BRITISH STANDARD

BS 159:1992

Specification for

# High-voltage busbars and busbar connections

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Policy Committee (PEL/-) to Technical Committee PEL/92, upon which the following bodies were represented:

ASTA Certification Services

Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)

British Railways Board

Copper Development Association

Department of the Environment (Property Services Agency)

ERA Technology Ltd.

Electricity Industry in United Kingdom

GAMBICA (BEAMA Ltd.)

Health and Safety Executive

Transmission and Distribution Association (BEAMA Limited)



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# Content

# Foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee. This standard takes into account current British and International Standards and supersedes BS 159:1957 which is withdrawn.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

**Summary of pages**

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

## 1 Scope

This British Standard specifies requirements for both enclosed and open busbars and busbar connections which are components of a.c. high-voltage electrical systems (above 1 kV) and are composed of metal such as copper or aluminium, with air, oil, gas, solid or semi-solid materials as principal insulation.

This British Standard can apply, for aspects other than frequency, to high voltage d.c. busbars and busbar connections (above 1.5 kV) which have similar characteristics to those for a.c.

Insulators such as bushings and supports can comprise part of the assembly, and detailed requirements for such insulators are specified in BS 223.

For degrees of protection for enclosures, reference should be made to BS 5490

The busbars in this standard can also form a component of metal enclosed switchgear (see BS 5227 and BS 5524).

This British Standard does not apply to:

- insulated cables which can form a part of busbars and busbar connections;
- low-voltage busbars which are specified in BS 5486-1.

For the purpose of this standard the requirements for the ratings and type tests of BS 6581 for switchgear and controlgear are considered to apply to both busbars and busbar connections.

In addition to the definitive requirements, this British Standard also requires the items detailed in clause **9** to be documented. For compliance with this British Standard, both the definitive requirements and the documented items have to be satisfied.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

## 2 Definitions

For the purposes of this British Standard the following definitions apply.

**2.1**
**busbar**

a conductor with associated connections, joints and insulated supports forming a common electrical connection between a number of circuits or individual pieces of apparatus

**2.2**
**busbar connection**

a conductor that forms the electrical connection between a busbar and an individual piece of apparatus that is within reasonable proximity

**2.3**
**open busbar**

a busbar that is not provided with a protective cover

**2.4**
**enclosed busbar**

a busbar that is contained in a duct or casing of any material. When the material is metal the term metal-enclosed is used

**2.5**
**outdoor busbar**

an open busbar or enclosed busbar suitable for installation in the open-air, i.e. capable of withstanding wind, rain, snow, dirt deposits, condensation, ice and hoar frost

**2.6**
**indoor busbar**

an open busbar or an enclosed busbar designed solely for installation within a building or other housing, where the busbar is protected against wind, rain, snow, abnormal dirt deposits, abnormal condensation, ice and hoar frost

**2.7**
**air-insulated busbar**

a busbar which, except at points of support, is designed with air as the principal dielectric. It can be covered with insulation material

**2.8**
**gas-insulated busbar**

an enclosed busbar in which the insulation is achieved by insulating gas other than atmospheric air

**2.9**
**oil-immersed busbar**

an enclosed busbar that is totally immersed in an insulating oil

**2.10**
**compound-immersed busbar**

an enclosed busbar that is totally immersed in a solid or semi-solid insulating compound

**2.11**
**bushing type busbar**

an enclosed busbar which may consist of one or several jointed sections of tubular or solid conductor, the sections being covered with solid insulation with an external earthed sheath. The joint between sections can be air insulated, or immersed in oil or insulating compound. The solid insulation of the sections can include coaxial conducting layers for the control of internal or external electrical stresses (see BS 223)

**2.12**
**isolated-phase enclosed busbar**

a metal-enclosed busbar in which each phase conductor is enclosed by an individual metal housing separated from adjacent conductor housings by an air space

**2.13**
**non-segregated phase enclosed busbar**

an enclosed busbar in which all phase conductors are in a common enclosure without metal partitions between the phases. Where phase conductors are protected against electrical failure mainly by solid insulation the additional term, phase insulated, can be used. Where phase conductors are protected mainly by solid insulation and additionally by earthed metal interposed between them in such a manner that disruptive discharges cannot occur between them then the additional term, phase separated, can be used

**2.14**
**segregated phase enclosed busbar**

an enclosed busbar in which all phase conductors are in a common enclosure with earthed metal interposed between them in such a manner that disruptive discharges can only occur to earth

**2.15**
**rated value**

a quantity value assigned, generally by a manufacturer, for a specified operating condition of busbars

NOTE See clause **4** for individual rated values.

