

BS 5L 100:2011+A1:2013



BSI Standards Publication

Procedure for inspection, testing and acceptance of wrought aluminium and aluminium alloys

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Contents

Foreword *vi*

Section 1: General requirements 1

- 1 Scope 1
- 2 Normative references 1
- 3 Definitions 2
- 4 General 5
- 5 Information and requirements to be agreed and to be documented 5
- 6 Manufacture and freedom from defects 8
- 7 Cast aggregation 9
- 8 Heat treatment 9
- 9 Chemical composition 9
- 10 Testing 10
- 11 Marking 12
- 12 Protection and packaging 12
- 13 Certification 13

Section 2: Ingot for hot working 14

- 14 General 14
- 15 Dimensions and tolerances 14
- 16 Tensile test 14
- 17 Electrical conductivity measurement 14
- 18 Internal defects 14
- 19 External defects 15
- 20 Marking 15

Section 3: Extruded bar and section for forging 16

- 21 General 16
- 22 Manufacture 16
- 23 Dimensions and tolerances 16
- 24 Tensile test 16
- 25 Internal defects 17
- 26 External defects 17
- 27 Etch inspection 17
- 28 Marking 18

Section 4: Bar for machining and extruded section not subject to solution treatment 19

- 29 General 19
- 30 Manufacture 19
- 31 Dimensions and tolerances 19
- 32 Batch size 20
- 33 Tensile test 20
- 34 External defects 20
- 35 Marking 20

Section 5: Bar for machining and extruded section subject to solution treatment 21

- 36 General 21
- 37 Manufacture 21
- 38 Dimensions and tolerances 21
- 39 Batch size 22
- 40 Batch uniformity 22
- 41 Tensile test 24
- 42 Internal defects 24
- 43 External defects 24
- 44 Etch inspection 24
- 45 Surface finish 24
- 46 Resistance to stress corrosion cracking 25
- 47 Marking 25

Section 6: Bar for machining and extruded section for highly stressed structures 26

- 48 General 26
- 49 Manufacture 26
- 50 Tensile test 26
- 51 Internal defects 27

Section 7: Forgings 28

- 52 General 28
- 53 Manufacture 28
- 54 Pre-production forgings 28
- 55 Production forgings 29
- 56 Procedure X for process control testing 29
- 57 Forgings subject to heat treatment after delivery 30
- 58 Batch acceptance tensile tests 30
- 59 External defects 32
- 60 Internal defects 33
- 61 Batch uniformity 33
- 62 Grain flow and grain size 34
- 63 Resistance to stress corrosion cracking 34
- 64 Fracture toughness 35
- 65 Special tests 35
- 66 Marking 35

Section 8: Sheet and strip not subject to solution treatment 36

- 67 General 36
- 68 Dimensions and tolerances 36
- 69 Batch size 36
- 70 Tensile test 36
- 71 External defects 37
- 72 Marking 37

Section 9: Sheet and strip subject to solution treatment 38

- 73 General 38
- 74 Dimensions and tolerances 38
- 75 Batch sizes 38
- 76 Tensile test 38
- 77 Batch uniformity 39
- 78 External defects 40
- 79 Cladding thickness 40
- 80 Copper diffusion of 2024 and 2014 A alloys clad with commercially pure aluminium alloy 1050 A 40
- 81 Marking 41

Section 10: Seamless tube not subject to solution treatment 42

- 82 General 42
- 83 Manufacture 42
- 84 Dimensions and tolerances 42
- 85 Batch size 42
- 86 Tensile test 42
- 87 Examination for defects 43
- 88 Surface finish of hydraulic tube 43
- 89 Hydraulic distension test 43
- 90 Drift test for hydraulic tube 44
- 91 Flattening test 45
- 92 Bore test 46
- 93 Marking 46

Section 11: Seamless tube subject to solution treatment 47

- 94 General 47
- 95 Manufacture 47
- 96 Batch uniformity 47

97 Drift test for hydraulic tube 48

Section 12: Wire for rivets 50

98 General 50

99 Dimensions and tolerances 50

100 Batch size 50

101 Tensile test 50

102 External defects 50

103 Grain size 50

104 Torsion test 51

105 Marking 51

Section 13: Hot rolled plate for forgings 52

106 General 52

107 Dimensions and tolerances 52

108 Tensile test 52

109 Electrical conductivity measurement 52

110 Internal defects 52

111 External defects 52

112 Marking 53

Section 14: Plate subject to solution treatment 54

113 General 54

114 Dimensions and tolerances 54

115 Batch sizes 54

116 Tensile test 54

117 Batch uniformity 55

118 Internal defects 56

119 External defects 56

120 Resistance to stress corrosion cracking 56

121 Fracture toughness 56

122 Marking 57

Annexes

Annex A (normative) Rules for application of values for chemical composition and mechanical properties given in material specifications 58

Annex B (normative) Location of tensile test pieces for bar and section 58

Annex C (normative) Tolerances for bar and extruded section 62

Annex D (informative) Application of dimensional tolerances for forgings given in Annex E 68

Annex E (normative) Dimensional tolerances for forgings 72

Annex F (normative) Tolerances on sheet, strip and plate 74

Annex G (normative) Tolerances for drawn tube 81

Annex H (normative) Tolerances on wire diameter 85

List of figures

Figure B.1 – Location of longitudinal tensile test pieces for round, square and regular polygonal bar 59

Figure B.2 – Location of longitudinal tensile test pieces for rectangular bar 60

Figure B.3 – Location of transverse tensile test pieces for round, square, regular polygonal and rectangular bar 61

