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GOVERNMENT OF INDIA

MINISRY OF RAILWAYS

TECHNICAL SPECIFICATION

FOR

RESONANCE SUPPRESSING C-R DEVICE

FOR

2X 25 KV AT FEEDING SYSTEM

DRAFT SPECIFICATION No. TI/SPC/PSI/C-R DEV/4200

This Specification supersedes the Specification No. ETI/PSI/128 (8/89)

~~**AUGUST 1989**~~

ISSUED BY

TRACTION INSTALLATIONS DIRECTORATE

RESEARCH DESIGNS AND STANDARDS ORGANISATION

LUCKNOW-226011

	Prepared By	Checked By	Approved By
Signature			
Date			
Designation			

~~SPECIFICATION FOR~~

~~RESONANCE SUPPRESSING C-R DEVICE FOR 2X25 KV AT FEEDING SYSTEM~~

~~SPECIFICATION NO. ETI/PSI/128(8/89)~~

1.0 SCOPE

1.1 It is to be noted that "The Make in India Policy of Government of India shall be applicable."

1.2 All the provisions contained in RDSO's ISO procedures laid down in Document No. - QO - D-8.1-11 Ver. 1.2 dated 22.06.2020 (titled "Vendor changes in approved status") and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendor/vendors in the contracts floated by Railways to maintain quality of products supplied to Railways

1.3 This specification covers design, manufacture, supply testing and commissioning of Resonance suppressing C-R device intended for suppressing of the higher harmonic resonance in the feeding circuit and for outdoor installation at ~~a at~~ 2x25 AT system switching station on Indian Railways. The C-R device is directly connected with feeder circuit as shown in Figure-1 and ~~the~~ no protection device for that is provided. Two(2) sets (Four (4) numbers) of C-R Devices will be required at a sectioning and paralleling Post which may be either for a single track or double track section, as shown in RDSO's Drawing Nos. ETI/PSI/AT/00101(Mod A) or latest and ETI/PSI/AT/00102 (Mod A) or latest respectively.

1.4 ~~The equipment shall be complete with control gear and accessories necessary for its efficient operation~~. All necessary parts and accessories for the efficient operation of the equipment, weather specifically mentioned or not, shall be deemed to be within the scope of this specification.

1.5 The equipment shall be installed by Railways under the supervision of the suppliers who shall however commission the equipment.

1.6 All civil engineering works connected with foundation of equipment etc. shall be done by the Railways.

2.0 GOVERNING SPECIFICATIONS

2.1 The resonance suppressing C-R Device shall, unless otherwise specified herein, conform to the latest revision of RDSO specification, Indian Standard specification/ IEC recommendations as indicated below and the Indian Electricity Rules, whenever applicable.

SN	Specification	Description
i.	IS 513	Cold rolled carbon steel sheets.
ii.	IS 800	Code of practice for use structural steel in general building construction.
iii.	IS 1554 Pt. II	PVC insulated (heavy duty) electrical cable Pt. II for voltage above 1 kV.
iv.	IS 2099	Bushing for alternating voltages above 1 kV.
v.	IS 11298 Pt. III/Sec. I	Specification for plastic films for Electrical purposes.
vi.	IEC 70	Power capacitors
vii.	IEC 137	Bushings
viii.	~~IEC 593~~	~~Internal fuse and internal over pressure disconnect or for shunt capacitors.~~
ix.	IEC 114	Specification for resistors.
x.	~~RDSO specn. ETI/OHE/13(4/84)~~	~~Specification for dip zinc galvanisation.~~
xi.	~~RDSO Specn. No. ETI/OHE/18(4/84)~~	~~Specification for steel and stainless steel bolts, nuts and washers.~~
xii.	~~RDSO specn. No. (CP) No. ETI/PSI/120(7/88)~~	~~Code of practice for earthlings of power supply installation for 25 kV ac, 50 Hz, single phase traction system.~~
xiii.	IEC: 60071	Insulation co-ordination and system engineering of high voltage electrical power installations above 1.0 kV AC and 1.5 kV DC
xiv.	IEC: 62271-1	High-voltage switchgear and control gear – Part 1: Common specifications

2.2 Any deviations from these specifications calculated to improve the performance, utility and efficiency of the equipment proposed by the ~~tenderer~~ Vendor, will be given due consideration, provided full particulars with justification is furnished. In such case, the ~~tenderer~~ Vendor shall quote according to this specification and deviations, if any, proposed by him shall be quoted as an alternate/alternatives.

2.3 In case of any conflict between the contents of the above IS and this specification, the stipulation of this specification shall prevail.

3.0 ENVIRONMENTAL CONDITIONS:

3.1 The C-R device shall be suitable for outdoor use in moist tropical climate and in areas subject to heavy rainfall pollution due to industry and marine atmosphere and severe lightning. The limiting weather conditions which the equipment has to withstand in service are indicated below.

SN	Description	Value at altitude up to 1000 m	Value at altitude above 1000 m and up to 2500 m
i)	a. Maximum ambient air temperature b. Minimum ambient	45 deg. C 0° C	45 deg. C -15 deg. C

	air temperature		
ii)	Average ambient air temperature over a period of 24 hours.	35 deg. C	35 deg. C
iii)	Maximum relative humidity	100%	100%
iv)	Annual rainfall	Ranging from 150 to 6250 mm	Ranging from 150 to 6250 mm
v)	Maximum number of thunder storm days per annum	85 days	85 days
vi)	Maximum number of dust storm days per annum	35 days	35 days
vii)	Number of rainy days per annum	120 days	120 days
viii)	Basic wind pressure	200 kg/sq. m.	216 kg/sq. m.
ix	Altitude	Not exceeding 1000 meters.	Above 1000 m and up to 2500 m.