## 3 Service conditions

The normal and special conditions referred to in clause **2** of BS 6581:1985 shall apply.

## 4 Rating

### 4.1 General

The common ratings a) to g) in clause **4** of BS 6581:1985 shall apply to a.c. equipment.

NOTE Ratings for d.c. equipment are subject to agreement between manufacturer and purchaser, see **9.3** a).

### 4.2 Rated voltage

The requirements in **4.1** of BS 6581:1985 shall apply.

### 4.3 Rated insulation level

The requirements in **4.2** of BS 6581:1985 shall apply, with the exception of columns 3, 5 and 7 of Table I; columns 3 and 5 of Table III and columns 3, 5, 6 and 8 of Table IV.

### 4.4 Rated frequency

The requirements in **4.3** of BS 6581:1985 shall apply.

### 4.5 Rated normal current and temperature rise

The requirement in **4.4** of BS 6581:1985 shall apply with the following addition.

The temperature rise of terminals shall be considered in conjuction with the connected apparatus.

### 4.6 Rated short-time withstand current

The requirements in **4.5** of BS 6581:1985 shall apply with the following addition.

Where busbars and busbar connections are directly associated with a circuit-breaker or switch, the value and the duration of the rated short-time withstand current of the busbars and busbar connections shall be either not less than the corresponding rating of the equipment to which it is connected or as stated by the manufacturer.

NOTE It is to be recognized that in some instances, e.g. generator circuits, the value and duration of the short time current in any tee-offs to main connections can be in excess of the ratings assigned to connected equipment owing to fault infeeds from more than one source.

### 4.7 Rated peak withstand current

The requirements in **4.6** of BS 6581:1985 shall apply.

### 4.8 Rated duration of short-circuit

The requirements in **4.7** of BS 6581:1985 shall apply.

## 5 Design and construction

NOTE Certain clearances are given in Table 1, see **5.3**. Certain creepage distances are given in Table 2, see **5.5.2**. Test voltages for tests after erection on site are given in Table 3 and Table 4, see **7.2**.

### 5.1 Conductors

Conductors with suitable material for busbars and busbar connections shall be as specified in BS 2898 for aluminium and BS 1433, BS 1977, BS 4109, BS 4608 and BS 6926 for copper.

### 5.2 Clearances for air-insulated busbars and busbar connections

For clearances to earth ascribed to insulation structures which have not been type tested, unless otherwise required by legislation one of the following shall apply:

a) BS 5622-2;

b) as agreed at the time of enquiry and/or order, see **9.3** b).

NOTE 1 Column 2 of Table 5 in Appendix A lists the basic electrical clearances used in the UK which incorporate the practice of increasing the clearance to 500 mm for all values of 33 kV [170 kV Basic Insulation Level (BIL)] and below.
NOTE 2 Column 3 of Table 6 in Appendix A lists basic electrical clearances used for international practice as given in BS 5622-2.
NOTE 3 Basic electrical clearances do not include any additions for constructional tolerances, effects of short-circuit, wind effects etc.
NOTE 4 Where Standard Insulation Level (SIL) is the determining overvoltage an additional clearance can be added to the BIL as a provision against the infrequent tendency for switching surge flashovers not to occur across the shortest gap, (anomalous flashover).

### 5.3 Clearances for oil-immersed and compound-immersed busbars and busbar connections

Clearances shall be measured as follows:

a) *For clearances to earth*. From the metallic surfaces of all the live parts to the nearest earthed metal.

b) *For clearances between phases*. From the metallic surfaces of all the live parts of each phase to the metallic surface of the adjacent phase.

Either clearances shall be not less than those given in Table 1 or conductors shall be covered with solid insulation, additional to the oil or compound, which is capable of withstanding the appropriate power-frequency test voltage specified in Table 1 of BS 6581:1985.

