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Indian Standard

SPECIFICATION FOR INTERCONNECTING BUS-BARS FOR AC VOLTAGE ABOVE 1 kV UP TO AND INCLUDING 36 kV

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6

November 1976

Indian Standard

SPECIFICATION FOR INTERCONNECTING BUS-BARS FOR AC VOLTAGE ABOVE 1 kV UP TO AND INCLUDING 36 kV

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Indian Standard

SPECIFICATION FOR INTERCONNECTING BUS-BARS FOR AC VOLTAGE ABOVE 1 kV UP TO AND INCLUDING 36 kV

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 7 May 1976, after the draft finalized by the Switchgear and Controlgear Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 With large scale manufacture of bus-bars in this country, the need for specifying uniform requirements of such equipment was felt, particularly in view of different practices being followed by the manufacturers. This standard has, therefore, been prepared to meet this need and also to provide guidance to the manufacturers in this field.

0.3 In preparing this standard, assistance has been derived from B.S. 159 : 1957 'Busbars and busbar connections', issued by the British Standards Institution.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard relates to ac interconnecting bus-bars and bus ducts (other than by cables) having rated voltage above 1 kV up to and including 36 kV, open or enclosed type which are part of ac electrical power systems and used as external connections between terminals of equipment. These are composed of metals such as copper or aluminium with air, oil/compound, solid or semisolid materials as insulation. This standard also covers enclosures, support structure, etc, associated with bus-bars arrangement.

1.2 Insulators, bushings and cables, etc, which may be used with bus-bar assemblies are not covered in this standard.

*Rules for rounding off numerical values (*revised*).

1.3 This standard does not cover bus-bars forming part of factory built switchgear assemblies and also bus-bars used in outdoor switch yards.

1.4 The service conditions for which the bus-bars conforming to this standard are suitable are given in Appendix A.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Interconnecting Bus-Bar — A conductor other than cable, used for external interconnection between terminals of equipment.

2.2 Open Bus-Bar — A bus-bar that is not provided with a protective enclosure.

2.3 Air-Insulated Bus-Bar — A bus-bar which except at points of support is designed with air as principal dielectric. It may be covered with insulating material.

2.4 Oil/Compound Immersed Bus-Bar — An enclosed bus-bar which is totally immersed in insulating oil/compound.

2.5 Metal Enclosed Bus Duct — An assembly of bus-bar with associated connections, joints and insulator supports within a grounded metal enclosure. Metal enclosed bus ducts shall be, in general, of three basic types that is, non-segregated phase, segregated phase and isolated phase.

2.5.1 *Non-segregated Phase Bus Duct* — Metal enclosed bus duct in which all the phase conductors are in a common metal enclosure without barrier between the phases.

2.5.2 *Segregated Phase Bus Duct* — Metal enclosed bus ducts in which all the phase conductors are in a common metal enclosure but are segregated by metal/insulation barrier between phases.

2.5.3 *Isolated Phase Bus Duct* — Metal enclosed bus duct in which each phase conductor is enclosed by an individual metal housing and separated from adjacent conductor housing by an air space. Isolated phase bus ducts shall be of two basic types in general, that is, discontinuous and continuous.

2.5.3.1 *Discontinuous isolated phase bus duct* — Isolated phase bus duct system in which the various sections of bus duct are so interconnected and earthed that no path is provided for the induced circulating currents to flow from one phase enclosure to other phase enclosure.

2.5.3.2 *Continuous isolated phase bus duct* — Isolated phase bus duct system in which the various sections of bus duct are so interconnected that low resistance path for the induced circulating current is provided from one phase enclosure to other phase enclosure.

2.6 Rated Current — The rms value of current which the bus-bar assembly shall be able to carry continuously under prescribed conditions.

2.7 Rated Voltage — Voltage assigned by the manufacturer to indicate the highest system rms voltage between phases for which the bus-bar is intended.

2.8 Rated Frequency — The service frequency for which the bus-bar is designed.

2.9 Rated Insulation Level — The combination of test voltage values (both power frequency and impulse) which characterize the insulation of bus-bar assemblies with regard to its capability of withstanding dielectric stresses.

2.10 Rated Short Time Current — The rms value of the current which the bus-bar shall be able to carry for one second under specified conditions.

3. RATING

3.1 The bus-bar shall be rated in terms of the following:

a) Number of phases,
b) Rated voltage,
c) Rated current,
d) Rated frequency, and
e) Rated short time current.

3.2 Preferred Rated Voltage — Rated voltage of bus-bars shall be one of the highest system voltages given in Table 1.

3.3 Preferred Rated Insulation Level — The rated insulation level shall be selected from Table 1.

3.4 Preferred Rated Current — These shall be selected from the following standard values (in amperes) :

100, 250, 400, 630, 800, 1 250, 1 600, 2 000, 3 150, 4 000, 5 000, 6 300, 8 000, 10 000, 12 500 and 15 000.

NOTE — In power stations for connecting high current generator units to step up transformers it is usual practice to use metal enclosed bus-bars. In installations where main bus duct is of a particular type, various low current tap-offs from these shall be of similar type.

3.5 Rated Frequency — The bus-bar shall be designed for use on a supply frequency of 50 Hz.

3.6 Rated Short Time Current — The short time current rating of the bus-bar shall correspond to the fault level of the system and take into consideration the protective devices on the incoming side. Unless otherwise specified the duration of the short time current shall be one second.

