BS 5L 101:2011

BSI Standards Publication

Procedure for inspection, testing and acceptance of aluminium-base and magnesium-base ingots and castings

bsi.

...making excellence a habit.™

Publishing and copyright information

ISBN 978 0 580 70462 8

ICS 49.025.20

The following BSI references relate to the work on this standard:
Committee reference ACE/61
Draft for comment 10/30216241 DC

Publication history

First published February 1950
Second edition November 1959
Third edition March 1970
Fourth edition December 1990
Fifth (present) edition December 2011

Amendments issued since publication

Date	Text affected

Contents

List of tables

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 26, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 December 2011. It was prepared by Panel ACE/61/-/24, *Light alloys*, under the authority of Technical Committee ACE/61, *Metallic materials for aerospace purposes*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This standard supersedes BS 4L 101:1990, which is withdrawn.

Information about this document

This standard is a full revision of BS L 101. The principal changes from the previous edition are:

Section 1:

a) Definitions amended.

b) Information to be supplied by purchaser added.

c) Information to be agreed between manufacturer and purchaser added.

d) Qualification of foundry technique requirements added.

e) Impregnation requirements added.

f) HIPping requirements added.

g) Temperature control during heat treatment to BS M 54 replaced by AMS 2750.

h) Re-qualification requirements added.

i) Application of values requirements added.

j) Tensile testing at ambient temperature to BS A4-1.1 replaced by BS EN 2002-1.

k) Hardness testing to BS A4-5 replaced by BS EN ISO 6506-1 and BS EN ISO 6508-1.

l) Heat treatment temperature tolerances added.

m) Penetrant flaw detection to BS M 39 replaced by EN 2006-16 and requirements for penetrant sensitivity added.

n) Radiological examination to BS M 34 replaced by BS 2002-21.

o) Protection requirements amended.

Section 3:

- Impregnation requirements deleted and transferred to Section 1.

Appendix A:

- Re-identified as Annex B and reference to withdrawn BS 1957 replaced by details for rounding of values.

Appendix B:

- Re-identified as Annex A and quenchant temperature requirements amended.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its methods are expressed either as a set of instructions or in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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.

Section 1: General

1 Scope

This British Standard specifies a procedure for the inspection and testing of aluminium alloy and magnesium alloy ingots and castings to be used for aerospace purposes and other critical applications.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 2002-1, *Metallic materials – Test methods – Part 1: Tensile testing at ambient temperature*

BS EN ISO 3452-2, *Non-destructive testing – Penetrant testing – Part 2: Testing of penetrant materials*

BS EN ISO 6506-1, *Metallic materials – Brinell hardness test – Part 1: Test method*

BS EN ISO 6508-1, *Metallic materials – Rockwell hardness test – Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

EN 2002-16, *Metallic materials – Test methods – Part 16: Non-destructive testing – Penetrant testing*[1)]

EN 2002-21, *Metallic materials – Test methods – Part 21: Radiographic testing of castings*[1)]

AMS 2750, *Pyrometry*

ASTM E155, *Standard reference radiographs for inspection of aluminium and magnesium castings*

3 Definitions

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

3.1 alloying additions

materials in elemental or alloy form for use in making up melts from a virgin metal base

3.2 approved ingot

ingot which has been proved to conform to the chemical composition specified in the material specification

3.3 approved scrap

scrap which arises from the founder's own production from approved material and which is segregated and identified. It may include headers, runners and heavy fettling scrap, but excludes all small particles

[1)] Published as ASD Prestandard at the date of publication of this standard.

3.4 batch

ingots for remelting or castings, each of which is:

a) of the same form and of the same nominal dimensions or of the same drawing number; and

b) from the same cast for ingots or from the same melt for castings; and

c) from the same heat treatment charge.

3.5 cast (term used for ingots)

metal taken from the same furnace or from the same ladle or from several furnaces and mixed in the same furnace or in the same ladle before pouring where a continuous melting process is used, a cast may be defined as metal taken from the furnace before the next following charge

3.6 designated area

highly stressed or otherwise important region of a casting, the location of which is determined by the Design Authority and stated on the drawing or associated documents

3.7 design authority

organization responsible for the detailed design of materiel and which has the responsibility of certifying and/or sealing drawings and specifications

NOTE The Design Authority may not be the purchaser

3.8 melt (term used for castings)

metal taken from the same furnace or from the same ladle, or from several furnaces and mixed in the same furnace or in the same ladle before pouring

3.9 permanent mould casting

casting made by introducing molten metal by gravity or pressure into a metal mould

3.10 precision casting

casting made by any of the following processes or any similar process:

a) investment, including ceramic shell, and block mould;

b) ceramic piece moulding, e.g. Shaw;

c) resin shell mould;

d) plaster.

3.11 purchaser

body which purchases the products from a founder

NOTE The purchaser may not be the Design Authority

3.12 quality assurance authority

body responsible for authorizing the founder or supplier to issue certification, when to certify means to attest as meeting a standard

3.13 sand casting

casting made by a process involving the moulding of a pattern with a suitably bonded sand

3.14 undesignated area

regions within a casting which have not been designated

3.15 virgin metal

pure aluminium or magnesium with impurity levels such that they will conform to the material specification for which its use is intended

4 General

This standard details the basic requirements for the inspection and testing of British Standard Aerospace L series cast aluminium base and magnesium base alloys.

In addition to the definitive requirements, this standard also requires the items detailed in Clause **5** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

If the purchaser wishes to specify an inspection, testing or acceptance procedure for any property of any product, which differs from that specified in this standard, this shall be agreed between the purchaser and the manufacturer and shall be fully documented on the order, drawing or inspection schedule, provided that the purchaser is also the quality assurance authority. If the purchaser is not also the quality assurance authority, deviations from the requirements of this standard shall only be agreed and documented after written approval has been obtained from the quality assurance authority.

5 Information and requirements to be agreed and to be documented

5.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser, which is specified in the clauses referred to, shall be fully documented on the order, drawing or inspection schedule, on which the number of this British Standard shall also be given.

Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard [2)] can be made and verified.

a) General:

   1) the number of the material specification with which this standard is to be used;

   2) all details relating to pre-production castings in order to optimize and qualify the method of manufacture and mould configuration and to demonstrate that the requirements of the Design Authority can be met (see **6.1**);

   3) the heat treatment required if different from that specified in the material specification (see **9.1**);

   4) radiological examination technique (see **13.7.1**);

[2)] Marking a British Standard identifier (e.g. BS 2L 169:2002) on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

5) the radiological acceptance standard if other than level B (see **13.7.3**);

6) all details relating to any special protective treatment (see Clause **16**);

b) Castings not subject to cut-up testing:

1) if one test sample per casting is required (see **24.1.4**);

c) Castings subject to cut-up testing:

1) the method of obtaining the test samples (see **30.1.1**)

5.2 Items to be agreed between the founder and the purchaser

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 the standard and the following documented items shall be satisfied before a claim of compliance with the standard [3)] can be made and verified.

a) if weld repair is permitted in order to consistently produce castings fully compliant with drawing requirements (see **6.3**);

b) if correction of distortion is permitted (see **7.2**);

c) if impregnation is permitted (see **7.3**);

d) if Hot Isostatic Pressing (HIPping) is permitted (see **7.4**);

e) method of temperature control if other than AMS 2750 (see **9.2**);

f) if the use of polyalkylene glycol is permitted as a quenchant (see **9.4**);

g) if non-standard test pieces cut from castings, cast integrally with castings or gated to castings are permitted (see **13.2.2**);

h) if non-standard separately cast test-pieces are permitted (see **13.2.3**);

i) if flaw detection using non-fluorescent penetrants is permitted (see **13.6.1**);

j) standards of acceptance for other than cracks or crack-like defects (see **13.6.4**);

k) if weld repair of series production castings is permitted (see **14.1**);

l) any special requirements for approved ingots (see Clause **20**);

m) if it is permissible to relax the frequency of chemical composition determination (see **23.2**);

n) if it is permissible to use one test sample to represent a series of melts made from one cast of approved ingot (see **24.1.2**);

o) if it permissible, for re-test purposes, to submit one or more representative castings to cut-up test (see **26.1 3**);

p) for re-test purposes, the form, size and location of the test pieces and the minimum mechanical test values to be obtained (see **26.1 3**);

q) if it is permissible for the number of test pieces machined from each casting to be less than that machined from the pre-production approval casting(s) during routine cut-up testing (see **30.1.2**);

[3)] Marking a British Standard identifier (e.g. BS 2L 169:2002) on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

6 Pre-production castings – qualification of foundry technique

6.1 Prior to commencing series production of a design, pre-production castings shall be produced in order to optimize and qualify the method of manufacture and mould configuration and to demonstrate that the requirements of the Design Authority can be met.

NOTE It is strongly recommended that the technical representative of the founder should be given the opportunity to examine the casting drawing at the initial stages of design and to advise on the optimum design which will enable acceptable castings to be produced consistently.

The following requirements shall be specified on the order, drawing and / or inspection schedule [see **5.1**a)2)]:

a) number of pre-production castings to be produced for evaluation / qualification;

b) heat treatment condition of the pre-production castings including any requirements for machining prior to heat treatment;

c) any areas on the castings which are critical and for which a high internal and / or external defect standard is required;

d) type, number and locations of tests / inspections necessary to evaluate and qualify the method of manufacture such as dimensions, mechanical properties, microstructure, macrostructure, etc;

e) whether the method of manufacture needs to be agreed with the Design Authority or shall be at the founder's discretion;

f) the surface finish required;

g) any special requirements for the repair and impregnation of the castings;

h) who shall perform the evaluation / qualification.

6.2 Qualification of the pre-production castings shall be carried out and include those inspections and tests which will be performed on production castings. All manufacturing parameters shall be recorded with the following foundry techniques, in particular, being noted:

a) position of runners and risers;

b) position and nature of chills;

c) type of moulding material and details of mould manufacturing parameters;

d) mould temperature;

e) maximum amount of approved scrap which may be added to the melt (at the founder's discretion);

f) casting temperature range;

g) heat treatment details;

h) method of surface finishing.

6.3 Unless otherwise agreed with the Design Authority, it shall be demonstrated that the casting procedure developed is capable of consistently producing castings fully compliant with drawing requirements, without the need for weld repair [see **5.2**a)].

6.4 When all inspection and test results relating to pre-production castings required by **6.2** have been reported and considered as satisfactory by the Design Authority, the founder shall compile a manufacturing schedule defining the

foundry technique and inspection requirements, including any radiographic techniques to be used. This shall be made available to and / or be subject to written agreement with the Design Authority as required. Series production shall commence when written agreement or an order has been received from the Design Authority or purchaser.

7 Manufacture of production castings

7.1 General

The method of manufacture of production castings shall be the same as the method of manufacture of the pre-production castings, except by agreement between the founder and the Design Authority and following written approval by the Design Authority including any requirement for re-qualification of the castings.

7.2 Correction of distortion

Correction of distortion shall be carried out only by agreement between the founder and Design Authority [see **5.2**b)]. The founder shall be responsible for specifying the conditions under which such correction shall be carried out, subject to any requirements of the Design Authority. The method agreed shall be incorporated in the manufacturing schedule. After correction of distortion, all castings so treated shall be examined by penetrant flaw detection (see **13.6**).

7.3 Impregnation

Impregnation shall only be used with the prior, written agreement of the Design Authority [see **5.2**c)].

If required, impregnation of castings shall be as stated on the drawing, order or associated documents together with the system to be used.

All welding, heat treatment, or other heating processes which would subject the casting to temperatures exceeding 150 °C, shall be completed before impregnation is carried out.

7.4 Hot Isostatic Pressing (HIPping)

HIPping shall only be used as an integral part of the casting technique with the prior, written agreement of the Design Authority [see **5.2**d)].

8 Re-qualification requirements

At the discretion of the Design Authority, re-qualification of serial production castings shall be required in the following instances:

a) modification to the drawing;

b) use of re-melt stock from a different source;

c) modifications to the approved casting route;

d) use of a new casting founder;

e) when a significant time interval (usually several years) has elapsed between casting campaigns for a specific part;

f) if new tooling is used;

g) when required by the Design Authority for any other reason.

Re-qualification testing requirements, especially location / type of test samples, shall be identical to those used for the initial qualification of the pre-production castings unless otherwise specified on the order, drawing or inspection schedule.

9 Heat treatment

9.1 Heat treatment shall be carried out in accordance with the material specification or order [see **5.1**a)3)].

9.2 Unless otherwise agreed between the manufacturer and the purchaser [see **5.2**e)], temperature control during heat treatment shall be in accordance with AMS 2750.

9.3 If a specific temperature (value and tolerance) is given in the material specification, that temperature shall be used. If a temperature range is given in the material specification, a temperature within that range, reduced by the tolerance, shall be selected that will give the properties specified in the material specification. The charge shall be maintained at the heat treatment temperature ±5 °C for the period given in the material specification. If no period or temperature are given in the material specification these shall be at the discretion of the manufacturer.

9.4 When minimum distortion or low residual stresses are desired, and where permitted by the material specification, or agreed by the Design Authority [see **5.2**f)], it is permissible for castings to be quenched in an aqueous solution of polyalkylene glycol (polymer quenchant). The control and use of such solutions shall be in accordance with Annex A.

10 Chemical composition

10.1 The chemical composition of the ingots, castings, and melts made from virgin metal plus alloying additions shall conform to the material specification.

10.2 From each cast of ingot and each melt of castings, a chill cast analytical sample or samples shall be prepared and suitably marked to ensure identification.

10.3 No additions shall be made to cast or melt after the final analytical sample(s) has been selected.

10.4 Elements not quoted in the material specification shall not be intentionally added to the alloy except for the purpose of fluxing, degassing or modification of the cast or melt.

10.5 If in the course of routine analysis the presence of elements other than those named in the material specification is detected, the amounts of these other elements and/or their total shall not exceed the limits given in the material specification.