Figure B.4 – Location of longitudinal test pieces for section 61

Figure C.1 – Illustration of principle of equivalent rectangles for determination of tolerances 62

Figure D.1 – Illustration of the application of fillet radius dimensions 72

Figure D.2 – Illustration of the application of male edge radius dimensions 72

List of tables

Table 1 – Tolerances for bar for machining and extruded section not subject to solution treatment	19
Table 2 – Tolerances for bar for machining and extruded section subject to solution treatment	22
Table 3 – Batch uniformity measurements of electrical conductivity and frequency of testing	23
Table 4 – Maximum number of forgings to be manufactured between the collection of test samples	30
Table 5 – Tensile property requirements for forgings	32
Table 6 – Tolerances for sheet and strip not subject to solution treatment	36
Table 7 – Location and direction of tensile test pieces	37
Table 8 – Tolerances for sheet and strip subject to solution treatment	38
Table 9 – Location and direction of tensile test pieces	39
Table 10 – Batch uniformity measurements of electrical conductivity and frequency of testing	39
Table 11 – Maximum grain boundary diffusion of copper into cladding	40
Table 12 – Tolerances for drawn tube	42
Table 13 – Batch sizes for tube	42
Table 14 – Requirements for drift test on tube not subject to solution treatment	45
Table 15 – Sampling frequency for tube flattening test	45
Table 16 – Requirements for drift test on tube subject to solution treatment	48
Table 17 – Tolerances for plate subject to solution treatment	54
Table 18 – Batch sizes for plate subject to solution treatment	54
Table 19 – Direction of tensile test samples and position of tensile test pieces	54
Table 20 – Reduced measurement frequency for electrical conductivity	55
Table 21 – Orientation and locations of fracture toughness specimens	57
Table B.1 – Location of tensile test pieces for bar	59
Table C.1 – Tolerances on straightness of $\square_{A1}$ bar, regular section and tube $\square_{A1}$	62
Table C.2 – Tolerances on twist of extruded sections	62
Table C.3 – Tolerances on angles of regular sections	63
Table C.4 – Tolerances on lengths of bars and extruded sections	63
Table C.5 – Tolerances on thickness of bars and regular sections	63
Table C.6 – Tolerances on width across flats of hexagonal bar for nuts and bolts	64
Table C.7 – Tolerances on diameters, overall widths and widths across flats for bars (other than that covered by Table C.6) and regular sections	65
Table C.8 – Tolerances on concavity and convexity over the width of flat faces of bar and section	65
Table C.9 – Tolerances on open ends of channel and I beams	66
$\square_{A1}$ Table C.10 – Normal radii for corners on square and rectangular sections (informative) $\square_{A1}$	68
$\square_{A1}$ Table C.11 – Normal radii for corners on rectangular sections: angle, channel, I and T sections (informative) $\square_{A1}$	68
Table D.1 – Classes of dimensional tolerances for forgings	69
Table D.2 – Class AF4. Recommended fillet radii	71
Table D.3 – Class AF4. Recommended male edge radii	71
Table E.1 – Class AF1. Thickness tolerances	73
Table E.2 – Class AF2a. Die wear tolerances	73
Table E.3 – Class AF2b. Tolerances on centres	74
Table E.4 – Class AF2c. Offset (mismatch) tolerances	74

Table F.1 – Tolerances on thickness of hot-rolled plate	76
Table F.2 – Tolerances on thickness of cold-rolled sheet, strip and plate, including heat-treated sheet, strip and plate	77
Table F.3 – Close tolerances on thickness of as-rolled or annealed sheet and strip	78
Table F.4 – Close tolerances on thickness of heat treated sheet and strip	78
Table F.5 – Cutting tolerances for sheet and plate	79
Table F.6 – Shearing tolerances for strip	79
Table F.7 – Tolerances on lateral curvature for sheet, strip and plate	79
Table F.8 – Tolerances on flatness of plate	80
Table G.1 – Tolerances on outside or inside diameters of drawn tube	81
Table G.2 – Tolerances on wall thickness of drawn tube	83
Table G.3 – Cutting to length tolerances for drawn tube	84
Table H.1 – Tolerances on wire diameter	85

Summary of pages

This document comprises a front cover, an inside front cover, pages i to viii, pages 1 to 86, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from the British Standards Institution, and came into effect on 31 December 2011. It was prepared by Panel ACE/61/-/24, *Light alloys for aerospace purposes*, 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 100:1993, which is withdrawn.

BS 5L 100:2011+A1:2013 supersedes BS 5L 100:2011, which is withdrawn.

Information about this document

Text introduced or altered by Amendment No. 1 is indicated in the text by tags **A1** **A1**. Minor editorial corrections are not tagged.

BS 5 L 100:2011 was a full revision of BS L 100. The principal changes from the previous edition were:

Section 1:

- a) Temperature control during heat treatment to BS M 54 replaced by AMS 2750.
- b) Tensile testing at ambient temperature to BS A4 1.1 replaced by BS EN 2002-1.
- c) Hardness testing to BS A4 5 replaced by BS EN ISO 6506-1, BS EN ISO 6507-1 and BS EN ISO 6508-1.
- d) Reference to withdrawn BS 1133-6 deleted.

Section 2:

Inspection and testing requirements summary table deleted.

Section 3:

- a) Ultrasonic testing to BS EN 2004-2 (not published) replaced by **A1** BS EN 4050-2 and BS EN 4050-4 **A1**.
- b) Inspection and testing requirements summary table deleted.

Section 4:

Inspection and testing requirements summary table deleted.

