

BS 3L 500:2011+A1:2017



BSI Standards Publication

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



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Summary of pages

This document comprises a front cover, and inside front cover, pages i to vi, pages 1 to 47, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution and came into effect on 31 December 2011. It was prepared by Panel ACE/61/-/24, *Light alloys*, 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

BS 3L 500:2011 superseded BS 2L 500:1973, which has been withdrawn.

BS 3L 500:2011+A1:2017 supersedes BS 3L 500:2011, which is withdrawn.

Information about this document

BS 3L 500:2011 was a full revision of the standard, and introduced 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).

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

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.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

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

Compliance with a British Standard cannot confer immunity from legal obligations.

Section 1: General requirements

1 Scope

This British Standard specifies procedures for inspection, testing and acceptance of wrought 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, *Aerospace series — Test method for metallic materials — Ultrasonic inspection of bars, plates, forging stock and forgings — Part 2: Performance of test*¹

EN 4050-4, *Aerospace series — 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.

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

¹ Published as ASD Prestandard at the date of publication 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 [A1](#) [C.2](#) [A1](#))

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 standard² 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](#)).

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](#)).

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.

- 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 standard³ 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](#)).

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.

- 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 5.1a)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 5.1a)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 5.2a)], 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 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 $\pm 5^\circ\text{C}$ 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 5.1a)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 Standard⁴.
- f) Description of the material supplied, including dimensions, drawing numbers and part numbers if appropriate and any other identification, together with the number(s) of the inspection or manufacturing schedule, where applicable.
- g) Quantity supplied.
- h) Cast number(s) and batch number(s) or unique identification, including the ingot and the position within the ingot, where applicable.
- i) Condition of the material as delivered.
- j) Heat treatment details, including details of test sample heat treatment where appropriate.
- k) Detail of all the tests carried out, or the reference numbers of the relevant test reports, copies of which shall be attached.
- l) Where capability is specified, a statement that the material has the capability to conform to the specified requirements.
- m) Inspection stamp.
- n) A certification clause signed by a duly authorized employee of the manufacturer, in the following form unless otherwise required by the quality assurance authority:

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

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.

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.

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 5.1b)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 5.1b)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.

- b) 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.