4. LIMITS OF TEMPERATURE-RISE

4.1 The temperature-rise limits shall be in accordance with Table 2.

TABLE 1 RATED INSULATION LEVEL (FOR RATED VOLTAGES ABOVE 1 kV)

(*Clauses* 3.2, 3.3 *and* 7.1.4.1)

Rated Voltage (Highest System Voltage)	Standard Impulse Withstand Voltage	One-Minute Power Frequency Withstand Voltage
(1)	(2)	(3)
kV (rms)	kV (peak)	kV (rms)
3·6	40	10
7·2	60	20
12·0	75	28
17·5	95	38
24·0	125	50
36·0	170	70

Note 1 — The values given in this table are based on an ambient temperature of 20°C, pressure of 760 mmHg at 0°C and humidity of 11 g of water per cubic metre. The values corresponding to the Indian Standard reference temperature of 27°C, when available, will replace the values given in the present table.

Note 2 — A standard impulse wave is one with a wavefront of 1·2 microsecond and a time to half value of wave-tail of 50 microsecond.

TABLE 2 TEMPERATURE-RISE LIMIT

(*Clauses* 4.1 *and* 7.1.2.5)

Bus-Bars and Conductors of Copper and Aluminium	Temperature Rise Over Reference Ambient Temperature of 40°C*
Accessible external enclosures and covers:	
Metal surfaces	30°C†
Insulating surfaces	40°C

*Limited by:

a) mechanical strength of conducting material,

b) possible effect on adjacent equipment,

c) permissible temperature limit of the insulating materials in contact with the conductor, and

d) the effect of the temperature of the conductor on the apparatus connected to it.

†Unless otherwise specified in the case of covers and enclosures which are accessible but need not be touched during normal operation, temperature-rise limits, increased by 10°C are permissible.

5. CONSTRUCTION

5.0 General construction of various types of metal enclosed bus-bars is outlined below for the purpose of reference of manufacturers and users in particular.

5.1 Non-segregated Phase Bus Duct — This consists of three phase bus-bars running in a common metal enclosure made of steel or aluminium. The enclosure provides safety for the operating personnel and reduces chances of faults. The bus duct shall be factory assembled or site fabricated if facilities are available. The enclosure is effectively grounded. This type of bus duct is illustrated in Fig. 1.

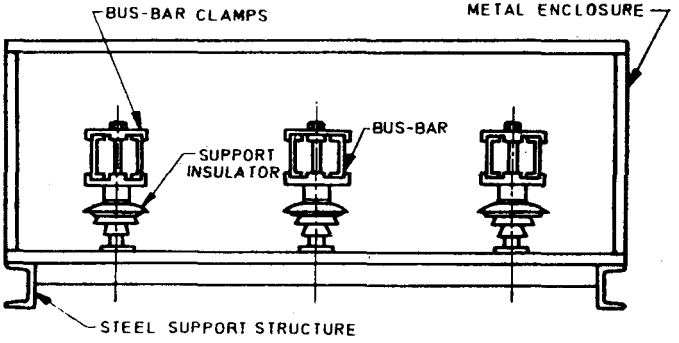


FIG. 1 TYPICAL NON-SEGREGATED PHASE BUS DUCT

5.2 Segregated Phase Bus Duct — This type is similar to non-segregated phase bus duct except that metal or insulation barriers are provided between phase conductors to reduce chances of phase to phase faults. This type of design is illustrated in Fig. 2. The metal barriers are preferred.

5.3 Isolated Phase Bus Duct — In this construction each phase conductor is housed in a separate non-magnetic enclosure. The bus duct is made of sections which are assembled together at site to make complete assembly. The enclosures are generally round or square in shape and are of welded construction. The enclosures of all phases are usually supported on a common steel structure.

5.3.1 In discontinuous type designs the enclosures and structures are so interconnected and grounded that effective grounding is achieved without forming closed circuit for induced circulating currents; suitable insulation is provided between enclosure joints wherever necessary to avoid these currents. Metal and insulation braces are provided between enclosures to take care of short circuit forces, etc. This type of design is illustrated in Fig. 3.

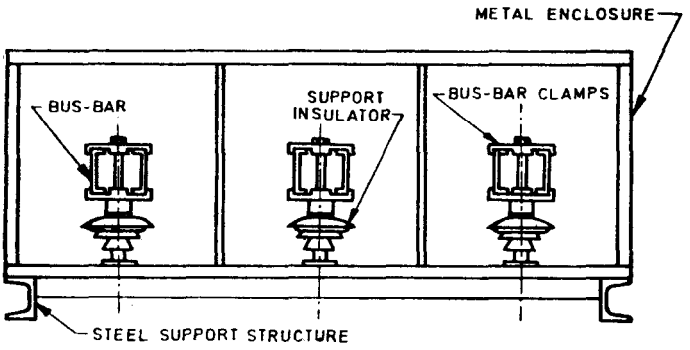


FIG. 2 TYPICAL SEGREGATED PHASE BUS DUCT

5.3.2 In continuous type designs, phase enclosures are effectively welded or connected at the two ends to other phase enclosures to form a low resistance path adequate to carry current of the same order as the bus-bar unless the circulating currents are limited by some suitable means such as the use of reactors. This design may not require insulation at enclosure joints. This type of design is illustrated in Fig. 4.

5.4 Conductors — Conductors suitable for bus-bars and bus-bar connections are specified in the following Indian Standards:

Copper Conductors

IS: 282-1963 Specification for hard-drawn copper conductors for overhead power transmission (*revised*)

IS: 613-1964 Specification for copper rods for electrical purposes (*revised*)

IS: 1897-1971 Specification for copper strip for electrical purposes (*first revision*)

Aluminium Conductors

IS: 398-1961 Specification for hard-drawn stranded aluminium and steel-cored aluminium conductors for overhead power transmission purposes (*revised*)

IS: 1841-1971 Specification for EC grade aluminium rod produced by rolling (*first revision*)

IS: 2067-1962 Specification for wrought aluminium for electrical purposes, wire (other than that used for overhead conductors)

IS: 4026-1969 Specification for aluminium ingots (EC grade) (*first revision*)

IS: 5082-1969 Specification for wrought aluminium and aluminium alloys, bars, rods, tubes and sections for electrical purposes

