Specification for

Performance of bonds for electric power cable terminations and joints for system voltages up to 36 kV

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Cables and Insulation Standards Policy Committee (CIL/-) to Technical Committee CIL/20, upon which the following bodies were represented:

Aluminium Federation
Association of Consulting Engineers
Association of Manufacturers of Domestic Electrical Appliances
British Approvals Service for Electric Cables
British Cable Makers' Confederation
British Plastics Federation
British Railways Board
British Shipbuilders
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British Telecommunications plc
Department of the Environment (Property Services Agency)
Department of Trade and Industry (Consumer Safety Unit, C A Division)
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
ERA Technology Ltd.
Institution of Electrical Engineers
London Regional Transport

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)
Department of Transport
Electrical Installation Equipment Manufacturers' Association (BEAMA Ltd.)
Institution of Lighting Engineers
Ministry of Defence

This British Standard, having been prepared under the direction of the Cables and Insulation Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 29 June 1990

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Contents

Foreword

This British Standard has been prepared under the direction of the Cables and Insulation Standards Policy Committee.

Power cables used for the distribution of electricity are generally provided with a metallic envelope. This envelope, generally known as a screen, functions as the protective conductor of the cable. It is designed to have an adequate current rating to enable it to carry, without damage, any fault current that may flow during the time taken for the devices protecting the cable to operate. Therefore in a cable joint, provision has to be made to connect together screens of the cables in the joint and/or terminations by means of bonds.

This specification not only specifies the general requirements of such bonds but also gives recommended cross-sectional areas of copper, aluminium and steel bonds. An appendix gives guidance on various forms of bonding.

There is currently no published International Standard for bonds covered by this standard.

It is assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

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 12, 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 bonds for connecting the metallic envelopes (protective conductors) of electric power cables at terminations and joints for system voltages up to 36 kV for the different types of cables covered by British Standards.

The standard describes performance test methods, tables cross-sectional areas of solid copper, aluminium and steel bonds calculated in accordance with a given formula and gives guidance on matters which affect the following.

a) Provision of a circuit in joints between cables and between a cable and its terminal equipment for the transmission of currents which may arise under system fault conditions.

b) Provision of bonding for neutral conductors (CNE only).

c) Provision of overall protective conductors at joints to provide for the passage of a fault current in the event of mechanical damage or failure of the insulation and to contain the electric field around high voltage conductors.

Guidance on bonding is given in Appendix A.

The standard specifically excludes additional safety precautions necessary when jointing live cables.

NOTE The title of the publication referred to in this standard is given on the inside back cover.

2 Definitions

For the purposes of this British Standard, the definitions given in BS 4727-2:Group 08 apply, together with the following.

2.1
low voltage

a system voltage normally exceeding 50 V but not exceeding 600/1 000 V a.c.

2.2
high voltage

a system voltage exceeding 600/1 000 V a.c.

2.3
SNE (separate neutral earth)

a cable in which the neutral load carrying conductor is separate from and insulated from the earth conductor

2.4
CNE (combined neutral earth)

a cable in which the neutral load carrying conductor is also the earth conductor

2.5
straight through joint

a connection between two identical or substantially similar cables

2.6
termination

a device fitted to the end of a cable to ensure electrical connection with other parts of the system and to maintain the insulation up to the point of connection

2.7
branch joint

a connection with three cable entry ports used to connect one cable (designated branch) to a through cable (designated main), the cables being of comparable size

NOTE The geometric arrangement may be "T" or "Y" form and the main cable may be cut or uncut.

2.8
transition joint

a connection between cables having different types of insulation

2.9
service joint

similar to a branch joint but with the tap off cable (designated service) considerably smaller than the main cable and generally not greater than 35 mm²

2.10
earth conductor

the metallic conductor that may be in the form of a metallic screen, lead or aluminium sheath, armour or a separate conductor cable which is intended to form a continuous electrical connection to earth

2.11
earth bond

a connection between the earth potential components of cable, joint or termination to the cable earth conductor

2.12
earth continuity bond

1) A connection between the earth conductors of cables within a joint which maintains earth continuity throughout the jointed cable.

2) A connection between the earth conductor of a cable and a suitable earthing point at a termination.

2.13
earth screen

a metallic layer over or within a joint the principal function of which is to provide a protective screen against electric fields

2.14
earth fault current

the prospective short time current (generally less than 3 s) that can flow to earth under system phase to earth fault conditions without permanent system damage

2.15
three phase symmetric fault current

the prospective short time current (generally less than 3 s) that can flow between phases under system phase to phase fault conditions without permanent system damage

2.16
continuous load current

the maximum continuous current that can flow in the system under normal operating conditions for an unrestricted time and without system damage

2.17
protective conductor

a conductor used for some measures of protection against electric shock, and intended for connecting together any of the following parts:

exposed conductive parts;

extraneous conductive parts;

the main earthing terminal;

earth electrode(s);

the earthed point of the source, or an artificial neutral.