**Table 1 — Clearances for busbars and busbar connections immersed in oil or compound**

| 1 | 2 | 3 |
|---|---|---|
| **Rated voltage** | **Minimum clearance to earth** | **Minimum clearance between phases** |
| kV | mm | mm |
| 3.6 | 12.5 | 20.0 |
| 7.2 | 20.0 | 25.0 |
| 12 | 25.0 | 40.0 |
| 17.5 | 31.5 | 45.5 |
| 24 | 45.5 | 62.5 |
| 36 | 62.5 | 91.0 |

### 5.4 System earthing

The clearances specified in Table 1 and Table 5 and Table 6 (see Appendix A) shall apply to busbars and busbar connections for use on systems earthed as specified in conditions a) and b) below. For open outdoor type busbars and busbar connections for systems of 110 kV and above, and effectively earthed in accordance with condition a), the clearances specified in Table 5 and Table 6 can be used. Busbars for use on systems having other earthing conditions as specified in c) and d) below require special consideration (see clause **8**). System earthing condition e) relates to very large generator circuits where isolated phase metal-enclosed busbars are employed. Such conductor systems are subject to type testing to prove adequacy of insulation levels.

The following system earthing conditions are recognized.

a) At least one of the neutral points of a three-phase system permanently earthed, either solidly or through a resistor or reactor of low impedance.

A three-phase system is considered to be effectively earthed if, during phase-to-earth faults, the voltage to earth of the sound phases does not exceed 80 % of the voltage between lines of the system. Generally this involves solid earthing of all transformer neutrals.

b) At least one of the neutral points of a three-phase system earthed normally through an arc suppression coil.

c) All the neutral points of a three-phase system insulated from earth.

d) A single-phase system having one line earthed.

e) At least one of the neutral points of a three-phase system permanently earthed through a resistor or reactor of high impedance.

### 5.5 Creepage distances

#### 5.5.1 *Outdoor insulation*

For outdoor insulation clause **9** of BS 223:1985 shall apply.

#### 5.5.2 *Indoor insulation*

It is not practicable to specify the minimum creepage distances over insulating supports or separators for open or enclosed busbars in air. The minimum distance which is satisfactory for a given service voltage is affected by a large number of factors, notably by the degree of protection from dust and damp, the configuration of the parts and the nature of the insulating material.

While moderate distances may be satisfactory with dust deposits free from carbon or metal, in a dry state, considerably greater distances or altered configurations are needed if moisture is also present. With commonly used synthetic-resin bonded materials, the degree of resistance to surface tracking materially influences the minimum distance required. Resistance to tracking is in turn influenced by surface contamination and in laminated material by the direction of the voltage stress.

NOTE As minimum figures cannot be safely specified, the figures of Table 2 are given as guidance for those busbars where the insulation is of porcelain, or of synthetic resin resistant to tracking and adequately protected from dust and damp. The creepage figures should be increased by at least 50 % when applied to insulation between phases.

**Table 2 — Creepage distances to earth in air for open and enclosed busbars of indoor-type switchgear**

| Rated voltage | Minimum creepage distance in air |
|---|---|
| kV | mm |
| 3.6 | 50 |
| 7.2 | 90.0 |
| 12 | 125.0 |
| 17.5 | 150.0 |
| 24 | 200.0 |
| 36 | 300.0 |

### 5.6 Joints

To ensure that joints are sound and do not deteriorate in service they shall be chemically and mechanically stable, i.e. there shall be no electrolytic action at the interface. The joint faces shall be suitably prepared and then clamped together at an appropriate pressure. In service, the temperature rise of a joint shall not exceed that specified in **4.4.2** of BS 6581:1985.

Mechanical joints between copper conductors shall be made after appropriate treatment to joint faces which can be tinning or silver plating. Mechanical joints between aluminium conductors or aluminium and copper conductors shall have effective treatment for maintaining the conductivity of the joint (see Appendix B).

Provision shall be made in joints between copper and aluminium conductors for the prevention of electrolytic action which can take place between those two metals in contact in the presence of moisture, either by the exclusion of moisture or by the introduction of a suitable bi-metallic connector or its equivalent.

All soldered joints subject to appreciable mechanical stress or vibration shall have the parts mechanically secured together.

NOTE 1 Soldered joints should not be installed if the temperature is likely to exceed 150 °C under short-circuit conditions.

When provision is made for connecting a cable socket, the size of bolt shall be suitable for use with a cable socket in accordance with BS 91.