Section 5:

- a) Ultrasonic testing to withdrawn BS EN 2004-2 replaced by **A1** BS EN 4050-2 and BS EN 4050-4 **A1**.
- b) Inspection and testing requirements summary table deleted.

Section 6:

- a) Ultrasonic testing to withdrawn BS EN 2004-2 replaced by **A1** BS EN 4050-2 and BS EN 4050-4 **A1**.
- b) Inspection and testing requirements summary table deleted.

Section 7:

- a) Ultrasonic testing to withdrawn BS EN 2004-2 replaced by **A1** BS EN 4050-2 and BS EN 4050-4 **A1**.

- b) Etch inspection in accordance with BS M 37 deleted.
- c) Visual examination after acid pickling in accordance with  Method N3 of BS ISO 27831-2  added.
- d) Visual examination after etching at room temperature in accordance with  Method P4 of BS ISO 27831-2  added.
- e) Inspection and testing requirements summary table deleted.

Section 8:

- a) Tensile testing to BS A4 1 replaced by BS EN 2002-1.
- b) Flatness tolerances to withdrawn BS 1470:1987 replaced by BS EN 485-3 and BS EN 485-4.
- c) Inspection and testing requirements summary table deleted.

Section 9:

- a) Tensile testing to BS A4 1 replaced by BS EN 2002-1.
- b) Flatness tolerances to withdrawn BS 1470:1987 replaced by BS EN 485-3 and BS EN 485-4.
- c) Inspection and testing requirements summary table deleted.

Section 10:

- a) Dimensional tolerances to withdrawn BS 1474:1987 replaced by BS EN 755-7.
- b) Tensile testing to BS A4 1 replaced by BS EN 2002-1.
- c) Details of test method deleted and replaced by reference to BS EN ISO 8493 for drift test.
- d) Details of test method deleted and replaced by reference to BS EN ISO 8492 for flattening test.
- e) Inspection and testing requirements summary table deleted.

Section 11:

Inspection and testing requirements summary table deleted.

Section 12:

- a) Tensile testing to BS A4 1 replaced by BS EN 2002-1.
- b) Inspection and testing requirements summary table deleted.

Section 13:

- a) Ultrasonic testing to withdrawn BS EN 2004-2 replaced by  BS EN 4050-2 and BS EN 4050-4 .
- b) Inspection and testing requirements summary table deleted.

Section 14:

- a) Tensile testing to BS A4 1 replaced by BS EN 2002-1.
- b) Ultrasonic testing to withdrawn BS EN 2004-2 replaced by  BS EN 4050-2 and BS EN 4050-4 .
- c) Stress corrosion testing to withdrawn BS EN 2004-4 replaced by  ASTM G47 .
- d) Inspection and testing requirements summary table deleted.

Annex A: Reference to withdrawn BS 1957 replaced by details for rounding of values.

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 requirements

1 Scope

This British Standard specifies procedures for inspection, testing and acceptance of wrought aluminium and aluminium alloys for aerospace purposes.

The standard is applicable to material specifications in the British Standard Aerospace L series and also to other British Standard material specifications for wrought aluminium and aluminium alloys which are suitable for aerospace use.

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 7448-1, *Fracture mechanics toughness tests – Part 1: Method for determination of K_{Ic} critical CTOD and critical J values of metallic materials*

 Text deleted 

BS EN 485-3, *Aluminium and aluminium alloys – Sheet, strip and plate – Part 3: Tolerances on shape and dimensions for hot-rolled products*

BS EN 485-4, *Aluminium and aluminium alloys – Sheet, strip and plate – Part 4: Tolerances on shape and dimensions for cold-rolled products*

BS EN 755-7, *Aluminium and aluminium alloys – Extruded rod/bar, tube and profiles – Part 7: Seamless tubes, tolerances on dimensions and form*

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

BS EN 2004-1, *Test methods for aluminium and aluminium alloy products – Part 1: Determination of electrical conductivity of wrought aluminium alloys*

BS EN 2004-5, *Test methods for aluminium and aluminium alloy products – Part 5: Determination of cladding thickness and copper diffusion of clad semi-finished products*

BS EN 2101, *Specification for chromic acid anodizing of aluminium and wrought aluminium alloys*

 BS EN 4050-2, *Aerospace series - Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 2: Performance of test* 

 BS EN 4050-4, *Aerospace series – Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 4: Acceptance criteria* 

 BS ISO 27831-2, *Metallic and other inorganic coatings – Cleaning and preparation of metal surfaces – Part 2: Non-ferrous metals and alloys* 

AMS 2750, *Pyrometry*

ASTM E112, *Test methods for determining average grain size*

ASTM E215, *Standard practice for standardizing equipment for electromagnetic examination of seamless aluminium-alloy tube*

 ASTM G47, *Standard test method for determining susceptibility to stress-corrosion cracking of 2XXX and 7XXX aluminium alloy products* 

3 Definitions

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

3.1 aggregated cast

cast produced from the aggregation of individual casts

3.2 approved scrap

scrap which has been segregated and identified as being derived from material, the composition of which has been established with regard to the complete range of both alloying and impurity elements given in the material specification

3.3 bar

wrought material of uniformly round, half round, square, rectangular, hexagonal, octagonal or regular polygonal solid section supplied in straight lengths

3.4 batch

material which is of the same product form and of the same nominal dimensions; from the same cast; manufactured in the same production period; from the same heat treatment charge

NOTE 1 In the case of solution heat treatment in a continuous furnace, material from a maximum period of 8 h is regarded as the same heat treatment charge.

NOTE 2 Where applicable, batch sizes for specific products are given in the relevant sections of this standard.