3 Bonds

3.1 General

NOTE 1 Power cables used for the distribution of electricity are generally provided with a metallic envelope(s) [protective conductor(s)]. The purpose of this envelope is:

a) to contain the electric field around the cores where there is no dielectric screen;

b) to ensure that in the event of a failure of the insulation of the cable, a circuit is provided to enable current to flow through the fault to the neutral point of the system supplying the cable which is usually connected to the mass of earth;

c) to carry fault current, derived from a failure of insulation in electrical plant that is connected to the cable, to the neutral point of the system supplying the cable;

d) for use, in certain designs of low voltage cable, as a neutral conductor which will carry the neutral current of the circuit and is rated accordingly.

The metallic envelope may be made from steel, copper or aluminium wires that are equally spaced around the circumference of the cable or cores and wound in a helix or waveform along the length of the cable or cores. Screens can also be made from lead or aluminium that has been extruded over the cable to form a metallic tube. In addition tapes of copper or aluminium may be wound in a helix around the cable or cores, or applied longitudinally along the cable or cores, and folded around the circumference of the cable to provide a complete screen.

The metallic envelope is designed to have an adequate current rating to enable it to carry, without damage, any fault current that may flow during the time taken for the protective devices to operate.

Provision shall be made in a cable joint to connect together the metallic envelope(s) of the cables in the joint by means of bonds. Collectively the bonds need to have the same fault current rating as the envelope which in turn shall be not less than the earth fault rating of the cable.

At cable terminations, connections shall be included as part of the termination to provide means whereby the envelope(s) of the cable can be connected to:

1) the metallic enclosure of an item of electrical plant;

2) any other electrical circuit that will enable fault current to return to the neutral point of the supply system.

The connections shall be rated to carry a current no less than the earth fault rating of the cable.

NOTE 2 Different types of envelope will require different methods of connection to provide adequate earth continuity bonds.

3.2 Construction

3.2.1 ***General***

Each bond shall consist of the following:

a) a metallic conductor with, if necessary, protection against corrosion; and

b) a means of connection to the cable protective conductors by either mechanical clamps, soldering or compression with, if necessary, protection against corrosion.

Alternatives, including the use of the cable protective conductor(s) itself as the joint or termination earth continuity bond, are acceptable providing they comply with this standard.

NOTE If the cable protective conductor is used its rating within a joint or at a termination might be lower than its rating within the cable. In particular, bunched armour or screen wires may have only about 50 % of the rating of the same wires applied helically in the cable.

3.2.2 ***Additional requirements for joints that require screening by a protective conductor***

In joints that incorporate a metallic screen surrounding the insulated conductors, the metallic screen shall cover the full length of the joint from one metallic envelope to the other. The metallic screen of the joint shall be bonded to the metallic envelope of the cable and it is permitted to form all or part of the bond. Screens in joints and terminations for use on systems up to and including 12 kV shall not have any aperture greater than 8 mm width.

3.3 Avoiding mechanical damage to cable components

The bond shall be of a suitable form to allow effective connection without damaging the cable protective conductor or other cable components.

NOTE The following recommendations should be taken into account.

a) If of the mechanical type, the bond should not impose undue pressure on the cable insulation.

b) If of the soldered type, the bond should not require heating of the earth continuity conductor during installation in a manner liable to damage the cable.

c) If of the compression type, the bond should not require the use of tooling liable to damage the cable components.

3.4 Avoiding corrosion

The bond shall be constructed of materials, compatible with the components of the cable and joint or termination, which may include dissimilar metals, or be suitably protected, to prevent corrosion.

3.5 Performance in single core cables

In single core circuits, bonding at both ends of the sheath may result in circulating currents of the same order of magnitude as the current in the cable conductor.

The bonds shall be capable of carrying this current continuously without overheating or progressive deterioration arising from normal and short circuit operational conditions.

3.6 Neutral protective conductor bonding

3.6.1 *General*

Bonds for use with neutral/protective conductors shall be of such design that they may be fitted without at any time losing continuity of the neutral protective conductor.

3.6.2 *Load current requirements*

The bond shall be constructed in such a way that its temperature when carrying the required neutral load current does not exceed the design operating temperature of the cable neutral/earth conductor, and/or that of the joint.