NOTE 2 It is essential that joints are properly made and protected where necessary to ensure that they remain efficient during their service life. Particular care should be exercised in preparing and making busbar joints on site, and it is especially desirable to check, before filling, those joints which are to be immersed in compound.

NOTE 3 No specific test is laid down but reference should be made to Appendix B, which deals with the checking of joints made on site, and with joint resistance measurement.

### 5.7 Mechanical strength

Busbars and busbar connections shall be so supported and proportioned as to be capable of safely withstanding stresses to which they may be subjected, including those due to short-circuit and service conditions.

Wind and ice loadings for open outdoor busbars shall be either as specified in **2.1.2** of BS 6581:1985 or as agreed at the time of enquiry and/or order, see **9.3** c).

### 5.8 Thermal expansion

Provision shall be made, where necessary, to allow for expansion and contraction of busbars and busbar connections, caused by temperature variations.

### 5.9 Marking of busbars and busbar connections

The marking of busbars and busbar connections for identification purposes by colour or an alphanumeric system shall be in accordance with BS 5559.

Conductors used for the purpose of making connection to earth shall be distinguished by green/yellow and the initial letter E.

NOTE Current UK practice is to employ the colours red, yellow and blue or the corresponding initial letters R, Y and B. Neutral conductors are distinguished by the colour black or by the initial letter N whether earthed or unearthed.

### 5.10 Arrangements of busbars and busbar connections

Busbars and busbar connections which are substantially in one plane shall be arranged in the sequence in which the phase voltages rise. Where the equipment of which they form a part has a clearly defined front or operating face the first phase, or red phase to UK practice, shall be positioned as follows.

a) When the run of the conductors is horizontal, the red shall be the top, or the left or farthest away as viewed from the front.

b) When the run of the conductors is vertical, the red shall be the left or farthest away as viewed from the front.

c) When the system has a neutral connection in the same plane as the phase connections, the neutral shall occupy an outer position.

Unless the neutral connection can be readily distinguished from the phase connections, the order shall be red, yellow, blue, black.

## 6 Type tests

### 6.1 General

NOTE Because of the variety of types, ratings and possible combinations, it is impracticable to type test all arrangements of busbars and busbar connections. The performance of any particular arrangement can be substantiated by test data and experience in service on comparable arrangements, and such data is considered as evidence of compliance with the requirements of the standard.

Records of type tests shall include drawings, photographs, oscillograms and other data that enables the manufacturer to satisfy the purchaser that an arrangement tested and the arrangement offered are comparable.

In the absence of such data it shall be specificed and agreed at the time of enquiry/order whether types tests are required, see **9.3** d).

Where the busbars and busbar connections are tested, any busbar connections not carrying the test current shall have the lowest rating assigned to the connections for use with that busbar arrangement.

The manufacturer shall be responsible for type tests, in accordance with **6.1** to **6.5.5**.

### 6.2 Dielectric tests

#### 6.2.1 *Ambient air conditions during tests*

The requirements in **6.1.1** of BS 6581:1985 shall apply.

#### 6.2.2 *Wet test procedure*

The requirements in **6.1.2** of BS 6581: shall apply.

#### 6.2.3 *Condition of apparatus during dielectric tests*

The requirements in **6.1.3** of BS 6581: shall apply.

#### 6.2.4 *Application of test voltage and test conditions*

The requirements in **6.1.4** of BS 6581:1985 shall apply, however in Tables VIII, IX and X, only the closed position is relevant.

#### 6.2.5 *Test voltages*

The requirements in **6.1.5** of BS 6581: shall apply.

#### 6.2.6 *Lightning and switching impulse voltage tests*

The requirements in **6.1.6** of BS 6581:1985 shall apply.

#### 6.2.7 *Power-frequency voltage withstand tests*

The requirements in **6.1.7** of BS 6581:1985 shall apply.

#### 6.2.8 *Artificial pollution tests*

The requirements in **6.1.8** of BS 6581:1985 shall apply.

#### 6.2.9 *Partial discharge tests*

The requirements in **6.1.9** of BS 6581:1985 shall apply.

### 6.3 Radio interference voltage (r.i.v.) test

The requirements in **6.2** of BS 6581:1985 shall apply.

### 6.4 Temperature-rise tests

#### 6.4.1 *Condition of the apparatus to be tested*

The requirements in **6.3.1** of BS 6581: shall apply.

