BS 3L 500:2011

BSI Standards Publication

# Procedure for inspection, testing and acceptance of wrought magnesium base alloys

bsi.

...making excellence a habit.™

## Publishing and copyright information



ISBN 978 0 580 70460 4

ICS 49.025.99

The following BSI references relate to the work on this standard:
Committee reference ACE/61
Draft for comment 10/30216237 DC

## Publication history

First published January 1967
Second edition, March 1973
Third (present) edition, December 2011

## Amendments issued since publication

| Date | Text affected |
|---|---|

# Contents

**Summary of pages**

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 46, 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This British Standard supersedes BS 2L 500:1973, which is withdrawn.

## Information about this document

This is a full revision of the standard, and introduces the following principal changes.

Section 1:

a) Information to be supplied by purchaser added.

b) Information to be agreed by manufacturer and purchaser added.

c) Heat treatment requirements added.

d) Application of values requirements added.

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

Section 5:

External and internal defects requirements added.

Section 6:

Position of tensile test piece requirements added.

Section 7:

Position of tensile test piece requirements added.

Appendix A: Re-identified as Annex A (Rules for application of values for chemical composition and mechanical properties given in material specifications).

Appendix B: Re-identified as Annex B (Protection against corrosion).

Appendix C: Re-identified as Annex C (Tolerances for bars and extruded sections).

Appendix D: Re-identified as Annex D (Tolerances for sheet, strip and plate).

Appendix E: Re-identified as Annex E (Tolerances for tube).

## 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 requirements are expressed 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.**

*This page deliberately left blank*

# Section 1: General requirements

## 1 Scope

This British Standard specifies procedures for inspection, testing and acceptance of wrought magnesium-base 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 magnesium-base 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 M 93, *Protection of magnesium – Rich alloys against corrosion – Specification*

BS X 38, *Heat curing paint scheme for aerospace purposes – Specification*

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

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

EN 4050-2, *Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 2: Performance of test* [1)]

EN 4050-4, *Test method for metallic materials – Ultrasonic inspection of bars, plates, forging stock and forgings – Part 4: Acceptance criteria* [1)]

## 3 Definitions

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

### 3.1 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

### 3.2 bar

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

### 3.3 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.*

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

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

### 3.4 billet or slab

cast product destined for subsequent hot working. A rectangular billet is usually called a slab

### 3.5 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

### 3.6 coil

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

### 3.7 design authority

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

### 3.8 extruded length

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

### 3.9 extruded section

length of extruded material other than bar, wire or tube

### 3.10 forging

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

### 3.11 forging stock

wrought or cast material intended for the production of forgings

### 3.12 harmful defect

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

### 3.13 hollow section

extruded section which completely encloses a hollow or hollows

### 3.14 ingot

cast form suitable for hot working

### 3.15 inspection schedule

details of inspection and test requirements specified by the purchaser

### 3.16 inspection stamp

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

### 3.17 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

### 3.18 manufacturer

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

### 3.19 plate

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

### 3.20 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

### 3.21 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 or C (see **45.1**).*

### 3.22 purchaser

company which orders and purchases the product

### 3.23 quality assurance authority

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

### 3.24 regular section

solid extruded section which can be conveniently divided into approximate rectangles with measurable dimensions, e.g. angles, channels, tees etc. The ratio of maximum thickness to minimum thickness of such regular sections does not exceed 4:1 (see **B.2**)

### 3.25 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

### 3.26 strip

flat rolled product of rectangular section and of uniform thickness from 0.2 mm up to and including 3.0 mm, supplied in coil form with slit edges

### 3.27 supplier

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

### 3.28 tube

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

# 4 General

This standard details the basic requirements for the inspection and testing of British Standard Aerospace L series wrought 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) The required delivery condition of the material if other than that specified in the material specification (see **6.2**).

   3) The heat treatment required if different from that specified in the material specification (see **7.1**).

   4) The nature and colour of the marking ink and type of characters if other than at the discretion of the manufacturer (see **10.3**).

b) Cast billets and slabs for hot working.

   1) The supply condition of the material if other than as cast (see Clause **14**).

   2) The dimensional tolerances of the product (see Clause **15**).

c) Extruded bar and section for forging.

   If required, the dimensions and tolerances of the product (see Clause **21**).

[2)] Marking a British Standard identifier (e.g. BS L 513:1973) 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.

d) Forgings.

1) Any dimensions which require checking on each forging (see **42.2.2**).

2) 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 **43.1** and **43.2**).

3) 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 **44.3**).

4) If a sampling procedure other than procedure A is to be used for batch acceptance tensile tests (see **45.1.1**).

5) For forgings tested in accordance with procedure C, the number, location, form and size of the test samples (see **45.2.2.1**).

6) If, in the case of procedure C, separation of the test samples from the forgings before heat treatment is permitted (see **45.2.2.2**).

7) The location of the test samples to be machined from forgings in accordance with procedure D (see **45.2.3.2**).

8) Test piece preparation requirements, if other than in accordance with **9.3** (see **45.3**).

9) 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 **45.4**).

10) If a particular procedure is required for examination for external defects (see **46.2**).

11) If ultrasonic testing is required, where this is not specified in the material specification, the method to be used if other than 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 EN 4050-4 (see Clause **47**).

12) If grain flow examination and grain size measurement are required (see **48.1**); if so, the type of examination, and the sampling procedure as specified under procedure X (see **48.1**) and the required characteristics (see **48.2**).

13) If any special tests are required that are not specified in the material specification (see Clause **49**).

14) The location and method of marking if not given in the material specification, and if other than at the discretion of the manufacturer (see **50.2**).

e) Plate.

If ultrasonic testing is required, where this is not specified in the material specification, the method to be used if other than 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 EN 4050-4 (see Clause **62**).

## 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 [3] can be made and verified.

a) Method of temperature control if other than AMS 2750 (see **7.2**).

b) Condition of material of extruded bar for forging if other than not heat treated (see Clause **20**).

c) If front end examination of extruded bar for forging and bars for machining and extruded sections is required, details of requirements (see **24.5** and **35.2**).

d) If ultrasonic examination of extruded bar for forging and bars for machining and extruded sections is required, methods of examination and acceptance standards (see Clause **26** and Clause **36**).

e) If special dimensional tolerances are required for bars for machining and extruded sections (see Clause **32**).

f) Dimensional tolerances for forgings (see **42.2.1**).

g) If special dimensional tolerances are required for sheet and strip (see Clause **53**).

h) If special dimensional tolerances are required for plate (see Clause **59**).

i) If special dimensional tolerances are required for tube (see Clause **67**).

# 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**a)2)].

**6.3** The material shall be free for harmful defects.

**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 Heat treatment

**7.1** Heat treatment shall be carried out in accordance with the material specification or order [see **5.1**a)3)]. No material or test sample shall be re-heat treated more than twice.

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

**7.3** 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

[3] Marking a British Standard identifier (e.g. BS L 513:1973) 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.

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.

**7.4** 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.

# 8 Chemical composition

**8.1** The chemical composition shall conform to the material specification.

**8.2** 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.

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

**8.4** 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.

**8.5** 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.

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

# 9 Testing

## 9.1 General

**9.1.1** 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**.)

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

## 9.2 Selection and preparation of test samples

**9.2.1** 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.

**9.2.2** 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.

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

### 9.3 Tensile test

**9.3.1** Tensile testing shall be carried out in accordance with BS EN 2002-1.

**9.3.2** 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.

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

### 9.4 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.

### 9.5 Retesting procedures

#### 9.5.1 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.

#### 9.5.2 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.

### 9.6 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.

## 10 Marking

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

**10.2** 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.

**10.3** 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 **5.1**a)4)].

**10.4** 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.

# 11 Protection and packaging

**11.1** The material shall be protected before despatch in accordance with Annex B, by a particular route agreed between the manufacturer and the purchaser. The purchaser shall secure the agreement of the Design Authority.

The routes given in Annex B include not only the operations to be carried out by the material manufacturer but also those to be carried out subsequently by the manufacturer of the final component.

The agreed route and the operation up to which it shall be applied shall be quoted on all enquiries, contracts and orders, and on all subsequent release notes and other documentation (e.g. "Protection to BS L 500/Route 1/up to and including operation 5").

**11.2** 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.

# 12 Certification

**12.1** 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 [4)].

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.

[4)] Marking a British Standard identifier (e.g. BS L 513:1973) 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.

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."

**12.2** 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 **12.1**, as provided by the manufacturer, shall be supplied with each delivery.

**12.3** 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.

# Section 2: Cast billets and slabs for hot working

## 13 General

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

## 14 Condition

Unless otherwise stated on the order [see **5.1**b)1)], the material shall be delivered as cast.

## 15 Dimensions and tolerances

If required by the order, the dimensions of the product shall be measured and shall fall within the tolerances given on the order [see **5.1**b)2)]. The frequency of measurement shall be at the discretion of the manufacturer.

## 16 Internal and external defects

**16.1** The material shall be inspected and tested in one or both of the following ways, at the discretion of the manufacturer.

a) One or more transverse slices, each not less than 25 mm thick, shall be cut from the billets or slabs, the total representing not less than 1% of the billets or slabs. One sectioned face of each slice shall be finely machined and prepared for examination. The faces shall be free from harmful defects.