NOTE 1 *Mechanical considerations.* Under normal service conditions mechanical, tensile or compression stress can be induced in the cables as a result of thermal movement under load cycling conditions or ground subsidence. The neutral/earth bond should be designed such that it cannot be subjected to excessive mechanical stress under these conditions.

NOTE 2 *Thermal considerations.* Under single phase fault conditions the phase and neutral/earth conductors may rise to comparatively high temperatures. The neutral/earth continuity bond should not be more liable to thermally induced failure than the phase conductors.

3.7 Current equalization

Some designs of CNE cable incorporate a neutral/protective conductor comprising a number of individual wires which are not in contact with each other throughout the cable length. For a number of reasons, e.g. localized corrosion of some of the wires, or incorporation of service joints which require connection to only a fraction of the total conductors, the load current distribution may not be equal amongst the wires.

In these circumstances, when a number of discrete neutral/protective conductor bonds are used it is necessary to incorporate electrical connections between bonds to ensure load current equalization. This can often be achieved by:

a) *service joints,* that extend the service neutral/earth conductor and connect to all neutral/earth continuity bonds of the main;

b) *branch or straight through joints,* that extend one or more of the neutral/earth continuity bonds and connect to the remainder.

4 Performance

4.1 General

In order to comply with this standard, sample connections shall be made on a number of test specimens assembled as shown in Figure 1 and/or Figure 2 and then subjected to the sequence of tests listed in **4.3**.

4.2 Assembly of connection

4.2.1 *General*

The connections shall be assembled and installed strictly in accordance with the manufacturer's instructions. No subsequent tightening up of the connectors shall be made.

4.2.2 *Number of test specimens*

The number of specimens tested shall be as follows.

a) Six earth continuity bonds for use at terminations shall be tested, two at each end of three test specimens (see Figure 1).

b) All other earth continuity bonds shall be tested in sets of three (see Figure 2 for details of test connection).

The tests shall be carried out on sets of connectors on the largest and smallest cables for which approval is sought. The approval shall be extended to intermediate sizes providing connectors of a similar design are offered.

4.3 Summary of test sequence

4.3.1 *General*

Each specimen shall be subjected to the following after the connections have been assembled in accordance with **4.2**:

a) measure initial resistance in accordance with **B.1**;

b) assemble into the load cycling rig;

c) check the assembly by resistance measurement (see **B.1**);

d) carry out 100 load cycles (see **B.2**);

e) measure resistance (see **B.1**);

f) carry out 100 load cycles (see **B.2**);

g) measure resistance (see **B.1**);

h) carry out fault-circuit test (see **B.3**);

i) carry out 75 load cycles (see **B.2**);

j) measure resistance (see **B.1**);

k) carry out 75 load cycles followed by resistance measurement, and repeat cycling and measurement at every 75 cycles to an overall total of 1 025 cycles.

4.3.2 *Initial resistance value*

The initial resistance measured from A to B or A′ to B (see Figure 1) of each specimen, when measured as described in **B.1** shall not differ by more than 50 % from the mean resistance of the six specimens.

The initial resistance of an earth continuity bond measured between A and A′ (see Figure 1) shall not exceed the resistance of an equivalent length of cable earth conductor by more than 50 % when measured as described in **B.1**.

4.3.3 *Values measured during electrical loading tests*

The average resistance A to B or A′ to B (see Figure 1) of the test specimen taken over the last 500 cycles shall not exceed the average equivalent cable earth conductor resistance, taken over the same period, by more than 50 % when measured as described in **B.1**.

The average resistance A to B or A′ to B (see Figure 1) of the test specimen taken over the last 500 cycles shall not exceed the initial resistance of the test specimen as measured immediately before the start of the electrical load cycling test by more than 50 %.

The graph of resistance A to B or A′ to B against the number of cycles shall demonstrate with a reasonable probability that the change (rise or fall) of resistance over the last 500 cycles is not more than 20 % of the average resistance over the same period.

The temperature of the connection to the armour shall not exceed the temperature of the armour of the control cable by more than 5 °C.

4.4 Mechanical and thermal performance under short circuit conditions

The structure of the bond shall be such that it is capable of withstanding without distress mechanical forces liable to arise under system short circuit fault conditions.

The temperature of the bond under short circuit fault conditions shall be limited to a maximum value compatible with the materials in the joint or termination with which it is in contact but in no circumstances shall it exceed the following:

a) 250 °C for bonds employing mechanical or compression connections;

b) 160 °C for bonds employing soldered connections.

