

Procedure for

Inspection and testing of wrought magnesium-base alloys

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Foreword

This British Standard has been compiled to cover the general inspection and testing requirements for wrought magnesium-base alloys to be used for aerospace purposes. The procedure set out herein is for use in conjunction with the relevant specifications in the “L” series. The procedure is also applicable to other specifications for wrought magnesium-base alloy products for aerospace purposes, where appropriate, such as those in the Ministry of Defence (Procurement Executive) D.T.D. Series.

The first edition of this British Standard was published in January 1967. This revision has been undertaken to bring the procedures in line with current industrial practice in the United Kingdom and with international inspection and testing procedures established in AICMA¹⁾, and also to take account of metrication in the magnesium industry. The principal alterations are the deletion of all references to imperial units, the complete revision of the tables of dimensional tolerances and the inclusion of detailed requirements relating to protection against corrosion.

NOTE For a limited period, material in imperial unit sizes will be available subject to negotiation regarding tolerances between the supplier and the purchaser. In general it is intended that these tolerances should be conversions of the tolerances given in the tables in this standard.

This standard makes reference to the following specifications:

British Standard

BS A 4, *Test pieces and test methods for metallic materials for aircraft — Part 1: Tensile tests.*

Ministry of Defence (Procurement Executive) Specifications

D.T.D. 935 *Surface sealing of magnesium rich alloys*

D.T.D. 5562 *Clear baking resin for surface sealing magnesium*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 35 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ Association Internationale des Constructeurs de Matériel Aéronautique

1 General requirements

1.1 Definitions

For the purposes of this British Standard and associated material specifications the following definitions apply:

1.1.1 Materials

1.1.1.1

approved scrap

scrap which is:

- a) derived from material the composition of which has been established with regard to the complete range of both the alloying elements and impurity elements appropriate to the class of alloy being made, and
- b) segregated and identifiable to the satisfaction of the Inspecting Authority.

1.1.1.2

bar

a solid extruded section which is round, rectangular or regular polygonal in shape

1.1.1.3

billet or slab

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

1.1.1.4

cast

- a) The product of one furnace melt;
- b) the product of one crucible melt;
- c) the product of a number of crucible or furnace melts mixed prior to casting;
- d) the amount of metal tapped from the furnace without any further addition of metal having been made (when a continuous melting process is employed); or
- e) as may be otherwise defined by the Inspecting Authority.

1.1.1.5

coil

a length of a product wound into a cylindrical or annular form for convenient handling

1.1.1.6

extruded length

the length produced from one cast billet or, if a multi-hole die is used, each length produced from one cast billet

1.1.1.7

extruded section

any extruded shape generally delivered in straight lengths

1.1.1.8

forging

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

1.1.1.9

hollow section

an extruded section which completely encloses a hollow or hollows

1.1.1.10

plate

a rolled product of rectangular section over 6.0 mm thick, supplied flat and with less control of surface finish than applies to sheet

1.1.1.11

regular section

a 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 Appendix B.2)

1.1.1.12

sheet

a rolled product of rectangular section up to and including 6.0 mm thick, supplied flat

1.1.1.13

strip

a rolled product of rectangular section up to and including 3.0 mm thick, supplied in coil

1.1.1.14

tube

a hollow section of uniform wall thickness

1.1.2 Other terms

1.1.2.1

batch

material:

- a) from the same cast,
- b) of the same form,
- c) of the same nominal dimensions, except as otherwise permitted in the relevant section of this standard,
- d) if heat treated, that has been heat treated together, and
- e) in maximum quantities as stipulated in the relevant section of this standard.

1.1.2.2

certification

confirmation by the manufacturer or supplier that the material conforms to the requirements of the relevant specification, drawing, order or Inspection Schedule

NOTE The issue of certificates etc. is normally subject to the regulations of the Inspecting Authority.

1.1.2.3

harmful defect

any defect prejudicial to the subsequent manufacture, fabrication or use of the material

1.1.2.4

inspecting authority

the body responsible for authorizing the manufacturer or supplier to issue certification

1.1.2.5

inspection schedule

a schedule of any special test requirements agreed between the supplier and the purchaser

1.1.2.6

inspector

the individual responsible for the executive inspection and release of material

1.1.2.7

lateral curvature

the deviation from straightness of a sheet or strip edge when the sheet or strip is laid flat

1.1.2.8

manufacturer

the firm that produces the material in the form (billet, bar, forging, sheet etc.) in which it is consigned to the purchaser

1.1.2.9**supplier**

the firm (not necessarily the manufacturer) that consigns the material to the purchaser

1.2 Certification²⁾

1.2.1 The manufacturer shall supply to the purchaser the necessary certification²⁾ in respect of all material governed by this British Standard and relevant material specifications.