10.6 The values stipulated in the specification shall be applied in accordance with Annex B.

11 Dimensions and tolerances

11.1 The dimensions of the casting shall be measured and shall fall within the tolerances specified on the drawing.

11.2 Designated dimensions, as indicated on the drawing or inspection schedule, shall be measured on each casting. For other dimensions the frequency of measurement shall be at the discretion of the manufacturer.

11.3 The datum points to be used for dimensional inspection, machining or jigging shall be as stated on the drawing.

12 Freedom from defects

12.1 Ingots

The ingots shall be clean and free from harmful defects.

12.2 Virgin metal and alloying additions

Virgin metal and alloying additions shall be clean and free from harmful defects.

12.3 Castings

12.3.1 The castings shall be clean and free from harmful defects.

12.3.2 Any casting may be rejected for manufacturing faults, defects or incorrect dimensions, whether discovered during inspection or subsequently during machining, despite prior acceptance that the casting conformed to the chemical composition and mechanical test requirements of the material specification.

13 Testing

13.1 General

13.1.1 The tests carried out and the test methods used shall conform to either:

a) the material specification; or

b) the relevant section of this standard; or

c) the order or inspection schedule.

(See Clause **5**.)

13.1.2 The frequency of sampling shall be as given in the relevant section of this standard.

13.2 Preparation of test samples

13.2.1 Separately cast test samples shall be of such dimensions that test pieces of not less than 11.28 mm diameter are provided to represent sand and permanent mould castings, and test pieces not less than 3.99 mm diameter are provided to represent precision castings.

13.2.2 Test samples cut from castings, cast integrally with castings or gated to castings shall be machined to the dimensions of the largest size of test piece shown in BS EN 2002-1, that can be prepared from the test samples. If non-standard test pieces are to be prepared the prior agreement of the purchaser [see **5.2**g)] shall be obtained.

13.2.3 Separately cast test samples shall be of one of the forms shown in Table 1. If non-standard test-pieces are to be used, the prior agreement of the purchaser [see **5.2**h)] shall be obtained.

13.2.4 The metal for the test samples shall be taken from the melt from which the castings are to be poured and shall be in that condition, except that the temperature may be adjusted to that suitable for pouring the test samples.

13.2.5 The test samples shall not be mechanically worked nor subjected to any thermal treatment, other than that required by the material specification, before they are tested.

Table 1 **Cast test sampling**

Material represented	Test sample (see Figure 1 to Figure 5)
Sand castings	Form A, B, E or F sandcast Form A and B made in sand moulds rammed into any convenient container, e.g. a steel tube, so that the tapering portion of the bar is separated from the container walls by not less than 27 mm of sand
Permanent mould castings	Form C or D, chill cast
Precision castings	Form G or H cast to size or with a machining allowance, in mould material similar to that used for the castings, except for plaster based mould castings which may be represented by sand cast test samples (see Note) Alternative running systems are permitted

NOTE British Standards for castings for aerospace applications include a note drawing attention to the fact that the tensile values specified for test pieces prepared from separately cast test samples may not always be realized in certain portions of the castings. Attention is also drawn to the fact that, in the special case where castings are made by the plaster based mould process, they may have lower properties than similar castings made by the sand mould process, and that this will not necessarily be reflected in the results achieved from sand cast test samples used to represent plaster mould castings. For the purposes of this standard, separately cast test samples are required primarily to demonstrate that, when cast in a standard form, the metal used is of such a quality as will meet the minimum tensile test requirements and to provide a simple method of assessment of the control of heat treatment operations.

13.3 Tensile test at ambient temperature

13.3.1 Tensile testing at ambient temperature shall be carried out in accordance with BS EN 2002-1.

13.3.2 The test pieces shall be prepared from the test samples (see **13.2**) and shall be to the dimensions of the largest practicable size test piece specified in BS EN 2002-1.

NOTE Test piece form G may be tested unmachined.

13.3.3 The values obtained shall conform to the material specification and/or the Inspection Schedule or drawing requirements.

13.4 Hardness test

13.4.1 If required by the specification or drawing, hardness testing shall be carried out using one of the methods listed in **13.4.2** or **13.4.3** as specified in the material specification.

13.4.2 Brinell hardness testing shall be carried out in accordance with BS EN ISO 6506-1. If not specified in the material specification, the ratio of F/D^2 shall be 10. Periodic checking of the testing machine by the user shall be carried out in accordance with, and at the frequency specified in, BS EN ISO 6506-1.

13.4.3 Rockwell hardness testing shall be carried out in accordance with BS EN ISO 6508-1. Periodic checking of the testing machine by the user shall be carried out in accordance with, and at the frequency specified in, BS EN ISO 6508-1.

13.5 Application of values

For the purpose of determining conformity to the limits specified in the material specification, excluding dimensions, an observed or a calculated value obtained from a test shall be rounded in accordance with Annex B.

13.6 Penetrant flaw detection

13.6.1 After all specified heat treatments have been completed, each casting shall be penetrant flaw detected in accordance with EN 2002-16. Unless otherwise agreed with the Design Authority, flaw detection shall be carried using fluorescent penetrants [see **5.2**i)].

13.6.2 Fluorescent penetrants to be used for machined and unmachined castings shall have a sensitivity corresponding to at least sensitivity level 1 of BS EN ISO 3452-2.

13.6.3 Where the use of colour contrast penetrants is permitted, colour contrast penetrants to be used for machined and unmachined castings shall have a sensitivity corresponding to at least sensitivity level 1 of BS EN ISO 3452-2.

13.6.4 Castings shall be free from cracks and crack-like indications. The standard of acceptance for other defects shall be agreed between the founder and the purchaser [see **5.2**j)] and stated on the drawing, order or inspection schedule.

13.7 Radiological examination

13.7.1 Where radiological examination is specified, the castings shall be radiologically examined in accordance with EN 2002-21 to a technique stated on the drawing, order or inspection schedule [see **5.1**a)4)]. The radiological technique for each pattern of casting shall be agreed with the Design Authority.

13.7.2 The radiographs shall be suitably identified with the castings they represent and shall be supplied to the Design Authority with the castings.

13.7.3 Radiographic indications shall be identified in terms of the defects listed in Table 2 for aluminium alloy castings, or Table 3 for magnesium alloy castings. Acceptance shall be made in accordance with the defect level stated on the drawing, order or associated document [see **5.1**a)5)].

13.7.4 If no level is specified, level B shall apply to all radiographed areas of a casting. The castings shall conform to the appropriate acceptance levels for all the defects listed in Table 2 or Table 3. The acceptance levels given apply to each 50 mm × 50 mm area of the casting as defined in ASTM E155.

Despite conformance to the appropriate acceptance standard for individual defects the following shall apply to each 50 mm × 50 mm area.

a) No more than one type of defect shall be permitted at the minimum acceptance level.

b) If two types of defects are present, both shall be at least one level better than the minimum acceptance level.

c) Irrespective of level, not more than two types of defects shall be permitted in one area.

d) Defects associated with an edge or extremity shall not be permitted.