If the temperature rise of the bond is considered adiabatic, the required cross-sectional area can be found from the equation:

$$A = (I\sqrt{T})/K \qquad (1)$$

where

A is the required cross-sectional area;

I is the required earth fault current for duration T;

K is a variable which can be deduced from the equation

$$K = \sqrt{(\delta \cdot S_m/\rho \cdot d)}\sqrt{[(\theta_2 - \theta_1)/(1/\alpha) + + \{(\theta_2 + \theta_1/2\}]} \qquad (2)$$

where

δ is the specific gravity;

S_m is the mean specific heat (in J/kg at 140 °C);

ρ is the resistivity (in Ω/mm^2 per kilometre at 0 °C);

α is the thermal coefficient of resistance (in K at 0 °C);

θ_2 is the bond temperature immediately after fault (in °C);

θ_1 is the bond temperature prior to fault (in °C).

NOTE 1 θ_1 would normally be considered to be equal to the temperature of the earth continuity conductor in the cable operating at full load current.

NOTE 2 The above equations do not apply to flexible braids.

Values for the constants in equation 2 are given in Table 1, and calculated cross-sectional areas for typical bond requirements are given in Appendix C.

Table 1 — Physical constants for bonding materials

Property	Annealed copper	Aluminium	Steel
Specific gravity (δ)	8.89	2.703	7.8
Mean specific heat (S_m) in J/kg at 140 °C	400	910	505
Resistivity (ρ) in Ω/mm^2 per kilometre at 0 °C	15.886	25.983	124.2
Thermal coefficient of resistance (α) in K at 0 °C	0.004262	0.004386	0.005556
$\sqrt{(\delta \cdot S_m / \rho \cdot \alpha)}$	229.1	146.9	75.5

Appendix A Guidance on bonding

A.1 General

Various types of bonding may be employed on the protective conductors and/or sheaths of an electrical network, e.g. solid, single-point, cross-bonding, or in the case of protective multiple earthing (p.m.e.) systems, bonding to earth at terminal or intermediate points to reduce the overall earth resistance to a specified value.

This appendix is not intended to specify the type of bonding to be employed, but gives guidance on bonding when it has been established that earthing is necessary at a joint or termination.

A.2 Bonding low voltage SNE, CNE and high voltage cables

A.2.1 *General*

For joints and terminations other than cross-bonded and open-bonded systems, the bond(s) should be selected in accordance with the fault parameters given in **A.2.2** and the joint guidance as given in **A.2.3** should apply.

A.2.2 *Fault parameters*

The size, type and method of connection should be based on the following:

a) fault rating of the cable as specified by the manufacturer;

b) sizing as in accordance with **4.4**.

A.2.3 *Joint fault guidance*

The joint fault guidance should apply as follows:

a) *Straight through or transitional joints.* Bonds should be sized in accordance with **A.2.2** using the rating of the cable with the lower fault rating.

b) *Branch or service joints.* For bond(s) between the main cable earth continuity conductors, **A.2.2** need only apply to the main cable with the lower fault rating, and for bond(s) between the branch or service and main earth conductors, **A.2.2** need only apply to the service or branch cable.

A.3 Earthing facilities in the joint

In order to reduce the rise in potential of the protective conductor under fault conditions, in relation to the general mass of earth, it is sometimes considered necessary to provide a bond between the protective conductor and the general mass of earth at an intermediate jointing position.

A.4 Transitional joints between SNE and CNE cables

A protective conductor bond meeting all the parameters of **A.2** should be connected between the neutral earth conductor of the CNE cable and the protective/earth conductor of the SNE cable.

The neutral/earth conductor of the CNE cable should be connected to the neutral conductor of the SNE cable by a bond. The continuous current and fault rating of the bond should be not less than that of the smallest neutral conductor of either cable.

A.5 Earth bonding of other metallic cable components

A.5.1 In addition to protective conductor(s), a cable may incorporate additional metallic layers, e.g. for protection against mechanical damage, rodent or other pest attack.

A.5.2 All such metallic layers should be bonded at joints to the protective conductor and terminations except as allowed in **A.6** or as required by special system earthing requirements.

The fault current capability of the bond should be not less than that of the metallic layer to which it is connected.

A.5.3 A separate bond is not necessary when a metallic layer is in effective electrical contact with the cable protective conductor throughout the cable length.

A.6 Overall metallic screen of joints

Joints other than those of the hard resin, low voltage type, should incorporate a screen. The objective of this screen should be such as to minimize the danger of electric shock and provide for the passage of a fault current arising from failure of the joint insulation.

NOTE If the screen has an adequate cross-sectioned area, it may be used as the bond for the protective conductors of the cable.

Appendix B Performance test methods

B.1 Resistance measurement

Measure the resistance of each specimen between the potential points indicated in Figure 1 and Figure 2. Record the resistance between A and B, and also A′ and B. A and A′ should be as close to the connection as possible (see Figure 1 and Figure 2).