IS: 5484-1969 Specification for EC grade aluminium rod produced by continuous casting and rolling

5.4.1 Conductor jointing shall be done as given in Appendix B. Joints shall be such that the temperature-rise shall not exceed that specified in Table 2 and shall be so constructed or treated as to prevent deterioration in service and maintain the conductivity of the joint. Provision shall be made

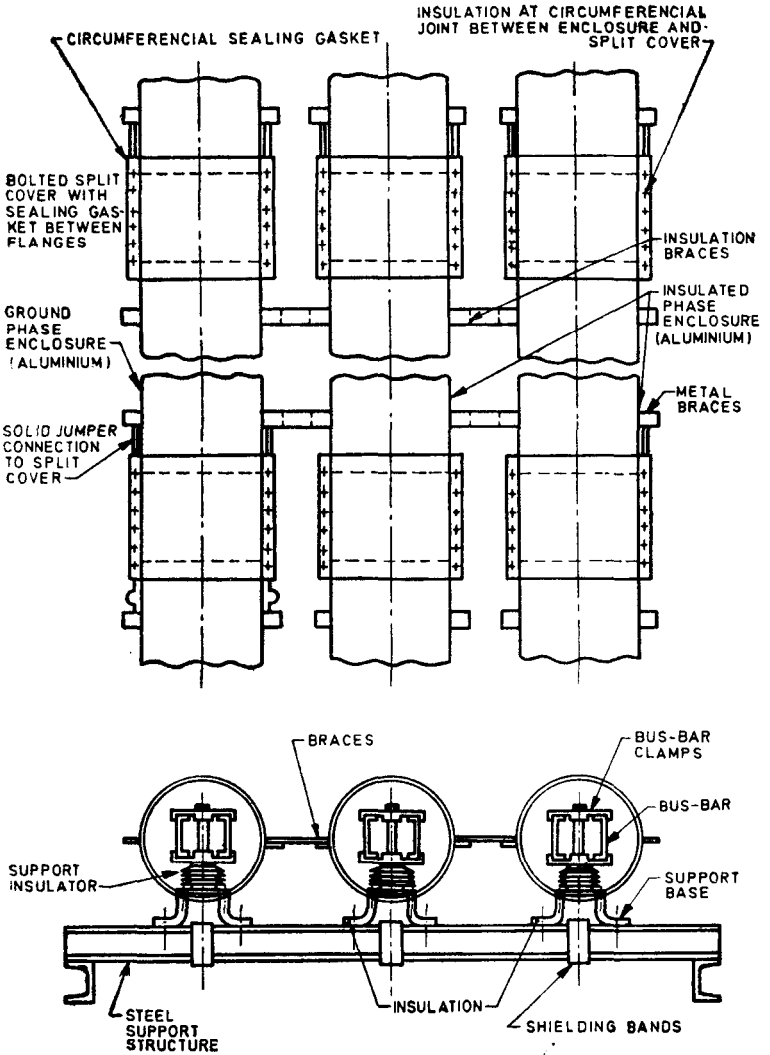


FIG. 3 TYPICAL DISCONTINUOUS TYPE ISOLATED PHASE BUS DUCT

in joints between copper and aluminium conductors for prevention of electrolytic action, either by exclusion of moisture or use of suitable bimetallic connector or its equivalent.

5.5 Enclosure

5.5.1 *Enclosure Material* — The material for enclosure of isolated types of bus-bar shall be non-magnetic.

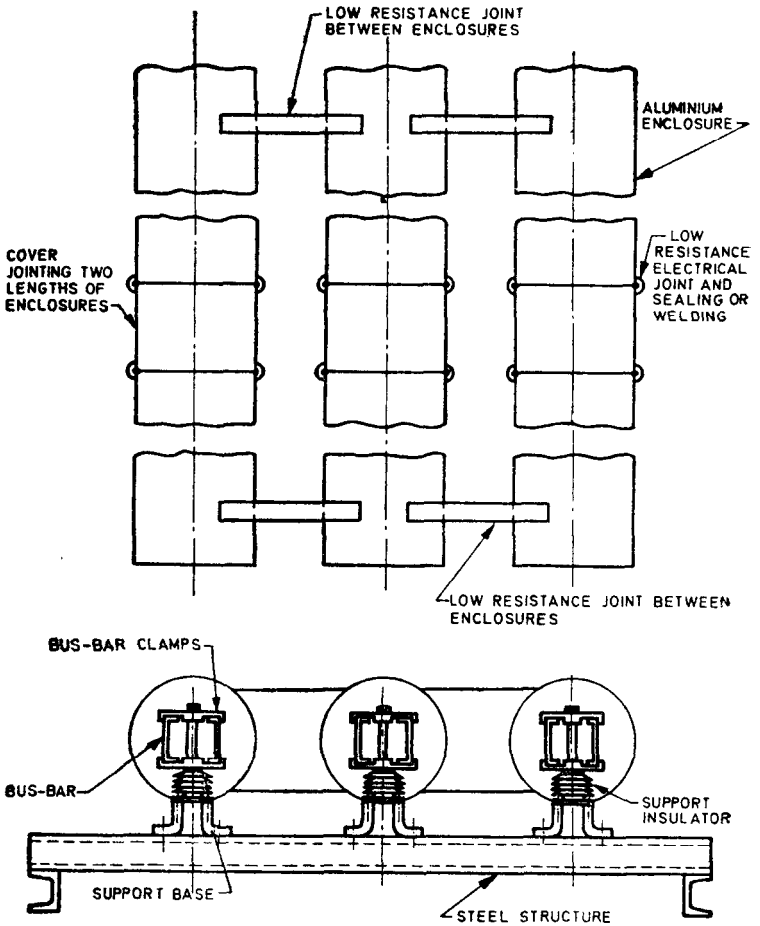


FIG. 4 TYPICAL ARRANGEMENT OF CONTINUOUS TYPE OF ISOLATED PHASE BUS DUCT

5.5.2 *Construction* — The enclosure for voltages more than 1 000 V are under consideration; till such time the purchasers may select one of the degrees of protection given in IS : 2147-1962*.

