Government of India
Ministry of Railways
(Railway Board)

INDIAN RAILWAY STANDARD SPECIFICATION FOR FERRO-RESONANT TYPE AUTOMATIC AC VOLTAGE REGULATOR FOR RAILWAY SIGNALLING INSTALLATIONS

(Tentative)

Serial No. S 74-89

0. FOREWORD

0.1 This specification is issued under the fixed Serial No. S 74 followed by the year of adoption as standard or in case of revision the year of latest revision.

ADOPTED 1989

0.2 This specification require reference to the following Indian Railway Standards (IRS) and Indian Standards (IS).

IRS: S 23	Electrical Signalling & Interlocking Equipment.
IRS: S 76/89	Indoor Signalling Cable
IS: 1248	Direct Acting Analogue Indicating Electrical Measuring Instruments & their accessories.
IS: 2026	Power Transformers.
IS: 2208	HRC Cartridge fuse links upto 650V.
IS: 2419	Dimensions for Panel Mounted Indicating and recording Electrical Instruments.
IS: 2959	Contactors for voltage not exceeding 1000V a.c or 1200V d.c.
IS: 4064	Air-break switches, Air-break disconnectors, Air-break switch-disconnectors & fuse combination units for voltages not exceeding 1000V a.c or 1200V d.c.
IS: 6297 (Pt.I & II)	Transformers and inductors (power audio, pulse & switching) for electric equipments.
IS: 9000	Basic environmental testing procedures for electronics and electric items.
IS: 9224	Low voltage fuses.

0.3 Whenever in this specification, any of the above mentioned specification is referred by number only, without mentioning the year of issue, the latest issue of that specification is implied, otherwise the particular issue referred to is meant.

0.4 This specification is intended chiefly to cover the technical provisions and does not include all the necessary provisions of contract.

1. SCOPE

1.1 This specification lays down the requirements and tests for Ferro-resonant type automatic AC voltage regulators for use in Railway Signalling installations, specially for colour light signal feed circuits.

1.2 Ferro-resonant type of voltage regulator shall generally be used with a minimum load of 25% of its rated capacity. However, the design of the voltage regulator shall cater for any load from no load to full load of its rated capacity.

1.3 The preferred KVA ratings for voltage regulators shall be as follows:

500VA, 1KVA, 3KVA, 5KVA or any other values specified by the purchaser.

1.4 This specification covers the voltage regulator of 230V and 110V AC output as specified by the purchaser.

2. TERMINOLOGY

2.1 For the purpose of this specification the terminology given in IRS :S 23 (as applicable) shall apply.

3. GENERAL

3.1 The Ferro-resonant voltage regulator shall conform to drawings, dimensions and layout, if any, specified by the purchaser.

3.2 The voltage regulator shall be completely static without any moving parts. It shall incorporate components like transformers, inductors, condensers etc. for voltage correction purpose.

3.3 The regulator shall be suitably screened so that other electronic equipments placed side by side of the regulator are not affected by the EM radiation of the regulator.

3.4 The voltage regulator shall be of natural air-cooled type and shall be suitable for indoor use in the cabins where maximum ambient temperature can reach upto 60ºC. The regulator shall be of shelf or floor mounting type as specified by the purchaser. The bottom of the regulator shall be at least 3 inches above the ground level.

3.5 The voltage regulator shall be of robust construction. It shall be housed in cubicles fabricated with cold rolled annealed mild steel sheet of thickness not less than 1.5mm. The cubicles shall be adequately ventilated. Ventilating opening shall be less than 3mm size to prevent entry of lizards etc. The cubicles shall be drip proof and shall be protected against ingress of water as per IP-31 type of protection as specified in table 1 of IS: 2147 -1962."

3.6 The voltage regulator cubicle shall be treated with Chromate Primer followed by Epoxy Powder Coating through Electrostatic method. Small metal parts such as nuts, bolts and washers shall be galvanized or plated to protect

against corrosion. All other metal parts of the regulator shall be plated, painted or otherwise protected against corrosion.