   The slices shall then be fractured so that the fracture extends across the full diameter of billet or the full width of slab. The fracture surfaces shall be free from harmful defect.

a) The billets or slabs shall be examined by a non-destructive test to the satisfaction of the Quality Assurance Authority. The material shall be free from harmful defects.

**16.2** The metallographic structure of a cast billet or slab for forging, representative of each cast, shall be examined. The structure shall be suitable for the forging process to a standard agreed between the material manufacturer and the forger.

## 17 Retesting procedure

If, on sectioning, any billet or slab exhibits harmful defects, further billets or slabs shall be examined as required by the Quality Assurance Authority.

## 18 Marking

**18.1** Each cast billet and slab 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.

**18.2** 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

## 19 General

This section covers the inspection and testing procedures for extruded bar and section for the manufacture of forgings covered by Section **5** of this standard and shall be used in conjunction with Section **1**.

## 20 Condition

The material shall not be heat treated unless the manufacturer and the purchaser agree [see **5.2**b)] otherwise, in which case the condition in which the material is to be supplied shall be stated on the drawing, order or Inspection Schedule.

## 21 Dimensions and tolerances

If required by the order, the dimensions of the product shall be measured and shall fall within the tolerances given on the drawing, order or Inspection Schedule [see **5.1**c)1)]. The frequency of measurement shall be at the discretion of the manufacturer.

## 22 Selection and preparation of mechanical test samples

### 22.1 Selection

**22.1.1** Bars and sections shall be grouped in batches of products within the dimensional ranges shown in Table 1.

Table 1 **Batch sizes for extruded bar and section for forging**

| **Nominal dimensions or major sectional dimensions (d)** mm | **Maximum mass of batch** kg |
|---|---|
| $d \leq 75$ | 350 |
| $75 < d \leq 150$ | 700 |
| $> 150$ | 1 500 |

**22.1.2** One test sample shall be selected from a bar or section of the largest size in each batch for tensile testing.

**22.1.3** Test samples from bars or sections not greater than 30 mm diameter or minor sectional dimensions shall be heat treated, if applicable, in full section.

**22.1.4** Test samples from bars or sections greater than 30 mm diameter or minor sectional dimension shall be, at the option of the manufacturer, either heat treated, if applicable, in full section or forged to not less than 30 mm diameter or equivalent section and heat treated, if applicable.

### 22.2 Preparation

**22.2.1** For test samples representing bars for forging, up to and including 50 mm diameter or minor sectional dimension, the test piece shall be machined coaxially from the test sample.

**22.2.2** For test samples representing bars for forging over 50 mm diameter or minor sectional dimension, the longitudinal axis of the test piece shall be half way between the central axis and the outer surface of the test sample.

**22.2.3** For extruded sections whose minor sectional dimension in the thickest part is not more than 50 mm, the test piece shall be machined from the thickest part of the section. The longitudinal axis of the test piece shall be equidistant from the longer sides and 25 mm (or as near 25 mm as is practicable) from a shorter side of the selected part of the section.

**22.2.4** For extruded sections whose minor sectional dimension in the thickest part is greater than 50 mm, the longitudinal axis of the test piece shall be half way between the central axis and the outer surface of the thickest part of the section.

# 23 Tensile testing

The test pieces prepared in accordance with Clause **22** shall be tested in accordance with **9.3** and the tensile properties shall conform to the material specification.

# 24 Etch inspection

**24.1** During each single working period a specimen of each size of bar or section produced shall be selected.

**24.2** Each specimen shall be of the full cross section and shall be taken from the back end of the extruded length or from the front end of the final discard.

**24.3** The specimen shall be in the as-worked and, if appropriate, heat-treated condition in accordance with the material specification suitably prepared and etched.

**24.4** The etched surface shall be free from harmful defects.

**24.5** When examination of the front end of the selected bar or section is required, the details shall be agreed between the manufacturer and the purchaser [see **5.2**c)], and shall be stated on the order or Inspection Schedule.

# 25 Fracture test

A sample, selected as in Clause **24**, shall be examined as detailed and the fracture surface shall be free from harmful defects:

For bars and sections up to and including 60 mm diameter or minor sectional dimension, the sample shall be fractured transversely to the direction of extrusion. It is permissible for the sample to be nicked or sawn to aid fracture but the fracture surface shall extend the full diameter or width of the bar or section and shall be not less than 75% of the cross-sectional area of the bar or section.

For bars and sections of more than 60 mm diameter or minor sectional dimension, the sample shall be fractured along the direction of extrusion. A transverse slice not less than 12 mm thick shall be cut from the sample. It is permissible for the sample to be nicked or sawn to aid fracture, the nick or saw-cut being not more than 6 mm deep made across the face of the slice. The sample shall be fractured so that the fracture surface extends the full diameter or width of the bar or section at the centre of the cross section.

# 26 Internal defects

If required by the drawing, order or Inspection Schedule, bars and sections shall be examined by ultrasonic inspection, in the condition in which they are to be delivered.

The method of examination and acceptance standards shall be agreed between the manufacturer and the purchaser [see **5.2**d)], and shall be stated on the order or Inspection Schedule.

# 27 External defects

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

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

# 28 Retesting procedures for etch inspection, fracture test and external defects

If any specimen reveals a harmful defect, the relevant length of bar or section shall be cropped, and a further specimen subsequently prepared and examined in accordance with Clause **24**, Clause **25** and Clause **27**.

Examination of specimens from other bars or sections of the same size shall verify that the whole of the material represented by the selected bar or section is free from harmful defects.

# 29 Marking

**29.1** Products with a diameter or major sectional dimension ≥ 20 mm shall bear the following identification marking at, or near one end.

a) Number of the material specification.

b) Delivery condition.

c) Manufacturer's identification and site identification.

d) Batch number.

e) Inspection stamp.

**29.2** Products with a diameter or major sectional dimension <20 mm shall be either individually marked as required by **29.1** or shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by **29.1**.

# Section 4: Bars for machining and extruded sections

## 30 General

This section covers the inspection and testing procedures for bars for machining and extruded sections and shall be used in conjunction with Section **1**.

## 31 Condition

**31.1** The material shall be delivered in the condition required by the material specification.

**31.2** Hollow sections shall be extruded by a process approved by the Quality Assurance Authority.

## 32 Dimensional tolerances

The dimensions of the product shall be measured and, unless special tolerances are agreed between the supplier and the purchaser [see **5.2**e)], and stated on the order, shall fall within the tolerances given in Annex C, as listed in Table 2.

Table 2 **Tolerances for bars for machining and extruded sections**

| Dimension or feature | Product | Tolerance |
|---|---|---|
| Straightness | Bars and regular sections | Table C.1 |
| | Other sections | As agreed between the manufacturer and the purchaser, either directly or through an intermediary, and stated on the drawing, order or Inspection Schedule |
| Twist | Sections | Table C.2 |
| Angles | Regular sections | Table C.3 |
| | Other sections | As agreed between the manufacturer and the purchaser, either directly or through an intermediary, and stated on the drawing, order or Inspection Schedule |
| Length | Bars and sections | Table C.4 |
| Thickness | Bars and regular sections | Table C.5 |
| | Hollow sections | Table C.6 |
| Width and diameter | Bars, regular sections and hollow sections | Table C.7 |
| | Internal and external dimensions of open end channels and I beams | Table C.8 |

## 33 Selection and preparation of mechanical test samples

### 33.1 Selection

**33.1.1** Bars and sections shall be grouped in batches of products within the following dimensional ranges shown in Table 3.

Table 3 **Batch sizes for bars for machining and extruded sections**

| Nominal dimensions or major sectional dimension (d)<br>mm | Maximum mass of batch<br>kg |
|---|---|
| $d \leq 75$ | 350 |
| $75 < d \leq 150$ | 700 |
| $> 150$ | 1 500 |

**33.1.2** One test sample shall be selected from a bar or section in each batch for tensile testing.

**33.1.3** The test samples shall be selected after the bars or sections have been straightened.

### 33.2 Preparation

**33.2.1** For test samples representing bars up to and including 50 mm diameter or minor sectional dimension, the test piece shall be machined coaxially from the test sample.

**33.2.2** For test samples representing bars over 50 mm diameter or minor sectional dimension, the longitudinal axis of the test piece shall be half way between the central axis and the outer surface of the test sample.

**33.2.3** For extruded sections whose minor sectional dimension in the thickest part is not more than 50 mm, the test piece shall be machined from the thickest part of the section. The longitudinal axis of the test piece shall be equidistant from the longer sides and 25 mm (or as near 25 mm as is practicable) from a shorter side of the selected part of the section.

**33.2.4** For extruded sections whose minor sectional dimension in the thickest part is greater than 50 mm, the longitudinal axis of the test piece shall be half way between the central axis and the outer surface of the thickest part of the section.

## 34 Tensile testing

The test pieces prepared in accordance with Clause **33** shall be tested in accordance with **9.3** and the tensile properties shall conform to the material specification.

## 35 Etch inspection

**35.1** The etching test shall be applied to bars and sections that are greater in minor sectional dimension than 4 mm and are of a cross section that cannot be contained in a 20 mm diameter circle.

**35.2** During each single working period a specimen of each size of bar or section produced shall be selected.

Each specimen shall be of the full cross section and shall be taken from the back end of the extruded length or from the front end of the final discard.