Measure the resistance of a suitable length of protective conductor to enable the equivalent resistance of the connections to be determined.

Carry out the resistance measurements in steady temperature conditions, allowing time for the specimens to acquire the temperature of their surroundings. Record this temperature at the time the initial resistance is measured.

NOTE 1 The length of time for which samples are allowed to stand and/or cool before resistance measurements are made can have an effect on the value of resistance measured, and ideally an interval of 12 h should be allowed to elapse after switching off the load cycling test current.

NOTE 2 The devices and instruments used for resistance measurements should be capable of measuring resistance to within 1 % or 0.5 $\mu\Omega$, whichever is the greater, and the through current used by the instrument should be such that it does not affect the temperature of the specimen.

NOTE 3 It is possible for thermoelectric electromotive forces (e.m.fs) to affect the accuracy of low resistance measurements. To compensate for this, two resistance measurements may be taken with the measuring current reversed, the mean of two readings being regarded as the resistance of the sample.

B.2 Electrical load cycling

B.2.1 *Conditions*

Carry out the electrical load cycling in draught-free conditions. Erect the test loop so that the distance between specimens is sufficient to ensure negligible thermal interference.

Support each specimen in such a way that air may freely circulate around the assembly to provide cooling by natural convection.

NOTE The loop contains a length of control cable with not less than 1.2 m of cable protective conductor exposed, the central part of which is used as the control for temperature and resistance measurements. The control cable is the same as the cable used for the test specimens.

B.2.2 *Procedure*

Carry out the electrical load cycling on the number of specimens specified in **4.2.1**. After the samples have been assembled into the test loop, but prior to load cycling, the resistances across each connection are measured as described in **B.1**.

Circulate the current in the loop such that the temperature of the protective conductor of the control cable is raised to 10 ± 2 °C below the specified maximum continuous phase conductor temperature of the cable.

Ensure that the current in the loop does not exceed the maximum continuous current rating of the cable.

NOTE 1 Where the current is inadequate to raise the temperature of the protective control cable to that specified, heating is achieved by circulating current in the phase conductors.

Tests made at a higher temperature shall be in accordance with this appendix.

Maintain the temperature of the control conductor at or above this temperature for 10 min.

At the end of this period switch off the current, and allow the cable earth conductor of the control cable to cool naturally to within 5 °C of ambient temperature.

At the end of 100 load cycles (± 10 cycles) switch off the current and allow the test loop to cool until the specimens acquire the temperature of their surroundings. Measure and record the resistances as found in **B.1**.

Repeat this procedure after 200 cycles, before and after the fault circuit test (see **B.3**), and subsequently after every 75 cycles until 1 025 cycles are completed. Allow a tolerance of ± 10 cycles on the timing of any reading.

Measure and record the temperature of the connections and the control cable, together with the ambient temperature, during the heating period of the load cycle prior to each resistance measurement.

NOTE 2 The devices and instruments used for temperature measurement should have an accuracy of 2 °C or better.

B.3 Fault circuit test

Carry out a fault current test on the loop described in **B.2.2**.

Ensure that the fault current used has an equivalent I^2t value as the earth fault rating of the cable and that the test current duration is not less than 1 s or greater than 3 s.

Complete six applications of fault current after 200 ± 10 load cycles.

Apply each fault current with samples within 10 °C of ambient temperature and make the electrical resistance measurements after each application, allowing time for the temperature of the specimens to become stable.

Appendix C Bond cross-sectional areas

Table 2, Table 3 and Table 4 give cross-sectional areas in millimetres squared of solid copper, aluminium or steel bonds for given fault current requirements calculated in accordance with the formulae and constants given in **4.4**.

For each fault current, the required bond area is given for a number of initial temperatures prior to commencement of the fault (related to typical cables operating at full load current), and final temperatures of 160 °C or 250 °C after a 1 s fault duration.

For fault durations other than 1 s, the required bond area may be calculated from the equation.

$$A' = A\ \sqrt{t} \qquad (3)$$

where

A' is the required bond area for a fault of a duration t seconds;

A is the tabulated bond area.

For fault currents or initial temperatures not given, but within the tabulated ranges, interpolated values may be used.

In other cases, bond areas should be calculated in accordance with **4.4**.

NOTE Bond areas given are based on thermal performance requirements only. Larger bonds may be necessary due to mechanical considerations.