Table 2 **Radiographic defect acceptance levels for aluminium alloy castings**

Defect	ASTM E155 plate designation	Acceptance levels		
		A	B	C
Gas holes	¼ in	1	2	5
	¾ in	1	2	5
Gas porosity (round)	¼ in	1	3	7
	¾ in	1	3	7
Gas porosity (elongated)	¼ in	1	3	5
	¾ in	1	4	5
Shrinkage (cavity)	¼ in	1	2	3
	¾ in	As ¼ in	As ¼ in	As ¼ in
Shrinkage (sponge)	¼ in	1	2	4
	¾ in	1	2	3
Foreign material (less dense)	¼ in	1	2	4
	¾ in	1	2	4
Foreign material (more dense)	¼ in	1	2	4
	¾ in	1	1	3
Cracks	—	None	None	None
Cold shuts	—	None	None	None

NOTE 1 For thicknesses up to and including 13 mm, ¼in radiographs should be used. For thicknesses greater than 13 mm, ¾ in radiographs should be used.

NOTE 2 Level A is included to permit certain areas to be specified at superior quality and is only to be called up in designated areas. The level may not be achievable in all alloys and castings and should only be specified after discussion with the founder. Level C is provided for the convenience of purchasers to specify where level B is not required or is not attainable for particular castings.

NOTE 3 Other levels for radiographic indications may be agreed between founder and purchaser or as an alternative it is permissible for radiographs of actual castings to be used to record the standard of acceptance.

Table 3 **Radiographic defect acceptance levels for magnesium alloy castings**

Defect	ASTM E155 plate designation	Acceptance levels				
		All alloys	Alloys with zirconium		Alloys without zirconium	
		A	B	C	B	C
Gas holes	¼ in	1	3	5	2	3
	¾ in	1	3	4	2	3
Segregation (oxide skins)	¼ in	1 [A)]	2	3	[A)]	[A)]
Micro-shrinkage (sponge)	¼ in	1	2	3	2	3
	¾ in	1	3	4	2	3
Micro-shrinkage (feathery)	¼ in	1	3	4	3	4
	¾ in	1	4	5	3	4
Foreign material (less dense)	¼ in	2	2	3	2	3
	¾ in	2	4	4	2	3
Foreign material (more dense)	¼ in	1	1	1	1	1
	¾ in	0	1	1	1	1
Reacted sand inclusions	¼ in	2	3	4	—	—
Eutectic segregation (micro-shrinkage type)	¼ in	2	2	3	—	—
Gravity segregation	¼ in	2	3	5	—	—
Cracks	—	None	None	None	None	None
Cold shuts	—	None	None	None	None	None

NOTE 1 Where applicable, ¼ in radiographs should be used for thicknesses up to and including 13 mm and ¾ in radiographs should be used for thicknesses over 13 mm.

NOTE 2 Level A is included to permit certain areas to be specified at superior quality and is only to be called up in designated areas. The level may not be achievable in all alloys and castings and should only be specified after discussion with the founder.

Level C is provided for the convenience of purchasers to specify where level B is not required or is not attainable for particular castings.

NOTE 3 Other levels for radiographic indications may be agreed between founder and purchaser or as an alternative it is permissible for radiographs of actual castings to be used to record the standard of acceptance.

[A)] For oxide skins in alloys without zirconium use foreign material (less dense) plates, and their associated grades.

14 Repair of castings

14.1 Castings shall be repaired only with the agreement of the Design Authority [see **5.2**k)]. Unless the Design Authority stipulates a particular method of repair, the founder shall submit the proposed method to the Design Authority. All repairs shall be carried out before impregnation and/or sealing.

14.2 Prior to weld repair, defects shall be completely dressed out. Each weld preparation area shall be subject to penetrant flaw detection (see **13.6**) to ensure that defects have been completely removed.

14.3 If castings are pre-heated prior to weld repair, the pre-heating shall be carried out in such a manner that the mechanical properties of the finally heat treated castings are not adversely affected.

14.4 Weld repair of castings shall be carried out by a welder whose competence has been satisfactorily demonstrated. The founder shall devise a scheme for demonstrating the competence of the welder and, if required by the order, specification or associated document, shall submit details of the scheme and the results of any competence tests to the Design Authority for approval.

14.5 Castings that have been repaired shall be heat treated in accordance with the material specification. Each batch of repaired castings shall be heat treated together with the test samples, provided in accordance with Clause **24** or Clause **30**, as appropriate, which shall subsequently be tested and shown to conform to the material specification and/or the inspection schedule.

14.6 Repaired castings shall be radiographed to ensure that the repair has been carried out in such a manner as to give satisfactory fusion and freedom from harmful defects. The radiographs shall be suitably identified with the castings they represent and supplied to the purchaser with the castings. If the defect has been detected by radiography, the original radiographs shall also be supplied.

14.7 Repaired castings shall be subjected to penetrant flaw detection in accordance with **13.6**.

14.8 Repaired castings shall be identified as such and the release documentation shall be boldly over-stamped "Repaired Castings".

15 Identification

15.1 Ingots

Each aluminium alloy ingot of 4.5 kg and over, and each magnesium alloy ingot of 2.5 kg and over shall be marked with the identification mark of the founder, the specification number and the cast number. Ingots of lesser mass shall be similarly marked or shall be made into bundles, each of which shall have attached a durable label bearing and such other markings as will ensure full identification.

15.2 Virgin metal and alloying additions

When in ingot form, virgin metal and alloying additions shall be identified as given in **17.1**. When in other forms they shall be packed in suitable containers, each of which shall be marked to ensure full identification.

15.3 Castings

Each aluminium alloy casting of 2 kg and over, and each magnesium alloy casting of 1 kg and over shall be permanently identified with and such other markings as will ensure full identification. Castings of lesser mass shall be similarly marked or where this is not possible, shall be suitably bagged or boxed, each container being durably marked as above.

16 Protection against corrosion

The founder shall apply suitable protective treatment to ensure that castings are delivered in a satisfactory condition.

If the purchaser requires special protective treatment this shall be stated on the drawing or order [see **5.1**a)6)].

17 Certification

The founder shall supply with each delivery a certificate of conformity bearing a printed serial number and stating the following:

a) Founder's name and address;

b) Purchaser's contract and/or order number;

c) Material designation, or the number of the material specification, and the number of this British Standard [4];

d) Delivery condition of material;

e) Description of the supplies, with drawing or part number;

f) Quantity;

g) Melt/cast and batch number(s);

h) Process by which the castings were produced;

i) Batch heat-treatment details if appropriate;

j) Identification of casting weld repairs by drawing, sketch, photograph or radiograph;

k) Reference to the numbers of the relevant test reports, or reports containing the results of all the tests carried out including X-ray film serial numbers;

l) Deviations, e.g. concessions or production permits, or any non-conformance;

m) Certification clause signed by an authorized nominee of the founder, in the following form unless otherwise required by the Quality Assurance Authority.

