CARRIAGE DIRECTORATE
COMPUTER WING

COVERING LETTER

SUBJECT: SCANNING/DIGITISATION/INDEXING OF OFFICIALDOCUMENTS OF DIFFERENT DIRECTORATES OF RDSO

1	NAME OF THE DIRECTORATE		T I
2	NAME OF THE SUB-DIRECTORATE/SECTION		Doc- cell
3	NAME & DESIGNATION OF THE SCANNING-CORDINATION OFFICER/STAFF		-Anurag Srivastava / T. Hasa
4	NAME OF THE RECORD/FILE/ DOCUMENT/SPECIFICATION etc. AND ITS VOLUME/VERSION		Almira 4. ETI/PSI/72(9/89) =17+1 0005. ETI/PSI/90(6/95)-40 B5.
5	TOTAL NO OF PAGES/IMAGES		Total=18 No+40 No= 58 No Pages
6	NAME,SIGNATURE AND DESIGNATION OF THE HANDING OVER RDSO OFFICIAL		CR Sareen 21/06/10
7	NAME,SIGNATURE AND DESIGNATION OF THE TAKING OVER CMC OFFICIAL		Sobti - 21/06/10
8	DATE OF HANDING OVER FILE/DOCUMENT etc.		15/6/10
9	FIELDS FOR INDEXING		—
	1	Type of Document (File/ DRAWING/TECHNICAL CIRCULAR/MODIFICATION SHEET/SPECIFICATION/NP)	Spec
	2	Document No.	B5
	3	SUBJECT	Spec.
	4	SUB-SUBJECT	Spec.
	5	VOLUME	—
	6	Sr. No.	From 1 To 58.
	7	DATE OF CREATION OF FILE	15/6/10.
	8	Dealer	cmc
10	DATE OF RECEIVING BACK THE DOCUMENT		15/6/10.
11	NAME, SIGNATURE AND DESIGNATIONOF THE RDSO OFFICAL RECEIVING BACK THE DOCUMENT AFTER SCANNING (No of papers to be checked by department)		
12	REMARKS/FEEDBACK IF ANY (Quality of documents to be checked by department and certified)		
13	CATEGORY OF DOCUMENTS A) COMPUTER GENERATED GOOD QUALITY B) COMPUTER GENERATED (DOT MATRIX) C) TYPE WRITTEN D) HAND WRITTEN		

00002121 - 00002157

B-5

REFERENCE COPY

Specification No. ETI/PSI/72(9/85)

SPECIFICATION FOR ELECTRIC POWER CONNECTORS FOR A.C. TRACTION POWER SUPPLY SYSTEM

TRACTION INSTALLATION DIRECTORATE
RESEARCH DESIGNS & STANDARDS ORGANISATION
MINISTRY OF RAILWAYS
GOVERNMENT OF INDIA
MANAK NAGAR, LUCKNOW 226 011

Government of India
Ministry of Railways
Research Designs & Standards Organisation.

Specification No. ETI/PSI/72(9/85)

SPECIFICATION FOR ELECTRIC POWER CONNECTORS FOR A.C. TRACTION POWER SUPPLY SYSTEM

1 Scope

1.1 This specification covers the design, manufacture and testing of electric power connectors for outdoor use for horizontal and vertical take-off between the conductors (strung / rigid busbar) and equipment (like power transformer, circuit breakers, booster transformers, instrument transformers etc.) to establish electrical connection between them.

1.2 The connectors are generally composed of metals such as Aluminium-bronze, tin-bronze, Aluminium alloys inclusive of Aluminium-copper strip and fasteners. The materials of the connectors, clamps etc. are specified on the relevant standard drawings of the purchaser.

1.3 There are three types of connectors generally used at Traction sub-stations, switching stations and booster transformer stations, viz.

i) Rigid type connector designed for the purpose of connecting together equipment / terminal and busbar or connecting two conductors, with no allowance for the relative movement between the conductors.

ii) Expansion type connector designed for the purpose of connecting together equipment terminal and busbar or connecting two conductors, with ample allowance for the relative movement between the conductors.

iii) Bimetallic connector designed for the purpose of connecting together two conductors having dissimilar materials (generally copper and aluminium conductors) for preventing electrolytic corrosion. Bimetallic connectors can be of rigid type or expansion type.