3.2 The C-R device shall also be subjected to vibrations with the passage of trains. The amplitude of these vibrations lies in the range of 30 to 150 microns, with instantaneous peaks going upto 350 microns. These vibrations occur with rapidly varying time periods in the range of 15 to 70 ms.

4.0 TRACION POWER SUPPLY SYSTEM (2X 25 KV AT FEEDING SYSTEM)

4.1 General scheme:

The electric power for railway traction is supplied in ac 50 Hz single phase through 2 X 25 kV AT feeding system, which has a feeding voltage from the substation two times as high (2x 25kV) as catenary voltage (25 kV). This high voltage power supplied from the traction substation through catenary wire and feeder wire is stepped down to the catenary voltage by use of Auto transformers installed about every 13 to 17 km along the track, and then fed to the locomotives, in other words, both the catenary voltage and feeder voltage are 25 kV against the rail, although the substation feeding voltage between catenary and feeder is 50 kV. Therefore, the catenary voltage is the same as that of the conventional 25 kV system.

Since the power is supplied in two times higher voltage, the 2 X 25 kV AT feeding system is suitable for a large power supply, and it has the following advantages, compared with conventional feeding system.

a) Less voltage drop in feeder circuit.
b) Large spacing of traction substation.
c) Less telecommunication interference by use of AT installed with adequate spacing.

The power is obtained from 220/2x25 kV Scott-connected traction transformer or 132/2x25 kV single phase transformers. The primary windings of the single phase transformers are connected to two or three phases of 132 kV, three- phase effectively earthed transmission net-work of the electricity board, in case of a single phase transformer or in case of two single phase transformers connected in V, respectively. On the other hand, the primary windings of the Scott-connected transformers are connected to the other three phases of 220 kV three-phase, effectively earthed transmission net-work of the Electricity Board., The Scott-connected transformer and V-connected single phase transformers are effective in reducing voltage imbalance on the transmission net-work of the electricity board. The spacing between adjacent substations is normally ~~between~~ from 70 to 100 kms.

One outer side terminal of the secondary windings of traction transformer is connected to the catenary, other outer side terminal being connected to the feeder. Two inner side terminals are, via series capacitors or directly, connected to each other, and their joint is solidly earthed and connected to the traction rails.

The load current from the substation flows through the catenary and returns to the substations flows through the feeder, Between two adjacent ATs, the load current fed from the catenary to the locomotive flows in the rail and is boosted up to the feeder through the neutral tap of ATs at left and right sides of the locomotive.

At the points of substation and sectioning post, a dead zone knows as neutral section is provided in OHE to avoid a wrong phase coupling. The power to the catenary and feeder on one side of the substation is fed by one feeder circuit breaker, even if there exist two breakers for one side, and each track is controlled by an interrupter. The two breakers are used as a stand-by for each other. For maintenance work and keeping the voltage drop within limits, one or more sub sectioning and paralleling posts (known as SSP) are introduced between traction substation and a sectioning and paralleling post (known as SP) . A SSP on a double track section normally has four sectioning interrupters and one paralleling interrupter. In case of fault, the feeder circuit breaker of the substation isolates it.

A figure showing the principle of AT feeding system and a typical power supply diagram showing the general feeding arrangement at a traction substation and sections of the OHE are given in the sketch at the Appendix-1.

4.2 Protection System:

4.2.1 The following relays are provided for the protection of traction transformers:

a. Differential relay
b. Over current relay on 220 kv or 132 kV side.
c. Grounding overcurrent relay on 220 k V or 132 kV side.
d. High speed overcurrent relay on 220 kV or 132 kV side.
e. Phase failure relay (to detect a malfunction of a feeder circuit breaker)

4.2.2 The following relays are provided for the protection of OHE:

(a) Distance relay (with a parallelogram protection characteristics).
(b) Delta I type fault selective relay.
(c) Under voltage relay.

4.3 25 kV OHE and Traction Transformer-electric Parameters:

4.3.1 The OHE is made up of a stranded cadmium copper catenary of 65 sq. mm or a stranded aluminium alloy catenary or 116 sq. mm and a grooved contact wire of 107 sq. mm making up a total of 150 sqm mm or 140 sq. mm copper equivalent, respectively. As a feeder wire, a stranded aluminium alloy of 240 sq. mm is used. The calculated OHE impedance value of AT feeding circuit (OHE: Al 116-Cu 107 sq. mm. Feeder wire: Al 240 sq. mm) for a single track line is 0.0601+ Jo. 1419 ohms/km (at 25 kV system impedance)

4.3.2 Traction transformer : The percentage impedance of a 2x 25 MVA , 220/ 2x 25 kV Scott-connected transformer and a 20 MVA . 132/ 2x25 kV single –phase transformer are 12% (at 27 MVA base) and 12% (at 21.6 MVA base), respectively.

4.3.3 Clearance: Normally a clearance of 500 mm is provided between any live part at 25 kV and earth.

4.4 Nature of Faults on the OHE system:

4.4.1 OHE (Including a feeder wire is subjected to frequent earth faults caused by failure of insulation, or by the OHE snapping and touching the rail or earth, or by a piece of wire dropped by birds connecting the OHE to earthed overlying structures, miscreant activities etc. These faults are cleared by the feeder circuit breaker which operates on any one or both of the following relays.

(a) Distance relay (with parallelogram protection characteristics)
(b) Delta I type fault selective relay.