#### 6.4.2 *Arrangement of equipment*

The requirements in **6.3.2** of BS 6581:1985 shall apply.

#### 6.4.3 *Measurement of the temperature and the temperature rise*

The requirements in **6.3.3** of BS 6581:1985 shall apply.

#### 6.4.4 *Ambient air temperature*

The requirements in **6.3.4** of BS 6581:1985 shall apply.

#### 6.4.5 *Interpretation of the temperature rise tests*

The requirements in **6.3.6** of BS 6581:1985 shall apply.

### 6.5 Measurement of the resistance of the main circuit

The requirements in **6.4** of BS 6581:1985 shall apply.

### 6.6 Short-time withstand current and peak withstand current tests

#### 6.6.1 *General*

The requirements in **6.5** of BS 6581:1985 shall apply with the following addition. The test shall be arranged, as far as practicable, to produce conditions equivalent to those which would obtain in service when a section of busbars, including one joint, and typical busbar connections, carry fault conditions.

#### 6.6.2 *Arrangement of the apparatus and of the test circuit*

The requirements in **6.5.1** of BS 6581:1985 shall apply.

#### 6.6.3 *Test current and duration*

The requirements in **6.5.2** of BS 6581:1985 shall apply.

#### 6.6.4 *Behaviour of the apparatus during test*

The requirements in **6.5.3** of BS 6581:1985 shall apply.

#### 6.6.5 *Condition of the apparatus after test*

The requirements in **6.5.4** of BS 6581:1985 shall apply.

## 7 Routine tests

### 7.1 Power-frequency voltage tests at manufacturer's premises

Where practicable, power-frequency voltage tests shall be applied to busbars and busbar connections completely assembled with all joints as in service, or, where the insulation of joints between busbars can be completed only after erection on site, to individual sections of busbars with suitable temporary insulation applied to exposed connections. The r.m.s. test-voltages shall be as given in Tables I, III and IV of BS 6581:1985.

The test voltages 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 c/s and 100 c/s, as near to the service frequency as possible and approximately of sinewave form.

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 or busbar enclosure.

When the insulation is entirely of porcelain, a test at normal temperature shall be regarded as equivalent to one at the temperatures that may be reached in service, but if the insulation includes materials other than porcelain the test can be carried out 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 temperatures that can be reached in service.

### 7.2 Voltage tests after erection on site

#### 7.2.1 *General*

If a voltage test after erection on site is specified by the purchaser at the time of enquiry and/or order, see **9.3** e), the test shall be made either with a.c. voltage (see **7.2.2**) or d.c. voltage (see **7.2.3**).

The test voltage shall be applied between each phase and earth, with the remaining phases earthed. It shall be increased from its initial value as rapidly as is consistent with its value being indicated by the measuring instrument.

During the test, one pole of the testing supply shall be connected to earth and to the frame or busbar enclosure.

For three-phase rated voltages above 36 kV, the nature of the test (a.c. or d.c.) and the value of the test voltage shall be agreed between the manufacturer and the purchaser see **9.3** f) i). The a.c. test shall not exceed 80 % of the rated minute power frequency withstand voltage.

NOTE It may be necessary to disconnect certain auxiliary apparatus, such as instruments, during the test.

Enclosures designed for single point earthing shall have a high-voltage test applied to the complete installation between enclosure and earth and the earth connection to the earth bar shall be disconnected.

The test voltage shall be either:

a) a.c. or d.c. and of the value indicated for a 3.6 kV rated voltage in Table 3 or Table 4 as appropriate;

or

b) as agreed between manufacturer and purchaser, see **9.3** f) ii).

In the case of extensions to existing gear, the test values given in Table 3 and Table 4 shall apply when the new busbar can be tested before connection to the existing gear. If the new busbar cannot be tested before connection to the existing gear, test values shall be as agreed, see **9.3** f) iii).

#### 7.2.2 *Power-frequency tests*

The test voltage shall be alternating of any available frequency between 25 Hz and 100 Hz and approximately of sine wave form. The test voltage shall be applied for one minute and shall be as given in Table 3.

#### 7.2.3 *D.C. tests*

The d.c. test voltage shall be applied for 15 min and shall be as given in Table 4.