2/-

2 Governing specifications

2.1 Assistance has been taken from the following Indian and British Standards in preparation of this specification:

i)	IS:5561-1970	-	Specification for electric power connectors.
ii)	IS:1570(Pt.V) - 1972.	-	Schedule for wrought steels - Part-V stainless and heat resisting steels.
iii)	BS:2061-1953	-	Phosphor bronze spring washers for general engineering purposes.
iv)	IS:306-1983	-	Tin bronze ingots and castings.
v)	IS:617-1975	-	Aluminium & aluminium alloy ingots and castings for general engineering purposes.
vi)	IS:1897-1971	-	Copper strip for electrical purposes.
vii)	IS:3091-1965	-	Aluminium bronze ingots and castings for fittings & in electric traction.
viii)	IS:2654-1977	-	Method for tensile testing of copper and copper alloys.
ix)	IS:4027-1967	-	Method of chemical analysis of bronzes.
x)	IS:1408-1968	-	Recommended procedure for inspection of copper based alloy and castings.

3 Service conditions

3.1 The connectors are intended for use in Railways' electric traction substations, switching stations and booster stations and should be designed to provide uninterrupted service under all conditions of load and weather.

3.2 The equipments in which these connectors would be used are to be installed in moist tropical climate and in areas subjected to heavy rainfall and severe lightning in India.

3.2 Contd

Maximum ambient air temperature in shade not exceeding	=	45°C
Minimum ambient temperature	=	-5°C
Maximum temperature attainable by an object exposed to sun.	=	65°C
Maximum relative humidity.	=	100%
Maximum wind pressure.	=	200 kg/m²
Maximum altitude.	=	1000 metres.
No.of rainy days per annum.	=	120 days max.
Average annual rain-fall.	=	1750 to 6250 mm.
No.of thunder-storm days/year.	=	85 days max.
No.of dust-storm days/year.	=	35 days max.

3.3 They are also subjected to chemical pollution from the effluent gases of chemical plants, exhaust of steam/diesel locomotives and to saline atmosphere in coastal areas.

3.4 Vibrations

The equipments (along with the terminal connectors) are installed on steel structures located by the side of Railway tracks and are 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 up to 350 microns. These vibrations occur with rapidly varying time periods in the range of 15 to 70 ms.

4 General requirement

4.1 All parts of the connector shall be manufactured by the connector manufacturer at his works. However, components such as fasteners may be obtained from the Railways' approved suppliers with the specific approval of the indentor.

4.2 All connectors shall be manufactured by gravity diecasting process.

4.3 The detailed dimensional drgs.of connectors as per Railways' standard size of 210 mm x 297 mm or any integral multiple thereof, shall be submitted to RDSO for approval,before taking up the manufacture of test bars / prototype terminal connector. For the guidance of manufacturer, a list of RDSO's drawings for terminal connector equipment-wise,is given at Annexure-B.

4.4 The connectors of same identification number (R.I.No.) and materials shall have free interchangeability.

4.5 The connectors shall be smooth,free from cavities, sharp edges, blow-holes, cracks and such other defects which are likely to be detrimental to their performance while in service.

4.6 The connectors should withstand short-circuit forces and the loads normally expected to occur in outdoor conditions and the effect of vibration both on the conductor and the connector itself.

4.7 All connectors and hardwares shall be either inherently resistant to the atmospheric corrosion or suitably protected against corrosion both during storage and in service.

4.8 Bolted joints shall be so designed as to apply uniform pressure on the terminal and the conductor to provide adequate area for current transfer,and also to provide a mechanical strength not less than that of the conductor to which it is to be connected.

4.9 Since the connectors are to be used in current carrying circuits, all bolts,nuts and washers shall be made of stainless steel unless otherwise stated in the relevant drawings.

4.10 The connectors and clamps are required for use in Railways traction substation and other important locations where utmost reliability is required and as such the best material and workmanship are to be employed.