"Certified that the whole of the supplies detailed hereon have been inspected and tested and, unless otherwise stated above, conform in all respects to the requirements of the contract or order."

[4] Marking a British Standard identifier (e.g. BS 2L 169:2002) on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

Section 2: Approved ingots

18 General

This section covers the inspection and testing procedures for ingots and shall be used in conjunction with Section **1**.

19 Chemical composition

19.1 Samples shall be selected and analysed in accordance with Clause **10**.

19.2 The ingot founder shall supply to the founder, in respect of each cast, the results of analysis for the specified elements.

20 Special requirements

Details of any special requirements shall be agreed between the ingot founder and the founder [see **5.2**l)] and stated on the order or inspection schedule.

Section 3: Castings not subject to cut-up testing

21 General

This section covers the inspection and testing procedures for castings not subject to cut-up testing and shall be used in conjunction with Section **1**.

*NOTE The tensile values specified for test pieces from separately cast test samples may not always be realized in certain portions of castings. Castings for which specified mechanical properties are required for test pieces cut from those castings should be ordered in accordance with Section **4**.*

22 Manufacture

22.1 The foundry technique shall be qualified in accordance with Clause **6**.

22.2 The castings shall be made from:

a) approved ingots conforming to Section **2**; or

b) from virgin metal plus alloying additions, in which case, the ingredients shall be fully certified, and recorded by the founder.

NOTE Approved scrap may be added to the melt at the discretion of the founder.

23 Chemical composition

23.1 Except as permitted by **23.2**, the chemical composition of each melt shall be determined for each of the specified elements in accordance with Clause **10**.

23.2 This requirement may be relaxed by agreement with the purchaser [see **5.2**m)], but every specified element shall be analysed at a frequently of not less than one in five consecutive melts, and such relaxation shall be limited to a maximum of two elements.

This relaxation shall not apply, where the melt has been produced from virgin metal.

24 Mechanical testing

24.1 Provision of tensile test samples

24.1.1 Except as permitted by **24.1.2**, at least one test sample shall be separately cast and tested to represent each melt.

24.1.2 Where castings are produced from small melting units, the founder may, by agreement with the purchaser [see **5.2**n)], use one separately cast test sample to represent a series of melts made from one cast of approved ingot.

24.1.3 Sufficient separately cast test samples shall be tested to provide evidence of the quality of the material and of the satisfactory control of heat treatment operations.

24.1.4 If the purchaser requires one separately cast test sample to be tested to represent each casting this shall be stated on the drawing or order [see **5.1**b)1)].

24.2 Tensile test

Tensile testing shall be carried out in accordance with **13.2**.

24.3 Hardness test

Hardness testing shall be carried out in accordance with **13.3**.

25 Heat treated castings

Each batch of castings, together with its related test sample(s) provided in accordance with **24.1**, shall be heat treated in accordance with Clause **9.**

26 Retest procedure

26.1 If any test piece fails to conform to the specified tensile test requirements or if any casting fails to conform to any specified hardness test requirements, the founder shall adopt one or more of the following procedures.

1) select for test a further test sample representing the same casting(s).
2) allow heat-treated castings and test-pieces to be re-heat-treated in accordance with Clause **25** and retested.
3) with the agreement of the purchaser [see **5.2**o)], submit one or more representative castings to cut-up test. The form, size and location of the test pieces and the minimum mechanical test values to be obtained from them shall be agreed between the founder and the purchaser [see **5.2**p)].

26.2 If the retest or cut-up samples conform to the specified properties, the castings shall be accepted.

Section 4: Castings subject to cut-up testing

27 General

This section covers the inspection and testing procedures for castings subject to cut-up testing and shall used in conjunction with Section **1**.

28 Manufacture

The castings shall be made from approved ingots conforming to Section **2**, or alternatively, from virgin metal plus alloying additions. In the latter case, the ingredients shall be fully certified and recorded by the founder.

NOTE Approved scrap may be added to the melt at the discretion of the founder.

29 Chemical composition

The chemical composition of each melt shall be determined for each of the specified elements in accordance with Clause **10**.

30 Mechanical testing

30.1 Provision of tensile test samples

30.1.1 Production control test samples

Sufficient cast test samples shall be cast with each melt and tested to provide evidence of the quality of the material and of the satisfactory control of heat treatment operations.

Test samples for the tests required by the material specification shall be obtained by one or more of the following methods as specified by the purchaser [see **5.1**c)1)]:

a) test samples cut from castings;

b) test samples cast integrally with or gated to castings;

c) test samples cast under similar conditions to the castings they represent but cast in a separate mould from the same melt.

If no method is specified, method c) shall be used.

30.1.2 Routine cut-up tests

At least one casting shall be selected for cut-up testing from each 50 castings of the same pattern produced successively, subject to a minimum of one casting in each period of six months.

Unless otherwise agreed with the purchaser [see **5.2**q)], the number of test pieces shall be as specified in **6.1**d).

NOTE The castings selected may be those rejected for reasons which do not affect the strength properties, e.g. faulty fettling.

30.2 Tensile test

Tensile testing shall be carried out in accordance with **13.2**.

30.3 Hardness test

Hardness testing shall be carried out in accordance with **13.3**.

31 Heat treatment

Each batch of castings, together with its related test sample(s) provided in accordance with **30.1**, shall be heat treated in accordance with Clause **9**.

32 Retest procedure

32.1 Production control test samples

32.1.1 If any test piece prepared in accordance with **30.1** fails to conform to the material specification or other specified values, the founder shall adopt one or more of the following procedures.

a) select for test a further test sample representing the same casting(s);

b) allow heat-treated castings to be re-heat treated in accordance with Clause **31** and re-tested;

c) subject a related casting to the cut-up test procedure in **30.2**.

32.1.2 If the retest samples of **32.1.1**a) or **32.1.1**b) conform to the specified properties or all the test pieces cut from selected casting(s) in accordance with **32.1.1**c) conform to the agreed mechanical test requirements the castings shall be accepted.

32.2 Cut-up test samples

If any test piece prepared in accordance with **30.2** fails to conform to the material specification, the test results shall be submitted to the purchaser and, if appropriate, a retest procedure shall be agreed.

Annex A (normative) Procedure for the use and control of polymer quenchants

A.1 Introduction

This annex defines the procedure for the use and control of polymer quenchants (see **8.4**).

A.2 Procedures and equipment

A.2.1 The quench bath shall contain not more than 30% by volume of polyalkylene glycol additive in water.

A.2.2 The temperature of the quenchant before the commencement of quenching operations shall be as specified in the material specification. During the quench, the quenchant temperature shall not rise by more than 15 °C.

A.2.3 Adequate agitation and/or recirculation of the quenchant shall be provided during the quenching operation.

A.2.4 After quenching, draining and such intermediate rinsing as may be considered necessary, castings shall be finally rinsed in water to ensure that all traces of the quenchant are removed from the surface of castings. The water used for final rinsing shall contain not more than 2% by volume of polyalkylene glycol.