The specimen shall be in the as-worked and, if appropriate, heat-treated condition in accordance with the material specification, and shall be suitably prepared and etched.

The etched surface shall be free from harmful defects.

When examination of the front ends of bars or sections is required, the details shall be agreed between the manufacturer and the purchaser [see **5.2**c)] and shall be stated on the order or Inspection Schedule.

## 36 Internal defects

If required by the drawing, order or Inspection Schedule, bars and sections shall be examined by ultrasonic inspection, in the condition in which they are to be delivered.

The method of examination and standards of acceptance shall be agreed between the manufacturer and the purchaser [see **5.2**d)] and shall be stated on the order or Inspection Schedule.

## 37 Retesting procedures for etch inspection, fracture test and external defects

If any specimen reveals a harmful defect, the relevant length of bar or section shall be cropped, and a further specimen subsequently prepared and examined in accordance with Clause **35**.

Examination of specimens from other bars or sections of the same size shall verify that the whole of the material represented by the selected bar or section is free from harmful defects.

## 38 Marking

**38.1** Products with a diameter or major sectional dimension ≥ 20 mm shall bear the following identification marking at, or near one end.

a) Number of the material specification.

b) Delivery condition.

c) Manufacturer's identification and site identification.

d) Batch number.

e) Inspection stamp.

**38.2** Products with a diameter or major sectional dimension <20 mm shall be either individually marked as required by **38.1** or shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by **38.1**.

# Section 5: Forgings

## 39 General

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

**39.2** This section also applies to pre-production forgings intended for qualification of the method of manufacture, and inspection and testing.

## 40 Manufacture

**40.1** Forgings shall be manufactured from forging stock conforming to Section **2** or Section **3**.

**40.2** The method of manufacture of production forgings shall be the same as the method of manufacture of the pre-production forgings, except by agreement between the manufacturer and the purchaser and following written approval by the design authority including any requirement for re-qualification of the forgings.

## 41 Pre-production forgings

### 41.1 General

**41.1.1** The following information to be supplied by the purchaser shall be fully documented on the order, drawing or inspection schedule:

a) the number of forgings to be selected from initial production for evaluation;

b) the location, size and form of any test pieces to be cut from the forgings and the test properties required at each location;

c) any other test requirements such as grain flow, macrostructure, microstructure;

d) the condition of the forgings on which the tests are to be carried out together with any requirements for machining prior to heat treatment;

e) those areas of the forgings which are critical and for which special finishing prior to inspection is required together with the standard of such finish;

f) whether an agreed method of manufacture is required.

If procedure X is required (see Clause **43**), this shall be documented and the location of the required test pieces shall be shown.

**41.1.2** The inspection and testing of pre-production forgings shall be carried out, and the inspection and test conditions shall be recorded, to allow the definition of the optimum techniques to be used for production forgings.

**41.1.3** The inspection and tests carried out on pre-production forgings shall include those which will be carried out on production forgings (see Clause **42**).

### 41.2 Inspection and testing report

In addition to any information required by Section **1**, the inspection and testing report on the pre-production forgings shall include all the technical information that has been obtained on these forgings, e.g. photographs taken during macroscopic and microscopic examination, results of dimensional measurements.

### 41.3 Acceptance of pre-production forgings

When all inspection and test results relating to pre-production forgings have been reported, and accepted as satisfactory by the purchaser, written agreement for series production shall be obtained from the design authority.

## 42 Production forgings

### 42.1 General

Inspection and testing carried out on production forgings shall be under the same conditions as those applied to the pre-production forgings (see **41.1.2** and **41.1.3**).

### 42.2 Dimensions and tolerances

**42.2.1** The dimensions of the product shall be measured and shall fall within the tolerances agreed between the manufacturer and the purchaser according to the type of forging [see **5.2**f)] and stated on the drawing or inspection schedule.

**42.2.2** Designated dimensions, as indicated on the drawing or inspection schedule, shall be measured on each forging [see **5.1**b)1)]. For other dimensions the frequency of measurement shall be at the discretion of the manufacturer.

## 43 Procedure X for process control testing

*NOTE Procedure X is a process control procedure used to ensure that forgings continue to conform to specified requirements (see **3.21**).*

**43.1** Where procedure X is invoked, the testing requirements, including the position, size and number of test pieces to be machined from the forging and, where applicable, the properties required, shall be as stated on the order, drawing or inspection schedule [see **5.1**b)2)].

**43.2** Forgings selected for test in accordance with procedure X shall be to the frequency stated in the order, drawing or inspection schedule, but the number of forgings manufactured between the selection of the test samples shall not be more than that specified in Table 4 [see **5.1**b)2)].

Table 4 **Maximum number of forgings to be manufactured between the collection of test samples**

| **Mass of forging (m)** kg | **Number of forgings** |
|---|---|
| $m \leq 0.75$ | 1 500 |
| $0.75 < m \leq 1.5$ | 750 |
| $1.5 < m \leq 5$ | 300 |
| $5 < m \leq 25$ | 150 |
| $m > 25$ | As given on the order, drawing or inspection schedule |

*NOTE The number of test samples selected for grain flow examination may be less than that selected from the pre-production forgings as indicated by the drawing or inspection schedule.*

# 44 Forgings subject to heat treatment after delivery

**44.1** It shall be demonstrated that the forging stock has the capability to conform to the mechanical property requirements given in the material specification.

**44.2** Each delivery of forgings, subject to solution treatment and/or artificial ageing after delivery, shall be accompanied by representative test samples that reflect the heat treatment condition of the forgings as delivered.

*NOTE Where forgings are supplied in the annealed or solution annealed condition, test samples in the "as forged" condition may be supplied.*

**44.3** For forgings tested in accordance with Procedure A (see **45.1.1**) the number of test samples supplied with each delivery shall be as stated on the order [see **5.1**b)3)]. If it is subsequently found that insufficient test samples from the same cast are available for heat treatment control purposes, the purchaser shall, with the agreement of the design authority, use control samples of material conforming to the same material specification.

**44.4** For forgings tested in accordance with Procedure C (see **45.1.1**), one integral test sample shall be removed from one forging from each cast.

# 45 Batch acceptance tensile tests

## 45.1 Sampling

**45.1.1** The sampling procedure shall be one of the following as specified on the order [see **5.1**b)4)]. Where no procedure is specified, Procedure A shall be used.

a) Procedure A. Separate test samples shall be prepared from the same cast of forgings stock.

b) Procedure C. Integrally forged test samples shall be prepared.

c) Procedure D. Test samples shall be machined from selected locations on the forgings.

*NOTE 1 Procedure B (separate heat treatment control test samples conforming to the same material specification as the forgings), which is to be found in other standards, is not applicable to magnesium alloy forgings.*

*NOTE 2 The forging is destroyed if Procedure D is used.*

**45.1.2** When separate or integrally forged test samples are used, it shall be permissible for them to be employed alone (Procedure A or Procedure C), or with additional test samples cut from the forgings in accordance with Procedure X (Procedure AX or Procedure CX).

**45.1.3** Procedure D shall only be used for forgings supplied in the fully heat treated condition.

**45.1.4** Process control testing shall be employed when Procedure AX or Procedure CX is specified on the order.

## 45.2 Test sample preparation

### 45.2.1 Procedure A. Separate test samples prepared from the same cast of forging stock

**45.2.1.1** Forgings shall be grouped in batches of not more than 500 kg and shall be represented by at least one test sample per batch.

**45.2.1.2** Representative test samples shall be taken from forging stock of the same form, dimensions and cast as that used to make the forgings.

**45.2.1.3** At the discretion of the manufacturer, it shall be permissible for test samples from ingot and other forging stock greater than 30 mm diameter or minor sectional dimension to be forged to not less than 30 mm diameter or equivalent section.

**45.2.1.4** The heat treatment control test samples and the forgings they represent shall be heat treated together in accordance with the material specification and shall not be further heat treated or mechanically worked before being tested. Each batch of forgings heat treated shall be represented by at least one control sample.

### 45.2.2 Procedure C. Integrally forged test samples

**45.2.2.1** One or more mechanical test samples shall be forged integrally with each forging. The number, location, form and size of the test samples shall be as stated on the order, drawing or inspection schedule [see **5.1**b)5)].

**45.2.2.2** In the case of forgings to be subjected to heat treatment, test samples shall not be separated from the forgings before heat treatment unless stated on the order, drawing or inspection schedule that this is permitted [see **5.1**b)6)].

**45.2.2.3** At least one integral test sample shall be used to represent each batch of heat treated forgings for mechanical test purposes.

**45.2.2.4** The heat treatment control test samples and the forgings they represent shall be heat treated together in accordance with the material specification and shall not be further heat treated or mechanically worked before being tested.

### 45.2.3 Procedure D. Test samples machined from selected locations on the forgings

**45.2.3.1** The forgings shall be heat treated in accordance with the material specification. One forging shall be selected for testing from each batch of forgings of the same pattern, made from the same cast and that have been heat treated together.

**45.2.3.2** The location of the test samples shall be as stated on the drawing or inspection schedule [see **5.1**b)7)], with a minimum of one longitudinal and, where appropriate, one transverse sample.