5 <u>Rating and other particulars</u>

5.1 The various types of connectors covered by this specification are briefly described in Annexure-C.

5.2 The rating and other particulars of the connector assembly shall be as follows:

5.2 Contd.

		Rigid / HV(132kV side)	Expansion LV(25kV side)
i)	Type of connector:		
ii)	a) Continuous current rating.	200 Amps.	1250 Amps.
	b) Overload current for 15 minutes.	400 Amps.	2000 Amps.
iii)	Rated frequency.	50 Hz	50 Hz
iv)	Rated short-time current for one second.	40 kA(rms) 100 kA(peak)	25kA (rms) 62.5kA(peak)
v)	Material of the connector.	a) Aluminium-bronze/tin-bronze to the equipment terminal(copper or brass).	
		b) Aluminium-alloy to the busbar end(spider AAC or aluminium tube).	
		c) 2 mm thick aluminium copper(ALCU)strip for bimetallic terminal connector.	
vi)	Max.permissible temp. rise when carrying rated overload current for 15 minutes with reference to an ambient temperature of 45°C.	40°C	40°C

5.3 The ratings given in clause 5.2 refer to terminal connectors used on power transformers,circuit breakers,interruptors,current transformers and isolators. These ratings do not refer to terminal connectors used on potential transformers and 25kV booster transformers. The continuous current rating and overload rating for 15 minutes of terminal connectors for 25kV booster transformers shall be 800Amps and 1200 Amps respectively. The other rating as given at Sl No.(iii),(iv),(v) and (vi) of clause 5.2 shall also be applicable for connectors for 25kV booster transformers, 132kV potential transformers and 25kV potential transformers.

00002121

6 Material specification

6.1 Aluminium-bronze connector

6.1.1 Aluminium-bronze alloy used for the connector body & clamping piece shall conform to IS:3091-1966.

6.1.2 The material when analysed in accordance with IS: 4027-1967 shall have the chemical composition as, givenbelow:

Chemical composition of aluminium-bronze ingots and castings.

	Constituent	Per cent
i)	Aluminium	9.0 to 11.0
ii)	Iron	4.0 to 5.0
iii)	Manganese	0.1 to 0.5
iv)	Copper	Remainder.

6.1.3 The material when tested in accordance with IS: 2654-1977 shall have the following mechanical properties:

Mode of casting.	Properties.	Values.
Chill cast or any other casting process.	i) Tensile strength, Min.	60kgf/mm^2
	ii) Elongation on 50mm gauge length, Min.	20 per cent.
	iii) 0.2 per cent permanent set stress, Min.	25kgf/mm^2

6.2 Tin-bronze connector.

6.2.1 Tin-bronze alloy used for the connector body and clamping piece shall conform to IS:306-1983.

6.2.2 The material when analysed in accordance with IS:4027-1967 shall have the chemical composition as given below:

6.2.2. Contd.

Chemical composition of tin-bronze ingots and castings.

	Constituent.	Composition per cent	
		Ingots.	Castings.
i)	Tin	9.5 - 10.5	9.5 - 10.5
ii)	Zinc	1.75 - 3.25	1.5 - 3.0
iii)	Lead, Max.	1.5	1.5
iv)	Nickel, Max.	1.0	1.0
v)	Iron, Max.	0.15	0.15
vi)	Aluminium, Max.	0.01	0.01
vii)	Silicon, Max.	0.02	0.02
viii)	Bismuth, Max.	0.03	0.03
ix)	Total impurities, Max. (includes iron, aluminium, arsenic, antimony, silicon, bismuth).	0.50	0.50
x)	Copper	Remainder.	Remainder.

6.2.3 The material when tested in accordance with IS: 2654-1977 shall have the following mechanical properties:

Mode of casting.	Tensile strength MPa. Min. (Kgf/mm^2).	0.2 per cent proof stress MPa. Min. (Kgf/mm^2).	Elongation per cent on gauge length $5.65\sqrt{A}$. Min.
Sand casting (separately cast).	260 (26.5)	120 (12.5)	13
Chill casting (separately cast).	210 (21.5)	120 (12.5)	3

6.3 Aluminium and aluminium alloy connector.

6.3.1 The aluminium alloy used for the connector body and clamping piece shall conform to grade 4600(M) of IS 617-1975.

6.3.2 The chemical composition and mechanical properties of aluminium and aluminium alloy are given below:

a) Chemical composition (condition-M):

Alloy designation (pressure diecast alloy).	Per cent, Max.
i) Copper	0.1
ii) Silicon	10.0 to 13.0
iii) Magnesium	0.10
iv) Iron	0.6
v) Manganese	0.5
vi) Nickel	0.1
vii) Zinc	0.1
viii) Lead	0.1
ix) Tin	0.05
x) Titanium	0.2
xi) Aluminium.	Remainder.