Table 2 — Solid copper bond cross-sectional areas for 1 s fault duration

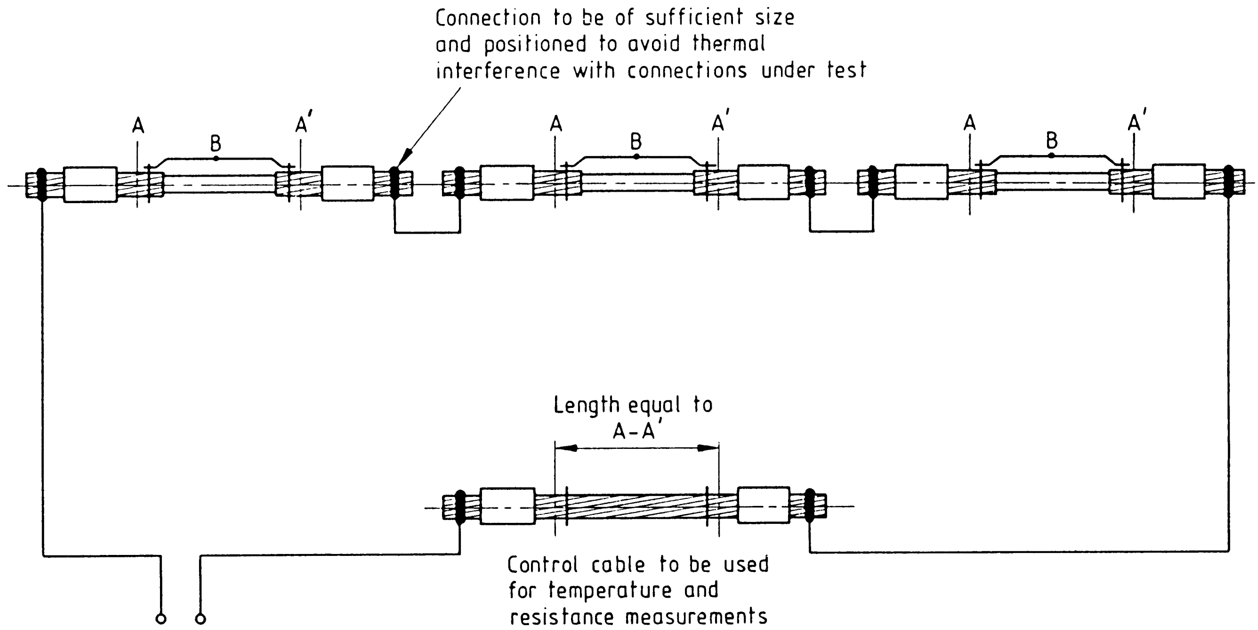
Fault current	Final temperature of 160 °C				Final temperature of 250 °C			
	Initial temperature °C				Initial temperature °C			
	55	65	75	85	55	65	75	85
A	mm²	mm²	mm²	mm²	mm²	mm²	mm²	mm²
1 000	8	9	9	10	7	7	7	7
2 000	16	17	18	20	13	13	14	14
3 000	24	26	27	29	19	20	20	21
4 000	32	34	36	39	25	26	27	28
5 000	40	42	45	48	31	32	33	35
6 000	48	51	54	58	37	39	40	41
7 000	56	59	63	67	44	45	47	48
8 000	64	67	72	77	50	51	53	55
9 000	71	76	80	86	56	58	60	62
10 000	79	84	89	96	62	64	66	69
11 000	87	92	98	105	68	70	73	75
12 000	95	101	107	115	74	77	79	82
13 000	103	109	116	124	80	83	86	89
14 000	111	117	125	134	87	89	93	96
15 000	119	126	134	143	93	96	99	103
16 000	127	134	143	153	99	102	106	110
17 000	134	142	152	162	105	109	112	116
18 000	142	151	160	172	111	115	119	123
19 000	150	159	169	181	117	121	125	130
20 000	158	167	178	191	124	128	132	137
21 000	166	176	187	201	130	134	139	144
22 000	174	184	196	210	136	140	145	150
23 000	182	192	205	220	142	147	152	157
24 000	190	201	214	229	148	153	158	164
25 000	197	209	223	239	154	159	165	171
26 000	205	217	231	248	160	166	171	178
27 000	213	226	240	258	167	172	178	184
28 000	221	234	249	267	173	178	185	191
29 000	229	242	258	277	179	185	191	198
30 000	237	251	267	286	185	191	198	205
31 000	245	259	276	296	191	198	204	212
32 000	253	267	285	305	197	204	211	219
33 000	261	276	294	315	203	210	217	225
34 000	268	284	303	324	210	217	224	232
35 000	276	293	311	334	216	223	231	239