**Table 3 — Power-frequency test voltages on apparatus after erection on site**

| 1 | 2 |
|---|---|
| **Rated voltage** | **Site test voltage** |
| kV | kV |
| 3.6 | 8 |
| 7.2 | 16 |
| 12 | 22.4 |
| 17.5 | 30.4 |
| 24 | 40 |
| 36 | 56 |

**Table 4 — D.C. test voltages**

| 1 | 2 |
|---|---|
| **Rated voltage** | **Site test voltage** |
| kV | kV |
| 3.6 | 7.5 |
| 7.2 | 15 |
| 12 | 25 |
| 17.5 | 32 |
| 24 | 45 |
| 36 | 66 |

## 8 The selection of busbars and busbar connections for service

Busbars and busbar connections complying with this standard shall be suitable for use on circuits of the relevant type and voltage under the following conditions:

a) an ambient temperature not exceeding that specified in **2.1.1** and **2.1.2** of BS 6581:1985;

b) an altitude not exceeding 1 000 m above sea level;

c) an atmosphere not subject to excessive pollution by smoke, chemical fumes, salt-laden spray etc. Such pollution occurs in some industrial areas and coastal districts.

The rated voltage and, where applicable, the impulse-voltage withstand level, of busbars shall be selected in accordance with **4.2** and **4.3**

NOTE On systems having permanently insulated neutrals the possibility exists of arcing faults occurring between one line and earth, with the result that high over-voltages may be produced. This necessitates special consideration being given to the insulation of busbars, particularly where the transmission is by overhead line.

## 9 Information and requirements to be agreed and to be documented

### 9.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be fully documented.

Both the definitive requirements specified throughout this standard and the following documented items shall be satisfied before a claim of compliance with this standard can be made and verified.

a) *Particulars of system,* i.e. normal operating voltage, frequency, number of phases, number of wires and details of system neutral earthing (see clause **8** and BS 5622-2).

b) *Service conditions,* including maximum and minimum ambient temperatures, altitude (if over 1 000 m), humidity, and any special conditions likely to exist or arise, e.g. exposure to steam or vapour, fumes, explosive gases, excessive dust or salt-laden atmosphere.

c) *Type of busbar*

1) Indoor or outdoor.

2) Open or enclosed type (if enclosed type state any special requirements regarding type of enclosure).

3) Type of principal insulation required, e.g. air-insulated, compound-immersed (if the type of busbar concerned allows a choice of insulation medium).

4) Relevant particulars in accordance with BS 5227, BS 5524 and BS 7354 where the busbars form part of a switchboard or switchgear installation.

d) *Rating of busbars*

1) Number of poles.

2) Voltage.

3) Normal current of busbars and busbar connections.

4) Frequency.

5) Short-time current and duration or, if the busbars and busbar connections are protected by circuit breakers fitted with direct-acting trips or by fuses, give particulars.

e) *Testing of busbars.* Details of any special testing which the purchaser requires the manufacturer to undertake (see clause **6**), and whether testing after erection on site is required (see **7.2**).

f) *Special conditions*. The enquirer shall give information about any special conditions not included in a) to e) that might influence the tender or order.

**9.2 Information to be supplied by the manufacturer**

When technical particulars of standard busbars are requested, the following information shall be fully documented and given to the purchaser/enquirer with descriptive matter and drawings, where applicable.

Both the definitive requirements specified throughout this standard and the following documented items shall be satisfied before a claim of compliance with this standard can be made and verified.

a) *Rating*

1) Number of poles.

2) Voltage.

3) Normal current of busbars and busbar connections.

4) Frequency.

5) Short-time current (1 s or 3 s, as applicable).

b) *Type tests*. Certificate or report.

c) *Constructional features*

1) Whether indoor or outdoor.

2) Type of enclosure.

3) Type of principal insulation.

4) Conductor material.

5) Minimum clearance in air:

i) between poles;

ii) between live parts and earth.

6) Minimum clearance in oil or compound:

i) between poles;

ii) between live parts and earth.

7) Mass of busbar and enclosure, if relevant, (including oil or compound where applicable).

8) Quantity of oil, compound or gas in busbar unit (where applicable).

d) *Special conditions*. Any special information requested under item f) of **9.1** (e.g. creepage distances).

**9.3 Items for agreement**

The following items to be agreed between the contracting parties, which are specified in the clauses referred to, shall be fully documented.