8

8.1

8.2

b) Mechanical properties:

Mode of casting.	Tensile strength kgf/mm², Min.	Elongation (on 50 mm gauge length) Min. percentage.
Sand cast	16.5	5
Chill cast	19.0	7

8.3

9/-

6.4 Fasteners (hardwares)

Stainless steel bolts, nuts and washers shall conform to Grade O_4 Cr 17 Ni 12 Mo_2 of IS: 1570(Pt.V)-1972.

7 Tolerances

7.1 Tolerances of ± 0.5 mm shall be permissible on all dimensions unless otherwise specified on the relevant drawing of the purchaser.

7.2 Alternatively, whenever not specified on the relevant drawing furnished by the purchaser, the following tolerances shall apply for non-mating surfaces:

Dimension.		Tolerances:
i)	Up to and including 35 mm.	±0.5 mm
ii)	Over 35 mm	± 1.5 %
iii)	Wall thickness.	+ 1.0 mm - 0.5 mm

8 Tests on test bars.

8.1 These tests shall be carried out, as described below, on test bars before conducting type test on terminal connectors by RDSO to check the chemical composition and mechanical properties of the material used for the terminal connector.

8.2 The supplier shall have to manufacture three numbers of cast-to shape test bars for each of the materials used for the connector. The test bar shall be made in accordance with the drawing placed at Annexure-A. The bars shall be cast to the dimensions, dressed or cleaned and shall be tested in the machined condition. The test bars shall be from the same melt from which the samples of the connectors have been cast.

8.3 One test bar shall be tested for chemical composition and mechanical properties in accordance with clause-6 as applicable. If the bar fails in any test, two more test bars shall be tested. The samples shall be deemed to have passed the tests if there is no failure in the re-test.

10/-

8.4 If the mechanical and chemical properties of the test bars are acceptable, the terminal connector shall be subjected to all the type tests as per clause 10.1 in the presence of RDSO's representative.

8.5 All type tests on the samples including various tests on test bars shall be arranged by the manufacturers free of cost to the Railways in the presence of RDSO's representative.

9 Deviations from specification

9.1 Any deviation from this specification to improve the performance, efficiency and utility of the connectors proposed by the tenderer, will be given due consideration provided full particulars with justification thereof are furnished.

10 Tests

10.1 Type tests

10.1.1 These tests are normally made before the approval of the prototype samples, but may be repeated at the discretion of RDSO, at any time. The following type tests shall be carried out on three prototype samples of terminal connectors to prove the general quality and designs:

i) Visual inspection Cl.11.1

ii) Dimensional verification. Cl.11.2

iii) Electrical resistance (milli-volt drop) test. Cl.11.3

iv) Slip test (tensile test) Cl.11.4

v) Temperature rise test. Cl.11.5

vi) Short time current test. Cl.11.6

10.2 Acceptance test

The number of terminal connectors for acceptance tests, to be selected at randon, shall be the nearest whole number to 10 per cent of the batch offered for acceptance. The following acceptance tests shall be carried out:

i)

10.2 Contd.

i) Dimensional verification. Cl.11.2

ii) Electrical resistance test. Cl.11.3

iii) Slip test(Tensile test). Cl.11.4

10.3 Routine test

The following shall constitute the routine tests and shall be carried out on all the terminal connectors:

i) Visual inspection. Cl.11.1

ii) Dimensional verification. Cl.11.2

11 Test methods

11.1 Visual inspection

All connectors shall be examined visually for good workmanship and smooth finish i.e. free from cavities, blow-holes, hair-line cracks and other defects.

11.2 Dimensional verification

The dimensions of the connectors shall be checked by gauges, callipers and micrometers to ascertain conformity to the relevant approved drawing.