## 45.3 Test piece preparation

Unless otherwise specified on the drawing, order or inspection schedule [see **5.1**b)8)], the test piece shall be prepared in accordance with **9.3**.

## 45.4 Tensile testing

The test piece shall be tested in accordance with **9.3** and the tensile properties shall be as specified in Table 5 [see **5.1**b)9)].

Table 5 **Tensile property requirements for forgings**

| Procedure | Requirements |
|---|---|
| A | As specified in the material specification |
| C | As specified in the material specification or as stated on the drawing or inspection schedule |
| D | |
| X | As stated on the drawing or inspection schedule |

# 46 External defects

**46.1** All surfaces of each forging shall be examined using one of the following procedures.

a) Visual examination after pickling for 10 s to 15 s at room temperature in an aqueous solution containing 100 g/L of nitric acid.

b) Etching followed by penetrant flaw detection in accordance with EN 2002-16.

**46.2** The procedure used shall be at the discretion of the manufacturer unless a particular procedure is specified on the order or inspection schedule [see **5.1**b)10)].

**46.3** The surfaces of the forgings shall be free from harmful defects.

**46.4** Local dressing to remove defects shall be permitted provided the dimensions remain within the specified limits. Examination shall be repeated on dressed areas.

# 47 Internal defects

**47.1** If ultrasonic testing is specified in the material specification, order, drawing or inspection schedule, testing shall be carried out in accordance with the material specification, order or inspection schedule. If no method is specified, testing shall be carried out in accordance with EN 4050-2 [see **5.1**b)11)].

**47.2** The technique shall be defined during the qualification of the pre-production forgings. The manufacturing stage i.e. final or intermediate, and the heat treatment condition, in which each forging is to be tested shall be as specified on the drawing or inspection schedule [see **5.1**b)11)].

**47.3** The acceptance level shall be as specified in the material specification, order or inspection schedule. If not specified, the acceptance level shall be class 3 of EN 4050-4. [see **5.1**b)11)].

# 48 Grain flow and grain size

**48.1** If grain flow examination and grain size measurement are specified on the order or inspection schedule [see **5.1**b)12)], macrographic and micrographic examination shall be carried out.

The type of examination shall be as specified on the order or inspection schedule and the sampling frequency shall be as specified on the order or inspection schedule under procedure X [see **5.1**b)12)].

**48.2** The grain flow and the grain size shall be the same as those obtained on the pre-production forgings and shall conform to the order or inspection schedule [see **5.1**b)12)].

# 49 Special tests

Special tests and inspections (e.g. internal stress, intergranular corrosion, micrographic examination) shall be carried out in accordance with the material specification, order, drawing or inspection schedule [see **5.1**b)14)].

# 50 Marking

**50.1** Forgings shall bear the following identification marking.

a) Number of the material specification.

b) Part number or drawing number and, where required, serial number.

c) Delivery condition.

d) Manufacturer's identification.

e) Batch number.

f) Inspection stamp.

**50.2** Forgings with a large enough surface area to accommodate the markings specified in **50.1** shall be individually marked. The location and method of marking shall be as specified in the material specification or order [see **5.1**b)14)]. If not specified in the material specification or order, the location and method of marking shall be at the discretion of the manufacturer.

**50.3** Forgings with too small a surface area to accommodate the marking specified in **50.1** shall be packed in bags or bundles each of which shall have attached a durable label indelibly marked with the information required by **50.1**.

# Section 6: Sheet and strip

## 51 General

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

## 52 Condition

The material shall be delivered in the condition required by the material specification.

## 53 Dimensional tolerances

The dimensions of the product shall be measured and, unless special tolerances are agreed between the supplier and the purchaser [see **5.2**g)], and stated on the order, shall fall within the tolerances given in Annex D, as listed in Table 6.

Table 6 **Tolerances for sheet and strip**

| Dimension or feature | Product | Tolerance |
|---|---|---|
| Thickness | Sheet and strip | Table D.1 |
| Width and length | Sheet | Table D.3 |
| Width | Strip | Table D.4 |
| Lateral curvature | Sheet | No part of the edge of any sheet shall be distant from a 3 000 mm chord by more than 6 mm.<br>In the case of lengths shorter than 3 000 mm the distance shall be proportionate. |
| | Strip | Each coil shall be so free from lateral curvature that when laid out flat no part of its edge shall be distant from a 3 000 mm chord by more than 12 mm.<br>In the case of lengths shorter than 3 000 mm the distance shall be proportionate. |
| Squareness | Sheet | The diagonal distances between the opposite corners of any sheet shall not differ by more than the total tolerance on the length of the sheet. |

## 54 Selection and preparation of mechanical test samples

### 54.1 Selection

**54.1.1** Sheets and coils of strip shall be grouped in batches of not more than 500 kg.

**54.1.2** One test sample shall be selected from each batch, after any flattening or straightening operation, for tensile testing.

**54.1.3** If any subsequent heating operation is given to the material after the test sample has been removed, the test sample shall accompany the material during the further heating operation or a further test sample shall be selected after that operation.

### 54.2 Preparation

The test samples shall be cut so that the longitudinal axis of the test piece is in a direction parallel to the direction of final rolling and the position of the test piece axis relative to width *b* shall be *b*/3.

## 55 Tensile testing

The test pieces prepared in accordance with Clause **54** shall be tested in accordance with **9.3** and the tensile properties shall conform to the material specification.

## 56 Marking

### 56.1 Sheet

Each sheet shall bear the following identification marking.

a) Overall marking in ink or similar medium, giving the following information, all of which shall be visible on any separate piece 300 mm × 300 mm.

b) Number of the material specification.

c) Delivery condition.

d) Manufacturer's identification and site identification.

e) End marking in ink or by hard stamping on one face in one corner, giving the following information.

f) Batch number.

g) Inspection stamp.

### 56.2 Strip

Each coil of strip shall have attached a durable label indelibly marked with the information required by **56.1**.

# Section 7: Plate

## 57 General

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

## 58 Condition

The material shall be delivered in the condition required by the material specification.

## 59 Dimensional tolerances

The dimensions of the product shall be measured and, unless special tolerances are agreed between the supplier and the purchaser [see **5.2**h)], and stated on the order, shall fall within the tolerances given in Annex E, as listed in Table 7.

Table 7 **Tolerances for plate**

| Dimension or feature | Tolerance |
|---|---|
| Thickness | Table D.2 |
| Width and length | Table D.3 |
| Lateral curvature | No part of the edge of any plate shall be distant from a 3 000 mm chord by more than 6 mm.<br>In the case of lengths shorter than 3 000 mm the distance shall be proportionate. |
| Flatness | Table D.5 |

## 60 Selection and preparation of mechanical test samples

### 60.1 Selection

**60.1.1** Plates shall be grouped in batches of not more than 500 kg. If a plate exceeds 500 kg, it shall be regarded as a batch.

**60.1.2** One test sample shall be selected from each batch, after any flattening or straightening operation, for tensile testing.

**60.1.3** If any subsequent heating operation is given to the material after the test sample has been removed, the test sample shall accompany the material during the further heating operation or a further test sample shall be selected after that operation.

### 60.2 Preparation

One test sample shall be prepared from each batch in each of the directions specified in the material specification. If directions are not specified in the material specification, one sample shall be prepared from each batch in each of the directions specified in Table 8. The positions of the test pieces taken from the test samples shall be as specified in Table 8. Test samples shall be selected clear of any stretcher jaw markings.

Table 8 **Direction of tensile test samples and position of tensile test pieces**

| **Plate thickness, *a*** mm | **Direction of test sample** | **Position of test piece axis relative to** | |
|---|---|---|---|
| | | **Thickness, *a*** | **Width, *b*** |
| $6.0 \leq a \leq 12.5$ | Long transverse | *a*/2 | b/3 |
| $a > 12.5$ | Longitudinal<br>Long transverse | *a*/2 | *b*/3 |

# 61 Tensile testing

The test pieces prepared in accordance with Clause **60** shall be tested in accordance with **9.3** and the tensile properties shall conform to the material specification.

# 62 Internal defects

**62.1** If ultrasonic testing is specified in the material specification, order, drawing or inspection schedule, testing shall be carried out in accordance with the material specification, order or inspection schedule. If no method is specified, testing shall be carried out in accordance with EN 4050-2 [see **5.1**c)1)].

**62.2** The technique shall be defined during the qualification of the pre-production forgings. The manufacturing stage i.e. final or intermediate, and the heat treatment condition, in which each forging is to be tested shall be as specified on the drawing or inspection schedule [see **5.1**c)1)].

**62.3** The acceptance level shall be as specified in the material specification, order or inspection schedule. If not specified, the acceptance level shall be class 3 of EN 4050-4. [see **5.1**c)1)].

# 63 Marking

Each plate shall bear the following identification marking.

a) Overall marking, in ink or similar medium, giving the following information, all of which shall be visible on any separate piece 250 mm × 250 mm.

b) Number of material specification.

c) Delivery condition.

d) Manufacturer's identification and site identification.

e) Thickness.

f) End marking in ink or similar medium or by hard stamping, on material <12 mm thick on one face in a corner and on material ≥ 12 mm thick on one edge, giving the following information.

g) Batch number or plate number.

h) Inspection stamp.

# Section 8: Tube

## 64 General

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

## 65 Manufacture

Tubes shall be extruded by the process approved by the Quality Assurance Authority.