5.6 Thermal Expansion — Provision shall be made, where necessary, to allow for longitudinal expansion and contraction of bus-bars and bus enclosures, caused by temperature variation.

5.7 Grounding of Isolated Phase Bus Duct — A continuous ground conductor shall be provided in parallel with the isolated phase bus to ensure that all enclosures are grounded. The ground bus may take the form of a separate bar or wire (copper or aluminium), it may be the enclosure itself, or it may be the supporting structure, if a continuous electrical path can be provided suitable for the same rated short time current as the main bus conductors.

5.7.1 The ground conductor shall preferably be connected to the station ground at one point only, although more connection points are satisfactory if induced current loops have been avoided. Induced voltages across insulated joints in the housing should be kept as low as possible and preferably below two volts during rated current operations.

5.8 Supporting Structure

5.8.1 The supporting structure for the bus duct shall be strong enough to cater for the various static and dynamic loadings, such as weight of the bus duct, short circuit forces, wind load, seismic forces, etc.

NOTE — For high current installations like isolated phase bus ducts, considerations shall be given to the problem of induced magnetic heating and circulating current in the structure. Suitable insulated gaps in the steel work to eliminate closed loops and short-circuiting band around the steel members aid in solving the problem. This problem is prominent in discontinuous type designs and the necessity of incorporating short-circuiting bands is recommended beyond 6 000 amperes ratings.

5.9 Ventilation — The bus ducts shall be normally natural cooled. Forced cooling may be considered beyond 10 000 amperes ratings.

5.9.1 For enclosed bus-bars, provision shall be made to prevent accumulation of condensation of moisture. This may be done by providing heaters, dry air circulation, pressurization, ventilation through breathers or filtered drains where necessary. When filtered drains are provided they should be provided at the low point in vertical sections to prevent accumulation of condensation.

5.10 Terminations — For terminating the bus conductors at the generator and transformer terminals suitable flexible connections made of braids or multiple laminations shall be used. Termination at generator may require seal off bushings or baffles with provision for escape to atmosphere of hydrogen from possible leaks in or around the generator bushing.

*Degrees of protection provided by enclosures for low-voltage switchgear and controlgear.

5.11 When specified by the purchaser the bus-bars may be provided with isolating shorting links. If so provided, they should be located at easily accessible position.

5.12 Secondary Wiring — Secondary control devices and their wiring shall be isolated by suitable barriers from all primary circuit elements with the exceptions of short lengths of wire at instrument transformer terminals.

6. MARKING

6.1 Each bus-bar or bus duct shall be provided with a name plate or plates carrying the following data, marked in a durable manner and located in a place such that it is visible and legible when the bus-bar is installed :

a) Reference to this standard, Ref IS : 8084;
b) Manufacturer's name or trade-mark;
c) Type designation or serial number;
d) Rated voltage;
e) Rated frequency;
f) Rated current;
g) Rated short time current;
h) Number of phases; and
j) Country of origin.

6.1.1 Bus-bars may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

7. TESTS

7.0 Classification of Tests

7.0.1 *Type Tests* — The following shall constitute type tests :

a) Impulse voltage test (*see* **7.1.1**),
b) Temperature-rise test (*see* **7.1.2**),
c) Short time current test (*see* **7.1.3**), and
d) Power frequency voltage withstand test (*see* **7.1.4**).

7.0.2 *Routine Test* — The following shall constitute routine test :

Power frequency voltage withstand test (*see* **7.2.1**).

7.0.3 *Site Test* — The following site tests shall be carried out after installation of bus-bar at site :

a) Power frequency voltage withstand test (*see* **7.3.1**), and

b) Insulation resistance test for enclosure circuit (*see* **7.3.2**).

7.1 Type Tests

7.1.0 *General* — Because of the variety of types, ratings and possible combinations, it is impracticable to do type test on all arrangements of bus-bars. The performance of any arrangement may be substantiated by test data and experience on comparable arrangements and such data shall be considered as evidence of compliance with the requirements of this standard. In the absence of the test data the purchaser may require the type test to be made but should in such case specify this in his enquiry or order.

7.1.1 *Impulse Voltage Test*

7.1.1.1 The bus-bar shall be subjected to impulse voltage dry tests with 1·2/50 microsecond impulses in accordance with IS : 2070-1962* and the appropriate test voltage specified in Table 1.

7.1.1.2 The shape of the test voltage applied shall be that of the standard impulse wave in accordance with the definition accuracy in IS : 2070-1962*.

7.1.1.3 During the test, the earthed terminal of the impulse generator shall be connected to the frame of the bus-bar.

7.1.1.4 Five consecutive impulse voltage waves shall be applied. If a flashover or puncture does not occur, the bus-bar shall be considered to have passed the test. If puncture occurs, or if two or more flashovers occur, the bus-bar shall be considered to have failed the test. If only one flashover takes place, 10 additional impulses shall be applied and only if flashover or puncture does not occur on any of these additional applications the bus-bar shall be considered to have passed the test successfully.

7.1.1.5 The bus-bar shall be capable of passing the specified tests with voltages of both positive and negative polarity. However, when it is evident which polarity will give the lower break down voltage, it shall suffice to test with that polarity.

7.1.1.6 The peak value and the wave-shape of the test voltage shall be recorded for all tests by means of a cathode-ray oscillograph with a calibrated voltage divider.

7.1.2 *Temperature-Rise Test*

7.1.2.1 The test shall be made with the specified nature of supply (ac or dc) and if ac at a frequency of 40 to 60 Hz.

*Method of impulse voltage testing.

