BRITISH STANDARD

BS 7609:1992
+A2:2009

Code of practice for

Installation and inspection of uninsulated compression and mechanical connectors for power cables with copper or aluminium conductors

ICS 29.120.20

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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 Cables
British Cable Makers' Confederation
British Plastics Federation
British Steel Industry
British Telecommunications plc
Department of the Environment (Property Services Agency)
Department of Trade and Industry (Consumer Safety Unit, CA Division)
Electricity Association
Engineering Equipment and Materials Users' Association
Institution of Electrical Engineers
London Regional Transport

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

Beccama (Beama Electrical Cable Connector and Accessories Manufacturers' Association)
Electrical Contractors' Association
Electrical Installation Equipment Manufacturers' Association (BEAMA Ltd.)
ERA Technology Ltd.
Institution of Lighting Engineers
London Underground Ltd.
Transmission and Distribution Association (BEAMA Ltd.)

This British Standard, having been prepared under the direction of the Cables and Insulation Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on
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The following BSI references relate to the work on this standard:
Committee reference CIL/20
Draft for comment 91/31861 DC

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Amendments issued since publication

Amd. No.	Date	Comments
16444	29 September 2006	See foreword
Amendment No. 2	31 December 2008	See foreword

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Contents

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Foreword

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

BS 7609 is intended to give guidance to manufacturers and contractors who use compression and mechanical connectors to enable power cables to be terminated using good engineering practice and to provide quality control guidance for the tools which are used to install connectors.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

The start and finish of text introduced or altered by Amendments No. 1 and No.2 is indicated in the text by tags [A1⟩ ⟨A1] and [A2⟩ ⟨A2].

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot 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.

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1 Scope

This British Standard recommends methods and procedures applicable for the installation of uninsulated compression and mechanical connectors for use on copper or aluminium conductors of insulated cables conforming to [A1] BS EN 60228:2005 [A1] having a cross-sectional area equal to or greater than 10 mm^2 for copper and equal to or greater than 16 mm^2 for aluminium.

2 References

2.1 Normative references

BS 7609 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this standard only when incorporated in it by updating or revision.

2.2 Informative references

BS 7609 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

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

3.1
connector

component or assembly of components designed to accept one or more conductor(s) for the purpose of making an electrical connection

3.2
mechanical connector

assembly designed to clamp conductors by mechanical screw force

3.3
insulation-piercing connector

mechanical connector which does not require removal of the conductor insulation to make an electrical connection

3.4
compression connector

component designed to make a connection by deformation of the barrel around the conductor

NOTE The term compression covers the term crimping.

3.5
barrel

part of a connector designed to accommodate the conductor

3.6
palm

part of a terminal lug formed flat to make a bolted connection to an equipment terminal

3.7
terminal lug

connector comprising a palm and a barrel, for connecting a conductor to an equipment terminal

4 Compression connectors

4.1 Selection of connectors and associated compression dies

Each connector should be clearly identified by a reference on the barrel or palm. This reference should enable the user to ascertain whether the fitting selected is of the correct size and type for the conductor(s) in question; it should also allow the correct die set and compression tool to be selected from the manufacturer's recommended list.

4.2 Preparation of a conductor

4.2.1 *General*

The insulation should be stripped back so that when assembled no insulation can be trapped in the barrel.

Care should be taken whilst stripping the insulation to avoid damaging the conductor strands with the stripping tool. The exposed conductor should be cleaned to remove any particles of the insulation material.

4.2.2 *Aluminium conductors*

Unless otherwise stated by the connector manufacturer, the conductor should be thoroughly abraded both to remove surface oxide and create a rough surface to ensure good electrical contact. Suitable abrasives are aluminium oxide cloth Grade 80 or a stainless steel wire brush; separate brushes should be kept for copper and aluminium. If cloth is employed, a fresh strip should be used for each connection made and if a wire brush is employed, the brush should be replaced when the wires are no longer sharp (indicated by the tendency for the brush to skate over the surface). During abrasion, care should be taken not to separate the strands of the conductor and the insulation should be protected from damage and particle ingress. For a conductor from mass impregated non-draining (MIND) cables as much of the compound as possible should be removed from the surface strands using a suitable degreasing agent prior to abrasion.

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To minimize further oxidation the insertion of the conductor into the connector and the subsequent compression should be carried out immediately in accordance with **4.3**.

NOTE The use of jointing compounds is not generally required where the connection is to be encapsulated to prevent moisture ingress, e.g. under resin or heat shrink materials. However, for connections which may be open to the atmosphere, the manufacturer's instructions should be followed where adverse environmental conditions are anticipated.

4.2.3 *Copper conductors*

Unless there are obvious signs of oxidation or other surface contamination no conductor preparation is normally required.

Where the surface appears tarnished, abrade the conductor surface by following the same procedure as recommended for aluminium conductors (see **4.2.2**) but excluding the coating procedure.

Separate brushes should be used for copper and for aluminium.