3.7 The layout of the cubicle housing, components and wiring shall be such that all parts are easily accessible for inspection, maintenance and repairs.

3.8 The input and output terminals shall be accessible only when the cover of the cubicle is removed. All the terminals shall be clearly, neatly and indelibly marked to correspond with the wiring diagram for easy identification.

3.9 All the cables and wires used for wiring shall conform to IRS: S 76/89 / IS 694 of 1100V grade and shall be neatly secured in position and adequately supported. Aluminium wires shall not be used for wiring. The gauge of the wiring shall be such that the current density does not exceed 3 Amps/sq.mm at 50Hz. The colour scheme employed for wiring shall conform to normal conventions and be shown in the instruction manual. The wire used as above shall be covered with glass sleeves at the joints and tapings.

3.10 All connections shall be either soldered or made through cramped eyelets and shall be numbered with PVC cable markers corresponding to the numbers shown in the schematic wiring diagram.

3.11 The schematic wiring diagram referred in Clause 3.8 shall show details of wiring used for inter-connecting the main components of the regulator. This diagram shall be firmly fixed on the inner side of the cover of the regulator.

3.12 All non-current carrying metal parts shall be bonded together and adequately earthed.

3.13 The regulator shall function satisfactorily under shock and vibration conditions encountered by the side of railway track. Main transformer shall be mounted on anti vibrating padding.

3.14 AC Metal Can Capacitors of 600V rating of approved type with inbuilt wire shall only be used. The capacitors shall be mounted at a minimum distance of 2 inches away from the main transformer's top plate with metal partition in between the transformer and capacitor.

3.15 The regulator of 110V AC output shall be provided with output tapings at 0, 110, 115 & 120V.

3.15.1 The regulator of 230V AC output shall be provided with additional output tapping at 235V ± 1V and 240V ±1V at 230VAC input.

4. COMPONENTS

4.1 Transformers and Inductors

4.1.1 The transformers and inductors used shall be vacuum impregnated and shall be of natural air-cooled type and shall conform to IS: 2026 & IS: 6297 as far as applicable. The gauge of the winding wires shall be such that the current density does not exceed 1.6 amps/sq.mm at 50Hz. The super enameled varnished Class F insulated, copper wire shall be used.

The firm shall submit the certificate regarding class F insulated super enameled varnished copper wire. The certificate may be obtained from manufacturer or authorised supplier of wire.

4.1.2 When tested in accordance with Clause 6.2.1.6 of IS: 6297 (Pt.I) the transformer shall show an insulation resistance of not less than 100 Megohm measured at a temp. of not more than 40ºC and relative humidity of not more than 60% (Clause 9.8). This value shall not fall below 50 Megohm at the end of climatic tests as per Clause 9.14.4 of IS: 6297.

4.2 Meters

4.2.1 Two AC voltmeters one each for input and output to the accuracy class not worse than 1.5 of IS: 1248-1968 shall be provided on the front panel to indicate r.m.s voltage of input and output terminals respectively.

4.2.2 The dimensions of the meter shall conform to IS: 2419.

4.2.3 An AC ammeter shall be provided on the front panel to indicate RMS value of the output current. The range of the ammeter scale shall not be less than double of the rated output current.

4.2.4 The voltmeter shall have a range of 0-300V, the scale length being not less than 84 mm. A red mark shall be provided at the regulated voltage of 230V/110V. The voltmeter shall be protected by a suitable device against over voltages.

4.3 Switches, Terminals, Indicators etc.

4.3.1 Two pole ON/OFF rotary switch confirming to IS: 4064 (Pt.I) shall be provided for input to the regulator.

4.3.2 A lamp to indicate that the unit is 'ON' shall be provided on the front panel.

4.3.3 An earth terminal suitable for connecting 4mm dia wire and marked 'E' shall be provided.

4.3.4 Components used in the regulator shall not be operated at more than 50% of the rated value, under any working condition specified in this specification.