7.1.2.2 The bus-bar shall be mounted approximately as under usual service conditions and shall be protected against undue external heating or cooling. Temporary connections to the bus-bar shall be such that no appreciable amount of heat is conducted away from, or conveyed to the bus-bar during the test. In case of doubt, the temperature-rise at the terminals of the main circuits, and at the temporary connections at a distance of one metre from the terminals shall be measured. The difference of temperature shall not exceed 5°C.

7.1.2.3 The test shall be made over a period of time sufficient for the temperature-rise to reach a constant value. (This condition is obtained for practical purposes when the variation does not exceed 1°C per hour).

7.1.2.4 The recommended methods of measurement of temperature and precautions to be observed while carrying on the temperature-rise measurement are given in Appendix C.

7.1.2.5 At the end of the tests, the temperature-rise of the different parts of the main circuit shall not exceed the values specified in Table 2.

7.1.3 *Short Time Current Test*

7.1.3.1 The tests shall be made as necessary to determine the thermal and mechanical adequacy of buses and connections. Short time tests of metal enclosed bus shall be made with a three-phase section having a minimum length of 5 m. The power supply may be three-phase or single-phase. If three-phase, these conductors shall be connected together at one end, while the other ends are connected to the power source. If single-phase power is used, the circuit shall be arranged so that current flow is through two adjacent phase conductors. The force due to a three-phase fault is approximately 86·6 percent of that due to a single-phase fault for the same current. Therefore, for single-phase testing, the current shall be 7·0 percent below the current for three-phase testing.

7.1.3.2 The test may be done at any suitable voltage with bus-bars at any convenient temperature. The short time current shall be applied for one second and its rms value shall be determined from the oscillogram as indicated in Appendix D. The highest peak value of the major current loop during the first cycle of test shall not be less than 2·55 times the rated short time current.

7.1.3.3 The short time current shall not produce any mechanical damage, permanent distortion or burning of part and shall not cause a temperature-rise that added to maximum temperature attained at the rated current would damage the insulation of current carrying parts.

7.1.3.4 After the test, the bus-bars shall be in a condition to comply with their ratings as specified in **3** when they are again at the ambient temperature.

7.1.4 *Power Frequency Voltage Withstand Test*

7.1.4.1 Where practicable, power frequency voltage test shall be applied to bus-bars and bus-bar connections completely assembled with all joints as in service or where the insulation of joints between bus-bars may be completed only after erection on site, to individual sections of bus-bars with suitable temporary insulation applied to exposed connections. The rms test voltage shall be as given in Table 1.

7.1.4.2 The test voltage shall be applied between each phase and earth in turn with the remaining phases earthed.

The test voltage shall be alternating, of any frequency between 25 Hz and 100 Hz and approximately of sine-wave form.

7.1.4.3 The voltage shall be increased from its initial value as rapidly as is consistent with its value being indicated by the measuring instrument. The full test voltage shall then be maintained for one minute. During the test, one pole of the testing transformer shall be connected to earth and to the frame of the bus-bar enclosure.

7.1.4.4 When the insulation is entirely of porcelain, a test at ordinary temperature shall be regarded as equivalent to one at the maximum temperature that may be reached in service, but if the insulation includes materials other than porcelain the test may be made at ordinary temperature provided that the manufacturer satisfies the purchaser by means of a type test that representative individual sections of the insulation will withstand the test voltage at the maximum temperature that may be reached in service.

7.2 Routine Test

7.2.1 *Power Frequency Voltage Withstand Test* — This test shall be carried out at the manufacturers' premises on various forms of representative sections. This test shall be carried out in accordance with **7.1.4**.

7.3 Site Test

7.3.1 *Power Frequency Voltage Withstand Test* — For those bus-bars which are assembled at site the voltage test should be done as agreed between the manufacturer and the purchaser.

7.3.2 *Insulation Resistance Test for Enclosure Circuit* — This test is applicable to discontinuous type of isolated phase bus duct only, where insulation is provided in the enclosure circuit. This shall be done by a 1 000 V megger.

8. INFORMATION TO BE SUPPLIED TO THE MANUFACTURER WITH ENQUIRY

8.1 The information regarding particulars given in Appendix E shall be provided by the purchaser, if required by the supplier.

APPENDIX A

[*Clauses* 1.4 *and* C.1.1(e)]

SERVICE CONDITIONS

A-0. This standard applies to bus-bars which are designed to be used under the following conditions.

A-1. TEMPERATURE

A-1.1 Ambient temperatures are as follows :

a) Maximum ambient temperature 45°C,

b) Maximum daily average ambient air temperature 35°C, and

c) Maximum yearly average ambient air temperature 30°C.

A-2. ALTITUDE

A-2.1 The altitude of the site of installation does not exceed 2 000 m.

NOTE — For installations at higher altitudes, it is necessary to take into account the reduction of the dielectric strength and of the cooling effect of the air. Bus-bars and their enclosures so used shall be designed or used according to an agreement between manufacturer and user. Information given in the manufacturer's catalogue may constitute such an agreement.

A-3. ATMOSPHERIC CONDITIONS

A-3.1 Atmosphere which is not heavily polluted.

A-3.2 Atmospheric climate not conducive to the growth of fungi and condensation of moisture.

A-4. CONDITION OF INSTALLATION

A-4.1 The bus-bars and their enclosures shall be installed in accordance with the manufacturer's instructions.

APPENDIX B

(*Clause* 5.4.1)

CONDUCTOR JOINTS

B-1. JOINTING PRACTICE FOR ALUMINIUM TO ALUMINIUM AND ALUMINIUM TO COPPER CONNECTION

B-1.1 Contact Pressure — Sufficient contact pressure should be maintained to ensure low contact resistance, but not so great as to cause relaxation of the joint by cold flow. The design of the joint should be such that the pressure is maintained within this range under all conditions of service. To avoid excessive local pressure the contact pressure should be evenly distributed by the use of pressure plates or washers of adequate area and thickness.