4.3 Compression

After cleaning, the conductor should be inserted into the barrel ensuring the palm is square to the equipment terminal thus avoiding excessive twisting of the completed termination.

NOTE For shaped stranded conductor and circular barrel connectors pre-rounding dies may be required prior to insertion; refer to manufacturer's data for information.

In an open ended terminal lug (see Figure 4) the conductor should protrude slightly at the palm end. With a closed ended terminal lug the conductor should be fully inserted as witnessed through the inspection hole (if provided). The connector should be compressed in accordance with the manufacturer's instructions with careful attention paid to the positioning of the die head on the barrel, the number and order of compression operations (if multiple) and whether overlapping is necessary or permissible.

Care should be taken to ensure the correct connector is chosen for the conductor and ⟨A2⟩ that the correct tool and die combination is used in order to achieve the same crimped connection as per the connector manufacturer's satisfactory type test.

a) For hexagon and circumferential crimping of both copper and aluminium connectors the the connector and die-set should be as specified by the manufacturer. The installer should ensure that the compression tool used is fully compatible with the crimp dies and that the dies fully close during the crimp operation.

b) For indent type crimping of both copper and aluminium connectors the connector, die-set and tooling should be as specified by the manufacturer. Specific attention should be paid to the servicing and calibration of the compression tool in order to guarantee the indent dies are compressed at the specified pressure. ⟨A2⟩

4.4 Inspection of completed compression connection

The completed connector should be examined to ensure:

a) the correct connector reference relative to conductor size;

b) that the correct die set has been used;

c) a completed compression is free from excessive flash or burrs, caused by incorrect compression, which are detrimental to the performance of the joint;

d) that no insulation is trapped in the barrel;

e) that excess grease is wiped off the cable insulation and connector;

f) that where inspection holes are provided, the conductor has been fully inserted.

NOTE 1 Examples of typical die sets, bolted terminations and good and poor compression connections are shown in Figure 1 to Figure 6.

NOTE 2 Reference should be made to the manufacturer's instructions to ascertain that the correct die set has been used.

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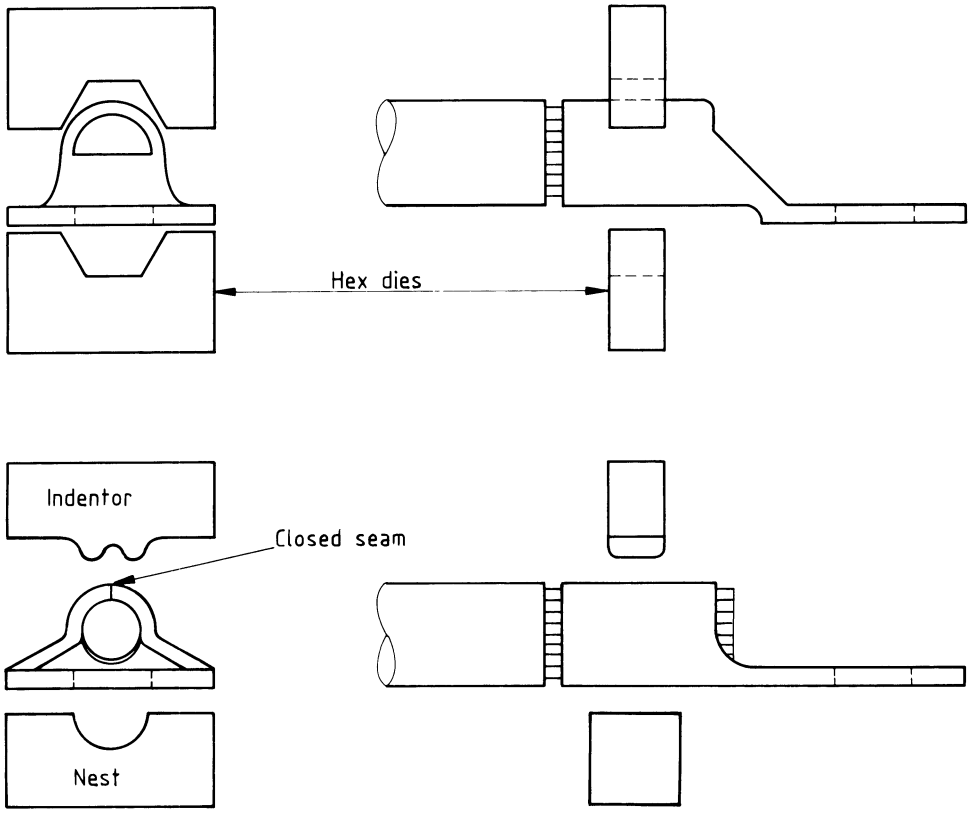