A.3 Testing and control

A.3.1 The temperature of the quench bath shall be determined at a point just below the top surface of the quenching medium and shall be recorded.

A.3.2 The concentration of the polymer quenchant shall be determined on a representative sample from the quench bath at intervals not exceeding one week. The temperature of the sample shall be adjusted to (20 ±5) °C and the concentration shall be determined by measuring the refractive index (which relates directly to concentration) using a refractometer. The refractometer shall be calibrated at intervals not exceeding one year and shall be capable of measuring to within ±1% of the true concentration (see **A.3.4**).

A.3.3 Except where running water is used for final rinsing or where the final rinse bath is drained and replenished at intervals not exceeding two weeks, the concentration of the quenchant in the water used for final rinsing shall be determined at intervals to ensure conformance to **A.2.4**.

A.3.4 To take account of the possible influence of contamination of the quench bath on the refractometer determinations, the true concentration of the quenchant in water shall be determined at intervals not exceeding one year. The determination shall be made on a representative sample from the quench bath by a reference test method.

A.4 Records

Records shall be maintained of the results of all tests and calibrations and of the action taken to correct deviations from this annex.

Annex B (normative) Rules for application of values for chemical composition and mechanical properties given in material specifications

For the purpose of determining conformity to the limits specified in the material specification, excluding dimensions, an observed or a calculated value obtained from a test shall be rounded in one step to the same number of figures used to express the specified limit in the material specification in accordance with the following procedures

a) For units of stress.

   Tensile strength and proof stress values shall be rounded as follows:

   1) stresses up to 250 MPa: to the nearest even number;

   2) stresses over 250 MPa up to and including 1 000 MPa: to the nearest multiple of five;

   3) stresses over 1 000 MPa: to the nearest multiple of 10.

b) For numerical values and other units.

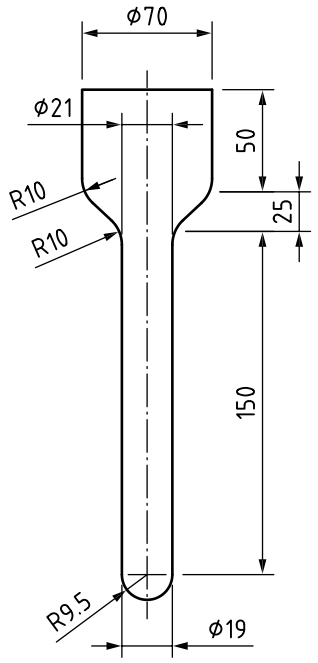
   1) when the figure immediately after the last figure to be retained is less than 5, the last figure to be retained shall remain unchanged;

   2) when the figure immediately after the last figure to be retained is greater than 5, or equal to 5 and followed by at least one figure other than zero, the last figure to be retained shall be increased by one;

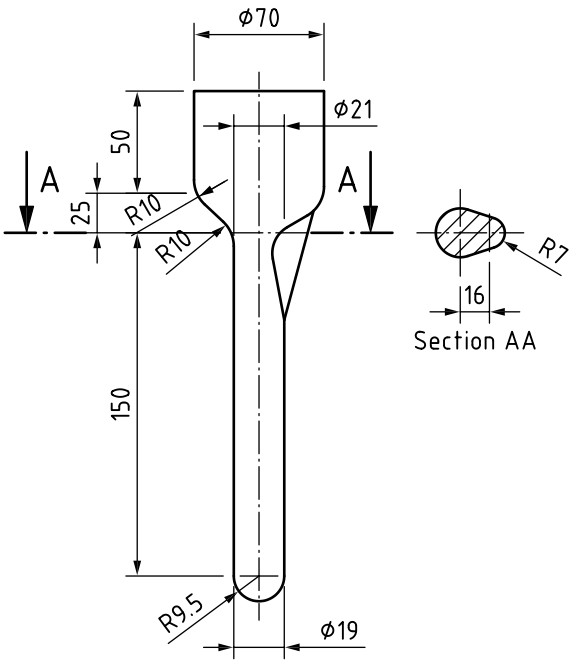
   3) when the figure immediately after the last figure to be retained is equal to 5 and followed by zeros only, the last figure to be retained shall remain unchanged if even and be increased by one if odd.

