactors, in effect on the date of application for qualification (paragraph 10), may be obtained from the American Standards Association, Incorporated, 10 East 40th Street, New York, New York 10016.

4. EXPLANATION OF REVISIONS. In addition to minor changes in the text, the following revisions were made:

   a. Characteristics were added for regulators with a 20.0-ampere output.

   b. Provisions were added for 25KW regulators.

   c. Provisions were added to permit the remote controlled primary oil switch and control voltage for "on-off" operation to be furnished as an integral part of the regulator.

   d. The test procedure for regulation was revised to require the use of local and remote controls.

   e. A test was added to check the remote operation of the regulator.

   f. An impulse test was added for the primary input and secondary output circuits of the regulators.

Initiated by: AS-580

5. SCOPE OF PUBLICATION. The specification requirements presented are for an oil-filled constant current regulator designed with either a saturable reactor or a floating coil. Provisions are made for stepless brightness selection without interrupting load current. The assembly has essentially an insulating transformer, current detecting system, lightning arresters, brightness selection control circuit, open-circuit and overcurrent protection, and an instrument current transformer. In addition, a transfer switch is provided in the control circuit for an "off" position, local operation, and transfer to remote operation. All parts are suitably enclosed for indoor and outdoor service. The regulator is wired at the factory as a complete assembly.

6. SIZES. Provisions are made for the regulator assemblies to be manufactured in the sizes listed in paragraphs a through j below. The primary input to the regulator assemblies is 2400 volts, 60 hertz, single phase. This equipment is acceptable for wye or delta connections. Provisions for regulators with optional requirements and modifications are contained in paragraph 8r.

   a. 10KW, 6.6-ampere output

   b. 10KW, 20.0-ampere output

   c. 20KW, 6.6-ampere output

   d. 20KW, 20.0-ampere output

   e. 25KW, 6.6-ampere output

   f. 25KW, 20.0-ampere output

   g. 30KW, 6.6-ampere output

   h. 30KW, 20.0-ampere output

   i. 50KW, 20.0-ampere output

   j. 70KW, 20.0-ampere output

7. PERFORMANCE REQUIREMENTS.

   a. Regulation. Design the regulator assembly to permit stepless control of output current. The assembly automatically compensates for variations of input voltage. At all loads from no load to full load, the assembly maintains its nominal output current within the limits set forth in Figure 1 for the input voltage range shown. The regulator is adjusted so that changes in input voltage will not cause the output current of the regulator to vary outside of the limits shown in Figure 3. The assembly meets these same

requirements with 10 percent of the total load consisting of open-circuited isolating transformers. When more than 10 percent of the total load consists of open-circuited isolating transformers, the output currents are not to exceed the limits shown in Figure 1.

FIGURE 1. TRANSFORMER CHARACTERISTICS

Nominal Output Current (Amperes)	Input Voltage Range (Volts)	Output Current Deviation From Nominal
6.6	2280-2640	±0.10 Ampere
2.8	2280-2640	±0.13 Ampere
20.0	2280-2640	±0.30 Ampere
8.5	2280-2640	±0.40 Ampere

b. Efficiency. Supply the regulator's input with 2400 volts and connect a unity power factor load to the output circuit. Measure the efficiency at full load. The regulator's efficiency at an ambient temperature of 25°C. is not less than the values shown in Figure 2.

FIGURE 2. TRANSFORMER EFFICIENCY

Regulator Size	Percent Overall Efficiency (Minimum)
10KW	88
20KW	90
25KW	91
30KW	92
50KW	93
70KW	94

c. Primary Power Factor. Operate the regulator as specified in paragraph 7b and calculate the uncorrected primary power factors. The power factor is not less than 70 percent at full load for all sizes of regulators.

d. Temperature Rise. Determine the winding temperature rise as measured by the resistance method. Obtain this temperature rise by operating the regulator continuously at full load and unity power factor. The maximum temperature rise of the regulator and regulator's oil under these conditions is 65°C. and 55°C., respectively.

e. Temperature Limits. Design and construct the unit and its accessories to operate at any ambient temperature from a minimum of -45°F. to a maximum of 120°F. at sea level.