Figure 1 — Illustrations of compression die sets

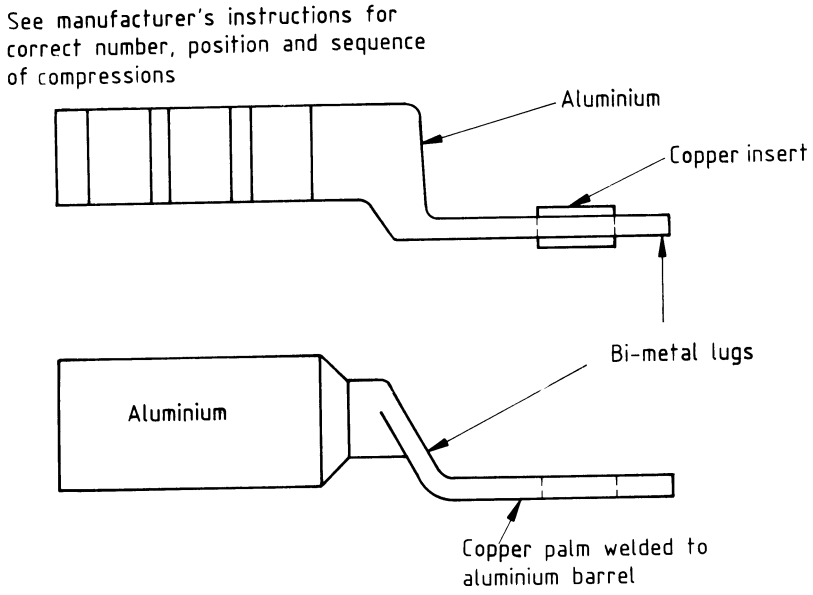

Figure 2 — Illustrations of bi-metallic connector

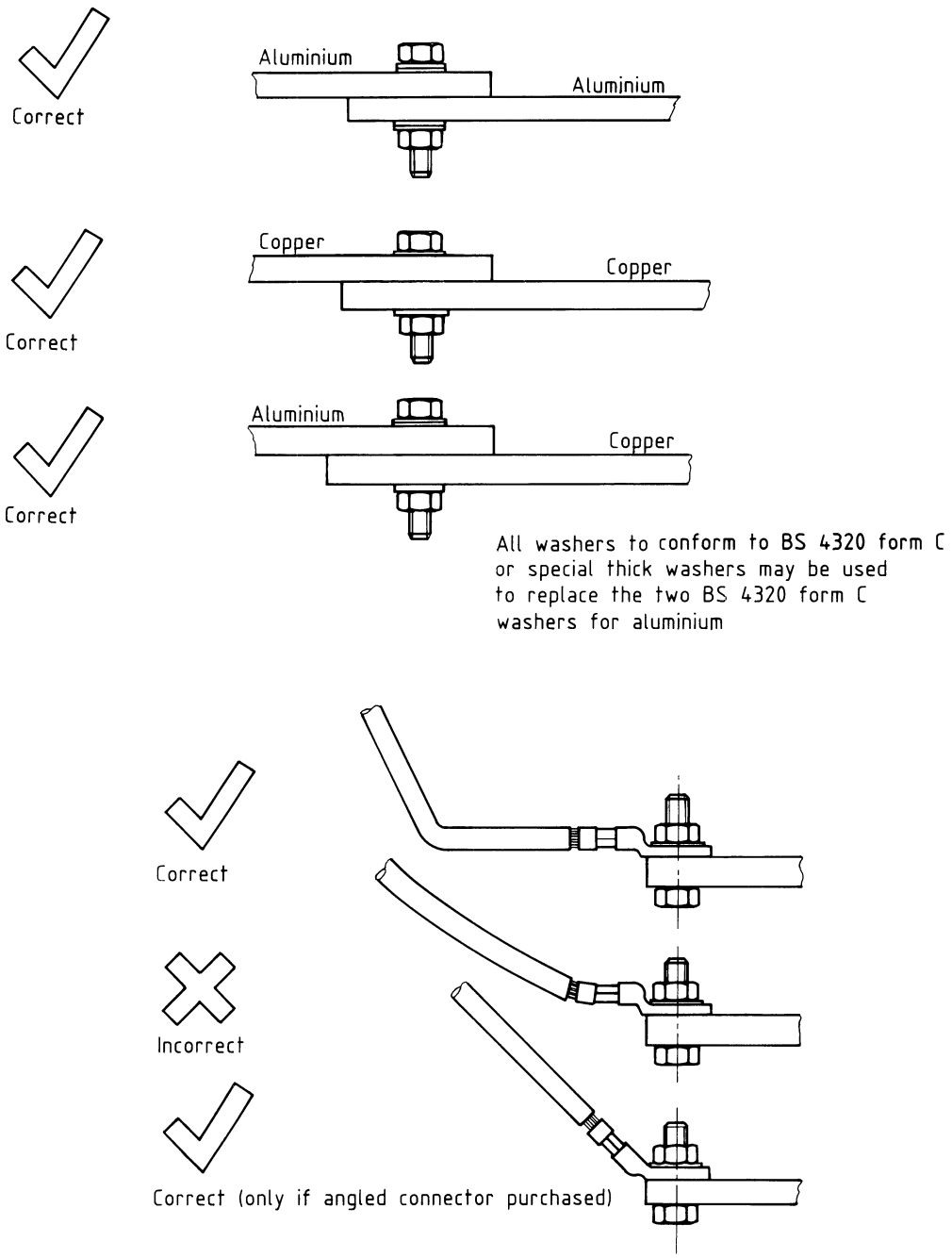