Figure B.1 **Forms of test samples A, B and C**

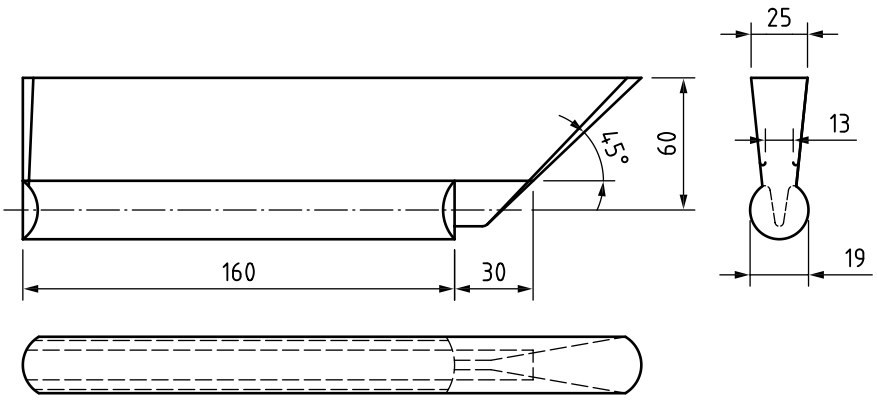
Linear dimensions in millimetres



Form A



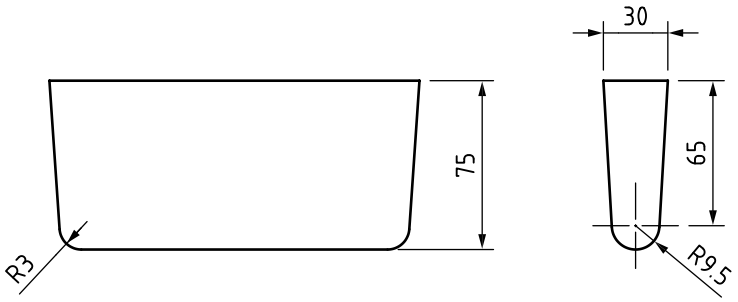
Form B

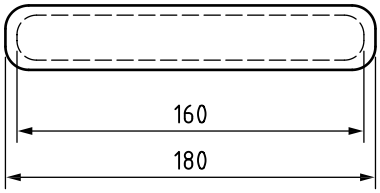


Form C

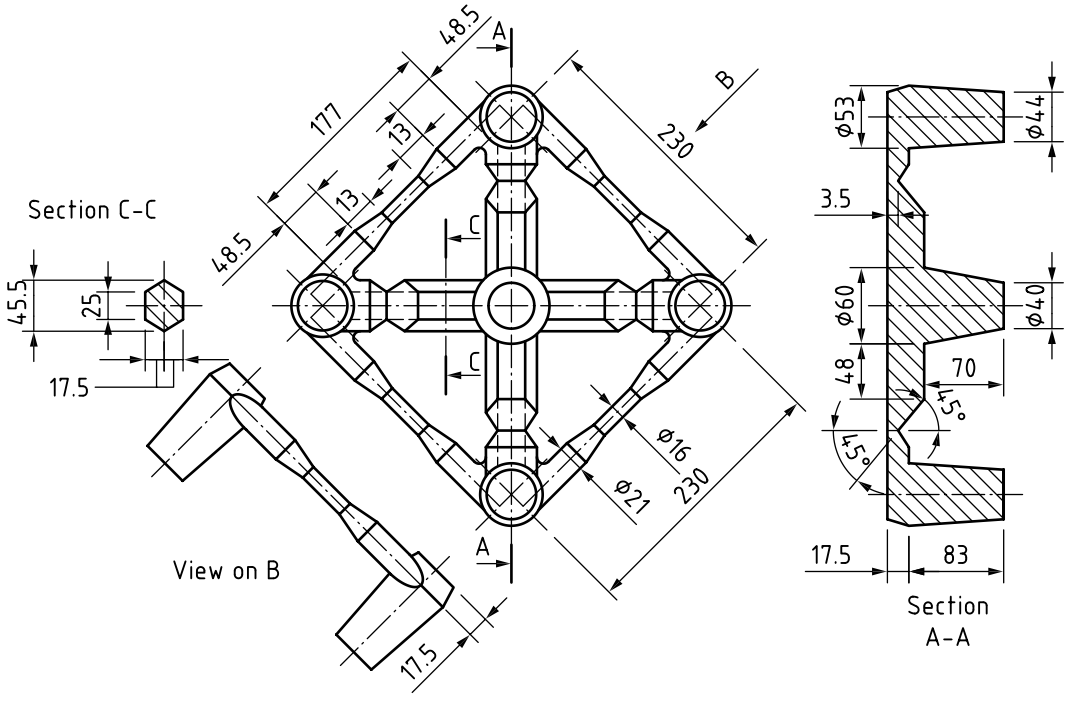
Figure B.2 **Forms of test samples D and E**

Linear dimensions in millimetres





Form D



Form E

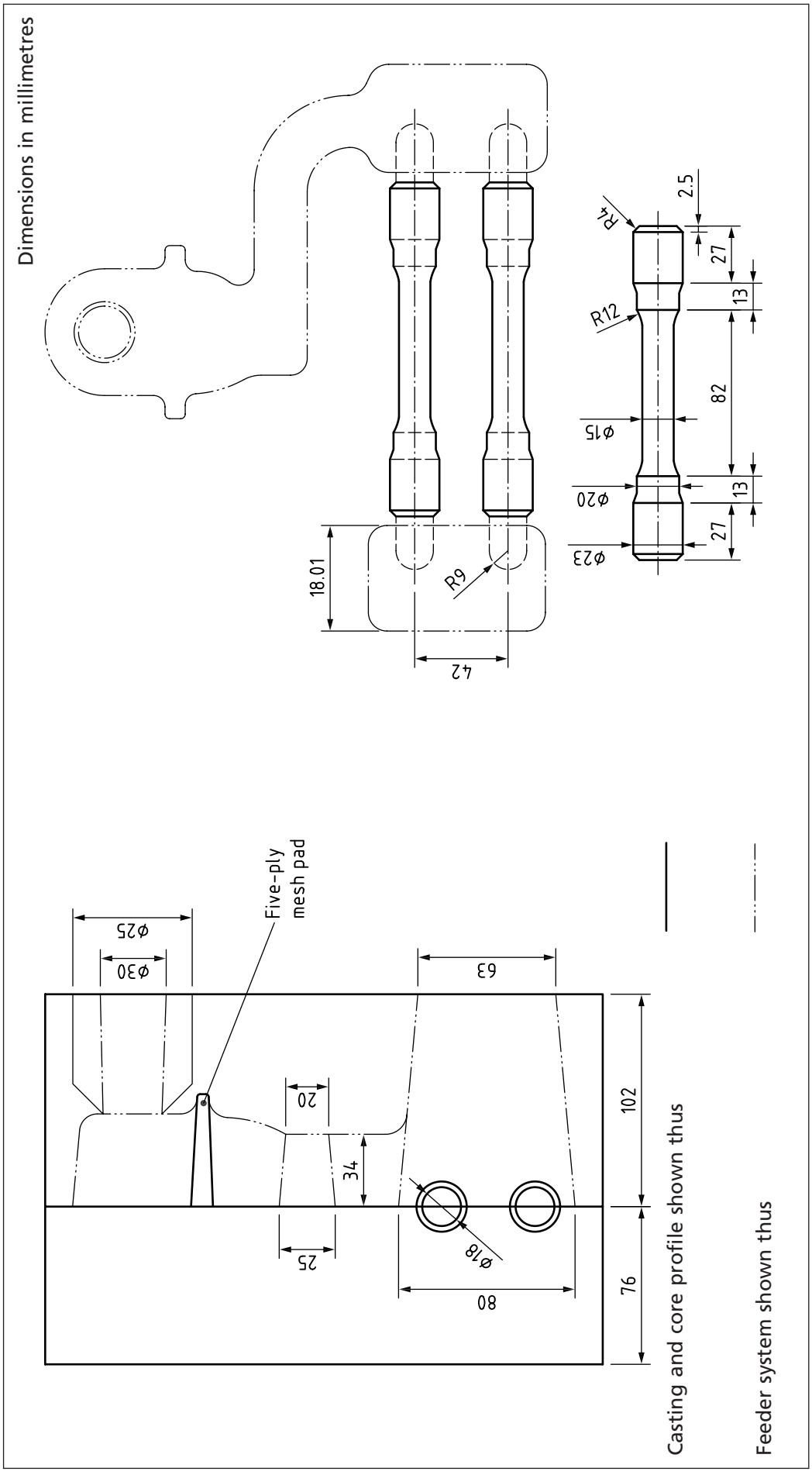
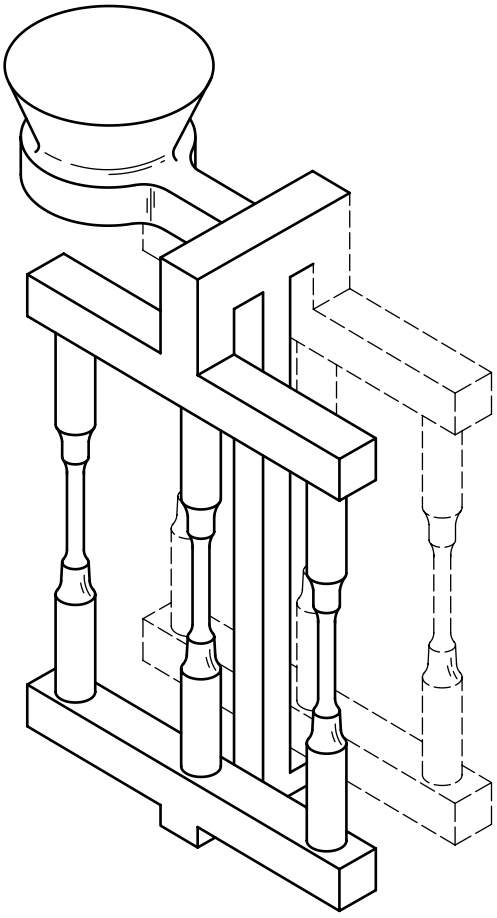