3.5 capability

ability of a material or a product to conform to a specified requirement

NOTE Capability is inferred by the manufacturer on the basis of inspection and/or testing and cumulative results. The frequency of inspection and/or testing is at the discretion of the manufacturer.

3.6 cast

metal taken from the same melt in a furnace or crucible or from several melts mixed in the same furnace or crucible; or, when a continuous process is used, metal taken from the furnace before the next charge

3.7 coil

length of a product wound into a cylindrical or annular form, without joint or seam

3.8 cold compression

compression after solution treatment and before artificial ageing to effect a specified percentage permanent set in order to reduce internal stresses and to minimize distortion during machining

3.9 controlled stretching

stretching after solution treatment and before artificial ageing to effect a specified percentage permanent extension in order to reduce internal stresses and to minimize distortion during machining

3.10 convertibility

ability of material supplied in one specified condition to meet other application requirements after specified heat treatments

3.11 design authority

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

3.12 diffusion

migration of an alloying element (e.g. copper) from the core to the cladding of a coated material

3.13 extruded length

length produced from one cast extrusion ingot using a single or multihole die

3.14 extruded section

length of extruded material other than bar, wire or tube

3.15 forging

shape produced by hammering or pressing between open or closed dies, usually when hot

3.16 forging stock

wrought or cast material intended for the production of forgings

3.17 harmful defect

any defect prejudicial to the suitable and proper use of the material

3.18 ingot

cast form suitable for hot working

3.19 inspection schedule

details of inspection and test requirements specified by the purchaser

3.20 inspection stamp

unique stamp of the person approved by the manufacturer to carry out final inspection

3.21 lateral curvature

deviation from straightness of a plate, sheet or strip edge when the product is laid flat on a table with a calibrated surface

3.22 manufacturer

company that produces the material in the form and condition in which it is supplied to the purchaser

3.23 parent plate

plate undergoing the same operations over its whole length (including controlled stretching) before being cut

3.24 plate

rolled product of rectangular section and of uniform thickness over 6.0 mm supplied in flat form with sheared or sawn edges

3.25 pre-production forgings

forgings produced to a particular design to qualify the method of manufacture and equipment configuration and to demonstrate that the requirements of the purchaser can be met

3.26 procedure X

process control procedure for forgings in which test samples are machined from specified locations in forgings and tested to demonstrate that the forgings continue to conform to specified requirements

NOTE 1 The forgings from which the samples are taken are destroyed.

NOTE 2 This procedure is used in conjunction with procedures A, B or C.

3.27 purchaser

company which orders and purchases the product

3.28 quality assurance authority

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

3.29 seamless tube

tube in which there is no deliberate longitudinal bonding of two or more edges by pressure, fusion or mechanical means

3.30 section

extruded, rolled or formed product of uniform solid or hollow cross-section other than bar, wire, tube, sheet, strip or plate, generally supplied in straight lengths

3.31 sheet

flat rolled product of rectangular section and of uniform thickness from 0.2 mm up to and including 6.0 mm, supplied in straight lengths with slit, sawn or sheared edges

3.32 strip

flat rolled product of rectangular section and of uniform thickness from 0.2 mm up to and including 6.0 mm, supplied in coil form with slit edges

3.33 supplier

organization which has not necessarily made the product, but which supplies it to the purchaser

3.34 tube

extruded and/or drawn hollow product of uniform wall thickness, generally supplied in straight lengths

3.35 wire

solid product of round, square or regular polygonal section not more than 10 mm in diameter or width across flats, produced by drawing and usually supplied in coil form

4 General

This standard details the basic requirements for the inspection and testing of British Standard Aerospace L series wrought aluminium and aluminium 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 ¹⁾ can be made and verified.

a) General:

- 1) the number of the material specification with which this standard is to be used;
- 2) the required delivery condition of the material if other than that specified in the material specification (see 6.2);
- 3) if all products in a heat treatment batch are to be traceable to the individual casts constituting an aggregated cast (see 7.2);
- 4) the heat treatment required if different from that specified in the material specification (see 8.1);
- 5) if a particular procedure is required for certification of capability (see 10.1.3);

¹⁾ Marking a British Standard identifier (e.g. BS L 171:1990) 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) the nature and colour of the marking ink and type of characters if other than at the discretion of the manufacturer (see 11.3);
 - 7) if the product is not to be protected by a coating of corrosion preventative (see 12.1);
 - 8) the required dimensions and tolerances of the product (see Clauses 15, 23 and 107);
 - 9) if ultrasonic testing is required, in cases where this is not a requirement of the material specification, and the acceptance level if other than class 3 of A_1 BS EN 4050-4 A_1 (see 25.1 and Clause 42);
 - 10) if required, and not specified in the material specification, the maximum thickness of peripheral coarse grain (see 27.4 and 44.4).
- b) Ingot:
- 1) if marking with the ingot number and position of the product relative to the original cast ingot are required (see 20.1 e).
- c) Extruded bar and section for forging:
- 1) the condition in which the product is to be subjected to ultrasonic testing if other than the delivery condition (see 25.2).
- d) Bar for machining and extruded section not subject to solution treatment
- 1) the required tolerances on straightness of section other than bar and regular section (see Clause 31, Table 1).
- e) Bar for machining and extruded section subject to solution treatment:
- 1) if multi-hole die extrusion is not permitted, where this is not precluded by the material specification (see 37.3);
 - 2) if die quenching from the solution treatment temperature is permitted in cases where this is not specified in the material specification (see 37.4);
 - 3) if controlled stretching is required in cases where this is not specified in the material specification (see 37.5);
 - 4) the required dimensional tolerances of products where minor straightening or other rectification is not permitted (see 37.6);
 - 5) the required tolerances on straightness and on angles of section other than bar and regular section (see Clause 38, Table 2).
- f) Bar for machining and extruded section for highly stressed structures:
- 1) the acceptance level for internal defects if other than class 3 of A_1 BS EN 4050-4 A_1 (see 51.1).
- g) Forgings:
- 1) if cold compression is required in cases where this is not specified in the material specification and the permanent set if other than 1% to 5% (see 53.2);
 - 2) the dimensional tolerances if other than those given in the material specification or in Annex E (see 55.2.1);
 - 3) any dimensions which require checking on each forging (see 55.2.2);
 - 4) where procedure X is invoked, the position, size and number of test pieces to be machined from each forging, the properties required and the frequency of testing (see 56.1 and 56.2);