Figure 3 — Examples of correct and incorrect bolted termination

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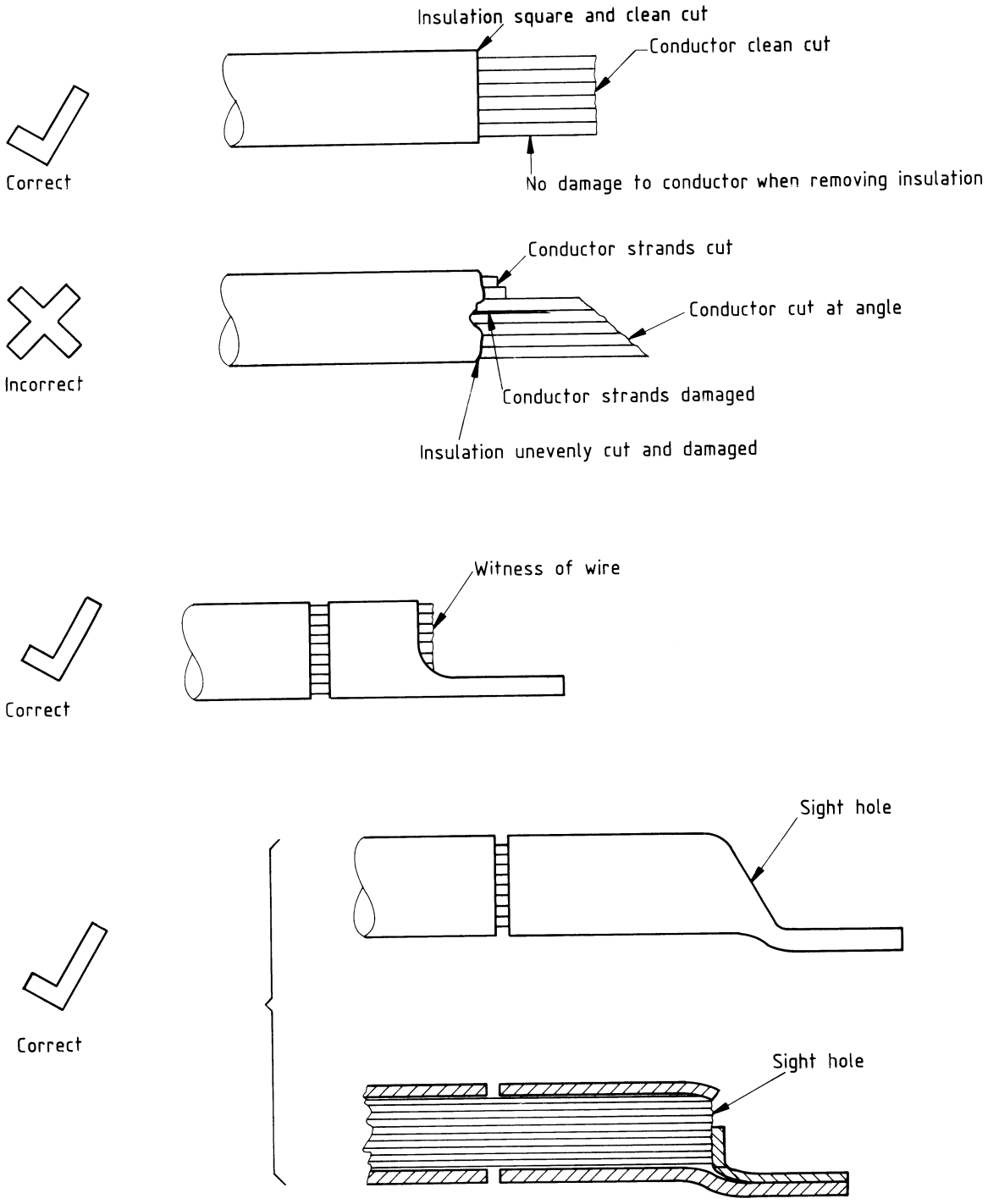