4.4.2 Short circuit Level:

The 220 kV and 132 kV source impedance may be, based on three phase symmetrical short ~~circuitr~~ circuit level, between 2000 and

10000 MVA, and between 1000 and 5000 MVA, respectively. The level of short circuit on the 25 kV side for a fault in the vicinity of a substation could be around 200 MVA or more. The exact short circuit level on 25 kV at each substation will be indicated in the tender papers.

4.5 Nature of load on the 25 kV System:

4.5.1 Traction load is of frequent and rapidly varying nature and may fluctuate between no load and over loads, and the system is subject to frequent short circuits due to earth faults. It is difficult, therefore to forecast precisely the load cycle of traction service because of the non-uniform pattern of traffic, which is different on different days.

4.5.2 At present AC locomotives are fitted, for conversion of ac to dc, with single phase bridge-connected silicon rectifiers with smoothing reactor for feeding the ~~do~~ DC traction motors. The ripple current is in the region of 25 to 40 % which introduces harmonics in the 25 kV power supply. In the near future, Indian Railways would be introducing phase-controlled asymmetrical thyristor bridges (two bridges connected in sequential control to improve power factor) which would further introduce ~~harmonies~~ harmonics in the system.

The typical percentages of harmonics present in the traction current with electric locomotive are as follows:

	~~With Diode rectifier~~	~~With thyristor~~
~~3rd harmonies (150 Hz)~~	~~15%~~	~~32%~~
~~5th harmonies (250 Hz)~~	~~6%~~	~~18%~~
~~7th harmonies (350 Hz)~~	~~4%~~	~~8%~~
~~9th harmonies (450 Hz)~~	~~—~~	~~4%~~
~~11th harmonies (550 Hz)~~	~~—~~	~~5%~~

	Feeder Current 142A	Feeder Current 480A
	Percentage	
3rd harmonies (150 Hz)	38.50	11.50
5th harmonies (250 Hz)	14.35	5.48
7th harmonies (350 Hz)	15.00	2.01

4.5.3 In big yards and loco sheds, a large number of locomotives stand idle with only the load of their auxiliaries drawing higher reactive power. The load power factor is therefore, rather low.

4.5.4 The average power-factor of electric locomotive and multiple unit trains generally varies between 0.7 and 0.8 lagging, without compensation.

5.0 TECHNICAL SPECIFICATION

5.1 Ratings and Other particulars.

i)	System	2x 25 kV AT Feeding system.
ii)	Nominal system voltage	25 kV (phase to earth)
iii)	System voltage Minimum Maximum Maximum (instantaneous)	 19 kV 27.5 kV 30 kV
iv)	Equipment voltage class	52 kV
v)	Rated frequency	50 Hz ± 3%
vi)	Rated voltage capacitor Resistor	 27.5 kV 3 kV
vii)	Rated capacity of Capacitor	1 micro farad
viii)	Rated resistance of resistor	300 ohms
ix)	Rated current of resistor and capacitor	10 A continuous
x)	Harmonics in the system	As given in para 4.5.2
xi)	Temperature category	50 deg. C
xii)	Location of C-R Device	Out-door

5.2 Capacitor Unit

5.2.1 Individual capacitor units of bank shall be self-contained, out-door type provided with double bushing protected by external fuse. The bushings shall be of porcelain and shall be jointed to the case by solder-sealing or any other approved technique. The minimum value of creepage distance for bushing shall be 25 mm/kV of the rated voltage. Each capacitor unit shall be built up of no. of elements having a ~~dielectrical~~ dielectrically of plastic film (polypropylene) between the Aluminium foils.

The capacitor element shall be assembled in a stack closely fitted into the container in order to reduce the amount of free impregnation fluid. The container shall accommodate changes in fluid volume due to variation in the temperature. Each individual unit shall consist of a number of elements connected in series parallel arrangement.

The capacitor unit shall be capable of withstanding transient over currents of high frequency and amplitude occurring at the time of their switching in the circuit.

Each capacitor unit shall satisfactorily operate continuously at rated voltage and shall withstand 30% over current (rms value) ~~give~~ due to over voltage and harmonics. The units shall also satisfactorily operate with traction harmonic currents as indicated in clause 4.5.2.

5.2.2 The polypropylene film conforming to IS: 11298 or latest shall be checked for proper thickness, roughness, breakdown voltage besides its physical appearance.

5.2.3 The capacitors shall be impregnated with non-PCB (polychlorinated-Biphenyl) impregnation fluids which have excellent electrical characteristics, low toxicity, low bioaccumulation and are biodegradable.

5.2.4 The aluminium used shall be of very high purity and free from materials like rolling oil and such other defects. The thickness of aluminium foil used shall not be less than 6 microns.

5.2.5 The container of each capacitor unit shall be leak and moisture proof. The capacitor container shall be made of CRCA steel sheets of drawing quality generally. As per IS: 513 or latest. The nominal thickness of steel shall be 1.25 mm. The inside surface of the container in contact with the impregnating fluid shall not be painted and shall only be degreased and made rust free. The steel surfaces exposed together shall be given a primer cost of zinc chromate and two coats of light grey enamel paint as per shade 631 of IS:5 or latest.

5.2.6 Each capacitor unit shall be provided with a directly connected internal discharge device to drain the residual voltage ~~to~~ from the crest value of the rated voltage ~~250 Volts~~ to 50 Volts or less within 5 minutes of disconnection of the capacitor from the source of supply.

This device shall be made from carbon ~~registers~~ resistors without lacquer coating.

5.2.7 The tolerance for electrostatic capacity should be between -5% and +10%. Electrostatic capacity between the terminals is measured using a power frequency possessing a voltage wave shape close to a sine wave, or a single phase power source with an audible frequency, by means of the AC bridge method.