Table 3 — Solid aluminium bond cross-sectional areas for 1 s fault duration

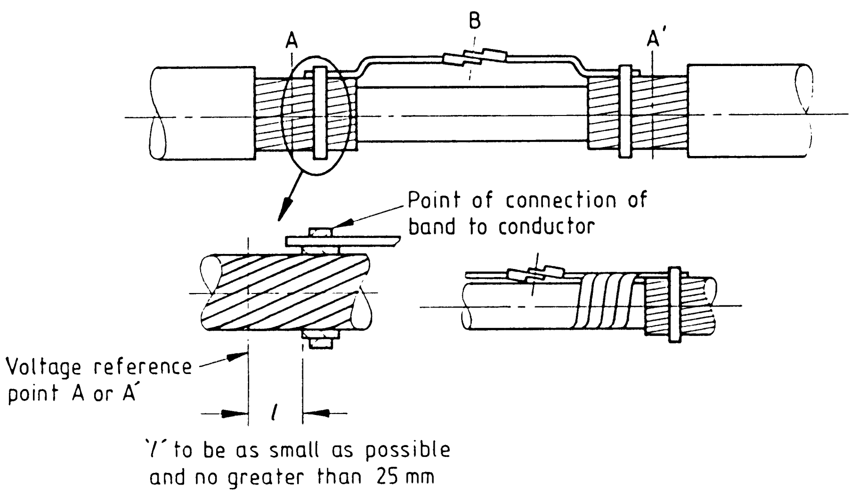
Fault current	Final temperature of 160 °C				Final temperature of 250 °C			
	Initial temperature °C				Initial temperature °C			
	55	65	75	85	55	65	75	85
A	mm²	mm²	mm²	mm²	mm²	mm²	mm²	mm²
1 000	13	13	14	15	10	10	11	11
2 000	25	26	28	30	20	20	21	22
3 000	37	39	42	45	29	30	31	32
4 000	49	52	55	59	39	40	41	43
5 000	61	65	69	74	48	50	51	53
6 000	74	78	83	89	58	59	62	64
7 000	86	91	97	104	67	69	72	74
8 000	98	104	110	118	77	79	82	85
9 000	110	116	124	133	86	89	92	95
10 000	122	129	138	148	96	99	102	106
11 000	134	142	151	162	105	109	112	116
12 000	147	155	165	177	115	118	123	127
13 000	158	168	179	192	124	128	133	138
14 000	171	181	193	207	134	138	143	148
15 000	183	194	206	221	143	148	153	159
16 000	195	207	220	236	153	158	163	169
17 000	207	220	234	251	162	168	173	180
18 000	220	232	248	265	172	177	184	190
19 000	232	245	261	280	181	187	194	201
20 000	244	258	275	295	191	197	204	211
21 000	256	271	289	310	200	207	214	222
22 000	268	284	302	324	210	217	224	232
23 000	280	297	316	339	219	227	234	243
24 000	293	310	330	354	229	236	245	253
25 000	305	323	344	368	238	246	255	264
26 000	317	336	357	383	248	256	265	275
27 000	329	348	371	398	257	266	275	285
28 000	341	361	385	413	267	276	285	296
29 000	353	374	399	427	276	285	295	306
30 000	366	387	412	442	286	295	306	317
31 000	378	400	426	457	295	305	316	327
32 000	390	413	440	471	305	315	326	338
33 000	402	426	453	486	314	325	336	348
34 000	414	439	467	501	324	335	346	359
35 000	426	452	481	516	333	344	356	369

Table 4 — Solid steel bond cross-sectional areas for 1 s fault duration

Fault current	Final temperature of 160 °C				Final temperature of 250 °C			
	Initial temperature °C				Initial temperature °C			
	55	65	75	85	55	65	75	85
A	mm²	mm²	mm²	mm²	mm²	mm²	mm²	mm²
1 000	22	24	25	27	18	18	19	20
2 000	44	47	50	54	35	36	38	39
3 000	66	70	75	80	52	54	56	58
4 000	88	93	100	107	70	72	75	77
5 000	110	117	124	133	87	90	93	97
6 000	132	140	149	160	104	108	112	116
7 000	154	163	174	187	122	126	130	135
8 000	176	186	199	213	139	144	149	154
9 000	198	210	224	240	156	162	167	172
10 000	220	233	248	266	173	179	186	193
11 000	242	256	273	293	191	197	204	212
12 000	263	279	298	320	208	215	223	231
13 000	285	303	323	346	225	233	241	250
14 000	307	326	347	373	243	251	260	270
15 000	329	349	372	399	260	269	278	289
16 000	351	372	397	426	277	287	297	308
17 000	373	396	422	453	295	305	315	327
18 000	395	419	447	479	312	323	334	346
19 000	417	442	471	506	329	340	353	366
20 000	439	465	496	532	346	358	371	385
21 000	461	489	521	559	364	376	390	404
22 000	483	512	546	586	381	394	408	423



(a) Test circuit



(b) Details of test connection

NOTE High temperature glass cloth tape can be wrapped around the sample to prevent movement during the fault circuit test.