Figure 4 — Examples of correct and incorrect compression preparation

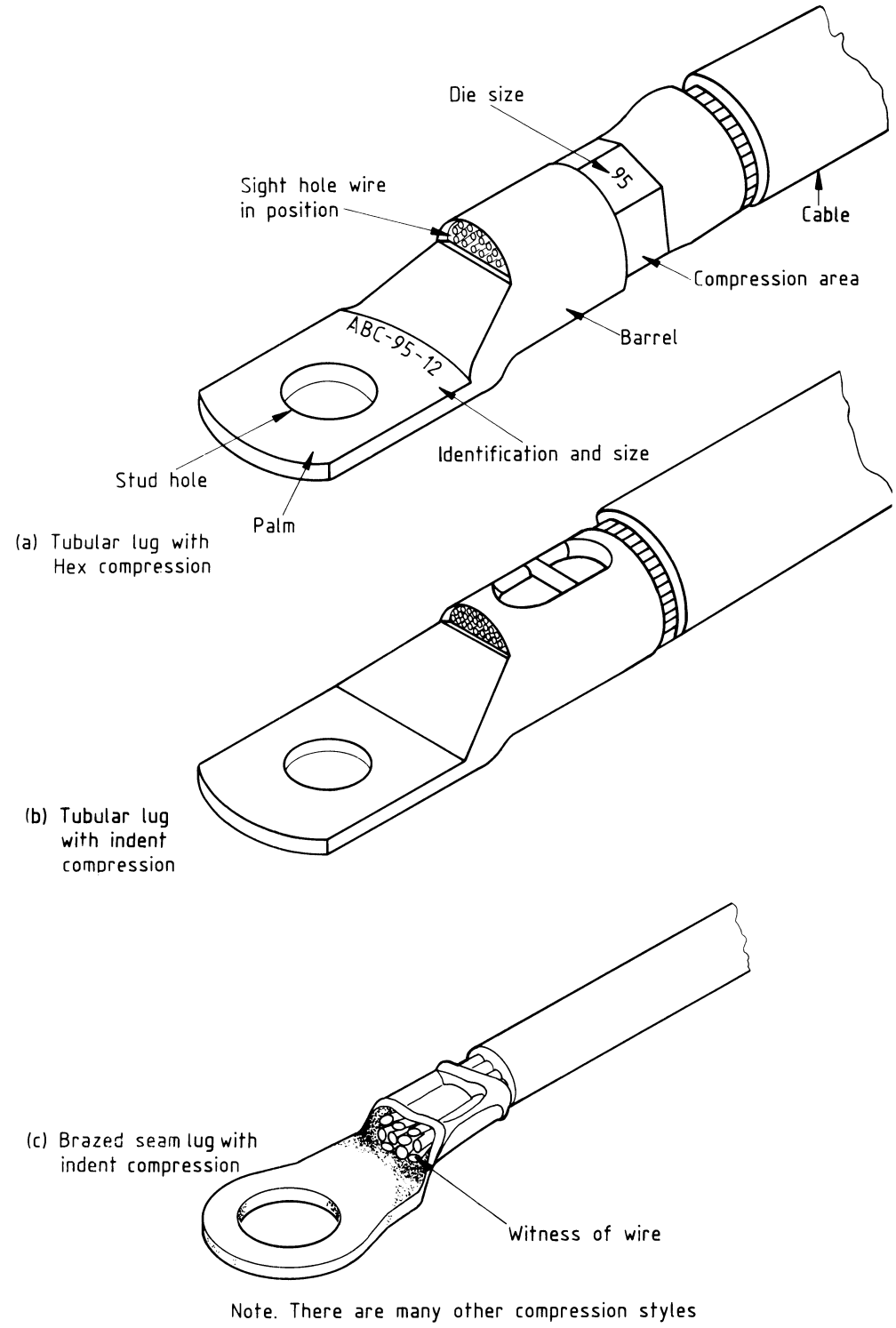

Figure 5 — Illustrations of three compression styles in use

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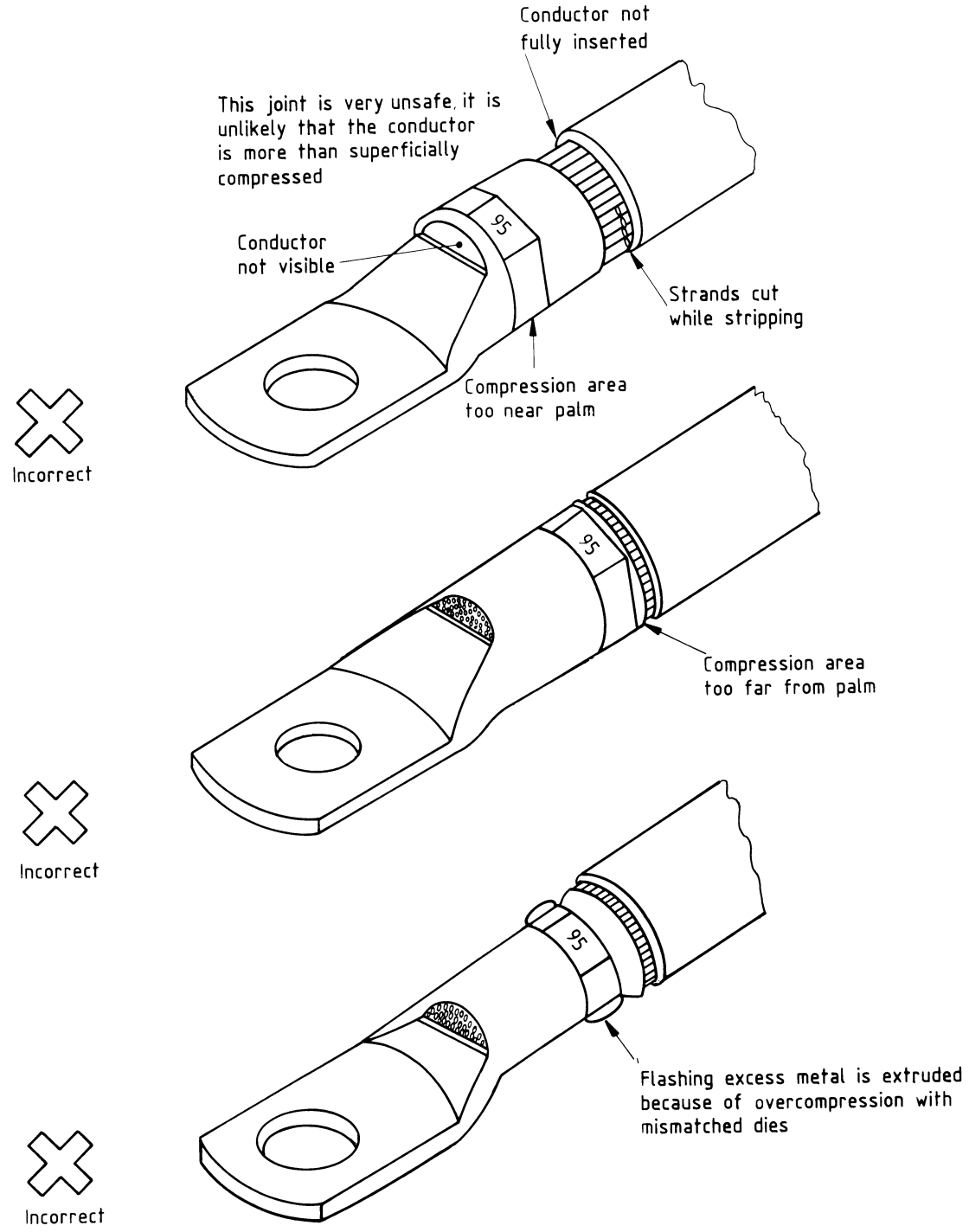

Figure 6 — Examples of common compression faults

5 Mechanical connectors

5.1 Identification

Each connector should be clearly identified by a reference on one or more component parts. Where this is impracticable then the reference should be clearly visible either on or within the packaging. This reference should enable the user to confirm that the fitting selected is the correct size and type for the conductor(s) in question.

5.2 Preparation of conductor

5.2.1 *General*

The insulation should be stripped back so that when assembled no insulation can be trapped in the barrel (except for insulation-piercing connectors).

Care should be taken whilst stripping the insulation to avoid damaging the conductor strands with the stripping tool. The exposed conductor should be cleaned to remove any particles of the insulation material.

5.2.2 *Aluminium conductor*

Unless otherwise stated by the connector manufacturer, the conductor should be thoroughly abraded both to remove surface oxide and create a rough surface to ensure good electrical contact. Suitable abrasives are aluminium oxide cloth Grade 80 or a stainless steel wire brush; separate brushes should be kept for copper and aluminium. If cloth is employed, a fresh strip should be used for each connection made and if a wire brush is employed, the brush should be replaced when the wires are no longer sharp (indicated by the tendency for the brush to skate over the surface). During abrasion, care should be taken not to separate the strands of the conductor and the insulation should be protected from damage and particle ingress. For a conductor from MIND cables as much of the compound as possible should be removed from the surface strands using a suitable degreasing agent prior to abrasion.