8. DETAILED REQUIREMENTS.

a. Rating. Design the regulator to supply the applicable range of current to a load of incandescent filament lamps, with each lamp connected to an individual isolating transformer. Determine the maximum load by multiplying the output voltage and current obtained at brightness step 5. This calculated KW is not in excess of the KW rating of the regulator. The nominal primary voltage is 2400 volts, single phase, 60 hertz; however, the regulator operates and meets the output current regulation requirements shown in Figure 1 for primary voltages varying from 2280 to 2640 volts. Design the regulator to automatically compensate for any input voltage variations within this range.

b. Constant Current System. Completely isolate (electrically) the input power circuit of the regulator from the output series circuit. Make the root mean square (RMS) value of the open-circuit output voltage of the regulator not in excess of 140 percent of the rated load voltage when operating at nominal input voltage. The constant current regulator consists of the following components as required by the specific design.

(1) Saturable Reactor. Design the constant current regulator with transformers and saturable reactors utilizing a current detector and control circuit devices to produce a constant current of the values specified under paragraph 7a.

(2) Floating Coil. Design the constant current regulator with a transformer constructed with the vertical axis of the floating coil coinciding with the vertical axis of the fixed coil throughout its range of travel. Use no pivots. Incorporate in this design a means for absorbing the shock of repeated de-energizing with the moving coil in the extreme upper position without damage to coils or other components. Use a control circuit with the transformer to produce a constant current of the values specified under paragraph 7a.

c. Control Equipment. Provide one of the control systems specified below as part of the assembly to obtain stepless brightness control. The control is capable of completing its full travel cycle in not more than ten seconds. It is capable of stopping and holding at

any output current within the specified range. For remote control, use a detented potentiometer equal to General Radio Company's Part No. 975KS5G1. The remote detented potentiometer is not a part of this specification.

(1) Saturable Reactor Design. Provide a saturable reactor regulator with a motor-driven variable ratio transformer as a part of the assembly. Control this unit on local operation with a single pole, double throw (SPDT), momentary contact switch, mounted on the regulator control cabinet. Use a SPDT, polarized, open-center DC relay for remote control of the auto transformer's drive. Install in the regulator control cabinet the components required to control the regulator including the control power supply.

(2) Floating Coil Design. Provide a floating coil regulator with a suitable adjusting device mounted on the regulator control cabinet to obtain stepless brightness control from local control position. Make provisions in control circuits to prevent voltages in excess of 120 volts from being in the control cabinet. Make the components required to control the regulator, including the control power supply, accessible from within the regulator cabinet.

d. Remote Control Output Current. Design the regulator to supply an output current, when remotely controlled by a potentiometer equal to General Radio Company's Part No. 975KS5G1, within the limits listed in Figure 3. Base these values on rated tolerances for input voltage and load.

FIGURE 3. TRANSFORMER CHARACTERISTICS

Potentiometer Brightness Position	Nominal Output Current (Amperes)	Output Current Adjustment Range
5	6.6	6.4 - 6.7
4	5.2	4.9 - 5.5
3	4.1	3.8 - 4.4
2	3.4	3.2 - 3.7
1	2.8	2.6 - 3.1
5	20.0	19.4 - 20.3
4	15.8	14.9 - 16.7
3	12.4	11.5 - 13.3
2	10.3	9.5 - 11.0
1	8.5	7.7 - 9.3

e. Control and External Power. If internal control voltage is not included as specified in paragraph 8r(3), make provisions for the use of control power from an external 115 to 120 volt, 50/60 hertz external source. This external voltage will be provided to the regulator at the installation. Provide internally any other control power requirements which may be needed for the brightness control.

f. Open-Circuit Protection. Provide an automatic open-circuit protective device to prevent damage or injury in the event that an open circuit develops in the secondary. The protective device operates when the secondary circuit is opened. The device operates by opening the main primary control circuit in not more than two seconds after the open circuit occurs. It resets automatically within 1/10 second after the master control switch (not a part of the regulator assembly) is opened or after the remote and local control switch (a part of the regulator assembly) is returned to the "off" position.