B-2. REMOVING THE OXIDE FILM

B-2.1 Satisfactory methods of removing the oxide film include draw filing, light machining or very vigorous scratch brushing under neutral grease. The scratch brushes should not have been previously used on other metals.

B-2.2 Special jointing compounds that fulfil the same purpose and eliminate the need for any abrasive action are also available.

B-2.3 One of the procedures of **B-2.1** and **B-2.2** should always be applied when a joint is reassembled after being broken down.

B-3. JOINTS

B-3.1 Excellent permanent connections in aluminium bars may be made by fusion welding. Inert gas metal or tungsten arc welding processes are recommended.

B-3.2 Aluminium-copper connections are designed on the same principles as aluminium connections and surface preparation is the same. The copper surface may be tinned if desired.

B-3.3 Bimetallic joints located outdoors, particularly in industrial or marine locations, should be protected from the effects of electrolytic action.

APPENDIX C

(*Clause* 7.1.2.4)

TEMPERATURE-RISE MEASUREMENTS

C-1. GENERAL

C-1.1 While assessing the temperature-rise of bus-bar the following factors will be considered :

a) Allowance for temperature coefficient of resistance,
b) Skin effect ratio,
c) Proximity effect ratio,
d) Effect of the presence of enclosure, and
e) Service conditions (*see* Appendix A).

C-1.2 The following methods of measuring temperature are recognized :

a) Thermometer method, and
b) Thermocouple method.

C-1.3 In order that the measurement of temperature may produce consistent results, certain precautions should be observed. These are specified in **C-2** to **C-3**.

C-2. THERMOMETER METHOD

C-2.1 The thermometer may be bulb thermometer containing mercury or alcohol or resistance thermometer.

C-2.2 When bulb thermometers are used in places where there is any varying or moving magnetic field, those containing alcohol should be employed in preference to those containing mercury.

C-2.3 When a bulb thermometer is used to measure the temperature of a surface of a conductor, the bulb should be surrounded by a single wrapping of tin foil of thickness not less than 0·025 mm. The foil shall be turned up at the end to form complete covering for the bulb and shall then be secured in contact with the surface under test. The exposed part of the wrapped bulb shall be completely covered with a pad of insulating material without unduly shielding the test surface from normal cooling.

C-3. THERMOCOUPLE METHOD

C-3.1 The two conductors between which the thermoelectric effect is produced shall be soldered or welded at both the hot and cold junctions.

C-3.2 When applied to the surface of live conductors, the hot junction is

covered with insulation and shall be wrapped with tin-foil as described for bulb thermometers. The thermocouple circuit should be earthed to minimize the possibility of capacitive currents.

C-3.3 The protecting pad of heat insulating material specified in **C-2.3** shall be employed whether junction is insulated or not.

C-3.4 The cold junction shall be immersed in oil preferably contained in a vacuum flask, the temperature of which is measured by a thermometer.

C-4. MEASUREMENT OF AMBIENT TEMPERATURE

C-4.1 The temperature of surrounding air shall be measured by means of at least two thermometers so placed as to take account of the maximum and minimum ambient temperature and mean reading shall be used for calculations. Each thermometer shall be immersed in oil contained in a bottle of about half litre capacity completely filled.

APPENDIX D

(*Clause* 7.1.3.2)

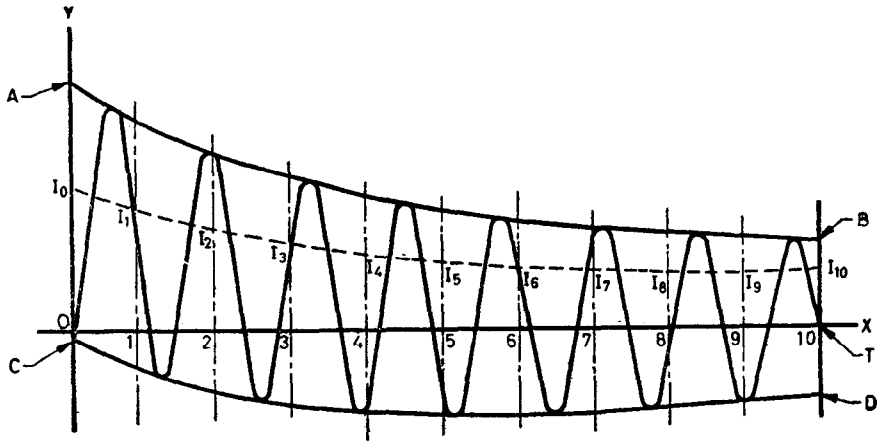
DETERMINATION OF THE EQUIVALENT rms VALUE OF A SHORT-TIME CURRENT DURING A SHORT CIRCUIT OF A GIVEN DURATION

D-1. The oscillogram in Fig. 5 indicates by way of example the current that has passed through the bus-bar during a short circuit. The rms value of the current during the time interval 0 to T of such a wave is given by the formula:

$$I_{\text{rms}} = \sqrt{\frac{1}{T}\int_0^T i^2 \, \text{dt}}$$

where T is the duration of the current in seconds, and i is the instantaneous value of the current expressed in amperes.

D-2. The times in Fig. 5 are indicated as abscissae on the axis OX, and the current values as ordinates on the axis OY, the origin O of the co-ordinates representing the beginning of the short circuit and OT its duration.



OT = Duration of short circuit

$\left.\begin{matrix} AB \\ CD \end{matrix}\right\}$ = Envelope of current-wave

I_0, I_1, I_2, etc = rms value of asymmetrical current at each instant

FIG. 5 DETERMINATION OF EQUIVALENT rms VALUE OF A SHORT TIME CURRENT

D-3. The equivalent rms value of the current is determined as follows:

Let the time interval OT be divided into ten equal parts and determine for the instants 0, 1, 2, 3, etc, 9, 10 the rms values I_0, I_1, I_2, etc, I_9, I_{10}, of the asymmetrical current from the formula:

$$I_{asym} = \sqrt{(I_{sym})^2 + (I_{DC})^2}$$

where

I_{sym} = the rms value of ac component of the current at the instant under consideration, and

I_{DC} = the value of the dc component of the current at the same instant.