To minimize further oxidation, the insertion of the conductor into the connector and the subsequent assembly should be carried out immediately in accordance with **5.3**.

NOTE The use of jointing compounds is not generally required where the connection is to be encapsulated to prevent moisture ingress, e.g. under resin or heat shrink materials. However, for connections which may be open to the atmosphere, the manufacturer's instructions should be followed where adverse environmental conditions are anticipated.

5.2.3 *Copper conductors*

Unless there are obvious signs of oxidation or other surface contamination no conductor preparation is normally required.

Where the surface appears oxidized, abrade the conductor surface by following the same procedure as recommended for aluminium conductors (see **5.2.2**). A separate brush should be kept for this material type.

5.3 Assembly of connector

After cleaning the conductor, the connector should be assembled as follows:

a) insert any interface material or apply jointing compounds if specified by the manufacturer;

b) fit connector around the conductor and complete assembly according to manufacturer's instructions;

c) tighten clamp screws consecutively one turn at a time until either:

1) any torque-limiting device operates; or

2) until the manufacturer's recommended tightening torque has been reached.

5.4 Inspection of completed mechanical connection

The completed connection should be examined to ensure:

a) correct alignment of conductor in the connector as shown in the manufacturer's instructions;

b) correct connector reference relative to conductor size (see manufacturer's instructions);

c) that no insulation is trapped in the barrel;

d) that the clamping screws have been tightened to the manufacturer's instructions.