g. Overcurrent Protection. Provide an automatic overcurrent protective system, where required, to protect the regulator load from overcurrent conditions. Design the overcurrent protection to operate by opening the main primary control circuit when the output current is outside the maximum allowable nominal output current by no less than 8 percent and no more than 12 percent. Provide the protective system with an instantaneous reset feature.

h. Remote and Local Control Switch. Provide a three-position selector switch for switching from "remote to off and to local" control. Mount this selector switch on the regulator with the operating control externally located for easy access to an operator. Mark the three positions of the selector switch as follows: "remote, off, and local." Provide connections for these positions as listed below.

(1) Remote. Remote control circuits connected and local control circuits open. (The remote control station is not furnished as part of this assembly).

(2) Off. Remote and local control circuits open.

(3) Local. Local control circuits connected and remote control circuits open.

i. Instrument Current Transformer. Provide a suitable current transformer with provisions for obtaining an indication of output current through an indicating ammeter. Mount the indicating ammeter (not less than three inches in diameter) flush on the side of the control cabinet or in the control cabinet door so that it can be read externally. Provide a 3"x5" cardholder near the ammeter for the user's "current-brightness calibration."

j. Terminal Board and Wiring. Provide a suitable pressure-type terminal board in the control compartment. Label the terminals as shown below. Delete terminals not required when the remote controlled primary oil switch is integral as specified in paragraph 8r(3).

(1)	71	Control Neutral
(2)	72	Control Power
(3)	73	Remote Control Power
(4)	74	Remote Oil Switch Control
(5)	75	Primary Oil Switch Coil
(6)	81-82-83	Brightness Control

k. Tank and Control Cabinet. House the reactors and/or the coils of the transformer in a sheet metal steel tank. Equip the tank with a removable gasketed cover held securely in place by bolts or clamps. Set the tank on a steel base plate with feet or channels and provide a drain plug and sampling valve on the side of the tank not more than 2 inches above the bottom. Provide the tank with 4 stud terminals (2 labeled "input" and 2 labeled "output") suitable for the voltage involved. Protect these terminals from damage with a suitable shield. Provide the tank with lifting lugs. Attach a suitable sheet steel control cabinet permanently to the side of the tank for housing the relays, sensing device, protective relay, control terminal board, and the control and transfer switch. Provide not less than four 1-inch i.p.s. threaded bosses at suitable locations on the sides and bottom of the cabinet. Make the complete assembly weatherproof for installation outdoors.

(1) Make all low voltage control components accessible by opening the cabinet door. Permit no voltage over 600 volts within the control cabinet. Make the door capable of being tightly fastened to minimize entrance of dust or insects. Make the knob of the control and transfer switch accessible without opening the cabinet door. The exact shape of the tank and attached control cabinet is optional provided that all other requirements are met. Ship the regulator filled with oil and ready for service. For all connections leaving the tank, provide means to prevent oil siphoning. Mount a clamp-type terminal lug on the outside of the regulator case for ground connections. Install an oil level gauge in the tank.

(2) Make the overall physical dimensions of the regulator assembly for all sizes and types so as to permit passage through a doorway 39 inches wide and 78 inches high.

l. Capacitors. Provide capacitors, where required, with at least 25 percent higher than the normal working voltage. Provide adequate cooling to insure long life. Provide capacitors with ratings to perform within the temperature limits specified in paragraph 7e.

m. Output Current Surge Limitation. Design the regulator so that any output surges caused by switching the regulator on and off, changing brightness steps, or shorting the load will not damage a series incandescent lamp. Time delay, if incorporated, when switching the regulator on and off, will not cause an interval of more than two seconds to elapse before the unit operates to deliver the current selected.

n. Wiring Diagram. Mount a wiring diagram permanently inside the control cabinet. Make it legible and readily accessible.

o. Painting and Finish. Give the inside and outside of the tank one prime coat and one finish coat of oilproof and weatherproof paint. Give the outside of the tank a touchup after final assembly.

p. Nameplate. Securely attach a nameplate, permanently and legibly filled in with at least the following information, to the outside front of the regulator housing:

(1) Constant current regulator, single phase

(2) Input: _____ Volts _____ Cycles _____ Amperes

(3) Control: _____ Volts _____ Cycles

(4) Output: _____ KW at _____ amperes _____ Serial No.