5. PERFORMANCE REQUIREMENTS

5.1 A) The regulator shall be designed for continuous operation for any load at an ambient temperature upto 60ºC and at a relative humidity upto 95% at 30ºC.

B) The output voltage shall be maintained at the nominal value of 230V±1% or 110V ±2% as the case may be at all the loads from 25% load to full load keeping the input voltage constant at 230V 50Hz.

C) All performance test shall be carried out at 230V /110V AC output tapping.

5.2 The regulator shall work satisfactorily within supply frequency of 50Hz ± 2.5 Hz. The value of output voltage at rated load with an input of 230V at 50 Hz

shall be taken as the reference output voltage for individual unit. When input frequency is varied from 47.5 Hz to 52.5 Hz, keeping the input voltage constant the output voltage of the regulator unit shall be maintained within ± 3% of the reference output voltage for ± 1 Hz variation and within ±6% for ± 2 Hz frequency variation.

5.3 The regulator shall work satisfactorily within a range of 160V to 270V input at 50Hz main supply. The output voltage shall be maintained within 230±1% / 110±2%, when the unit is connected to rated load.

5.3.1 The lower input voltage range may be extended to 150 volts, if required by the purchaser. For the input voltage from 150V to 160V, the output voltage shall be maintained at the nominal value of not less than 230V ± 4% or 110V ± 2% for the regulator at all the loads from 25% load to full load.

5.4 The response time of regulator for sudden changes of 50 volt AC input voltage or load variation from 25% to 75% of the rated load shall be such that the output voltage should settle 230V ± 1% or 110V ± 2% within 3 cycles /60 milli seconds.

5.5 The no load current shall not be more than 30% of the rated input current and the no load power shall not be more than 15% of the rated output power at nominal input voltage of 230V at 50Hz.

5.6 The overall watt efficiency shall not be less than 80% in case of 500VA regulators and not less than 85% in case of 1 KVA, 3 KVA & 5 KVA regulator at full load under any working condition as specified in Clause 5.1, 5.2 and 5.3.

5.7 The total harmonic distortion measured at the output of the regulator shall not exceed 8% under any working conditions specified in Clause 5.1, 5.2 & 5.3.

5.8 The voltage regulator shall be capable of handling any load from unity PF to 0.8 PF lagging. The total harmonic distortion shall be maintained within 8%. The line regulation shall be within 1.5%. For line regulation output voltage at 230V input and rated load at 0.8PF lagging should be taken as reference voltage. The output voltage shall not fall below 222V in any case.

5.9 When continuously operating at full load at any ambient condition specified in clause 5.1, the regulator shall withstand short-circuit on output side for one hour without any damage or deterioration to the regulator or any of its components.

5.10 The resonant voltage across the capacitor bank must not exceed 480V at all input voltage and frequency conditions i.e 160-270V & 47.5 Hz to 52.5 Hz at no load.

5.11 **Noise** / **Sound Power**: The FRVR at no load and at 270V input supply shall not contribute more than 10dB for FRVR of capacity upto 1 KVA, 15 dB for FRVR of capacity >1KVA upto 3 KVA & 20 dB for FRVR of capacity >3KVA weighted to the ambient lowest level taken as 45dBA. It shall be measured at a distance of 1 meter from the unit in all the sides including top in the full

audio range upto 3.4 KHz. The correction factor for total noise when the ambient noise level is more than 45dBA shall be as given below:

Ambient Noise(dBA)	Correction Factor (dB)	Ambient Noise (dBA)	Correction Factor (dB)
45	0	53	2.07
46	0.18	54	2.43
47	0.39	55	2.82
48	0.61	56	3.25
49	0.86	57	3.69
50	1.12	58	4.17
51	1.41	59	4.68
52	1.73	60	5.21

Note: The correction factor shall be added to the limit of 55, 60 & 65dBA to arrive at the limit of greater than 45dBA. The measurement to be recorded after 2 hours of switching on the unit.