6 Bolting of terminal lugs to equipment

6.1 Preparation of surfaces

6.1.1 *Connector palms*

The manufacturer's instructions should be followed for any surface treatment that is required prior to bolt-up, although most terminal lugs are factory prepared and no further treatment is necessary.

6.1.2 *Equipment terminal*

A variety of contact surfaces and metal finishes can be encountered but where the equipment manufacturer does not issue any specific instructions it is recommended that the following surface preparation procedures be should be carried out.

a) *Aluminium or copper or other plain metal flag.* Follow the abrading technique in accordance with **4.2.2** or **4.2.3**.

b) *Plated surfaces.* Clean with a degreasing agent and lightly abrade to remove the tarnish without scoring.

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6.2 Bolting of connections

6.2.1 *Connection between the same metals*

Offer up the connector to the equipment terminal and bolt up according to the manufacturer's instructions but where no guidance is given on bolting torque the settings given in Table 1 should be used. Backing washers (fitted under the securing nut and bolt head) supplied by the manufacturer should be used. If not supplied by the manufacturer then washers conforming to BS 4320 form C should be used (2 off for aluminium and 1 off for copper each side [see Figure 6)].

Table 1 — Recommended torque wrench settings for aluminium and copper terminations

Stud size (full nut) mm	Grade 8.8 stainless steel or equivalent studs N · m	Brass or high conductivity copper studs N · m
6	7	5
8	20	10
10	35	20
12	50	40
14	70	65
16[a]	90	90
20	150	—

[a] 16 mm aluminium or copper stemmed bushings: full nuts, 70 N · m; half nuts, 55 N · m

If minor ajustment to the palm alignment is required, the cable core should be twisted in a manner which avoids damage to the core insulation. Care should be taken not to apply force to the connection.

6.2.2 *Connections between dissimilar metals*

Care should be taken where dissimilar metals are in contact to ensure their compatibility. To overcome incompatibility between dissimilar metals in contact various proprietary products are available and suitable for connecting aluminium and copper conductors, which when used should follow the lug manufacturers' instructions with regard to assembly and bolting torques.

NOTE Bimetallic connectors, transition washers and interface compounds are examples of proprietary products.

7 Tooling

Hydraulic compression equipment should be examined before use to ensure that it is functioning satisfactorily and all couplings are tight. Hoses should be checked for kinks or external damage and there should be no leakage of oil from the end fittings. It is essential that the hose and compression tool couplings are kept clean and capped when not connected to each other.

Occasionally it may be necessary to bleed the equipment of air and this should be done in accordance with the manufacturer's instructions.

Instructions for topping up or replacing the special hydraulic fluid should also be followed. Where there is doubt as to the performance of a hydraulic tool, the tool should not be used. Equipment should not be operated without the correct dies inserted as damage can result. Dies should be inspected periodically for wear or signs of damage.

8 Maintenance and certification of tooling

All tooling should be certified for fitness of use before entry into service and re-certified periodically or when doubt arises as to the quality of the connection produced.

NOTE 1 It is suggested that 6 months be a suitable period if used continuously, but not exceeding 12 months if used occasionally.

NOTE 2 Guidance on the maintenance, testing and certification of tooling is given in Annex A.

Certification should be carried out by an accredited authority.

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Annex A (informative) Maintenance, testing and certification of tooling

A.1 General

All tooling used in the application of cable connectors should be kept in a good state of repair and adjustment. Tools and associated parts should be serial numbered for identification and records of repairs, performance and certification kept on file by the user.

At suitable intervals not exceeding 12 months and, depending upon tool types, usage and manufacturer's recommendations, the tools should be submitted to a suitably qualified maintenance, test and inspection authority. Such an authority should operate a quality system assessed and registered to [A1]BS EN ISO 9000, MOD or UKAS[A1] accreditation where the scope of the approval includes all the appropriate activities listed in this annex.

The authority should maintain records of tool history indexed by serial numbers which should be permanently marked on tools by the authority. These records should show details of each submission including tensile test figures and any comments. When a tool is received for maintenance, the records should be consulted, for example, if an important previous comment appears to have been ignored it can then be restated with greater emphasis.

When submitting tooling for maintenance, test and certification it is recommended that the tooling is accompanied by specimens of work performed by the normal operator immediately before submission and that this course of action is advised by the manufacturer. The specimens should be prepared for tensile testing in the manner required by the maintenance, test and inspection authority. The authority should be consulted regarding any use of the tooling which falls outside the normal specifications or operating standards so that due allowance can be made for the user requirements.

A.2 Examination of initial specimens

Upon receipt by the authority, initial specimens should be examined and tensile tested in accordance with **A.8**. If the test results are below the required level, or examination shows other faults, the user should be notified. If a fault is sufficiently serious to cast doubt upon the quality of work performed by the tooling in question, the user should be notified by telephone or fax as soon as possible. Details of faults should be entered on the certificate.

A.3 Hand tools

Tools and accompanying dies should be examined carefully for missing parts, damage and excessive wear. Interchangeable dies should be checked for correctness of fit. All pins, linkages and joints should operate smoothly without excessive play.