- 5) for forgings subject to heat treatment after delivery and tested in accordance with procedure A, the number of the test samples required with each delivery (see 57.3);
 - 6) if a sampling procedure other than procedure A is to be used for batch acceptance tensile tests (see 58.1.1);
 - 7) for forgings tested in accordance with procedure C, the number, location, form and size of the test samples (see 58.2.3.1);
 - 8) if, in the case of procedure C, separation of the test samples from the forgings before heat treatment is permitted (see 58.2.3.2);
 - 9) the location of the test samples to be machined from forgings in accordance with procedure D (see 58.2.4.2);
 - 10) test piece preparation required, if other than in accordance with Annex B (see 58.3), and details of preparation of transverse test pieces from section, if required (see B.2.2);
 - 11) the tensile properties required from forgings tested in accordance with procedure C or procedure D, if other than in accordance with the material specification, or forgings tested in accordance with procedure X (see 58.4);
 - 12) if a particular procedure is required for examination for external defects (see 59.2);
 - 13) if ultrasonic testing is required, where this is not specified in the material specification, the method to be used if other than  BS EN 4050-2 , the stage of manufacture and the heat treatment condition in which it is to be carried out and the acceptance level if other than class 3 of  BS EN 4050-4  (see Clause 60);
 - 14) the required locations for electrical conductivity measurements and hardness tests (see 61.2.2 and 61.3);
 - 15) if grain flow examination and grain size measurement are required (see 62.1); if so, the type of examination, and the sampling procedure as specified under procedure X (see 62.1) and the required characteristics (see 62.2);
 - 16) if fracture toughness capability is required in cases where this is not specified in the material specification; if testing is to be carried out other than in accordance with BS 7488-1 or the material specification, and the location and orientation of the test pieces (see 64.1 and 64.2);
 - 17) if any special tests are required that are not specified in the material specification (see Clause 65);
 - 18) the location and method of marking if not given in the material specification, and if other than at the discretion of the manufacturer (see 66.2).
- h) Sheet and strip:
- 1) the tolerance on width and thickness of sheet and strip if other than normal, and if class A tolerance on lateral curvature of strip is required (see Clause 68 and Clause 74).
- i) Tube:
- 1) if tube is for non-hydraulic or hydraulic applications (see Clause 82 and 94.1).
- j) Wire for rivets:
- 1) required colour marking for bundles or coils if not specified in the material specification (see 105.2).

- k) Hot rolled plate for forgings:
 - 1) if ultrasonic testing is required (see Clause 110).
- l) Plate subject to solution treatment:
 - 1) the form, dimensions and method of measurement of elongation if the thickness of the plate does not allow test pieces to be prepared in accordance with the proportional round test pieces specified in BS EN 2002-1 (see 116.2).

5.2 Items to be agreed between the contracting parties

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 ²⁾ can be made and verified.

- a) if cast aggregation is to be practiced, the maximum and minimum limits for each alloying element (see 7.2);
- b) method of temperature control if other than AMS 2750 (see 8.2)
- c) if bridge die extrusion is permissible for hollow sections (see 30.2 and 37.2);
- d) dimensional tolerances for products with widths or thicknesses larger than those given in Annex C (see 31.2 and 38.2);
- e) dimensional tolerances for sections of complicated shape and sections for which specially close tolerances are required (see 31.3 and 38.3);
- f) if it is permissible for total tolerances (i.e. the sum of the plus and minus limits) to be applied in one direction only (see 31.4, 38.4 and Clause 84);
- g) if multi-hole die extrusion is permissible (see 49.2);
- h) dimensional tolerances for forgings of mass above 9 kg (see 55.2.1);
- i) close tolerances if required for material of greater width or thickness than those covered by Table F.3 (see Clause 68);
- j) flatness tolerances for plate greater than 3 m in length and greater than 2 000 mm in width (see F.5).

6 Manufacture and freedom from defects

6.1 The method of manufacture shall conform to the material specification and/or the relevant section of this standard. If alternative methods are given in the material specification, or if no method is specified, the selection of the method shall be at the discretion of the manufacturer.

6.2 Material shall be delivered in the condition specified in the material specification or order [see 5.1 a2)].

6.3 The material shall be free for harmful defects.

²⁾ Marking a British Standard identifier (e.g. BS L 171:1990) 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.

6.4 Notwithstanding prior acceptance of a material as conforming to this standard, any defect in the material which is found at a later stage, and which is likely to be detrimental to subsequent use, shall be a cause for rejection.

7 Cast aggregation

7.1 Cast aggregation shall be permitted in the case of extruded bar and section (excluding forging stock), tube and wire provided that the following conditions are met.

- a) The aggregated cast shall not exceed a mass of 30 t.
- b) The aggregated cast mass shall be obtained from a maximum of ten individual casts produced consecutively in a 24 h period.