5.2.8 Temperature - rise limit

Temperature - rise at an ambient temperature of 45 deg. C at the rated load shall not exceed 20 deg. Measured on the case wall.

5.3 Resistor

5.3.1 The tolerance of the resistor should be within ± 5%. Also the resistance should not change more than 10% when the rated current is continuously applied.

5.3.2 The resistance between the conducting part and the case should be more than 50 mega-ohms measured with an insulation resistance meter (1,000 V).

5.3.3 Temperature rise: The temperature rise of the surface of the resistor beat radiator should be less than 350 deg. C when power frequency or direct current of 10 A is continuously applied to the resistor in normal use condition.

5.4 Basic Insulation Level:

The basic insulation level of the complete capacitor bank and resistor shall be as follows:

5.4.1 Capacitor:

i)	1.2/50 Micro seconds impulse withstand voltage (peak) between terminals and case	250kV
ii)	1 minute wet power frequency withstand voltage (rms) between terminals and case	105kV
iii)	Between terminals 10 seconds wet power frequency withstand voltage.	60kV (rms)

5.4.2 Resistor:

i)	Between terminals and case one minute wet power frequency withstand voltage	20kV (rms)
ii)	Between terminals and case impulse withstand voltage.	60kV (peak)

5.5 Bushings:

The high voltage side bushing BIL of the capacitor, and the resistor should be 250 kVp, and the low voltage side bushing BIL of the resistor should be ~~45 kVp~~ 60kVp.

5.6 For altitude above 1000 m and up to 2500 m, the value of basic insulation level for Capacitor, Resistor and Bushing shall be calculated as per IEC 62271-1 and IEC 60071-1&2 by multiplying of correction factor (k) in value of insulation level up to 1000m at the required altitude.

As per IEC 62271-1, the formula for correction factor is

$k = e^{m\,(H-1000)/8150}$

Where,

H is the altitude, in meters;

m = 1 for power frequency and lightning impulse voltage;

m = 0.75 for switching impulse voltage.

6.0 GENERAL ARRANGEMENT OF C-R DEVICE:

6.1 ~~The C-R device shall be of outdoor type, mounted on steel racks for connection to the 25 kV bus~~. The capacitor bank shall be of outdoor type, mounted on steel racks for connection to the 25kV bus. The capacitor bank shall consists of one capacitor unit or on groups of individual capacitor unit connected in series combination to deliver

the rated capacity. The capacitor bank shall be supplied complete with mounting steel rack assembly, inter - connectors between units, insulators, suitable earthing lugs including terminal connectors but without connecting jumper to 25kV bus and any other material required to make the bank complete in all respects for its satisfactory operation.

The resistor shall be outdoor type, installed on the concrete bed via insulating pedestals and surrounded by a wire netting fence for protection.

6.2 Mounting arrangement:

6.2.1 The C-R device consists of serially connecting a capacitor bank on the higher bank on the high voltage side and a resistor on the low voltage side.

6.2.2 The ~~tenderer~~ Vendor is free to suggest any other arrangement for mounting the capacitor bank and resistor which is considered economical without sacrificing the safety of the personnel working in traction substation. Full details of such arrangements shall be furnished with the tender.

7.0 EARTHING:

Earthling arrangement shall be provided for series capacitor installation in accordance with RDSO specification No. ETI/PSI/120~~(7/88)~~ (2/91) with A&C Slip No. 1 or latest code of practice for earthing of power supply installation for 25 kV, 50 Hz, single phase traction system.

8.0 GALVANISING:

All steel supporting frame shall be hot dip galvanised as per RDSO's specification No. ETI/OHE/13(4/84) With A & C Slip No. 1 to 4 or latest and the weight of zinc coating shall be not less than 1000 gm/sq.m.

9.0 FASTERNERS:

All fasteners of 12 mm diameter and less exposed to atmosphere shall be of stainless steel and those above 12 mm dia shall be preferably of stainless steel or mild steel hot dip galvanised to RDSO specn. No. ~~ETI/OHE/18(4/84)~~ TI/SPC/OHE/FASTERNERS/0120 Rev. 1 or latest.

10.0 TESTS

10.1 Type test shall be conducted on the first prototype unit manufactured after all the design and drawings have been approved and clearance given by RDSO to this effect.

10.2 Before giving the call to RDSO/ Chief Electrical Engineer for inspection and testing of the prototype of the system, the manufacturer shall submit a detailed test schedule of proto type testing indicating the name of the test with internal test report (Test report of Routine Test) ~~test schedule consisting of schematic circuit diagrams for each of the tests and nature of the test,~~ venue of the test and the duration of each test and the total no. of days required to complete the test at one stretch. Once the schedule is approved, the test shall invariably be done accordingly. However, during the process of type testing or even later. RDSO representative reserves the right to conduct any additional test(s) besides those specified herein, or any equipment/subsystem or system so as to test the equipment/ item ~~system~~ to his satisfaction or for gaining additional information and knowledge. In case any dispute or disagreement arises between the manufacturer and RDSO/ The Chief Electrical Engineer during the process of testing as regards the type tests and /or the interpretation and acceptability of the type test results, it shall be brought to the notice of the Director General (Traction Installations), RDSO/ The Chief Electrical Engineer as the case may be, whose decision shall be final and binding.

10.3 All type and routine tests shall be conducted on the capacitor units, resistor and the complete C-R device as per the governing specifications mentioned in clause 2.1. The tests on all equipment's shall be conducted in the presence of purchaser's representative.