Any faulty parts should be replaced and the tools be cleaned and lubricated.

The full closure mechanism should be tested for correct operation and release point and, if necessary, be adjusted or replaced.

Die cavities which form the compression should be checked with the use of "go/no-go" gauges and if possible adjusted as necessary to ensure correct die-space when the tool is closed. It should be noted that gauging of dies is not a definitive test of tooling efficiency as it is possible for faulty tooling to be gauged as being satisfactory and yet fail to achieve sufficient pressure to close the dies when compressing.

A.4 Pneumatic tools

Tools and accompanying die sets should be examined carefully for missing parts, damage and excessive wear. Die sets should be checked for correctness of fit. All pins, linkages and joints should operate smoothly without excessive play. Valves, cylinders, pistons and seals should be carefully examined and adjusted or replaced as necessary. All parts should be cleaned and lubricated as appropriate and reassembled. The tool actions should be checked at maximum and minimum rated air pressures to ensure correctness of action and an absence of air leaks. If the condition of a tool indicates that it has been used without an air service unit, the user should be advised accordingly. Each tool should have its own lubricator/filter/pressure-regulator set.

NOTE Pneumatic compression tooling usually achieves the required compression forces by the use of levers, the maximum force being achieved at the point of die closure. The die levers will normally click past this point of highest pressure on closing, thus indicating the completion of compression action.

Tool and die combinations should be checked for the clicking action at the minimum rated air pressure whilst compressing appropriate sized terminals to their rated conductors which, if satisfactory, can be used as specimens for tensile testing. Dies should also be checked using "go/no-go" gauges whilst in the closed position.

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A.5 Hydraulic compression tools with integral pumps

Tools and accompanying dies should be examined carefully for missing parts, damage and excessive wear. Dies should be checked for correctness of fit and to ensure the correct compression cavity when the dies are closed by use of "go/no-go" gauges. If the dies do not gauge correctly, the appropriate repair or replacement should be undertaken. All pins, linkages, joints and levers should operate smoothly without excessive play. Hydraulic fluid should be drained and all valves, cylinders, pistons and seals should be carefully examined and adjusted or replaced as necessary. All parts should be thoroughly cleaned and lubricated as appropriate and reassembled.

After filling with the correct grade of clean hydraulic fluid, tools should be tested at operating pressures for presence of leaks. The pump pressure or operating force as specified by the manufacturer should be checked to ensure that the pressure relief valve operates correctly.

A.6 Hydraulic compression heads

Compression heads should be examined in a similar manner to hydraulic compression tools with integral pumps. The compression head should be fitted with the correct dies and tested using a service pump providing the correct pressure and volume of oil for the purpose. Dies should be checked for correctness of fit and to ensure the correct compression cavity using "go/no-go" gauges when the dies are closed. If the dies do not gauge correctly, the appropriate repair or replacement should be undertaken.

A.7 Hydraulic pumps

Hydraulic pumps should be examined in a similar manner to hydraulic compression tools with integral pumps. The hydraulic pumps should be tested for pressure using a suitably calibrated hydraulic pressure gauge.

A.8 Preparation and testing of compression specimens

Specimens should be prepared and tested in accordance with the tensile test requirements of the reference standard, e.g. BS 4579 ⟩A1⟨ or BS EN 61238-1, as appropriate ⟩A1⟨, as follows.

a) For single die tools, three specimens.

b) For tools with multiple or interchangeable dies, three specimens per die to fit the largest die specified by the user.

c) For pneumatic tools with interchangeable die sets, three specimens per die set.

The specimens should be tensile tested in accordance with the reference standard. If a specimen should fail to meet this requirement, the tool responsible should be adjusted as necessary and retested to ensure conformity.

Details of the above operations should be entered on the tool history record.

A.9 Certificate

The Inspection and Test Certificate should show the following:

a) user (customer) name, address, contact name and order number;

b) date, Certificate serial number, tool history reference number, user's tool reference number (if any) and the tool manufacturer and paint number;

c) style of tool with completed check-list of operations;

d) details of any special requirements, non-typical applications, etc.;

e) details of tensile test showing the reference standard, the standard acceptance level and the results, manufacturer and paint number of the terminal manufacturer and details of the cable used;

f) comments to the user;

g) authorized signature on behalf of the maintenance, test and certification authority;

h) quality system status of inspection and certification authority.

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List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 4320:1968, *Specification for metal washers for general engineering purposes. Metric series.*

[A1]BS EN 60228:2005, *Conductors of insulated cables.*[A1]

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

[A1]BS 4579-2:1973, *Specification for the performance of mechanical and compression joints in electric cable and wire connectors — Part 2: Compression joints in nickel, iron and plated conductors.*

BS EN 61238-1:2003, *Compression and mechanical connectors for power cables for rated voltages up to 36 kV (U_m = 42 kV) — Part 1: Test methods and requirements.*

BS EN ISO 9000:2005, *Quality management systems — Fundamentals and vocabulary.*[A1]

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