11.3 Electrical Resistance test

11.3.1 The largest conductor / busbar which the connector will accommodate shall be used during the resistance test.

11.3.2 The resistance measurement shall be made by millivolt drop with the help of an accurate resistance bridge or other approved method.

11.3.3 Ambient temperature shall also be recorded during the test.

11.3.4 The resistance of 1.25 m of a conductor, inclusive of one connector assembly shall not exceed the resistance of 1.25m of the identical conductor without connector assembly, by more than 10 per cent. The resistance measurement shall be taken from A to B, C to D and A to D as shown in Fig. A below. The resistance measured from A to D

0002127

11.3.4 Contd.

shall be within ±10% of the sum of resistances of 0.625 m length of one conductor and 0.625 m length of another conductor, which are to be connected through the terminal connector under test.

The resistance measured between A and B shall be within ±10 percent of half of the resistance of 1.25 m of the particular conductor to which it is connected. And similarly the resistance between C and D shall be within ±10 per cent of half of the resistance of 1.25 m of the another conductor to which it is connected.

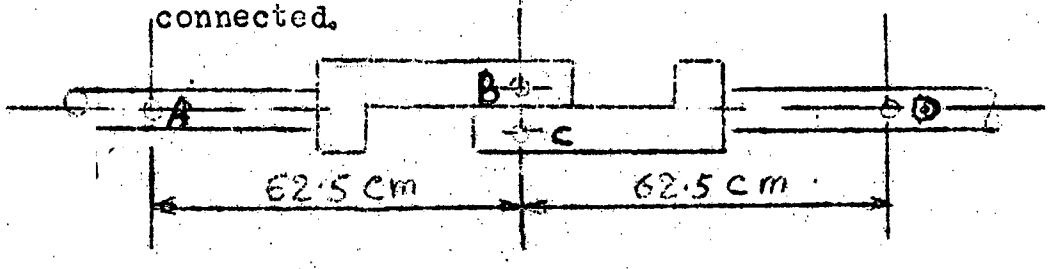


Fig. A

11.4 Slip test (Tensile test)

a) The connector with a suitable length of the conductor with which it is intended to be used shall be mounted vertically in a tensile machine and anchored suitably in such a way that the tests load is applied in the direction of the conductor. The assembly shall be tightened to the required torque.

b) If the nominal breaking load of the conductor is 1100 kgs or more, a tensile load of 55kg shall be applied initially and the conductor shall be marked in such a way that movement relative to the connector can easily be detected. The value of the load at which the conductor in the connector body begins to slip shall be noted. Without any subsequent adjustment on the connector, the load shall be steadily increased to 110 kgs. This load shall be maintained for one minute.

c) There shall be no movement of the conductor relative to the connector due to slip during this one-minute period and no failure of the connector.

11.5 Temperature rise test

a) The current applied during the temperature rise test shall be the rated current assigned to the connector.

b) The temperature rise test for power connectors shall be made with alternating current at an average frequency not below 95% of the rated frequency.

c) The connector shall be assembled indoorson conductors of size and type with which it is to be used. Air shall be freely circulated around the assembly, but no draughts shall be allowed.

d) Each test shall be made over a period of time sufficient for the temperature to reach a constant value (for practical purposes, this condition is attained when the variation does not exceed 1°C per hour). After steady state the current shall be increased and overload currents flown in the test piece for a time as speciried in Clause 5.2(ii)(b). Temperature shall be recorded immediately after the specified overload time is over. Temperature measurements shall be made using either thermocouples or thermometers. There shall be two spare thermometers for measuring ambient temperature and the same shall be protected from any air draught /abnormal heat radiations.

e) The temperature rise of the connector assembly shall not exceed 40°C over a reference ambient air temperature of 45°C. If the ambient temperature exceeds 45°C, the permissible temperature rise shall be reduced by an amount equal to the excess ambient temperature.

11.6 Short-time current test

a) The test shall be arranged, as far as practicable, to produce conditions equivalent to those within which would be obtained in service, when the connector under test carries fault current. The test may be made at /any suitable voltage & with the connector at any/ convenient temperature. The short time current shall be applied for the specified time and its rms value shall be determined as specified in Appendix-A of IS: 5561-1970. The procedure of the tests shall be in accordance with Clause 13 of IS:5561-1970.