10.4 The following type test shall be carried out at the works of the manufacturer or at ~~a~~ any Government approved testing laboratory if testing is done in India ~~reputed testing laboratory~~ on the prototype units of the capacitor as per IS: 2834 or latest and IEC: 70 or latest. At the works of the manufacturer, the testing shall be conducted in the presence of the authorized representative of the purchaser. However for the tests in the any Government approved testing laboratory if testing is done in India, the presence of representative of the purchaser may be decided by the RDSO.

10.4.1 Test for output ~~a capacitance~~ of the capacitor

The output of the capacitor shall be determined in accordance with Appendix-F of IS: 2834 or latest and shall be within -5 to +10 % of the rated value for capacitor units for making capacitor banks but within -0 to 10 % of the rated value in case of capacitor banks.

10.4.2 Voltage tests between terminals and container (for capacitor units).

An AC test voltage of the value specified in col. 2 of Table 3 of IS: 2834 or latest shall be applied between the terminals (short circuited) of each capacitor unit and its container, and maintained for a period of 1 min, except that when one terminal of the capacitor is connected to the container.

10.4.3 Measurement of tangent dielectric loss angle:

The dielectric loss angle (tangent) shall be determined by means of Schering bridge or other method capable of giving sufficiently accurate results. The measurement shall be carried out as per clause No. 14 of IS: 2834 or latest.

10.4.4 Thermal stability test:

This test shall provide thermal stability to capacitor under over load conditions and prepare the capacitor to give reliable loss measurements. This test shall be carried out as per clause no. 15 of IS: 2834 or latest.

10.4.5 Tangent of dielectric loss angle ~~of~~ at elevated temperature.

The dielectric loss angle (tan delta) shall be measured at a temperature of 70 deg. C or attained in thermal stability test. The measuring voltage shall be same as in thermal stability test.

10.4.6 Partial discharge test:

The test shall be carried out as per clause No. 17 of IS: 2834 or latest.

10.4.7 Impulse voltage test between terminal and container:

Five impulse waves of 1.2/5 micro second of each polarity having a peak value corresponding to the insulation level of the unit shall be applied between the terminals (joined together) and the container. The test shall be carried out as per clause No. 21 of IS: 2834 or latest.

10.4.8 Capacitor discharge test:

The capacitor shall be charged by means of dc volts equal to twice the rms value of the rated voltage of the unit and discharged through a gap situated as close as possible to the capacitor as per clause no. 21 of IS: 2834 or latest.

10.5 Routine tests:

The following tests shall be carried out as routine tests and shall be carried out on each and every units.

10.5.1 Visual examination :

All capacitors shall be examined for finish and marking verification of dimension shall also be done as per approved drawings.

10.5.2 Sealing test:

A sealing test shall be carried out to demonstrate that the impregnate does not leak from the capacitor. The test shall be carried out at 80+- 5 deg. C for a period of 3 hours.

10.5.3 Test for output and capacitance:

This test shall be carried out in accordance with clause 13 of IS: 2834 or latest.

10.5.4 Insulation resistance test:

Every capacitor shall be subjected to an insulation test between terminals and container except when one terminal of capacitor is connected to the container. The test shall be made with dc voltage (megger) not less than 500 V. The insulation resistance so determine shall not be less than 50 mega ohms.

10.5.5 Test for ~~efficiency~~ efficacy of discharge device:

A test for verifying the requirement of discharge device, as given in clause 6.1.1 to 6.1.3 of IS: 2834 or latest, shall made. Method of tests for efficiency of discharge device shall be as Per Appendix-G of IS: 2834 or latest.

10.5.6 Measurement of tangent of dielectric loss angle:

The dielectric loss angle (tangent delta) shall be made in accordance with clause 14 of IS: 2834 or latest.

10.6 Acceptance test:

The routine and /or type test or some of them, may be repeated by the purchaser by mutual agreement between the purchaser and the manufacturer, however, following tests acceptance shall be carried out in the sequence given below:

10.6.1 Visual examination:

All capacitors shall be examined for finish and marking verification of dimension shall also be done as per approved drawings.

10.6.2 Sealing Tests:

This test shall be carried out in accordance with clause no. 22 of IS: 2834 or latest.

10.6.3 Insulation resistance test:

This test shall be carried out in accordance with clause No. 12 of IS: 2834 or latest.

10.6.4 Test for ~~efficiency~~ efficacy of discharge device:

This test shall be carried out in accordance with clause No. 19 of IS: 2834 or latest.

10.6.5 Measurement of tangent of dielectric loss angle:

This test shall be carried out in accordance with clause No. 14 of IS: 2834 or latest.

10.7 Test on resistor:

10.7.1 The type test shall be carried out at the works of the manufacturer or at ~~a reputed testing laboratory~~ any Government approved testing laboratory if testing is done in India on the prototype units of the resistor as per relevant IEC/IS standard. At the works of the manufacturer, the testing shall be conducted in the presence of the authorized representative of the purchaser. However for the tests in the any Government approved testing laboratory if testing is done in India, the presence of representative of the purchaser may be decided by the RDSO.

10.7.2 The routine and acceptance test on the resistor shall be carried out as per relevant IEC/IS standard.

10.8 Bulk manufacture of the C-R device shall be taken up only after specific written approval is given by the purchaser to the ~~successful tenderer~~ Vendor on the basis of the tests conducted on the prototype units manufactured according to approved design and drawings.