(5) Output Current: _____ to _____ amperes. Gallons of oil _____.

(6) Identification: FAA L-828

q. Parts List and Installation Instructions. Furnish a component parts list and installation and maintenance instructions with each regulator assembly. Provide sufficient drawings or illustrations to clearly indicate the methods of installation and maintenance.

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

(1) Input voltage may be specified other than 2400 volts, 60 hertz. In this event, adjust the performance and testing requirements proportionately.

(2) Regulator ratings of not more than 90KW will be permitted when the 20-ampere output is specified.

(3) A remote controlled primary oil switch and internal control voltage may be furnished as an integral part of the regulator. The switch has a rating adequate for installation in the regulator's input circuit. The internal control voltage eliminates the requirement for the external voltage referenced in paragraph 8e.

s. Lightning Arresters. Install two lightning arresters across the output terminals of the regulator, one connecting each of the two legs of the output circuit to ground. Connect the ground side of the arresters to the ground clamp on the regulator case. Size the arresters to prevent lightning damage to the regulator. Disconnect the arresters for all high voltage testing of the regulator.

t. Warning. Place a plate or decal with the following legend on the front of the regulator control cabinet door as a warning:

WARNING

TURN LOCAL CONTROL TO "OFF" POSITION BEFORE OPENING COMPARTMENT DOOR

9. TESTING.

a. Qualification Testing.

(1) Supply one sample regulator for the tests to be performed.

(2) Subject the regulator to the electrical and physical tests described below, the applicable detailed requirements under paragraph 8, and the tests described in paragraph 9b.

(a) Test the preproduction model by energizing at 2400 volts (nominal), at 2640 volts (plus 10 percent), and at 2280 volts (minus 5 percent) to determine that it meets the regulation requirements of paragraph 7a. Tests shall be performed at one-half and at full load as outlined below. Make the tests using the control set for local operation with the regulator output current adjusted to 6.6 and 2.8 amperes (or 20.0 and 8.5 amperes), respectively, (no transformers open circuited) and with input voltage at 2400 volts. Repeat this test using the remote control potentiometer specified in paragraph (b) below. With the regulator so set, vary the input voltage to determine the regulator's ability to compensate for input voltage and to meet regulation requirements. The tests shall then be repeated with the equivalent of 10 percent of the isolating transformers, open circuited.

(b) With control set for remote operation, test the regulator using a detented potentiometer equal to General Radio Company's Part No. 975KS5G1 to determine compliance with the requirements of Figure 3. In this test, connect the potentiometer by simulated 100-foot lengths of No. 12 AWG wire (a resistance equal to 0.16 ohms per wire) and by simulated 10,000-foot lengths of No. 19 AWG telephone wire (a resistance equal to 87 ohms per wire and a capacitance between any two wires of 0.16 microfarads).

(c) Determine the temperature rise by the resistance method of the regulator with unity power factor and full load at the maximum and minimum brightness positions (e.g., 6.6 amperes and 2.8 amperes or 20.0 amperes and 8.5 amperes). Operate the regulator continuously until ultimate temperatures are reached.

(d) With 2400 volts connected to the primary and with a unity power factor load operating at the step 5 position, the overall efficiency and power factor at rated full load are not less than the values specified in paragraphs 7b and 7c.

(e) Check the output current of the regulator using the remote controlled potentiometer. A resistance load may be used in lieu of a lamp isolating transformer load. Calculate the regulator's full-load resistance for step 5 by dividing the rated watts of the regulator by the square of the rated output current. Full-load resistance for each of the lower steps can be obtained by multiplying the step 5 resistance by the factors shown below.