6. PROTECTION AND ADDITIONAL FACILITIES

6.1 Suitable surge voltage protection shall be incorporated in the circuit, preferably with high isolation between primary and secondary sides.

7. MARKING

7.1 All markings /indications shall be legible and long lasting. Where the marking is by use of labels, the labels shall be metallic /plastic and shall be firmly fixed and shall not be capable of being removed by hand. Durability of markings shall be checked by rubbing the marking by hand for 15 seconds with a piece of cloth soaked with petrol spirit.

7.2 All markings /indications shall be placed in the vicinity of the components to which they refer and shall not be placed on removable parts.

7.3 The words “INDIAN RAILWAY PROPERTY” shall be indelibly etched, engraved or embossed on the regulator at the conspicuous position. The size of the letters shall be chosen depending upon the size of the regulator cubicle.

7.4 Each regulator shall be provided with a rating plate of weatherproof material fitted at a conspicuous position. The date on the rating plate shall be indelibly marked (e.g. by etching, engraving or stamping). The information to be given on rating plate shall be as under:

a) Type of AC voltage regulator viz ferro-resonant type
b) IRS specification number
c) Name and trade mark of the manufacturer
d) Year of manufacture
e) Rated KVA
f) Rated frequency range
g) Input voltage range
h) Rated output voltage
i) Rated output current
j) Manufacturers serial No. & type No. if any.

8. INSTRUCTION MANUAL

8.1 Two copies of the instruction manual shall be supplied along with each regulator. The manual shall include the following information:

a) Installation instructions
b) Schematic Wiring diagrams showing components and their values
c) List of components used for the manufacture of regulator, their make and values
d) Drawing showing general mounting arrangements of various components
e) Trouble shooting procedures
f) Explanatory notes on operation, maintenance and adjustment procedures.
g) Any other information which the manufacturer may like to give
h) Guaranteed performance data.

9 TESTS AND REQUIREMENTS

9.1 Conditions of tests – Unless otherwise specified all tests shall be carried out at ambient atmospheric conditions.

9.1.1 For inspection of material, relevant clauses of IRS:S 23 shall apply.

9.2 **Test equipments** – The ammeters and voltmeters used in the test shall be of accuracy class 0.5 of IS: 1248-1968.

9.3 **Type tests** – The following shall constitute type tests and shall be carried out once in 3 years in the sequence given below:

a) Visual inspection	(Clause 9.6)
b) Applied high voltage test	(Clause 9.7)
c) Insulation resistance test	(Clause 9.8 & 4.1.2)
d) Tests for output regulation and performance characteristics	(Clause 9.9)
e) Temp. rise test	(Clause 9.10, 9.10.1)
f) Tests on protection and additional facilities	(Clause 9.11)
g) Tests for continuous operation	(Clause 9.12)
h) Climatic tests	(Clause 9.13)

9.3.1 Only one regulator of each type and output rating shall be tested for this purpose. The regulator shall successfully pass all the type tests for proving conformity with this specification. If the regulator fails in any of the type tests, the purchaser or his nominee at his discretion may call for another regulator of the same type and output rating and subject it to all tests or the tests in which failure(s) occurred. No failure shall be permitted in the repeat test (s).

9.4 **Acceptance tests** – The following shall comprise acceptance tests:

a) Visual inspection (Cl. 9.6)
b) Applied high voltage test (Cl. 9.7)
c) Insulation resistance test (Cl. 9.8)
d) Test for output regulation and performance characteristics (Cl.9.9)

e) Temperature rise test (Cl. 9.10)
f) Test for protection and other facilities (Cl. 9.11)

At least one sample during acceptance test shall also be tested for performance test as per clause 9.9 at 60ºC in heat chamber after conditioning of minimum 4 hours at rated input and full load. For voltage regulation the output voltage at 230V input and rated load shall be taken as reference voltage.