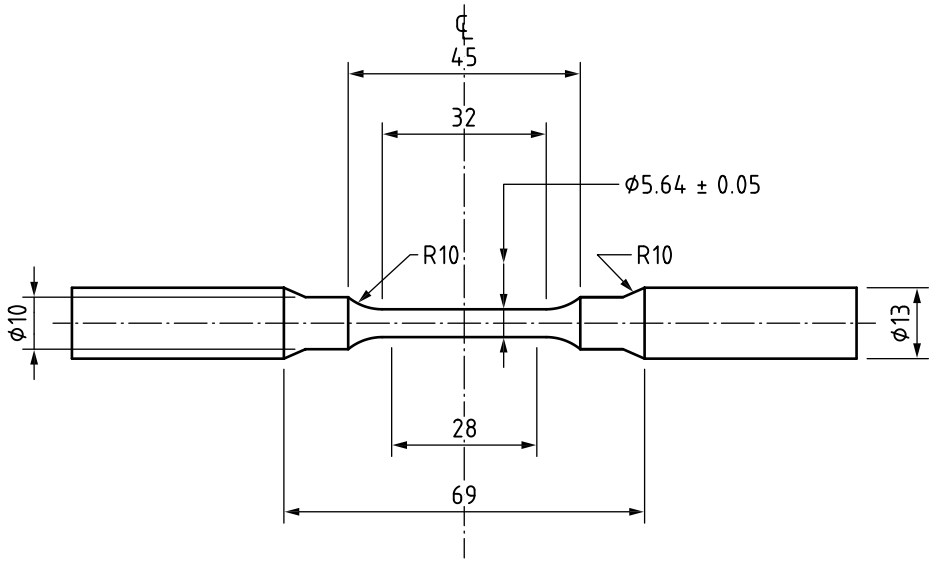
Figure B.3 **Forms of test sample F**

Figure B.4 **Forms of test sample G**

Dimensions in millimetres



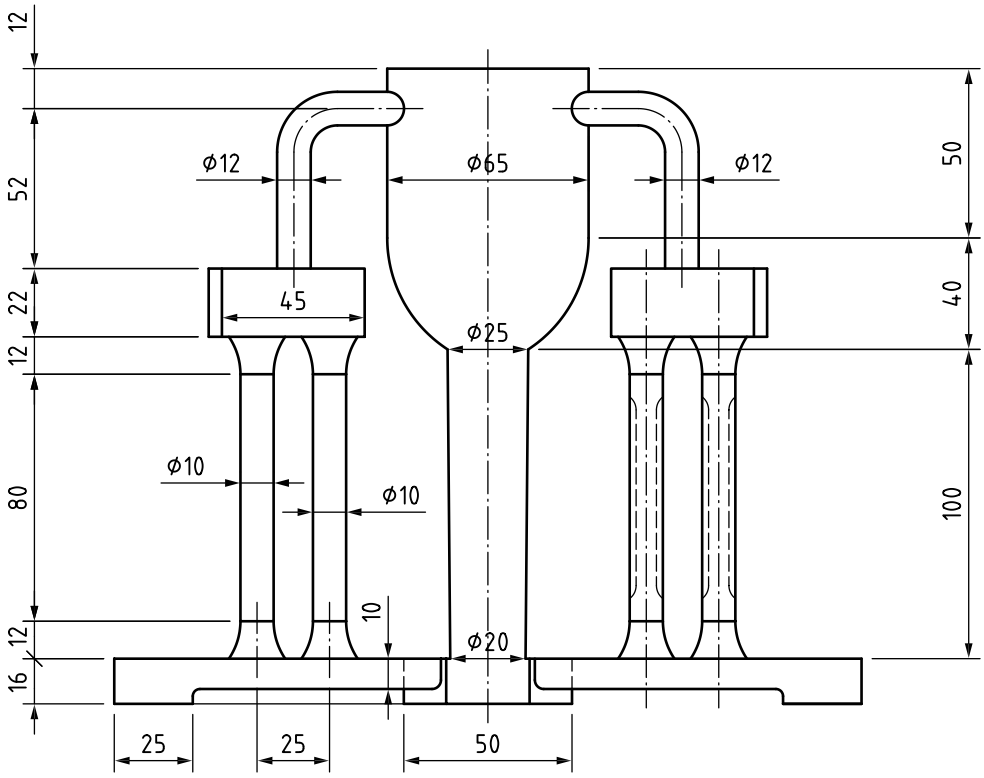
General tolerance ±0.25

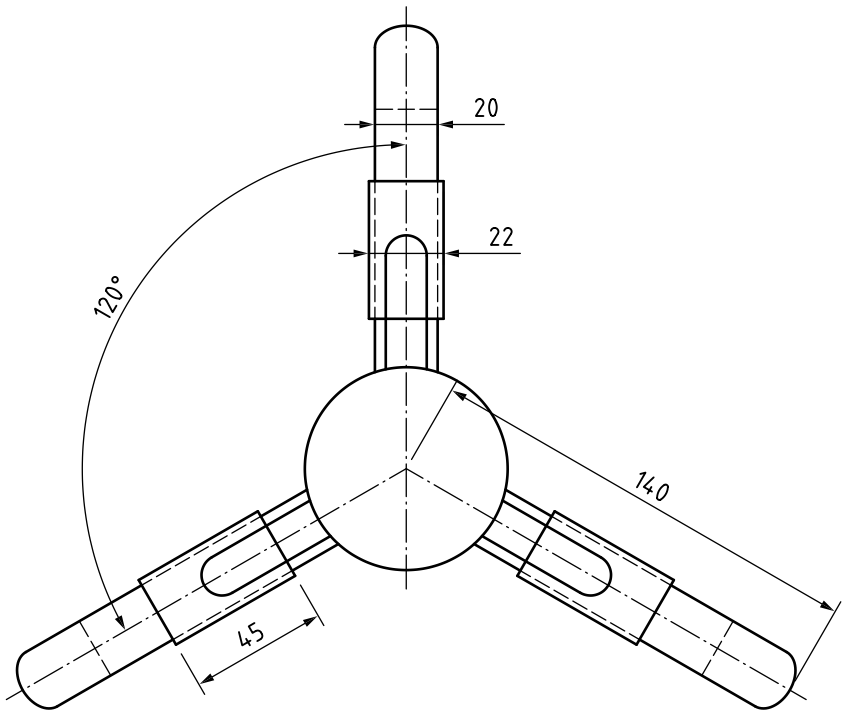


NOTE The mean diameter along the parallel length is not to vary by more than 0.06 mm.

Figure B.5 **Forms of test sample H**

Dimensions in millimetres





This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™