00002129

11.6 b) The rms value of the shorttime current shall be not less than the rated short time current and the highest peak value of the major current loop during the first cycle of the test should be not less then the corresponding values as specified in Clause 5.2(iv).

c) The shorttime current shall not produce any mechanical damage, such as permanent distortion or burning of parts, and shall not cause a temperature rise that added to the maximum temperature attained at rated current would damage the current carrying parts.

12 Markings

12.1 The name / initials / trade mark of the manufacturer, Railways identification No.(R.I.No.) and any other information required by the purchaser shall be cast on each connector.

13 Drawings

13.1 The manufacturer shall be required to submit in triplicate, the detailed dimensional drawings, showing all the three views (elevation, plan and side), cross-sections, wherever necessary, schedule of materials and their specifications etc. as per Railways' standards sizes of 210 mm x 297 mm or any integral multiple thereof for approval. A copy of the standard pro forma (Form-3) is attached at Annexure-D for guidance.

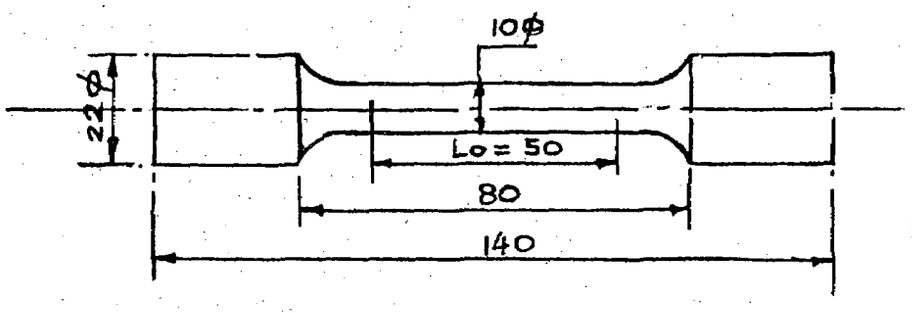
13.2 After the drawings are finally approved by RDSO, six copies of ammonia prints and one reproducible tracing shall be supplied by the successful manufacturer to purchaser.

14 Particulars of the equipment

Connectors in use at the Railways' traction sub-stations, switching stations, and booster transformers are given in Annexure-B attached.

===

INDIAN RAILWAYS	RESEARCH DESIGNS AND STANDARDS ORGANISATION	ANNEXURE-A TRACTION INSTALLATION DIRECTORATE



Lo = GAUGE LENGTH

FIG. 1 - ALUMINIUM-BRONZE CASTING (IS:3091:1965)

(THE TEST BAR SHALL BE MADE FOR EACH LOT AND IDENTIFIED WITH LOT & DATE OF MELT)

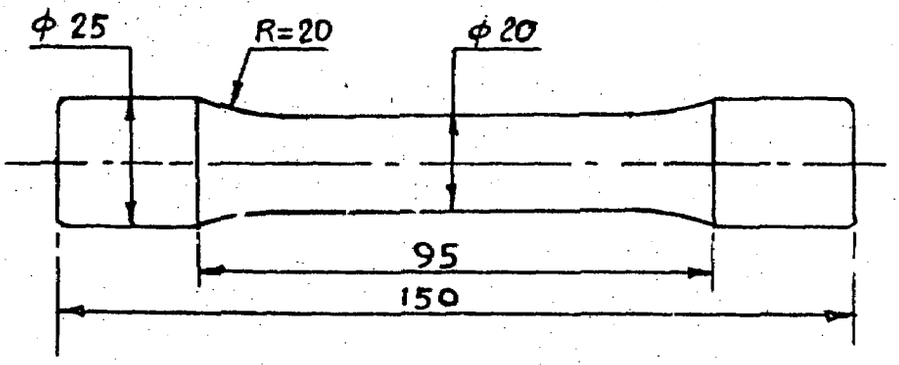
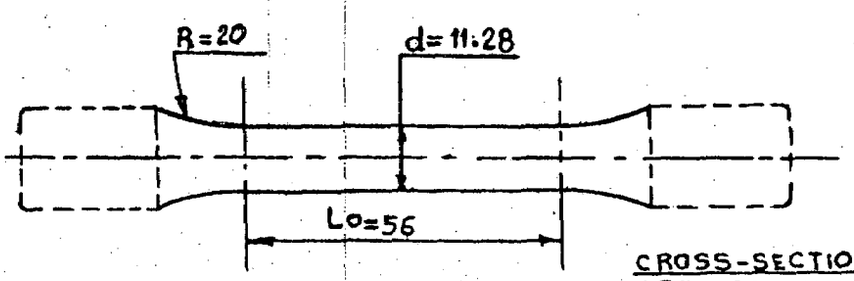