9.4.1 The following sampling plan shall be adopted. There shall not be any failure during acceptance test.

Lot size	Sample size for performance test as per Cl. 9.9	Sample size for other than performance test
2-8	2	1
9-15	3	1
16-25	5	2
26-50	8	2
51-100	13	3
101-150	20	3
151-200	32	3

9.5 Routine tests

The following shall constitute routine tests and shall be carried out on every regulator and test result will be submitted by the manufacturer to the Inspecting Authority at the time of inspection:

a) Visual inspection (Cl. 9.6)
b) Applied high voltage test (Cl. 9.7)
c) Insulation resistance test (Cl. 9.8)
d) Test for protection and additional facilities (Cl. 9.11)
e) Test for continuous operation (Cl. 9.12.1)
f) Tests for output regulation and performance characteristics (Cl. 9.9)

9.6 Visual Inspection

The regulator shall be examined for provisions of all facilities stipulated in this specification, correct wiring, proper mounting of components, marking, workmanship and finish for which no tests have been specified.

9.7 Applied High Voltage test

The regulator shall withstand for one minute without puncture and arcing a test voltage of 2000V AC, r.m.s applied between power components and the body of the regulator, which shall be earthed. The test voltage shall be approximately sinewave form and of any frequency between 50 and 100 Hz.

9.8 Insulation Resistance Test

This test shall be carried out:

a) Before the high voltage test
b) After the high voltage test
c) After the temperature rise test when the regulator has attained ambient temperature
d) After the climatic tests have been completed

The measurement shall be made at a potential of not less than 500V DC. The insulation resistance shall be measured between:

a) Input line terminals and the body of the regulator
b) Output line terminals and the body of the regulator

Value of the insulation resistance shall not be less than 10 M.ohm for the regulator and 100 M.ohm for the transformer and inductor when measured at a temperature of 40ºC and relative humidity of 60%. There shall not be appreciable change in the values measured before and after high voltage test and after the temperature rise test.

After completion of climatic test, the values shall not be less than 5 M.ohm for the regulator and 50 M.ohm for the transformer and inductor when measured at a temperature of 40ºC and relative humidity of 60%.

NOTE:- In case, temperature and humidity prevalent at the time of the above measurements of insulation resistance are different from those specified above, the values of I.R. shall be obtained from Table 'A' of Clause 9.8.1.

9.8.1 TABLE 'A'

Value of Insulation Resistance at different temperatures and relative humidity.

R.H	25ºC	30ºC	35ºC	40ºC
60%	>100 M.ohms	>100 M.ohms	>100 M.ohms	100 M.ohms
65%	100 M.ohms	90 M.ohms	85 M.ohms	80 M.ohms
70%	80 M.ohms	70 M.ohms	65 M.ohms	60 M.ohms
75%	60 M.ohms	53 M.ohms	47 M.ohms	43 M.ohms
80%	42 M.ohms	36 M.ohms	33 M.ohms	30 M.ohms
85%	29 M.ohms	25 M.ohms	22 M.ohms	18 M.ohms
90%	20 M.ohms	16 M.ohms	13 M.ohms	10 M.ohms
95%	15 M.ohms	10 M.ohms	7 M.ohms	5 M.ohms
100%	10 M.ohms	6 M.ohms	3 M.ohms	1 M.ohms

Note 1: The value of insulation resistance has been taken as 100 M.ohms at a temperature of 40ºC and RH of 60%. Values of IR at different temperature and RH may be obtained from the table.

2: To obtain the value of IR, corresponding to 50 M.ohm or 10 M.ohm or 5 M.ohm at 40ºC and 60% RH, a multiplying factor of 0.5 or 0.1 or 0.05 respectively may be used.

3: The value of insulation resistance for extreme conditions of the temperature and humidity shall not be less than 1 M.ohm even if the value at 60% RH and 40 º C temperature is less than 100 M.ohm.