7.2 Where aggregation is practised, the manufacturer shall work to agreed maximum and minimum limits for the content of each individual alloying element [see 5.2a)]. These maximum and minimum limits shall lie within the range permitted by the material specification and shall not differ by more than 60% of the difference between the maximum and minimum limits specified in the material specification. For impurity elements the maximum specified in the material specification shall apply. The composition range of the alloying elements and impurity levels of the aggregated cast shall be stated on the release documentation. If stated on the order all products in a heat treatment batch shall be traceable to the individual casts constituting an aggregated cast [see 5.1a)3)].

8 Heat treatment

8.1 Heat treatment shall be carried out in accordance with the material specification or order [see 5.1a)4)]. No material or test sample shall be re-heat treated more than twice.

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

8.3 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 furnace 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.

8.4 If no period or temperature is given in the material specification for a particular heat treatment these and their tolerances shall be at the discretion of the manufacturer.

9 Chemical composition

9.1 The chemical composition shall conform to the material specification.

9.2 The chemical composition of each cast shall be determined. The samples taken for analysis shall be representative of the cast. The method of analysis shall be at the discretion of the manufacturer. In case of dispute, the method of chemical analysis to be used shall be agreed between the purchaser and the manufacturer.

9.3 Elements not listed in the material specification shall not be added for any purpose other than fluxing, degassing or grain refining.

9.4 Overall control of the chemical composition, the use of scrap, and the method of analytical control shall be such that the chemical composition of the final product conforms to the material specification.

9.5 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.

9.6 Values for chemical composition given in the material specification shall be applied in accordance with Annex A.

10 Testing

10.1 General

10.1.1 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.)

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

NOTE Where capability to conform to a particular requirement is specified, sampling frequency is at the discretion of the manufacturer.

10.1.3 If the material specification or this standard specifies that the material shall have the capability to conform to particular requirements, the manufacturer shall adopt one of the following procedures, unless a particular procedure is stated on the order [see 5.1a)5)].

- a) The manufacturer shall verify by inspection and/or testing that the material is in accordance with the appropriate requirements of this standard and state the results on the release documentation.
- b) The manufacturer shall certify, based on cumulative inspection and/or testing results, that the material will conform to specified requirements.

If the manufacturer certifies capability and it is subsequently demonstrated by the purchaser that the material does not conform to the specified requirements, this shall be a cause for rejection of the material even though it conformed to the requirements for the condition of delivery.

10.2 Selection and preparation of test samples

10.2.1 Test samples shall be selected and prepared in accordance with the relevant section of this standard, and shall be fully representative of the material in its delivery condition. Where test samples represent products in the final heat treatment condition specified in the material specification they shall not be subjected to further heat treatment. Where test samples represent products to be delivered in a condition other than the condition of use they shall be heat treated to the use condition in accordance with the material specification before testing.

10.2.2 Test samples and associated test pieces shall be identified in such a manner that they are traceable to the batch from which they were taken and their orientation with respect to the product is clear.

10.2.3 Unless otherwise specified in the relevant section of this standard, test samples shall not be mechanically worked after removal from the products they represent.

10.3 Tensile test at ambient temperature

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

10.3.2 Unless otherwise specified in the relevant section of this standard, test pieces shall be to the dimensions of the largest practicable size of proportional round test piece specified in BS EN 2002-1.

10.3.3 The tensile test piece direction and location within the product shall be as specified in the relevant section of this standard.

10.4 Hardness test

10.4.1 Hardness testing shall be carried out using one of the methods listed in **10.4.2** to **10.4.4** as specified in the material specification.

10.4.2 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.

10.4.3 Vickers hardness testing shall be carried out in accordance with BS EN ISO 6507-1. 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 6507-1.

10.4.4 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.

10.4.5 All tests on the same batch (including test pieces, where applicable) shall be made by the same method and under the same conditions of loading.

10.5 Other tests

For those tests specific to a particular product form, the test procedure shall be as specified in the relevant section of this standard.

10.6 Retesting procedures

10.6.1 Mechanical testing

If the test procedure or test piece preparation is found to be faulty, testing shall be reapplied using the original sampling frequency after identification of the cause of the failure. When failure cannot be attributed to faulty testing or test piece preparation, additional test samples shall be selected at twice the original sampling frequency, at least one of which shall be from the product or products on which the original results were obtained.

If all retest results are satisfactory the batch shall be accepted. If one or more retest results are unsatisfactory the batch shall be:

- a) rejected; or
- b) every product tested, and the products conforming to the relevant requirement accepted; or
- c) for heat-treatable materials, re-heat treated and tested as a new batch.

10.6.2 Other tests

For those tests specific to a particular product form, the retest procedure shall be as specified in the relevant section of this standard.

10.7 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 A.

11 Marking

11.1 Products shall be marked in accordance with the relevant section of this standard.

11.2 In the case of products for which continuous or overall marking is specified, the direction of marking shall be parallel to the direction of final rolling, extrusion or drawing.

11.3 Unless specified on the order or inspection schedule, the type of characters used and the nature and colour of any marking ink or similar medium shall be at the discretion of the manufacturer [see 5.1a)6)].

11.4 If marking ink or a similar medium is used, this shall remain visible after handling and after contact with any corrosion preventative used. The ink shall be removable with cleaning products without leaving a residue which could affect further processing. Cleaning products and inks shall not give rise to corrosion.

12 Protection and packaging

12.1 The product shall be protected and/or packaged to prevent damage or corrosion during transport. Unless otherwise specified on the order, material shall be protected by an effective coating of corrosion preventative [see 5.1a)7)].