## 66 Condition

Tubes shall be delivered in the condition required by the material specification.

## 67 Dimensional tolerances

The dimensions of the tube shall be measured and, unless special tolerances are agreed between the supplier and the purchaser [see **5.2**i)], and stated on the order, shall fall within the tolerances given in Annex F, as listed in Table 9.

Table 9 **Tolerances for tube**

| **Dimension or feature** | **Tolerance** |
|---|---|
| Straightness | For tube supplied in straight lengths, the departure from straightness shall not exceed the limits given in Table E.1 |
| Length | Table E.2 |
| Diameter | Table E.3 |
| Wall thickness | Table E.4 |

## 68 Selection and preparation of mechanical test samples

**68.1** Tubes shall be grouped in batches of similar nominal dimensions as shown in Table 10.

Table 10 **Batch sizes for tubes**

| **Nominal outside diameter (D)** | **Maximum size of batch** |
|---|---|
| mm | |
| $D \leq 20$ | 350 |
| $20 < D \leq 50$ | 250 |
| $50 < D \leq 150$ | 150 |

**68.2** One test sample shall be selected from each batch, after any straightening operation, for tensile testing.

If any subsequent heating operation is given to the material after the test sample has been removed, the test sample shall accompany the material during the further heating operation or a further test sample shall be selected after that operation.

# 69 Tensile testing

The test pieces prepared in accordance with Clause **68** shall be tested in accordance with **9.3** and the tensile properties shall conform to the material specification.

# 70 Marking

**70.1** Tube with an outside diameter > 6 mm shall bear continuous marking, in ink or similar medium, repeated every 0.5 m along the length, giving the following information.

a) Number of the material specification.

b) Delivery condition.

c) Manufacturer's identification and site identification.

d) Batch number.

e) Inspection stamp.

**70.2** Tube with an outside diameter <6 mm shall be wired together in bundles. Each bundle shall have attached a durable label indelibly marked with the information required by **70.1**.

# Annex A (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, 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.

a) Stresses up to 250 MPa: to the nearest even number.

b) Stresses over 250 MPa up to and including 1 000 MPa: to the nearest multiple of five.

c) Stresses over 1 000 MPa: to the nearest multiple of 10.

d) For numerical values and other units.

e) When the figure immediately after the last figure to be retained is less than 5, the last figure to be retained shall remain unchanged.

f) 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.

g) 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.

# Annex B (normative) Protection against corrosion

## B.1 Procedure

**B.1.1** The material shall be protected from corrosion by a series of operations, carried out in accordance with the requirements of this Annex, in one of the standard sequences (known as "Routes") given in Table B.1.

*NOTE Surface sealing, whilst conferring considerable protection of itself, is basically intended as a preparation for subsequent protective treatment (e.g. painting).*

**B.1.2** It is permissible to use other routes subject to the prior approval of the Design Authority and/or the Quality Assurance Authority.

## B.2 Preliminary cleaning

### B.2.1 Rough cleaning

The surfaces of the material shall be free from embedded metal and other impurities.

### B.2.2 Degreasing

The material shall be degreased in accordance with BS M 93, Annex A.

## B.3 Fluoride anodizing

The material shall be fluoride anodized in accordance with BS M 93, Annex A.

## B.4 Fluoride film removal

The fluoride film shall be removed in accordance with BS M 93, Annex A.

## B.5 Chromate treatment

The material shall be chromate treated in accordance with BS M 93, Annex B, the choice of that to be used being dictated by the material being treated, the required final tolerances and the manufacturing procedures

## B.6 Surface sealing

*NOTE Attention is drawn to Note 3 to Table B.1.*

**B.6.1** Immediately following chromate treatment, the material shall first be pre-heated to a temperature of 180 °C to 200 °C and then allowed to cool to a temperature of 60°C ±10 °C.

The duration of heating shall be kept short but shall be sufficient to ensure that the temperature of the interior of the material is maintained at 180 °C to 200 °C for at least 10 minutes.

**B.6.2** When cooled, the material shall be:

Dipped in (preferably) or sprayed with an unpigmented resin solution conforming to BS X 38.

After thorough covering, withdrawn from the solution, being simultaneously turned slowly to ensure draining of the solution from recesses.

Allowed to drain in a dust free atmosphere for 15 minutes to 30 minutes during which time any tears and drips shall be removed with a palette knife or brush.

Baked for a period that will ensure its being at a temperature of 180 °C to 200 °C for 15 minutes.

Allowed to cool to a temperature of 60°C ±10 °C and any tears or drips on the hardened resin film shall be removed with a sharp knife or file, care being taken not to cut down to bare metal.

**B.6.3** The sequence of operations in **B.6.2** shall be repeated with minimum delay, the material being supported during baking in a position inverted from that of the first baking.

**B.6.4** The sequence of operations in **B.6.2** shall again be repeated with minimum delay, the material being supported during baking in a position different from that of previous treatments. The baking period shall be such as to ensure the material being at a temperature of 180 °C to 220 °C for 45 minutes to 60 minutes.

**B.6.5** The minimum thickness of the surface coating shall be 0.025 mm and the finished surface shall be glossy and free from pinholes and cissing.

## B.7 Painting

Painting, when required after surface sealing, shall consist of at least one coat of chromated primer followed by the required finishing coats conforming to BS X 38.

## B.8 Miscellaneous operations

### B.8.1 Temporary protection

Temporary protection shall be effected by thoroughly coating the material with lanolin, de-watering oil or other approved protective.

### B.8.2 Chromate film removal

The chromate film shall be removed in accordance with BS M 93, Annex B.

### B.8.3 Acid pickling

Acid pickling shall be carried out in accordance with BS M 93, Annex A.

Table B.1 **Standard routes for protection against corrosion**

| Operation (see Note 2) | | Reference | Route (see Note 1) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | | Forgings | | | | | Cast material for hot working | Extruded forging stock | Rolled and extruded products | |
| 1 | Preliminary cleaning | **B.2** | X | X | X | X | X | | | X | X |
| 2 | Fluoride anodizing | **B.3** | X | X | X | | | | | | |
| 3 | Fluoride film removal [A)] | **B.4** | X | X | X | | | | | | |
| 4 | Chromate treatment | **B.5** | X | X | X | X | X | | | X | X |
| 5 | Surface sealing | **B.6** | X | | | | | | | X | |
| 6 | Temporary protection | **B.8.1** | | | X | | X | | X | | X |
| 7 | Acid pickling | **B.8.2** | | | | | | X | | | |
| 8 | Degreasing | **B.2.2** | | X | X | | X | | | | X |
| 9 | Chromate film removal | **B.8.2** | | | | X [A)] | X [A)] | | | | |
| 10 | Fluoride anodizing | **B.3** | | | | X [A)] | X [A)] | | | | |
| 11 | Fluoride film removal [A)] | **B.4** | | | | X [A)] | X [A)] | | | | |
| 12 | Chromate treatment | **B.5** | | X | X | X [A)] | X [A)] | | | | X |
| 13 | Surface sealing | **B.6** | | X | X | X [A)] | X [A)] | | | | X |
| 14 | Machining | — | X | X | X | X | X | | | X | X |
| 15 | Degreasing | **B.2.2** | X | X | X | X | X | | | X | X |
| 16 | Chromate treatment | **B.5** | X | X | X | X | X | | | X | X |
| 17 | Surface sealing (see Note 3) | **B.6** | X | X | X | X | X | | | X | X |
| 18 | Painting | **B.7** | — | | | | | | | | |

*NOTE 1 The choice of route will depend on the form of the material, the processing of the material or component and the final treatment to be applied.*
*Route 1 is suitable for forgings requiring a high resistance to deterioration.*
*Routes 2 and 3 are suitable for forgings the surface of which the component manufacturer wishes to inspect. Whilst a fair storage life is to be expected after treatment by the material manufacturer, surface sealing should be carried out by the component manufacturer as soon as possible, particularly in the case of Route 2.*
*Routes 4, 5, 6 and 7 are suitable only for material which is to be processed immediately on receipt by the component manufacturer or stored in exceptionally good conditions.*
*Route 8 is suitable for sheet, tube and extrusions requiring a high resistance to deterioration.*
*Route 9 is suitable for sheet, tube and extrusions which the component manufacturer wishes to inspect. Whilst a fair storage life is to be expected, surface sealing should be carried out as soon as possible.*

*NOTE 2 Operations 1 to 7 are usually carried out by the manufacturer of the material. Operations 8 to 18 are usually carried out by the manufacturer of the final component.*

*NOTE 3 If the full surface sealing treatment at operation 17 would adversely affect the tolerances, the treatment may be reduced as necessary, as agreed with the Quality Assurance Authority.*

[A)] May be omitted on parts to be machined all over.

**Annex C (normative)**

# Tolerances for bars and extruded sections

**C.1** The dimensional tolerances for bars and extruded sections are detailed in the tables:

Table C.1 Tolerances on straightness of bars and regular sections.

Table C.2 Tolerances on twist of extruded sections.

Table C.3 Tolerances on angles of regular sections.

Table C.4 Tolerances on lengths of bars and extruded sections.

Table C.5 Tolerances on thickness of bars and regular sections.

Table C.6 Tolerances on thickness of hollow sections.