Both the definitive requirements specified throughout this standard and the following documented items shall be satisfied before a claim of compliance with this standard can be made and verified.

a) Ratings for d.c. equipment shall be agreed at the time of enquiry and/or order, see **4.1**.

b) Clearances to earth ascribed to insulation structures which have not been type-tested shall be agreed at the time of enquiry and/or order, see **5.2** c).

c) Wind and ice loadings for open outdoor busbars shall be agreed at the time of enquiry and/or order, see **5.7**.

d) If the manufacturer is unable to provide type test data that satisfies the purchaser, the purchaser can specify at the time of enquiry and/or order that type test shall be made, see **6.1**.

e) If a voltage test after erection on site is required, this shall be specified and agreed at the time of enquiry and/or order, see **7.2.1**.

f) If there is a voltage test after erection on site (see **7.2.1**) the following shall apply.

i) For three-phase rated voltages above 36 kV, the nature of the test (a.c. or d.c.) and the value of the test voltage shall be agreed at the time of enquiry and/or order, see **7.2.1**.

ii) For enclosures designed for single point earthing, if the purchaser chooses to specify the nature of the test (a.c. or d.c) and the value of the test voltage, these shall be specified and agreed at the time of enquiry and/or order, see **7.2.1**.

iii) When the new busbar cannot be tested before connection, test values for extensions to existing gear shall be agreed at the time of enquiry and/or order, see **7.2.1**.

## 10 Rules for transport, storage, erection and maintenance

The requirements in clause **10** of BS 6581:1985 shall apply.

## Appendix A Clearances: practice used within UK and international practice

**Table 5 — Clearances: practice used within UK**

| 1 | 2 | 3 |
|---|---|---|
| **Nominal system voltage/BIL/SIL** | **Basic electrical clearance (phase to earth)** | **Phase to phase clearance** |
| kV | m | m |
| 6,6/75 | 0.5 | 0.25 |
| 11/95 | 0.5 | 0.25 |
| 33/170 | 0.5 | 0.43 |
| 66/325 | 0.7 | 0.78 |
| 132/550 | 1.1 | 1.4 |
| 275/1 050/850 | 2.1 | 2.4 |
| 400/1 425/1050 | 2.8 | 3.6 |

NOTE Rated voltages are not nominal.

**Table 6 — Clearances: international practice**

| 1 | 2 | 3 | | 4 |
|---|---|---|---|---|
| **BIL** | **SIL** | **Basic electrical clearance (phase to earth)** | | **Phase to phase clearance** |
| | | **A** | **B** | |
| kV | kV | m | m | m |
| 20 | | 0.15 | | |
| 40 | | 0.15 | | |
| 60 | | 0.15 | | |
| 75 | | 0.15 | | |
| 95 | | 0.16 | | |
| 125 | | 0.22 | | |
| 145 | | 0.27 | | |
| 170 | | 0.32 | | |
| 250 | | 0.48 | | |
| 325 | | 0.63 | | |
| 450 | | 0.9 | | |
| 550 | | 1.1 | | See note 3 |
| 650 | | 1.3 | | |
| 750 | | 1.5 | | |
| 850 | 750 | 1.6 | 1.9 | |
| 950 | 750 | 1.7 | 1.9 | |
| 950 | 850 | 1.8 | 2.4 | |
| 1 050 | 850 | 1.9 | 2.4 | |
| | 950 | 2.2 | 2.9 | |
| | 1 050 | 2.6 | 3.4 | |
| | 1 175 | 3.1 | 4.1 | |
| | 1 300 | 3.6 | 4.8 | |
| | 1 425 | 4.2 | 5.6 | |
| | 1 550 | 4.9 | 6.4 | |

NOTE 1 Clearances under columns marked "A" are appropriate to "conductor-structure" electrode configuration. Clearances under columns marked "B" are appropriate to "rod-structure" electrode configuration.

NOTE 2 The "rod-structure" configuration is the worst electrode configuration normally encountered in service. The conductor-structure configuration covers a large range of normally used configurations.

NOTE 3 Phase to phase clearances are under consideration.