9.9 Test for output regulation and performance characteristics

The regulator shall be tested to check for output load and line regulation, transient response, no load current and power, total harmonic distortion, effect of frequency variation and efficiency to verify the provisions required under clauses 5.

For routine tests, requirements given under clauses 5.1 to 5.3 shall be verified.

9.10 Temperature rise test

The cold resistance of transformer winding shall be measured after conditioning the regulator until three consecutive temperature readings taken at 30 minute intervals are constant and the constant temperature shall be taken as reference temperature T1.

The regulator shall be operated at full rated load, the input voltage being set at the value at which lowest efficiency has been obtained during output regulation and performance characteristics test as per clause 9.9. The test shall be continued until thermal equilibrium is reached i.e. temperature variation between three successive reading taken at an interval of 30 minutes is less than 1ºC. Throughout the test, the rated load shall be maintained. Once the thermal equilibrium is reached the regulator shall be switched off and the hot resistance of the winding shall be measured within 1 minute of switching off.

The temperature rise of the winding shall be computed by the following formulae:

$$T = \frac{(R2 - R1)}{R1} \quad (234.5 + T1) - (T2 - T1)$$

Where T = Temperature rise of the winding
R1= Resistance at the beginning of the test at temperature T1
R2 = Resistance (hot) at the end of the test
T1 = Reference room temperature at the beginning of the test
T2 = Room temperature at the end of the test

The limits of the temperature rise has been fixed as under:

i) For units upto 1 KVA capacity : 65ºC above ambient
ii) For units more than 1 KVA rating & upto 2 KVA rating : 70ºC above ambient
iii) Units more than 2 KVA rating & upto 3 KVA rating : 75ºC above ambient
iv) Units more than 3 KVA & upto 5KVA : 85ºC above ambient

9.11 Test for Protection and Additional facilities

The tests shall be conducted to verify the provisions required under Clause 6.1.

9.12 Test for Continuous Operation

The voltage regulator shall be subjected to a continuous operation for 1000 hours with commercial input supply and rated load. No failures should be noticed at the end of the test.

Note: Immediately after continuous operation the regulator shall be checked for performance test as per Cl. 9.9. For load & line regulation the output voltage at rated input and rated load shall be taken as reference voltage.

9.12.1 **Continuous operation for routine test:** The regulator shall be subjected to continuous operation for 8 hours with commercial input supply and 100% load. Output voltage, load, frequency and harmonic distortion shall be monitored at the end of the test.

9.13 Climatic tests

9.13.1 Climatic tests shall consist of-

(i) Dry heat test at 60ºC ± 2ºC at full rated output for 16 hrs. duration as per IS: 9000 (Pt.III) Section 5. At the end of dry heat test the voltage regulator shall be tested for output regulation and performance characteristics as per Cl. 9.9. For voltage regulation the output voltage at 230V input and rated load shall be taken as reference voltage.

(ii) Damp heat (cycle) tests for variant 1 for 7 cycles at upper temperature range 40ºC ± 2ºC as per IS: 9000 Pt.V section 2.

9.13.2 At the end of climatic tests, and after recovery regulator shall not show sign of any apparent damage or deterioration and shall meet the requirements for output regulation and performance characteristics as per Clause 9.9.

10 PACKING AND LABELLING

10.1 The complete regulator unit shall be packed in suitable strong boxes/crates to prevent damage or loss of the unit during transit. Loose space inside the box/crate shall be filled up with suitable packing material.

10.2 It is desirable that the fragile components such as meters are individually packed to prevent damage.

10.3 Each box shall be legibly marked at one end with code numbers, contents, quantity and name of manufacturer/supplier.

ANNEXURE 'A'

INFORMATION TO BE SUPPLIED BY THE PURCHASER

1. Rated KVA (Clause 1.3)
2. Drawings, dimensions and layout if desired (Clause 3.1)
3. Type of mounting shelf or floor (Clause 3.4)
4. Input voltage range (Clauses 5.3, 5.3.1)
5. Output Voltage 230 or 110V AC (Clause 1.4)

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