Table C.7 Tolerances on diameters, overall widths and widths across flats of bars, regular sections and hollow sections.

Table C.8 Tolerances on open ends of channels and I beams

Table C.9 Normal radii for corners on square and rectangular sections (informative)

Table C.10 normal radii for corners on regular sections; angle, channel, I and T sections
(informative)

Bars and extruded sections with widths or thicknesses greater than those shown in Table C.5 to Table C.8 can be supplied by arrangement between the manufacturer and the purchaser either directly or through an intermediary.

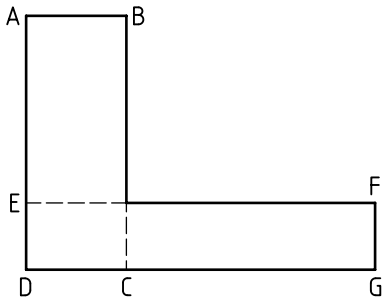
*NOTE* *Width* = *major sectional dimension.*

*Thickness* = *minor sectional dimension.*

**C.2** The term "regular sections" includes square and rectangular bars; it also includes angles, T, H, I and Z sections and other normal types of extrusions which can be divided conveniently into approximate rectangles with measurable dimensions and where the ratio of the maximum thickness to the minimum thickness of any part of the section does not exceed 4:1. For tolerancing purposes such sections shall be divided into a series of equivalent rectangles.

*EXAMPLE*

*An angle section shall be divided into two rectangles, the width of each rectangle being the major dimension of the relevant leg.*




*Thus, with the angle shown in the sketch, the rectangles are ABCD and DEFG respectively. The tolerances on the thickness of the legs shall be calculated as for rectangles of widths AD and DG respectively.*

**C.3** Tolerances for sections of complicated shape which cannot be divided conveniently into rectangles as described in **C.2** shall be agreed between the manufacturer and the purchaser but shall be based, as far as possible, on the standard tolerances.

Where specially close tolerances are required on sections, because additional manufacturing operations are necessary, the tolerances to be applied shall be agreed between the manufacturer and the purchaser.

**C.4** The tolerances on length shown in Table C.4 are on the length measured at normal room temperature of 20 °C and provide for out-of-squareness of cut to the extent of 1°.

Total tolerances (i.e. the sum of the plus and minus limits) may be applied unilaterally by agreement between the supplier and the purchaser.

**C.5** For information, the normal corner radii may be expected to be as detailed in the tables:

Table C.9 Corner radii for square and rectangular sections.

Table C.10 Corner radii for regular sections: angle, channel, I and T sections.

Table C.1 **Tolerances on straightness of bars and regular sections**

| **Diameter (D) [A)]** mm | **Departure from straightness over any selected length of 1 000 mm** mm |
|---|---|
| d ≤ 100 | 1.5 |
| d ≥ 100 | 2.5 |

[A)] Round bar: nominal diameter.

Section: diameter of circumscribing circle.

Tube: nominal outside diameter.

Table C.2 **Tolerances on twist of extruded sections**

| **Diameter of circle circumscribing the section (d)** mm | **Angle of twist per 300 mm run** | **Total angle of twist per length** |
|---|---|---|
| d < 40 | 1° | 5° |
| 40 ≤ d ≤ 80 | ½° | 3° |
| d > 80 (lengths ≤ 8 000 mm) | ¼° | 2° |

Table C.3 **Tolerances on angles of regular sections**

| **Nominal thickness of thinnest rectangle of the section (t) [A)]** mm | **Allowable deviation from angle specified** |
|---|---|
| t ≤ 1.6 | ±2° |
| 1.6 ≤ t ≤ 5.0 | ±1½° |
| t > 5.0 | ±1° |

[A)] See **C.2**

Table C.4 **Tolerances on lengths of bars and extruded sections**

Dimensions in millimetres

| **Length** | **Over** | **299** | **1 000** | **1 500** | **5 000** | **7 000** | **10 000** |
|---|---|---|---|---|---|---|---|
| | **Up to and including** | **1 000** | **1 500** | **5 000** | **7 000** | **10 000** | **—** |
| **Nominal diameter, overall width or width across flats (d or w)** | | ± | ± | ± | ± | ± | ± |
| d or w ≤ 60 | | 2.0 | 2.5 | 2.5 | 3.5 | 4.0 | 6.5 |
| 60 ≤ d or w ≤ 100 | | 2.0 | 2.5 | 3.5 | 4.0 | 5.5 | 7.5 |
| 100 ≤ d or w ≤ 140 | | 3.0 | 3.5 | 4.0 | 5.0 | 6.5 | 8.0 |
| 140 ≤ d or w ≤ 180 | | 3.5 | 4.0 | 5.0 | 6.5 | 8.0 | 9.5 |
| 180 ≤ d or w ≤ 240 | | 4.5 | 5.0 | 6.5 | 8.0 | 9.5 | 11.0 |

Table C.5 **Tolerances on thickness of bars and regular sections**

Dimensions in millimetres

| **Thickness** | **Over** | — | 1.6 | 3 | 6 | 10 | 18 | 30 | 40 | 60 | 80 | 100 | 120 | 140 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Up to and including** | 1.6 | 3 | 6 | 10 | 18 | 30 | 40 | 60 | 80 | 100 | 120 | 140 | 160 [A)] |
| **Nominal width (w)** | | **Tolerances on thickness** | | | | | | | | | | | | |
| | | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± |
| w ≤ 10 | | 0.16 | 0.18 | 0.20 | 0.22 | | | | | | | | | |
| 10 ≤ w ≤ 18 | | 0.18 | 0.20 | 0.22 | 0.24 | 0.26 | | | | | | | | |
| 18 ≤ w ≤ 30 | | 0.22 | 0.24 | 0.26 | 0.28 | 0.30 | 0.32 | | | | | | | |
| 30 ≤ w ≤ 60 | | 0.24 | 0.26 | 0.28 | 0.30 | 0.33 | 0.36 | 0.40 | | | | | | |
| 60 ≤ w ≤ 80 | | 0.28 | 0.30 | 0.32 | 0.34 | 0.37 | 0.40 | 0.43 | 0.45 | 0.50 | | | | |
| 80 ≤ w ≤ 120 | | 0.32 | 0.34 | 0.36 | 0.39 | 0.42 | 0.45 | 0.48 | 0.52 | 0.57 | 0.65 | 0.80 | | |
| 120 ≤ w ≤ 180 | | | 0.36 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.82 | 0.90 | 1.00 |
| 180 ≤ w ≤ 240 | | | | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.05 |
| 240 ≤ w ≤ 320 | | | | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 | 1.05 | 1.10 |

[A)] For thickness over 160 mm, the tolerances in Table C.6 and C.7 for comparable widths shall apply.



Table C.6 **Tolerances on thickness of hollow sections**

Dimensions in millimetres

| **Thickness** | **Over** | **1.59** | **3.0** | **6.0** | **10** | **18** |
|---|---|---|---|---|---|---|
| | **Up to and including** | **3.0** | **6.0** | **10** | **18** | **30** |
| **Nominal width or width across flats (w)** | | **Tolerances on thickness** | | | | |
| | | ± | ± | ± | ± | ± |
| 10 ≤ w ≤ 18 | | 0.28 | | | | |
| 18 ≤ w ≤ 30 | | 0.36 | 0.54 | | | |
| 30 ≤ w ≤ 60 | | 0.45 | 0.65 | 0.90 | 1.40 | |
| 60 ≤ w ≤ 80 | | 0.55 | 0.75 | 0.95 | 1.45 | |
| 80 ≤ w ≤ 120 | | 0.65 | 0.80 | 1.00 | 1.50 | 2.00 |
| 120 ≤ w ≤ 180 | | 0.75 | 0.85 | 1.10 | 1.60 | 2.20 |
| 180 ≤ w ≤ 240 | | | 1.00 | 1.20 | 1.80 | 2.40 |
| 240 ≤ w ≤ 320 | | | | 1.40 | 2.00 | 2.60 |

*NOTE 1 These tolerances apply only to sections of wall thickness not less than 1.6 mm or 1/24th of the overall width, whichever is the greater.*

*NOTE 2 Attention is drawn to the fact that tolerances on thickness of hollow sections depend on the alloy and the manufacturing process used, and that in certain cases the tolerances given in this table will not apply. In such cases, the tolerances shall be agreed between the manufacturer and the purchaser.*

Table C.7 **Tolerances on diameters, overall widths and widths across flats of bars, regular sections and hollow sections**

Dimensions in millimetres

| **Nominal diameter, overall width or width across flats (d or w)** | **Tolerance** |
|---|---|
| | ± |
| d or w ≤ 3 | 0.16 |
| 3 ≤ d or w ≤ 10 | 0.20 |
| 10 ≤ d or w ≤ 18 | 0.26 |
| 18 ≤ d or w ≤ 30 | 0.32 |
| 30 ≤ d or w ≤ 40 | 0.40 |
| 40 ≤ d or w ≤ 60 | 0.43 |
| 60 ≤ d or w ≤ 80 | 0.50 |
| 80 ≤ d or w ≤ 100 | 0.65 |
| 100 ≤ d or w ≤ 120 | 0.80 |
| 120 ≤ d or w ≤ 140 | 0.90 |
| 140 ≤ d or w ≤ 160 | 1.0 |
| 160 ≤ d or w ≤ 180 | 1.1 |
| 180 ≤ d or w ≤ 200 | 1.2 |
| 200 ≤ d or w ≤ 240 | 1.3 |
| 240 ≤ d or w ≤ 280 | 1.5 |
| 280 ≤ d or w ≤ 320 | 1.7 |