FIGURE 4. FACTOR FOR RESISTANCE VALUES

Step	Multiplier
5	1.00
4	0.82
3	0.67
2	0.57
1	0.48

The output current at each potentiometer brightness position setting is in accordance with Figure 3 while the regulator is operated under the following conditions:

1 Room temperature and 60 hertz input.

2 With input voltages of 2280 volts, 2400 volts, and 2640 volts.

(f) Subject the primary and secondary of the regulator to the impulse test as described in ASA C57 at the basic impulse insulation levels (BIL) shown in Figure 5.

FIGURE 5. BASIC IMPULSE INSULATION LEVELS

Regulator KW Rating	Primary Voltage	Secondary Amperes	Primary BIL(KV)	Secondary BIL(KV)
10	2400	6.6	60	45
10	2400	20.0	60	30
20	2400	6.6	60	60
20	2400	20.0	60	45
25	2400	6.6	60	60
25	2400	20.0	60	45
30	2400	6.6	60	60
30	2400	20.0	60	45
50	2400	20.0	60	60
70	2400	20.0	60	60

(g) Make additional inspections and tests as deemed necessary by the Federal Aviation Administration, Airports Service, Washington, D.C. 20590, to determine compliance with this specification.

b. Production Testing. Make the following tests on each regulator after final assembly.

(1) Dielectric Test. Test the circuits of all regulator sizes to determine the equipment's ability to withstand the following RMS 60 hertz test voltages for one minute without failure:

(a) Input circuit to ground - 19,000 volts

(b) 120 volt control circuits to ground - 1000 volts

(c) 48 volt control circuits to ground - 500 volts

(d) Output circuit to ground - 19,000 volts

(2) Performance Test. Test each regulator assembly for output currents at the maximum and minimum output values. When supplied with any voltage from 2280 volts to 2640 volts, the limits of the output current of the 6.6-ampere regulator are 6.7 amperes and 2.67 amperes for the maximum and minimum settings, respectively. The output current of the 20.0-ampere regulators at the above conditions are 20.3 amperes and 7.7 amperes for the maximum and minimum settings, respectively.

Perform the test at maximum output current with a unity power factor load equal to the KW rating of the regulator. Perform the test for the minimum output current with the output of the regulator short-circuited through an ammeter.

(3) Protective and Control Device Tests. Test all controls and protective devices for proper operation as specified in paragraphs 8c through 8h. This includes tests to determine that the open-circuit voltage does not exceed 140 percent of the rated load voltage as specified in paragraph 8b.

(4) Leakage Test. Test each regulator assembly to determine that all welds and gasketed seals are oiltight and weathertight.

c. Certification. The manufacturer certifies that all components and materials will operate satisfactorily within the ambient temperature limits specified.

10. QUALIFICATION. Send requests for approval to the Federal Aviation Administration, Airports Service, Washington, D.C. 20590.

a. Furnish a sample regulator to an independent testing laboratory acceptable to the Federal Aviation Administration, Airports Service, to be tested as described herein to obtain certification regarding the ability to manufacture regulators meeting the requirements of this specification. Furnish two copies of the testing laboratory's reports to Airports Service for review and approval consideration. Upon approval of the test reports which show satisfactory certification of compliance, the Airports Service will list the name of the qualified manufacturer and a description of their regulator in the latest issuance of Advisory Circular 150/5345-1A, Approved Airport Lighting Equipment. The cost of testing is borne by the manufacturer offering the material for qualification.

b. If the manufacturer has satisfactory laboratory facilities, the tests may be performed at the factory and such tests witnessed by a representative of the Federal Aviation Administration, Airports Service. The manufacturer furnishes written reports of these tests.

c. Submit for review and approval parts list, installation instructions, drawings, and theory of operation of all components installed as part of the regulator.

d. At anytime after approval has been granted under the above conditions, make available a certified copy of factory test reports on the latest production run upon written request by the Federal Aviation Administration, Airports Service, Washington, D.C. 20590.

11. HOW TO OBTAIN THIS CIRCULAR. Obtain additional copies of this circular, AC 150/5345-10B, Specification for L-828 Constant Current Regulator With Stepless Brightness Control, from the Department of Transportation, Distribution Unit, TAD-484.3, Washington, D.C. 20590.

Chester G. Bowers, Director
Airports Service