1.2.2 Except as provided in **1.2.3**, if any certification²⁾ is issued by a supplier other than the manufacturer, such supplier shall hold the equivalent certification²⁾ issued by the manufacturer of the material.

1.2.3 If a batch of material consigned by the manufacturer is subdivided by an approved supplier before re-consignment, the supplier shall carry out any consequent additional dimensional inspection and identification marking and shall certify accordingly.

1.3 Manufacture and freedom from defects

1.3.1 The material shall be made in accordance with the requirements of this British Standard and the relevant material specification.

1.3.2 The material shall be free from harmful defects.

1.3.3 Notwithstanding the previous acceptance of material as complying with the requirements of this British Standard, any material that is found at a later stage to contain harmful defects may be rejected.

1.4 Chemical composition

1.4.1 The chemical composition of the material shall comply with the requirements of the material specification. The values stipulated in the specification shall be applied in accordance with the instructions of the Inspecting Authority. Elements not quoted in the specification shall not be added for any purpose other than fluxing, degassing, grain refinement and the like.

1.4.2 Overall control of the chemical composition and the regulation of the use of scrap shall be such that the method of analytical control adopted for each particular material shall enable the inspector to certify compliance with **1.4.1**.

1.5 Mechanical properties of bars, extruded sections, sheet, strip, plate and tube

1.5.1 In the “L” series of specifications for magnesium-base alloys, the specified mechanical properties for bars, extruded sections, sheet, strip and tube refer to the longitudinal direction, whilst those for plate refer to the transverse direction. The specified properties relate to test pieces machined from test samples selected in the defined manner and will not necessarily be realized when tests are carried out on test pieces machined from test samples which do not conform to the requirements of this standard. Attention is directed to **1.6**.

1.5.2 The mechanical properties in the transverse direction will usually differ from those in the longitudinal direction. When it is decided that tests in a direction other than that normally specified are necessary, the required properties, the location of the test sample and the frequency of testing shall be agreed between the manufacturer and the purchaser and shall be stated on the order or Inspection Schedule.

1.6 Tensile test**1.6.1 General**

1.6.1.1 The test pieces, prepared as required by the following clauses, shall be tested in accordance with the requirements of BS A 4-1.1. The secondary methods of proof stress verification may be employed and the values obtained shall comply with the requirements of the material specification or, if appropriate, with requirements agreed between the manufacturer and the purchaser in accordance with this standard. The values stipulated in the specification shall be applied in accordance with the instructions of the Inspecting Authority.

²⁾ As defined in **1.1.2.2**.

1.6.1.2 The test samples shall be selected and identified as directed by the inspector before they are removed from the material.

1.6.1.3 Except as otherwise required in the relevant section of this standard, the test samples shall not be heat treated or mechanically worked after they have been separated from the material they represent.

1.6.2 Bars, extruded sections and forgings

1.6.2.1 Except as provided in **1.6.2.2** and **1.6.2.3**, the test piece shall be machined from the selected test sample (see **1.6.2.4**) to the dimensions of the largest practicable size of the proportional round test pieces shown in Table 1 of BS A 4-1.1.

1.6.2.2 Alternatively to **1.6.2.1**, at the option of the manufacturer, round, square and hexagonal bars not exceeding 125 mm² cross-sectional area shall be tested in full section or as near full section as possible: for these test pieces the elongation shall be measured on a gauge length of $5.65 \sqrt{\text{area}}$ or 50 mm, at the discretion of the manufacturer. The gauge length used shall be recorded on the manufacturer's test report.

1.6.2.3 Alternatively to **1.6.2.1**, at the option of the manufacturer, for rectangular bars and extruded sections not exceeding 10 mm minor sectional dimension in the thickest part, a test piece of rectangular cross section shall be machined with maximum available thickness and 12.5 mm width or as near 12.5 mm as the section will permit. For these test pieces the elongation shall be measured on a gauge length of $5.65 \sqrt{\text{area}}$ or 50 mm, at the discretion of the manufacturer. The gauge length used shall be recorded on the manufacturer's test report.

1.6.2.4 Unless otherwise stated in the specification, drawing or order the following requirements govern the location of test pieces:

- 1) For bars and for test samples representing forgings or 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.
- 2) For 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.
- 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.
- 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.

1.6.3 Sheet and strip

1.6.3.1 The test pieces shall be prepared in accordance with the requirements of BS A 4-1.1.

1.6.3.2 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.