FIG. 2 - TIN BRONZE CASTING

(THE TEST BAR SHALL BE ACCORDING TO ONE OF THE APPROPRIATE TYPES DESCRIBED IN IS: 1408 - 1968)



CROSS-SECTIONAL AREA So = 100 mm²

FIG. 3 - ALUMINIUM-ALLOY CASTING

(THE TEST BAR SHALL BE PREPARED FROM TEST SAMPLES SHALL BE MACHINED TO THE DIMENSIONS OF THE STANDARD ROUND TEST PIECE & THOSE PREPARED FROM CHILL MOULDS AS PER IS-617-1975)

NOTE:-
ALL DIMENSIONS ARE IN MILLIMETRES.

00002122

CAST TO SHAPE TEST PIECES	ETI/PSI/SK/299
	SCALE: NTS

Annexure-B

List of connectors used on the terminals of different electrical equipments is given below:

SNo.	Equipment.	Type of connector.	Drg./R.I. No.
1	132kV side of 13.5MVA traction transformer, 132 kV current transformer & 132kV potential transformer.	Rigid.	ETI/PSI/P/6800
2	25kV side of 13.5 MVA traction transformer, 25kV circuit breaker, 25kV interruptor.	Expansion.	ETI/PSI/P/6570.
3	132kV circuit breaker and 132kV isolator.	Rigid.	ETI/PSI/P/6830
4	25kV current transformer.	a) Rigid b) Expansion	) ETI/PSI/P/6860)
5	25kV booster transformer.	Expansion.	ETI/PSI/P/6850
6	25kV isolator.	Rigid.	ETI/PSI/P/6480.
7	25kV isolator (as a bus coupler)	Expansion.	ETI/PSI/P/6480-1
8	25kV potential transformer Type-I.	Rigid. Rigid.	ETI/PSI/6530 ETI/PSI/P/6830
9	25kV potential transformer, Type-II.	Rigid. Rigid.	ETI/PSI/P/6510 ETI/PSI/P/6830

===

Annexure-C

Details of the Equipment Terminals and Terminal Connectors.

SNo.	Equipment.	Description of equipment terminal.	Equipment to be connected to.	Brief description of termir l connector.
1	2	3	4	5
1	Power transformer 25 kV side, 25kV CBs, 25 kV interruptors (except few makes of interruptors), 25kV current transformers.	30mm dia copper stud.	36mm o.d. aluminium bus.	Continuous curre t rating 1250A; expansion/rigid type.
2	25kV SP & DP isolators, few makes of interruptors.	Square pad of copper/ aluminium.	36mm o.d. aluminium bus.	Continuous current rating 1250A; rigid/expansion type.
3	Power transformer 132kV side, 132kV current transformer.	30mm dia copper stud.	20mm (AAC) spider conductor.	Continuous current-rating 200A.
4	132kV CBs, 132kV isolators.	Square pad of aluminium alloy/copper.	20 mm (AAC) spider conductor.	Continuous current rating 200A.
5	25kV potential transformer (Type-I & II).	-do-	20 mm (AAC) spider conductor & this spider conductor connected to 36mm o.d. aluminium bus.	Type-I PT terminal connector from spider conductor to Aluminium bus is different from type-II PT as shown in the drgs.
6	132kV potential transformer.	30 mm dia. copper stud.	20mm (AAC) spider conductor.	
7	25kV booster transformer.	20mm dia. copper threaded stud.	36mm o.d. aluminium bus.	Continuous current rating 800A; expansion type.

==