~~10.9 The following test shall be conducted at site to verify the performance of the complete C-R device installation.~~

~~i) Tests for efficacy discharge device:~~

~~Test for verifying the requirement of discharge device, as given in clause 6.1.1 to 6.1.6 of IS: 2834 or latest.~~

~~ii) Rise in voltage due to capacitor bank connection.~~

~~At different loads, the voltage at the 25 kV bus bar shall be recorded for 24 hours each with and without the capacitor bank. The rise in voltage due to the capacitor bank shall be assessed from these observations.~~

~~iii) Harmonic analysis:~~

~~The harmonic analysis of current and voltage wave form shall be carried out by the tenderer Vendor with and without capacitor bank in circuit.~~

~~iv) Surge Voltage measurement:~~

~~The surge voltage shall be measured by the tenderer Vendor at the time of switching in the capacitor bank. This shall be done for 20 time, the voltage peak shall not exceed, 70 kVp in any case.~~

10.10 Schedule of pre-commissioning tests:

The schedule of pre-commissioning tests on the capacitor units, resistor and complete C-R device and other items shall be mutually agreed upon between the ~~successful~~ ~~tenderer~~ Vendor and the purchaser.

11.0 INDICATION:

Equipment should have a name plate describing name, rating, weight, name of manufacturer, date of manufacture, manufacturing number, etc.

12.0 TECHNICAL DATA AND DRAWINGS:

12.1 The ~~tenderer~~ Vendor shall furnish guaranteed performance data, technical and other particulars for the equipment offered in the preform attached as Annexure-A. ~~Technical details of the protection employed together with detailed calculation for the ratings of the equipment shall also be furnished with the tender~~.

12.2 The information furnished in schedule of guaranteed performance, technical and other particulars (Annexure A) shall be complete in all respects. If there is any entry like shall be furnished latter" or blanks are left against item, the tender is not likely to be considered as such commissions causes delay in finalising the tender.

12.3 The ~~tenderer~~ Vendor shall specifically indicate in a statement attached with his offer, his compliance with each clause and sub-clause of this specification. If any vague remarks on any clause or sub clause of this specification is given by the ~~tenderer~~ Vendor, then the once submitted by him is not likely to be considered. A separate deviation statement shall be furnished with the offer drawing attention to the clause(s) where the ~~tenderer~~ tender seeks deviations in details. Justification thereof. If there are no deviation, a NIL' statement shall be furnished.

~~12.4 The tenderer Vendor shall furnished the following calculations with their offer:~~

~~i) Detailed calculations for rating of C-R device.~~

~~ii) Calculations for design of supporting frame, fixing arrangement and foundation.~~

12.5 The ~~successful tenderer~~ Vendor shall be required to submit detailed dimensioned drawings for approval and shall also furnish six copies of the same, along with two copies of transparent reproducible prints, as per Railways standards in sizes of 210 mm x 297 mm or any integral multiple thereof.

a) Outline general arrangement drawing of the C-R device installation indicating necessary dimensions, clearances and location of equipment/ fittings (all the three views) name and rating plate with diagram of connection (one in English and the other in Hindi).

b) Schematic diagram.

c) Supporting frame with details of fixing arrangement and foundations along with calculation for their design.

12.6 After approval of designs and drawings by Director General (TI), RDSO, Lucknow the ~~tenderer~~ Vendor shall manufacture and acceptable prototype of C-R device as per approved drawings, The prototype inspection shall be carried out by the representative of RDSO. The bulk manufacture shall be taken up only after approval of prototype by Director General (TI), RDSO, Lucknow.

12.7 Routine inspection shall be carried out by the representative of Indian Railways at the manufacturer's works.

12.8 After approval, 6 copies of approved drawings along with two sets of reproducible prints shall be supplied to each consignee (s). Besides, two copies of drawings along with one set of reproducible prints shall be supplied to Director General (TI), RDSO, Lucknow. (India).

12.9 The ~~successful tenderer~~ Vendor shall supply 10 copies of instruction/ maintenance manual for the ~~capacitor bank~~ C-R device installation and its fittings and accessories, to each consignee (s) and two copies of Director General (TI), RDSO, Lucknow (India).

~~13.0 Additional Particulars:~~

~~The tenderer Vendor shall visit the traction substation location, if necessary, and collect any additional data/ details required for the design of capacitor and resistor. It would be responsibility of the tenderer Vendor to visualise the problems and understand the system conditions before evolving a suitable design.~~

14.0 Erection and testing and commissioning:

The C-R device shall be erected by the ~~successful tenderer~~ Railways under the supervision of a competent engineer of the ~~successful tenderer~~ Vendor/manufacturer/supplier. The ~~capacitor bank~~ C-R device installation shall be subjected to specified proving/pre-commissioning tests by the railway engineer at site and with which

the ~~successful tenderer~~ Vendor/manufacturer/supplier shall also be fully associated. For this purpose prior intimation regarding the date and location of the tests shall be given by the purchaser to the successful ~~tenderer~~ Vendor/manufacturer/supplier.

15.0 Spares

The ~~tenderer~~ Vendor shall furnish along with the offer a list of spares, with cost, recommended by him for maintenance of ~~capacitor bank~~ C-R device installation for a period of 2 year.

16.0 Training of Indian Railways' Engineers

The offer shall include the training of two engineers and four technicians of the Indian Railways Engineers free of cost at the manufacturer's works in dia or abroad and at the traction sub-station of a railways system or other public utility where C-R device of similar/ identical design are in operation. The total duration of training for each engineer/ technician shall be 4 weeks of which approximately 2 weeks will be at the manufacturer's works and 2 weeks on a Railway system or other public utility. The cost of travel to the country of manufacturer and back will be borne by the Indian Railways, other details shall be settled at the time of finalising the contract or purchase order.