The equivalent rms value of the current during the time of short circuit, $I_{average}$, is given with sufficient accuracy by the Simpson formula:

$$I_{average} = \sqrt{\frac{1}{30}\left[I_0^2+4\left(I_1^2+I_3^2+I_5^2+I_7^2+I_9^2\right)+2\left(I_2^2+I_4^2+I_6^2+I_8^2\right)+I_{10}^2\right]}$$

APPENDIX E

(*Clause* 8.1)

INFORMATION REQUIRED WITH ENQUIRY AND ORDER

E-1. The purchaser shall supply the following information along with the description and drawings, while making an enquiry:

a) *Type of Bus-Bar* — It shall be specified whether the bus-bars are:
   1) Open type,
   2) Non-segregated type with steel/aluminium trunking,
   3) Segregated with steel/aluminium, and
   4) Isolated phase type.

b) *Rating of Bus-Bars and Tee Offs* — The enquiry shall specify the following:
   1) Number of phases,
   2) Rated voltage,
   3) Rated current,
   4) Rated frequency, and
   5) Rated short time current.

c) *Service Conditions* — The enquiry shall specify the following:
   1) Reference ambient temperature;
   2) Altitude of site;
   3) System earthing;
   4) Whether the bus-bars are electrically exposed or non-exposed; and
   5) Other special conditions if any, such as exposure to corrosive, fumes, gas, etc.

d) *Tests* — Any special type tests required to be conducted for the bus-bars shall be specified.

e) *Installation Details* — The enquiry shall specify the following:
   1) The layout of equipment,
   2) Termination details of all the equipment to be connected,
   3) Details of current transformers and Potential transformers,
   4) Earthing equipment associated with bus-bars,
   5) The details of civil construction for supporting the bus-bars, and
   6) Requirements for sealing at various points of bus run.

f) *Special Requirement, if Any*

NOTE — For the execution of job, after placement of order, the exact and final details required under (d) shall be made available by the purchaser.

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AMENDMENT NO. 1 JANUARY 1979

TO

IS : 8084-1976 SPECIFICATION FOR INTERCONNECTING BUS-BARS FOR AC VOLTAGE ABOVE 1 kV UP TO AND INCLUDING 36 kV

Alteration

(*Page* 6, *Table* 2) — Substitute the following for the existing table:

TABLE 2 TEMPERATURE-RISE LIMIT

(*Clauses* 4.1 *and* 7.1.2.5)

DESCRIPTION OF PARTS	TEMPERATURE-RISE OVER REFERENCE AMBIENT TEMPERATURE OF 40°C
Bus-bars and conductors of copper and aluminium	*
Accessible external enclosures and covers:	
Metal surfaces	30°C†
Insulating surfaces	40°C

*Limited by:

a) mechanical strength of conducting material,

b) possible effect on adjacent equipment,

c) permissible temperature limit of the insulating materials in contact with the conductor, and

d) the effect of the temperature of the conductor on the apparatus connected to it.

†Unless otherwise specified in the case of covers and enclosures which are accessible but need not be touched during normal operation, temperature-rise limits, increased by 10°C are permissible.

(ETDC 58)

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AMENDMENT NO. 2 SEPTEMBER 1979
TO
IS : 8084 - 1976 SPECIFICATION FOR INTERCONNECTING BUS-BARS FOR AC VOLTAGE ABOVE 1 kV UP TO AND INCLUDING 36 kV

Alterations

(*Page* 11, *clause* **5.8.1**, *Note*, *line* 6) — Substitute '4 500 amperes' *for* '6 000 amperes'.

(*Pages* 13 *and* 14, *clauses* **7.1.2** *to* **7.1.2.5**) — Substitute the following for the existing clause:

'**7.1.2** *Temperature-Rise Test*

7.1.2.1 The test shall be made with the specified nature of supply (ac or dc) and if ac at a frequency of 40 to 60 Hz.

7.1.2.2 The test assembly shall be 3 phase unit or 1 phase unit, as applicable, having a minimum length of 5 m. It shall have at least 1 joint (conductor and enclosure) per phase, bolted, clamped or welded. Supply leads shall be of proper size to prevent heat interchange. Ends of the bus shall be sealed.

Test current shall flow through all phases, the current in each phase within 2 percent of the specific test current value. The test current shall be applied continuously until the temperature of all the bus bar parts and supports are substantially constant (three successive readings at not less than 30 minutes intervals shall show a maximum variation of ± 1°C in hottest spot temperature).

The test shall be conducted in a room reasonably free of drought. The bus arrangement shall be around 60 cm from the floor.

7.1.2.3 The recommended methods of measurement of temperature and precautions to be observed while carrying on the temperature-rise measurement are given in Appendix C.

7.1.2.4 At the end of the tests, the temperature-rise of the different parts of the main circuit shall not exceed the values specified in Table 2.'