Figure 1 — Test circuit for continuity bonds used in cable terminations

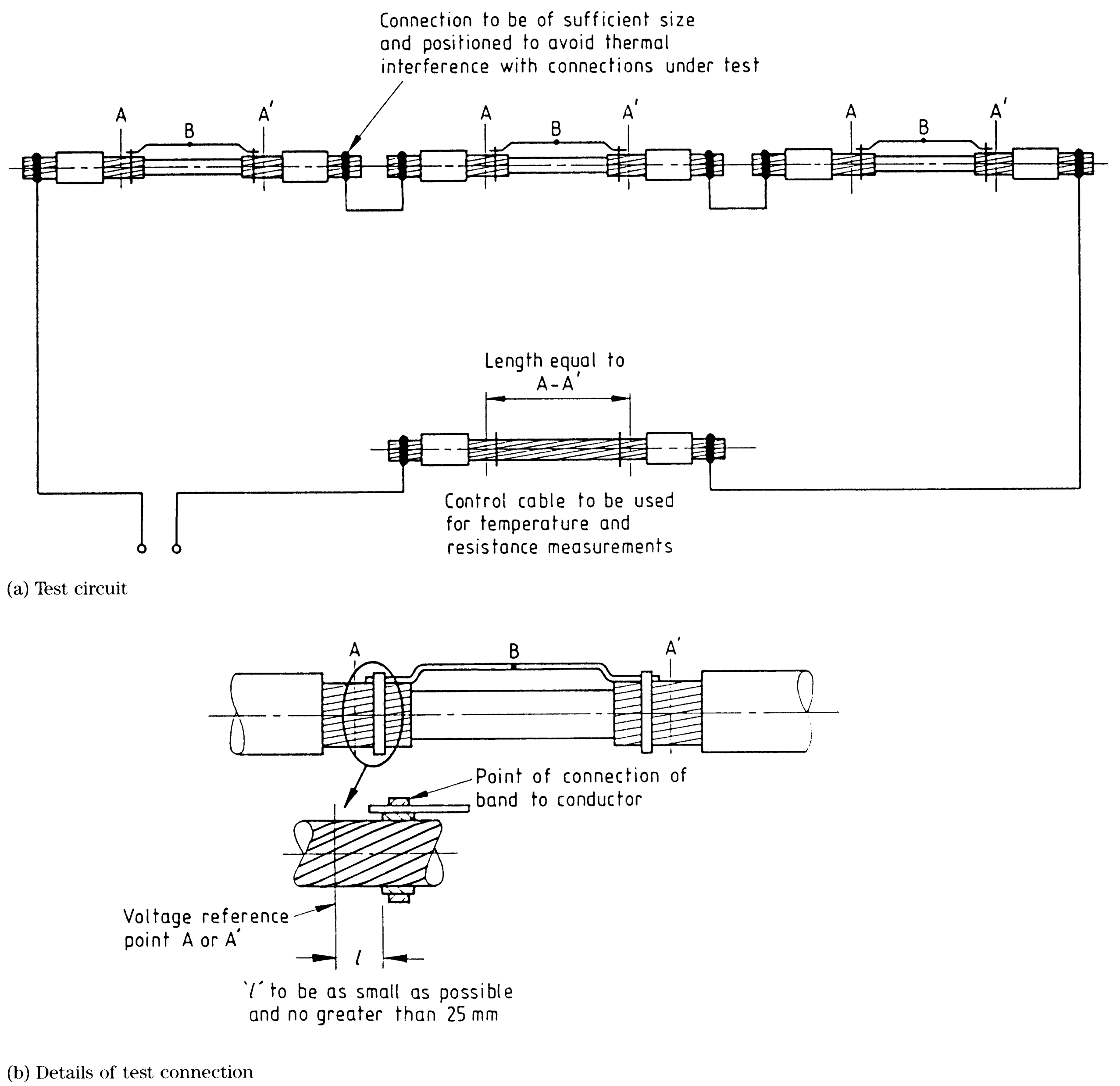


Figure 2 — Test circuit for cable joint earth continuity bonds

Publication referred to

BS 4727, *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms.*
BS 4727-2, *Terms particular to power engineering.*
BS 4727-2:Group 08, *Electric cable terminology.*

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