17.0 Warranty:

Each C-R device including all equipment supplied against a purchase order/contract in which this specification is quoted, irrespective of origin (imported or indigenous), shall be guaranteed for trouble free and satisfactory performance for a period of 24 months from the date of supply or 18 months from the date of commissioning at the substation on the Indian Railways, which ever period is shorter. Details of warranty clause, the extent of responsibility and other relevant aspects shall be included in the purchase order or contract. The ~~tenderer~~ Vendor shall furnish detailed terms and conditions in ~~the~~ this regard in his offer.

The ~~successful tenderer~~ Vendor shall make necessary arrangement for closely monitoring the performance of the ~~capacitor bank~~ C-R device installation through periodical visits preferably once in two months during the warranty period, to the sub-station for on-the – spot detailed observations. Arrangements shall also be successful replacement so as to put back the ~~capacitor bank~~ C-R device installation in service without unduly long interruption.

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Annexure – A ~~to Specification No. ETI/PSI/128(8/89)~~

Schedule of Guaranteed Performance Technical and other particulars

A – Capacitor

S.N.	Description	Unit of measurement
1	Maker's name	
2	Country of manufacture	
3	Manufacturer's type designation	
4	Nominal rated system voltage	kV
5	~~Rated voltage of unit~~ a. Equipment voltage class b. Rated Voltage of i. Complete capacitor bank ii. A unit	 kV kV kV
6	Maximum voltage (rms) which the capacitor unit can withstand continuously	kV
7	Rated frequency	Hz
8	No. of phase	No
9	Upper limit of temperature category	Deg. C
10	Capacity of individual unit at rated voltage of the unit	kVar
11	Capacity of the capacitor bank	Micro Farad
12	Continuous current	Amps
13	Basic insulation level of individual unit. (a) Power frequency voltage withstand (b) 1.2/50 microsecond impulse withstand voltage (c) Between terminals wet power frequency withstand voltage (Specify voltage and duration)	 KV(rms) KV(peak) kV (rms)
14	Basic insulation level of complete C-R Device a) Power frequency voltage withstand b) 1.2/50 microsecond impulse withstand voltage	 KV(rms) KV(peak)
15	Constructional details of capacitor unit i) Dielectric system ii) Foil material iii) Impregnating liquid used and its properties.	
16	Dielectric loss per kVAr at ~~25 kV~~ 27.5 kV 50 Hz	Watts
17	Capacitor unit. i) No. of elements in series ii) No. of elements in parallel iii) Capacitance of each unit	 No. No. Micro Farad
18	Capacitor bank i) No of series groups	 No.
19	Bushings i) Maker's name ii) Governing Specification iii) One minute wet power frequency voltage withstand iv) Impulse voltage withstand 1.2/50 micro second full wave. v) Creepage distance in air vi) No. of bushings in each unit	 kV (rms) KV (peak) mm No.

20	Overall dimensions i) Weight per unit ii) Weight of the complete bank	 Kg Kg.

B-RESISTOR

SN	Description	Unit of measurement
1	Rated current and voltage	Amps/Volts
2	Rated frequency	Hz
3	Rated resistance	ohms
4	Basic insulation level a) One minute wet power frequency with stand voltage between terminals and case b) 1.2/50 micro second full wave, withstand voltage between terminals and case.	 KV(rms) kV (peak)
5	Overall dimensions of the resistor a) Total weight of the resistor	mm kg

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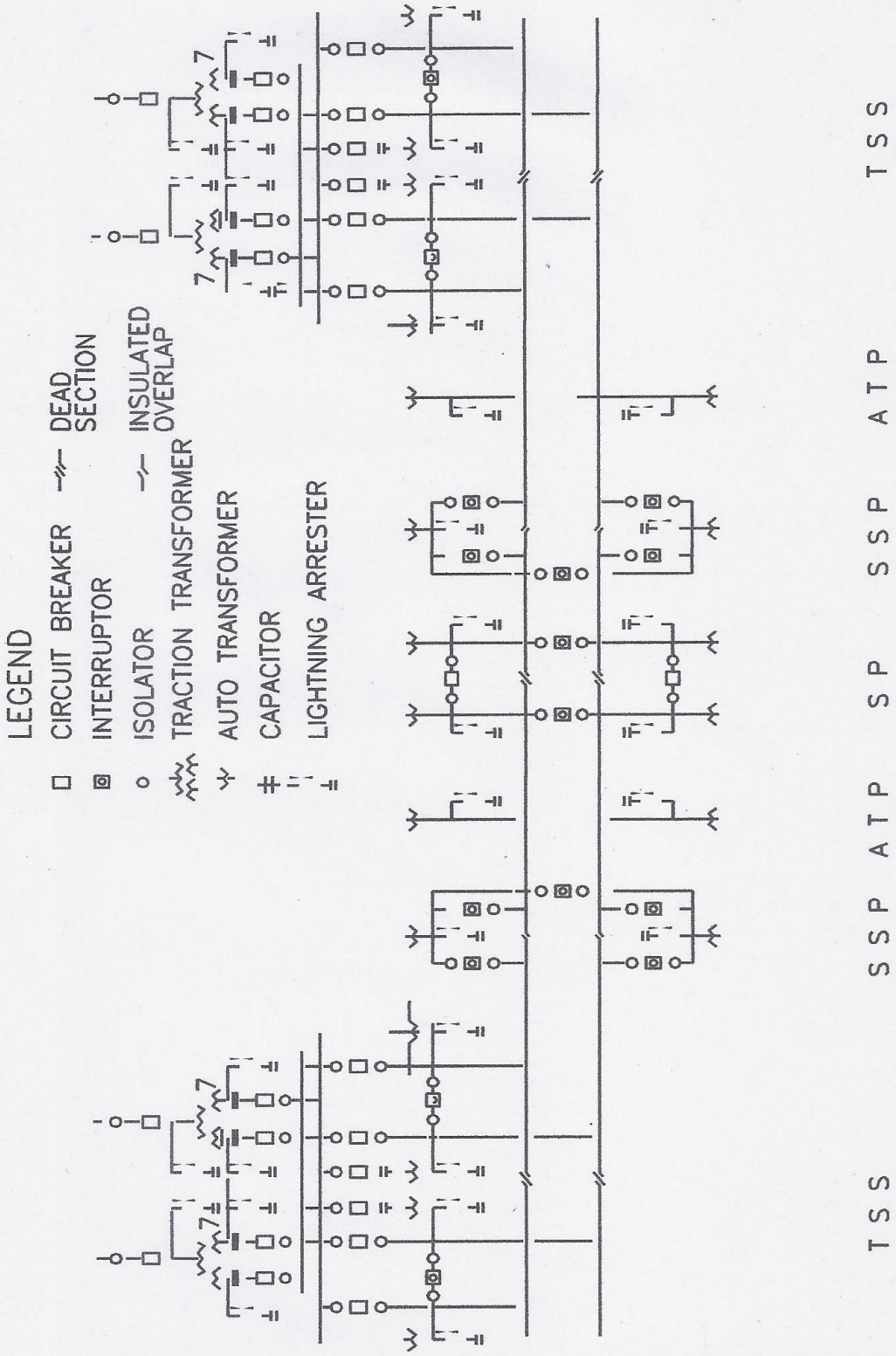
Appendix – I