(ETDC 58)

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AMENDMENT NO. 3 MARCH 1981

TO

IS : 8084-1976 SPECIFICATION FOR INTERCONNECTING BUS-BARS FOR AC VOLTAGE ABOVE 1 kV UP TO AND INCLUDING 36 kV

Alterations

(*Page* 5, *clause* **3.6**, *last sentence*) — Substitute the following for the existing sentence:

'The standard duration of short-time current shall be one second (*see also* Appendix F). '

(*Page* 6, *Table* 1) — Substitute the following for the existing table:

TABLE 1 RATED INSULATION LEVEL (FOR RATED VOLTAGES ABOVE 1 kV)

(*Clauses* 3.2, 3.3, 7.1.4.1 *and* F-2)

Rated Voltage (Highest System Voltage)	Standard Impulse Withstand Voltage	One Minute Power Frequency Withstand Voltage	
		Switchgear and Similar Equipment	Bus-Ducts Used for Generator Transformer Connections
(1)	(2)	(3)	(4)
kV (rms)	kV (peak)	kV (rms)	kV (rms)
3·6	40	10	21
7·2	60	20	27
12·0	75	28	35
24·0	125	50	55
36·0	170	70	75

Note 1 — The values given in this table are based on an ambient temperature of 20°C, pressure of 760 mm Hg at 0°C and humidity of 11 g of water per cubic metre. The values corresponding to the Indian Standard reference temperature of 27°C when available, will replace above values.

Note 2 — A standard impulse wave is one with wavefront of 1·2 microseconds and a time of half value of wave tail of 50 microseconds.

Note 3 — For the purpose of site tests 80 percent of the voltage withstand values specified above may be used, the test voltage being power frequency ac for 1 minute or dc for 15 minutes.

[*Page* 6, *Table* 2 (*see also* Amendment No. 1)] — Substitute the following for the existing table:

TABLE 2 TEMPERATURE-RISE LIMIT

(*Clauses* 4.1 *and* 7.1.2.5)

Sl No.	Description of Parts of Busducts	Temperature Rise Over Reference Ambient Temperature of 40°C
1)	(2)	(3)
i)	Busbars and conductors of copper or aluminium:	
	a) Bolted joints (plain or tinned)*	50°C
	b) Bolted joints (silver plated)†	65°C
	c) Aluminium welded joints	65°C
ii)	Enclosure and covers:	
	a) Accessible surface	30°C‡
	b) Inaccessible surface	50°C
ii)	Termination of busbars	As for conductors of busbars§

Note — For busbars in contact with insulating materials, the temperature rise shall be governed by the maximum permissible temperature for the class of insulation.

*For high current copper busbar joints in air, tinning or silver plating is recommended. For bolted aluminium busbar joints suitable jointing compounds are to be essentially used.

†For silver plated joints, the use of suitable jointing compound is essential to prevent galvanic corrosion and deterioration of joint in the presence of moisture.

‡Unless otherwise specified in the case of covers and enclosures which are accessible, but need not be touched during normal operation, temperature rise limits, increased by 10°C are permissible.

§The temperature rise limits for cable terminations shall be governed by the cable design.

Addenda

(*Page* 4, *clause* **1.4**) — Add the following new clause after **1.4**:

'**1.5** Additional guidelines for busbars used in interconnecting generator units to main step-up transformer in the power stations, are provided in Appendix F.'

(*Page* 5, *clause* **3.3**) — Add the following new matter at the end of the clause:

' (*see also* Appendix F).'

(*Page* 5, *clause* **3.4**) — Add the following new clause after **3.4**:

'**3.4.1** For installations where the above ratings may not be economical, other ratings of busbars based on actual capacity of source may be mutually agreed to between purchaser and manufacturer. In order to account for variations in voltage, power factor etc, a total overload factor of 10 percent of rated nominal current of source may be prescribed to arrive at the rated current of busbars. '

(*Page* 8, *clause* **5.3.2**) — Add the following new note after **5.3.2**:

'NOTE — For selection of type of busduct, *see* Appendix F. '

(*Page* 11, *clause* **5.5.2**) — Add the following new matter at the end of the clause:

'(*see also* Appendix F).'

(*Page* 11, *clause* **5.8.1**) — Add the following new matter at the end of the clause:

'(*see also* Appendix F). '

(*Page* 13, *clause* **7.0.3**) — Add the following new clause after **7.0.3**:

'**7.0.4** Tests to verify degree of protection provided by enclosures are given in Appendix F. '

(*Page* 21, *Appendix* E) — Add the following new Appendix after Appendix E:

'APPENDIX F

(*Clauses* 1.5, 3.3, 3.6, 5.3.2, 5.5.2, 5.8.1 *and* 7.0.4)

ADDITIONAL GUIDELINES FOR BUSBARS USED IN POWER STATIONS FOR INTERCONNECTION OF GENERATOR UNITS AND MAIN STEP-UP TRANSFORMER

F-0. The additional guidelines are given below in order to achieve standardization of the above busducts.

F-1. RATED SHORT TIME CURRENT

F-1.1 Separate fault level values shall be specified for the main and tap-off busducts.

NOTE — Faults on the main bus is fed on one side from generator and on the other side from grid. Any section of main bus will carry current from any one side at a time. For faults on tap-offs, the current from both sides add up in the tap-off portion. Hence fault current for main bus is invariably less than that of tap-off bus.

F-2. PREFERRED RATED INSULATED LEVEL

F-2.1 The rated insulation level shall be selected from Table 1.

F-3. SELECTION OF TYPE OF BUSDUCT

F-3.1 In order to limit heating of near-by steel structure and reinforcements, for ratings of 8 000 amperes and above continuous type isolated phase busduct designs may be preferred.

F-4. DEGREE OF PROTECTION

F-4.0 The enclosure of busduct shall meet the following requirements of water and air tightness tests.

F-4.1 Water Tightness Test — The enclosure of busduct shall prevent the entrance of power when a stream from 25 mm diameter hose under head of 11 metres (under flow condition) and with the nozzle 3 metres from the equipment, is directed downward on it over the full length at an angle of at least 45 degrees from the horizontal. The test shall be made for five minutes.

F-4.2 Air Tightness Test — When busduct is completely assembled in accordance with manufacturers direction it may be checked for air tightness by filling with air to a pressure of 150 mm of water. After the air supply is shut off the pressure drop shall not be more than 75 mm of water in 15 seconds. Any breather or drain valve hole shall be sealed before the test. '

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