## Appendix B Checking of mechanical joints made on site and measurement of joint resistance

The best method of checking joints made on site (see note 2 to **5.6**) will depend on the circumstances of the individual installation. For instance, in the case of bolted joints, inspection of joint surfaces to ensure they have been properly prepared and protected where necessary. Bolts with suitable spreader washers should be tightened to a specified torque using a torque spanner. Resistance of joints can be measured using a micro-ohmmeter or equivalent instrument.

a) Joints of heavy current busbars have very low values of resistance (of the order of a few microhms) which can be quickly and accurately measured by a micro-ohmmeter. This device, using a four wire measurement method, passes a precise current through the joint being tested. By reversing the current, the effects of thermal offset at the connection are accounted for and the average of the two readings is taken as the connection resistance.

b) Type test values of joint resistance measured with a micro-ohmmeter give a good indication of the values which should be obtained when measuring similar joints on site. The resistance measured includes that of conductor material and therefore will be higher than the true resistance at the joint interface.

c) If the resistances of a number of similar joints are measured in exactly the same way (i.e. the current and voltage connections are the same) then any variations in readings will indicate the differences in joint interface resistances. Wide variations will show which are poor joints, but some variations of the order of ± 20 % may be regarded as being acceptable.

d) In joints made with more than one bolt it is not always possible to detect with certainty insufficiently tightened bolts by means of resistance measurements, and other methods of assuring good workmanship may be preferable.

## Appendix C Notes on mechanical jointing practice for aluminium-to-aluminium and aluminium-to-copper connections

### C.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.

For bolted joints the importance of bolt tightening cannot be over-emphasized. Guidance on the relationship between applied torque and bolt load is given in BS 3580.

NOTE It has been ascertained by experiments with plain bars of pure aluminium in air clamped under a hydraulic press that, with normal surface preparation by filing or vigorous scratch brushing (under neutral grease) a contact pressure of the order of 10 $N/mm^2$ to 15 $N/mm^2$ of the nominal contact area is sufficient.

### C.2 Removing the oxide film

Satisfactory methods of removing the oxide film include light machining or very vigorous scratch brushing (under neutral grease). The scratch brushes should be of stainless steel bristle and should not have been previously used on other metals.

### C.3 Welded joints

Excellent permanent connections in aluminium bars can be made by fusion welding. Inert gas metal arc welding processes are recommended.

Cold pressure lap welding technique can also be used for permanent connections in copper and aluminium conductors.

### C.4 Stranded conductors

Compression jointing is recommended for stranded conductors. Surface preparation should be as recommended by the compression manufacturer. Exterior surfaces that are corroded or heavily oxidized should be scratch brushed under neutral grease. A neutral grease or suitable jointing compound should be incorporated in the joint.

### C.5 Aluminium-copper connections

Aluminium-copper connections are designed on the same principles as aluminium-aluminium connections and surface preparation is the same. The copper surface may be hot tinned if desired, electro tinning is not suitable for contact with aluminium. Alternatively, transition interfaces are available which obviate the need for cleaning the mating surfaces and also ensure that stable electrical contact is achieved.

# Publication(s) referred to

BS 91, *Specification for electric cable soldering sockets.*

BS 223, *Specifications for bushings for alternating voltages above 1 000 V.*

BS 1433, *Specification for copper for electrical purposes. Rod and bar.*

BS 1977, *Specification for high conductivity copper tubes for electrical purposes.*

BS 2898, *Specification for wrought aluminium and aluminium alloys for electrical purposes. Bars, extruded round tube and sections.*

BS 3580, *Guide to design considerations on the strength of screw threads.*

BS 4109, *Specification for copper for electrical purposes. Wire for general electrical purposes and for insulated cables and flexible cords.*

BS 4608, *Specification for copper for electrical purposes. Rolled sheet, strip and foil.*

BS 5227, *Specification for a.c. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 72.5 kV.*

BS 5486, *Low-voltage switchgear and controlgear assemblies.*

BS 5486-1, *Requirements for type-tested and partially type-tested assemblies.*

BS 5490, *Specification for classification of degrees of protection provided by enclosures.*

BS 5524, *Specification for gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above.*

BS 5559, *Specification for identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system.*

BS 5622, *Guide for insulation co-ordination.*

BS 5622-2, *Application guide.*

BS 6581, *Specification for common requirements for high-voltage switchgear and controlgear standards.*

BS 6926, *Specification for copper for electrical purposes: high conductivity copper wire rod.*

BS 7354, *Code of practice for design of high-voltage open-terminal stations.*

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