(b) Power Supply Diagram



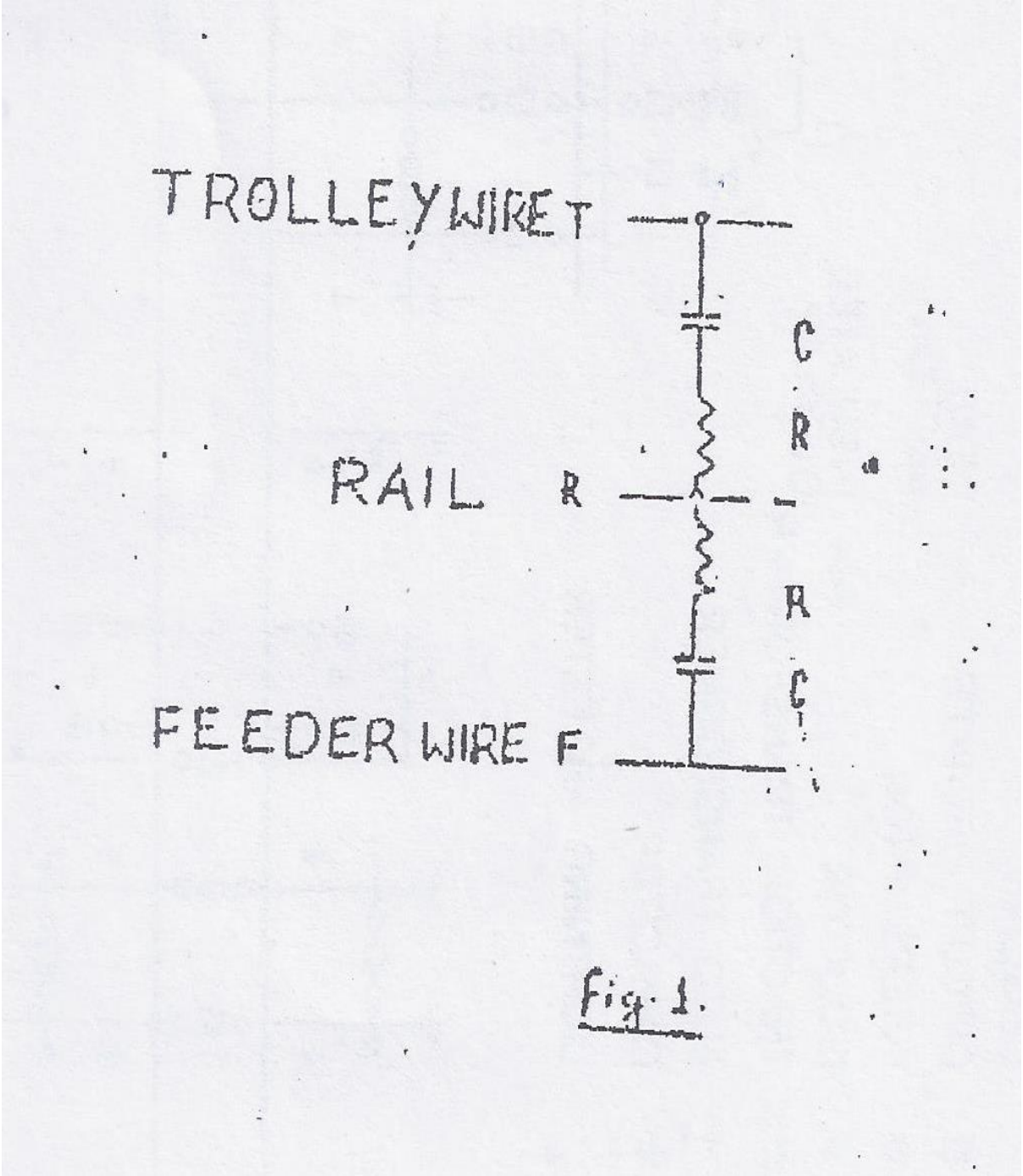


Fig. 1.