12.2 If the product is packaged, the outside of the package shall bear the following information:

- a) the name of the purchaser;
- b) the total mass of the package;
- c) the order number and sufficient information to enable the package to be related to the order and other relevant documentation.

13 Certification

13.1 The manufacturer shall supply with each delivery a certificate of conformity, bearing the name and address of the manufacturer and a printed serial number, containing the following minimum information.

- a) Purchaser's name and address.
- b) Contract and/or order number.
- c) Quality assurance authority under which the material is supplied and, where appropriate, the registration or approval number.
- d) Manufacturer's internal order number.
- e) Material designation, or the number of the material specification, and the number of this British Standard ³⁾.
- f) Description of the material supplied, including dimensions, drawing numbers and part numbers if appropriate and any other identification, together with the number(s) of the inspection or manufacturing schedule, where applicable.
- g) Quantity supplied.
- h) Cast number(s) and batch number(s) or unique identification, including the ingot and the position within the ingot, where applicable.
- i) Condition of the material as delivered.
- j) Heat treatment details, including details of test sample heat treatment where appropriate.
- k) Detail of all the tests carried out, or the reference numbers of the relevant test reports, copies of which shall be attached.
- l) Where capability is specified, a statement that the material has the capability to conform to the specified requirements.
- m) Inspection stamp.
- n) A certification clause signed by a duly authorized employee of the manufacturer, 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 and/or order."

13.2 When certification of the material is issued by a supplier who is not the manufacturer, the supplier shall hold equivalent certification issued by the manufacturer of the material. All the information required by **13.1**, as provided by the manufacturer, shall be supplied with each delivery.

13.3 If a batch of material consigned by the manufacturer is sub-divided, or the material cut to size, by a supplier before re-consignment, the supplier shall carry out any subsequent additional dimensional inspection or identification marking and shall certify accordingly.

³⁾ Marking a British Standard identifier (e.g. BS L 171:1990) 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: Ingot for hot working

14 General

This section covers the inspection and testing procedures for ingot for subsequent hot working and shall be used in conjunction with Section 1.

15 Dimensions and tolerances

The dimensions of the product shall be measured and shall fall within the tolerances given on the order [see 5.1a)8)]. The frequency of measurement shall be at the discretion of the manufacturer.

16 Tensile test

16.1 Capability

When forged to not less than 30 mm diameter or equivalent section and heat treated in accordance with the material specification where applicable, material shall have the capability to conform to the tensile properties specified in the material specification. Waiver of this requirement shall be permitted if the ingots are intended for use as specified in Sections 3 to 6 and 8 to 14.

16.2 Test piece preparation

A longitudinal co-axial tensile test piece shall be prepared from each test sample.

16.3 Tensile testing

Each test piece prepared in accordance with 16.2 shall be tested in accordance with 10.3 and the tensile properties shall conform to the material specification. Where the material specification does not specify tensile properties for separately forged test samples, the requirements specified for the longitudinal direction of the equivalent section shall apply.

17 Electrical conductivity measurement

17.1 Where the material specification specifies electrical conductivity, material for forging stock prepared in accordance with 16.1 shall have the capability to conform to the electrical conductivity requirements specified in the material specification.

17.2 Electrical conductivity shall be measured in accordance with BS EN 2004-1 on samples prepared in accordance with 16.1. The electrical conductivity of each sample shall conform to the material specification.

18 Internal defects

18.1 Ingots shall be inspected and shall be free from harmful defects.

18.2 The method of inspection e.g. macrography, fracture and/or ultrasonic inspection, and the acceptance criteria, shall be at the discretion of the manufacturer.

18.3 The frequency of inspection shall be at the discretion of the manufacturer.

19 External defects

19.1 Each ingot shall be visually examined and shall be free from harmful defects.

19.2 Removal of surface defects by local dressing shall be permitted provided that the product remains within the specified dimensions.

20 Marking

20.1 Each ingot shall be marked with the following information:

- a) the number of the material specification;
- b) the delivery condition;
- c) the manufacturer's identification and site identification;
- d) inspection stamp or cast number or unique identification;
- e) where specified on the order, the ingot number and position of the product relative to the original cast ingot [see 5.1b)1)].

20.2 Marking shall be carried out using ink or a similar medium, hard stamping or labels, at the discretion of the manufacturer.

Section 3: Extruded bar and section for forging

21 General

This section covers the inspection and testing procedures for extruded bar and section for the manufacture of forgings covered by Section 7 of this standard and shall be used in conjunction with Section 1.

22 Manufacture

Extruded bar and section shall be manufactured from ingot conforming to Section 2.

23 Dimensions and tolerances

The dimensions of the product shall be measured and shall fall within the tolerances given on the order [see 5.1a)8)]. The frequency of measurement shall be at the discretion of the manufacturer.

24 Tensile test

24.1 Capability

The material supplied shall have the capability to conform to the longitudinal tensile properties specified in the material specification.

24.2 Test sample preparation

Longitudinal test samples shall be prepared from a length of extruded stock either:

- a) by forging to a bar of not less than 30 mm diameter, or section of not less than 25 mm across the flats, and, if heat treatment is specified in the material specification, heat treated in that size; or
- b) by extracting from the full section, from a position in accordance with Annex B, after heat treatment, if heat treatment is specified in the material specification; or
- c) by extracting from the full section centred on the sampling position specified in Annex B. The dimensions of the sample shall be within the dimensional range for which tensile properties are specified in the material specification. The sample shall be heat treated if heat treatment is specified in the material specification.