*NOTE The tolerances given in this table shall apply only to hollow sections when the section thickness is not less than 1.6 mm or 1/24th of the overall width, whichever is greater.*

Table C.8 **Tolerances on open ends of channels and I beams**

Dimensions in millimetres

| **Depth** | **Over** | | **10** | **18** | **30** | **40** | **60** | **80** | **100** | **120** | **140** | **160** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Up to and including** | **10** | **18** | **30** | **40** | **60** | **80** | **100** | **120** | **140** | **160** | **180** |
| **Overall width of channel (w)** | **Minimum thickness of web or flange (t)** | **Tolerances on internal or external dimension at top of gap** | | | | | | | | | | |
| | | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± |
| w ≤ 10 | t ≤ 1.5 | 0.25 | 0.32 | 0.41 | | | | | | | | |
| | 1.5 ≤ t ≤ 3 | 0.23 | 0.28 | 0.34 | | | | | | | | |
| | t > 3 | 0.22 | 0.26 | 0.30 | | | | | | | | |
| 10 ≤ w ≤ 18 | t ≤ 1.5 | 0.31 | 0.38 | 0.47 | 0.56 | 0.70 | | | | | | |
| | 1.5 ≤ t ≤ 3 | 0.29 | 0.34 | 0.40 | 0.46 | 0.55 | | | | | | |
| | t > 3 | 0.28 | 0.32 | 0.36 | 0.41 | 0.47 | | | | | | |
| 18 ≤ w ≤ 30 | t ≤ 3 | 0.37 | 0.47 | 0.57 | 0.68 | 0.84 | 1.05 | 1.26 | | | | |
| | 3 ≤ t ≤ 6 | 0.37 | 0.44 | 0.53 | 0.62 | 0.76 | 0.93 | 1.11 | | | | |
| | t > 6 | 0.35 | 0.41 | 0.48 | 0.55 | 0.64 | 0.78 | 0.91 | | | | |
| 30 ≤ w ≤ 40 | t ≤ 3 | 0.45 | 0.55 | 0.65 | 0.76 | 0.92 | 1.13 | 1.34 | 1.55 | 1.76 | | |
| | 3 ≤ t ≤ 6 | 0.45 | 0.52 | 0.61 | 0.70 | 0.84 | 1.01 | 1.19 | 1.36 | 1.54 | | |
| | t > 6 | 0.43 | 0.49 | 0.56 | 0.63 | 0.72 | 0.86 | 0.99 | 1.12 | 1.25 | | |
| 40 ≤ w ≤ 60 | t ≤ 3 | | 0.60 | 0.70 | 0.81 | 0.97 | 1.18 | 1.39 | 1.60 | 1.81 | 2.02 | |
| | 3 ≤ t ≤ 6 | | 0.57 | 0.66 | 0.75 | 0.89 | 1.06 | 1.24 | 1.41 | 1.59 | 1.76 | |
| | t > 6 | | 0.54 | 0.61 | 0.68 | 0.77 | 0.91 | 1.04 | 1.17 | 1.30 | 1.43 | |
| 60 ≤ w ≤ 80 | t ≤ 3 | | 0.65 | 0.75 | 0.86 | 1.02 | 1.23 | 1.44 | 1.65 | 1.86 | 2.07 | 2.28 |
| | 3 ≤ t ≤ 6 | | 0.62 | 0.71 | 0.80 | 0.94 | 1.11 | 1.29 | 1.46 | 1.64 | 1.81 | 1.99 |
| | t > 6 | | 0.59 | 0.66 | 0.73 | 0.82 | 0.96 | 1.09 | 1.22 | 1.35 | 1.48 | 1.61 |
| 80 ≤ w ≤ 100 | t ≤ 6 | | | 0.90 | 1.01 | 1.17 | 1.38 | 1.59 | 1.80 | 2.01 | 2.22 | 2.43 |
| | t > 6 | | | 0.86 | 0.95 | 1.09 | 1.26 | 1.44 | 1.61 | 1.79 | 1.96 | 2.14 |
| 100 ≤ w ≤ 120 | t ≤ 6 | | | 1.05 | 1.16 | 1.32 | 1.53 | 1.74 | 1.95 | 2.16 | 2.37 | 2.58 |
| | t > 6 | | | 1.01 | 1.10 | 1.24 | 1.41 | 1.59 | 1.76 | 1.94 | 2.11 | 2.29 |
| 120 ≤ w ≤ 140 | t ≤ 6 | | | 1.15 | 1.26 | 1.42 | 1.63 | 1.84 | 2.05 | 2.26 | 2.47 | 2.68 |
| | t > 6 | | | 1.11 | 1.20 | 1.34 | 1.51 | 1.69 | 1.86 | 2.04 | 2.21 | 2.39 |
| 140 ≤ w ≤ 160 | t ≤ 6 | | | 1.25 | 1.36 | 1.52 | 1.73 | 1.94 | 2.15 | 2.36 | 2.57 | 2.78 |
| | t > 6 | | | 1.21 | 1.30 | 1.44 | 1.61 | 1.79 | 1.96 | 2.14 | 2.31 | 2.49 |



Table C.8 **Tolerances on open ends of channels and I beams**

Dimensions in millimetres

| **Depth** | **Over** | | **10** | **18** | **30** | **40** | **60** | **80** | **100** | **120** | **140** | **160** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Up to and including** | **10** | **18** | **30** | **40** | **60** | **80** | **100** | **120** | **140** | **160** | **180** |
| **Overall width of channel (w)** | **Minimum thickness of web or flange (t)** | **Tolerances on internal or external dimension at top of gap** | | | | | | | | | | |
| | | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± |
| 160 ≤ w ≤ 180 | t ≤ 6 | | | 1.35 | 1.46 | 1.62 | 1.83 | 2.04 | 2.25 | 2.46 | 2.67 | 2.88 |
| | t > 6 | | | 1.31 | 1.40 | 1.54 | 1.71 | 1.89 | 2.06 | 2.24 | 2.41 | 2.59 |
| 180 ≤ w ≤ 200 | t ≤ 6 | | | 1.45 | 1.56 | 1.72 | 1.93 | 2.14 | 2.35 | 2.56 | 2.77 | 2.98 |
| | t > 6 | | | 1.41 | 1.50 | 1.64 | 1.81 | 1.99 | 2.16 | 2.34 | 2.51 | 2.69 |
| 200 ≤ w ≤ 240 | t ≤ 6 | | | 1.55 | 1.66 | 1.82 | 2.03 | 2.24 | 2.45 | 2.66 | 2.87 | 3.08 |
| | t > 6 | | | 1.51 | 1.60 | 1.74 | 1.91 | 2.09 | 2.26 | 2.44 | 2.61 | 2.79 |
| 240 ≤ w ≤ 280 | t ≤ 6 | | | 1.71 | 1.80 | 1.94 | 2.11 | 2.29 | 2.46 | 2.64 | 2.81 | 2.99 |
| | t > 6 | | | 1.91 | 2.00 | 2.14 | 2.32 | 2.49 | 2.66 | 2.84 | 3.01 | 3.19 |

Table C.9 **Normal radii for corners on square and rectangular sections (informative)**

| Minor dimensions | Radius on corner |
|---|---|
| mm | mm |
| $d \leq 5$ | 0.4 |
| $5 \leq d \leq 10$ | 0.8 |
| $10 \leq d \leq 25$ | 1.6 |
| $25 \leq d \leq 50$ | 2.5 |
| $50 \leq d \leq 120$ | 3.0 |
| $d > 120$ | 5.0 |

Table C.10 **Normal radii for corners on rectangular sections: angle, channel, I and T sections (informative)**

| Thickness of section (t) | Radius on corner |
|---|---|
| mm | mm |
| $t \leq 5$ | 0.8 |
| $t > 5$ | 1.6 |

**Annex D (normative)**

# Tolerances for sheet, strip and plate

**D.1** The dimensional tolerances for sheet, strip and plate are detailed in the tables:

Table D.1 Tolerances on thickness of sheet and strip.

Table D.2 Tolerances on thickness of plate.

Table D.3 Cutting tolerances for sheet and plate.

Table D.4 Shearing tolerances for strip.

**D.2** Intermediate thicknesses shall be toleranced as for the next greater thickness.

**D.3** Attention is drawn to the fact that certain alloys are not normally supplied thinner than 0.8 mm. Some limitations on available width may also apply.

**D.4** For plate where unilateral tolerances are specified on the order, the total permissible variation in thickness shall be the sum of the plus and minus tolerances shown in Table D.2.