NOTE The size chosen is at the option of the manufacturer.

24.3 Test piece preparation

Test pieces shall be prepared from the test samples in accordance with 10.3.2. In the case of samples prepared in accordance with 24.2c), the longitudinal axis of the test piece shall be coaxial with the longitudinal axis of the sample.

24.4 Tensile testing

The test pieces prepared in accordance with 24.2 and 24.3 shall be tested in accordance with 10.3 and the tensile properties shall conform to the material specification. Where tensile properties for extruded stock are not specified in the material specification, samples prepared in accordance with b) or c) of 24.2 shall conform to the tensile properties for the same ruling section of a forging, or forged bar, specified in the material specification. In cases of dispute, the samples shall be prepared in accordance with 24.2a).

25 Internal defects

25.1 If required by the material specification, order or inspection schedule, the following products shall be ultrasonically tested:

- a) bar (excluding round bar) and extruded section with transverse section $\geq 650 \text{ mm}^2$ and minor dimension $\geq 12 \text{ mm}$;
- b) round bar of diameter $\geq 50 \text{ mm}$.

Testing shall be carried out in accordance with  BS EN 4050-2  and, unless otherwise specified in the material specification, order or inspection schedule, products shall conform to class 3 of  BS EN 4050-4  [see 5.1 a9)].

25.2 If the products are to be tested in a condition other than the delivery condition, the condition shall be as stated on the order or inspection schedule [see 5.1c1)].

26 External defects

26.1 Each product shall be visually examined and shall be free from harmful defects.

26.2 Removal of surface defects by local dressing shall be permitted providing the product remains within the specified dimensions.

27 Etch inspection

27.1 A transverse section from the back end of each extruded length shall be selected for test.

27.2 The test specimen shall be solution treated in accordance with the material specification, when applicable, and prepared, etched and subjected to macrographic examination.

27.3 The etched surface shall be free from harmful defects.

27.4 If the material specification, order or inspection schedule specifies a maximum thickness of peripheral coarse grain, the etch inspection specimen shall conform to this requirement [see 5.1a)10)].

27.5 If any specimen fails to conform to 27.3, additional specimens shall be taken and examined until a specimen is reached which conforms to 27.3.

The remainder of the extruded length shall then be accepted.

28 Marking

28.1 Products with a diameter or major sectional dimension ≥ 12.5 mm shall bear the following identification marking:

- a) continuous marking in ink or similar medium, repeated at least every 0.5 m, giving the following information:
 - 1) number of the material specification;
 - 2) delivery condition;
 - 3) manufacturer's identification and site identification;
- b) end marking by hard stamping at one end of the product, giving the following information:
 - 1) batch number;
 - 2) inspection stamp.

28.2 Products with a diameter or major sectional dimension < 12.5 mm shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by **28.1**.

Section 4: Bar for machining and extruded section not subject to solution treatment

29 General

This section covers the inspection and testing procedures for bar for machining and for extruded section, not subject to solution treatment and shall be used in conjunction with Section 1.

30 Manufacture

30.1 Bar and section shall be manufactured from ingot conforming to Section 2.

30.2 Bridge die extrusion shall only be used for hollow section if agreed between the manufacturer and the purchaser and stated on the drawing or order [see 5.2c)].

31 Dimensions and tolerances

31.1 The dimensions of the product shall be measured and shall fall within the tolerances given in Annex C as listed in Table 1. The frequency of measurement shall be at the discretion of the manufacturer.

Table 1 Tolerances for bar for machining and extruded section not subject to solution treatment

Dimension or feature	Product	Tolerance
Length	Bar and regular section	Table C.4
Thickness	Bar and regular section	Table C.5
Diameter	Bar and regular section	Table C.7
Width	Regular section	Table C.7
	Channels and I beams	Table C.9
Straightness	Bar and regular section	Table C.1
	Other section	As specified on the order, drawing or inspection schedule [see 5.1d)1)]

31.2 Tolerances for products with widths or thicknesses larger than those covered by Annex C shall be agreed between the manufacturer and the purchaser [see 5.2d)].

31.3 Tolerances for the following products, which are not covered by Annex C, shall be agreed between the manufacturer and the purchaser [see 5.2e)]:

- sections of complicated shape which cannot be divided into rectangles (see C.2);
- sections for which specially close tolerances are required, necessitating additional manufacturing operations.

31.4 It shall be permissible for total tolerances (i.e. the sum of the plus and minus limits) to be applied in one direction only if agreed between the manufacturer and the purchaser [see 5.2f)].

32 Batch size

A batch shall comprise a maximum of 250 products or a maximum total mass of 3 000 kg, whichever is the smaller.

33 Tensile test

33.1 Sampling

One test sample shall be selected from each batch.

33.2 Test piece preparation

One longitudinal tensile test piece shall be prepared from each sample in accordance with Annex B.

33.2.1 Tensile testing

Each test piece, prepared in accordance with 33.2, shall be tested in accordance with 10.3 and the tensile properties shall conform to the material specification.

34 External defects

Each product shall be visually examined and shall be free from harmful defects.

35 Marking

35.1 Products with a diameter or major sectional dimension ≥ 12.5 mm shall bear the following identification marking:

- a) continuous marking in ink or similar medium, repeated at least every 0.5 m, giving the following information:
 - 1) number of the material specification;
 - 2) delivery condition;
 - 3) manufacturer's identification and site identification;
- b) end marking by hard stamping at one end of the product, giving the following information:
 - 1) batch number;
 - 2) inspection stamp.

35.2 Products with a diameter or major sectional dimension < 12.5 mm shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by 35.1.