Table D.1 **Tolerances on thickness of sheet and strip**

Dimensions in millimetres

| **Width** | **Over** | | **500** | **1 000** |
|---|---|---|---|---|
| | **Up to and including** | **500** | **1 000** | **1 200** |
| **Nominal thickness** | | **Tolerance on thickness** | | |
| | | ± | ± | ± |
| 0.3 | | 0.05 | 0.05 | |
| 0.4 | | 0.05 | 0.06 | |
| 0.5 | | 0.05 | 0.06 | 0.09 |
| 0.6 | | 0.06 | 0.07 | 0.09 |
| 0.7 | | 0.06 | 0.07 | 0.09 |
| 0.8 | | 0.06 | 0.08 | 0.10 |
| 0.9 | | 0.07 | 0.08 | 0.10 |
| 1.0 | | 0.08 | 0.09 | 0.11 |
| 1.2 | | 0.08 | 0.09 | 0.11 |
| 1.4 | | 0.09 | 0.10 | 0.12 |
| 1.6 | | 0.09 | 0.10 | 0.12 |
| 1.8 | | 0.09 | 0.10 | 0.14 |
| 2.0 | | 0.10 | 0.11 | 0.15 |
| 2.5 | | 0.12 | 0.14 | 0.17 |
| 3.0 | | 0.13 | 0.15 | 0.19 |
| 4.0 | | 0.14 | 0.16 | 0.20 |
| 5.0 | | 0.15 | 0.18 | 0.22 |
| 6.0 | | 0.16 | 0.20 | 0.25 |

Table D.2 **Tolerances on thickness of plate**

Dimensions in millimetres

| **Nominal thickness** | **Tolerance on thickness up to and including 1 200 wide** |
|---|---|
| | ± |
| Over 6 to 7 | 0.40 |
| 8 | 0.50 |
| 10 | 0.55 |
| 12 | 0.60 |
| 14 | 0.65 |
| 16 | 0.70 |
| 20 | 0.75 |
| 22 | 0.80 |
| 25 | 0.85 |
| 30 | 0.90 |
| 35 | 1.00 |
| 40 | 1.10 |
| 50 | 1.35 |
| 60 | 1.50 |
| 75 | 1.90 |

Table D.3 **Cutting tolerances for sheet and plate**

Dimensions in millimetres

| | **Over** | | **1 000** | **2 000** |
|---|---|---|---|---|
| | **Up to and including** | **1 000** | **2 000** | **3 000** |
| **Nominal thickness (t)** | | **Tolerances on width and length** [A)] | | |
| | | ± | ± | ± |
| t ≤ 1.4 | | 2.0 | 3.5 | 5.0 |
| 1.4 ≤ t ≤ 3.0 | | 2.5 | 3.5 | 5.0 |
| 3.0 ≤ t ≤ 6.0 | | 3.5 | 5.0 | 7.0 |
| 6.0 ≤ t ≤ 75 | | 5.0 | 8.0 | |

[A)] Measured at normal room temperature of 20 °C.

Table D.4 **Shearing tolerances for strip**

Dimensions in millimetres

| **Width or length** | **Over** | | **100** | **200** | **400** |
|---|---|---|---|---|---|
| | **Up to and including** | **100** | **200** | **400** | **600** |
| **Nominal thickness (t)** | | **Tolerances on width** [A)] | | | |
| | | ± | ± | ± | ± |
| t ≤ 0.99 | | 1.0 | 1.5 | 1.5 | 2.0 |
| 0.99 ≤ t ≤ 1.99 | | 1.5 | 1.5 | 2.0 | 2.0 |
| 1.99 ≤ t ≤ 2.49 | | 1.5 | 2.0 | 2.0 | 2.5 |
| 2.49 ≤ t ≤ 2.99 | | 2.0 | 2.0 | 2.5 | 2.5 |

[A)] Measured at normal room temperature of 20 °C.

Table D.5 **Tolerances on flatness of plate**

Dimensions in millimetres

| **Width or length** | **Over** | | **500** | **1 000** |
|---|---|---|---|---|
| | **Up to and including** | **500** | **1 000** | **1 200** |
| **Nominal thickness (t)** | | **Maximum deviation** | **Deviation per 1 000** | |
| 6 ≤ t ≤ 16 | | 1.5 | 3.0 | 3.5 |
| 16 ≤ t ≤ 50 | | 1.0 | 2.5 | 3.0 |
| 50 ≤ t ≤ 75 | | 1.0 | 2.0 | 2.5 |

*NOTE These tolerances apply across the width of plate and for lengths up to 1 200 mm. For lengths over 1 200 mm the flatness is measured over any 1 200 mm gauge length.*

**Annex E (normative)**

# Tolerances for tube

The dimensional tolerances for tube are detailed in the tables:

Table E.1 Tolerances on straightness of tube.

Table E.2 Tolerances on lengths of tube.

Table E.3 Tolerances on outside and inside diameters of extruded round tube

Table E.4 Tolerances on wall thickness of extruded round tube

Table E.1 **Tolerances on straightness of tube**

| **Diameter (d) [A)]** mm | **Departure from straightness over any selected length of 1 000 mm** mm |
|---|---|
| d ≤ 100 | 1.5 |
| d ≥ 100 | 2.5 |

[A)] Nominal outside diameter.

Table E.2 **Tolerances on lengths of tube**

Dimensions in millimetres

| **Length** | **Over** | **299** | **1 000** | **1 500** | **5 000** | **7 000** | **10 000** |
|---|---|---|---|---|---|---|---|
| | **Up to and including** | **1 000** | **1 500** | **5 000** | **7 000** | **10 000** | **—** |
| **Nominal diameter (d)** | | ± | ± | ± | ± | ± | ± |
| d ≤ 60 | | 2.0 | 2.5 | 2.5 | 3.5 | 4.0 | 6.5 |
| 60 ≤ d ≤ 100 | | 2.0 | 2.5 | 3.5 | 4.0 | 5.5 | 7.5 |
| 100 ≤ d ≤ 140 | | 3.0 | 3.5 | 4.0 | 5.0 | 6.5 | 8.0 |
| 140 ≤ d ≤ 180 | | 3.5 | 4.0 | 5.0 | 6.5 | 8.0 | 9.5 |
| 180 ≤ d ≤ 240 | | 4.5 | 5.0 | 6.5 | 8.0 | 9.5 | 11.0 |

Table E.3 **Tolerances on outside and inside diameters of extruded round tube**

Dimensions in millimetres

| **Nominal outside diameter (d)** | **Tolerance on actual diameter** | **Tolerance on mean diameter [A)]** |
|---|---|---|
| | ± | ± |
| 12 ≤ d ≤ 18 | 0.25 | 0.19 |
| 18 ≤ d ≤ 30 | 0.30 | 0.23 |
| 30 ≤ d ≤ 40 | 0.36 | 0.27 |
| 40 ≤ d ≤ 50 | 0.45 | 0.34 |
| 50 ≤ d ≤ 60 | 0.54 | 0.40 |
| 60 ≤ d ≤ 80 | 0.60 | 0.45 |
| 80 ≤ d ≤ 300 | 1% of diameter | 0.75% of diameter |

*NOTE 1 These tolerances apply only to tube of wall thickness not less than 1.6 mm or 1/24th of the outside diameter, whichever is the greater.*

*NOTE 2 In the case of tube in straight lengths, these tolerance limits are inclusive of ovality.*

*NOTE 3 Attention is drawn to the fact that tolerances on diameters of extruded round tube depend on the alloy and the manufacturing process used, and that in certain cases the tolerances given in this table will not apply. In such cases, the tolerances shall be agreed between the manufacturer and the purchaser.*

[A)] Mean diameter: half the sum of any two diameters at right angles.

Table E.4 **Tolerances on wall thickness of extruded round tube**

Dimensions in millimetres

| Nominal thickness | Mean thickness tolerance [A)] | Thickness at any point | |
|---|---|---|---|
| | ± | Maximum | Minimum |
| 1.6 | 0.18 | 1.84 | 1.36 |
| 2.0 | 0.20 | 2.27 | 1.73 |
| 2.5 | 0.22 | 2.80 | 2.20 |
| 3.0 | 0.27 | 3.36 | 2.64 |
| 4.0 | 0.31 | 4.42 | 3.58 |
| 5.0 | 0.37 | 5.49 | 4.51 |
| 6.0 | 0.43 | 6.58 | 5.42 |
| 7.0 | 0.51 | 7.67 | 6.33 |
| 8.0 | 0.56 | 8.76 | 7.24 |
| 10.0 | 0.65 | 10.9 | 9.1 |
| 12.0 | 0.77 | 13.0 | 11.0 |
| 14.0 | 0.88 | 15.2 | 12.8 |
| 16.0 | 1.00 | 17.3 | 14.7 |
| 18.0 | 1.13 | 19.4 | 16.6 |
| 20.0 | 1.22 | 21.6 | 18.4 |
| 22.0 | 1.35 | 23.8 | 20.2 |
| 25.0 | 1.49 | 27.0 | 23.0 |

*NOTE 1 These tolerances apply only to tube of wall thickness not less than 1.6 mm or 1/24th of the outside diameter, whichever is the greater.*

*NOTE 2 These tolerances on wall thickness do not apply where tolerances on both the outside diameter and the inside diameter are required.*

*NOTE 3 Intermediate thicknesses are toleranced as for the next greater thickness.*

*NOTE 4 Attention is drawn to the fact that tolerances on wall thickness of extruded round tube depend on the alloy and the manufacturing process used, and that in certain cases the tolerances given in this table will not apply. In such cases, the tolerances shall be agreed between the manufacturer and the purchaser.*

*This page deliberately left blank*

*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.™