1.6.4 Plate

1.6.4.1 For plate that is not more than 12.5 mm thick, a test piece shall be cut from each test sample so that the longitudinal axis of the test piece is at right angles to the direction of final rolling and at the centre of the plate thickness. The dimensions of the test piece shall comply with the requirements for non-proportional test pieces shown in BS A 4-1.1.

1.6.4.2 For plate over 12.5 mm thick, a test piece shall be cut from each test sample so that the longitudinal axis of the test piece is at right angles to the direction of final rolling and at the centre of the plate thickness. The test pieces shall be machined to the dimensions of the largest practicable size of the proportional round test pieces shown in Table 1 of BS A 4-1.1.

1.6.5 Tube. The test pieces shall be prepared in accordance with the requirements of BS A 4-1.1.

1.7 Protection against corrosion

The material shall be protected before despatch in accordance with Appendix A, by a particular route agreed between the manufacturer and the purchaser³⁾.

³⁾ The purchaser is responsible for securing the concurrence of the parent design firm.

The routes given in Appendix A 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 batch cards (e.g. "Protection to BS L 500/Route 1/up to and including operation 5").

2 Cast billets and slabs for hot working

NOTE This section covers material purchased for subsequent hot working.

2.1 Condition

Unless otherwise stated on the order, the material shall be delivered as cast.

2.2 Dimensional tolerances

Dimensional tolerances, if required, shall be stated on the order.

2.3 Selection and preparation of mechanical test samples

None.

2.4 Tensile test

None.

2.5 Special tests

2.5.1 Unless otherwise agreed by the Inspecting Authority, the material shall be inspected and tested in one or both of the following ways, as decided by the manufacturer:

- 1) 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.
- 2) The billets or slabs shall be examined by a non-destructive test to the satisfaction of the Inspecting Authority. The material shall be free from harmful defects.

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

2.6 Retests

2.6.1 Special tests. If, on sectioning, any billet or slab exhibits harmful defects, further billets or slabs shall be examined as required by the Inspecting Authority.

2.7 Identification

Each billet and slab, passed by the inspector, shall be stamped with the mark of the inspector and such other marking as shall ensure full identification of the material.

3 Bars and extruded sections for forging

3.1 Condition

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

3.2 Dimensional tolerances

Dimensional tolerances, if required, shall be agreed between the supplier and the purchaser and shall be stated on the drawing, order or Inspection Schedule.

3.3 Selection and preparation of mechanical test samples

3.3.1 Bars and sections shall be grouped in batches (see 1.1.2.1) of products within the following dimensional ranges:

Nominal diameter or major sectional dimension		Maximum mass of batch
Over	Up to and including	
mm	mm	kg
—	75	350
75	150	700
150	—	1 500

3.3.2 The inspector shall select one test sample from a bar or section of the largest size in each batch for the specified tensile test (see 3.4).

3.3.3 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.

3.3.4 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.

3.4 Tensile test

The test piece, machined in accordance with the requirements in 1.6 from the test sample selected and prepared in accordance with 3.3, shall satisfy the appropriate tensile test requirements of the material specification.

3.5 Special tests

3.5.1 Etching test. 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, suitably prepared and etched. The etched surface shall be free from harmful defects. 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, and shall be stated on the order or Inspection Schedule.

3.5.2 Fracture test

3.5.2.1 A second sample, selected as in 3.5.1, shall be examined as follows and the fracture surface shall be free from harmful defects:

- 1) 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. The sample may 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.

2) 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. The slice may 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.

3.5.3 Ultrasonic testing. 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 and shall be stated on the order or Inspection Schedule.

3.6 Retests

3.6.1 Tensile test. If any test piece fails to satisfy the specified tensile test requirements, the inspector shall adopt one or both of the following procedures, as requested by the manufacturer:

- 1) Select for test from the same batch two other samples, one of which shall be taken from the bar or section from which the original test sample was taken, unless that bar or section has been withdrawn by the manufacturer. The test pieces prepared from both these further samples shall satisfy the tensile test requirements of the material specification.
- 2) Allow the batch to be re-heat treated or re-subjected to final hot operation in accordance with the material specification and to be retested in accordance with **3.3** and **3.4**.

3.6.2 Special tests. 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 **3.5.1** and **3.5.2**. The inspector shall verify, by examination of specimens from other bars or sections of the same size, that the whole of the material represented by the selected bar or section is free from harmful defects.

3.7 Identification

3.7.1 Each bar and each section over 20 mm diameter or major sectional dimension, passed by the inspector, shall be stamped with the mark of the inspector and such other marking as shall ensure full identification of the material. All stamping shall be done on or near one end of the bar or section.

3.7.2 Bars and sections not exceeding 20 mm diameter or major sectional dimension and from the same cast, passed by the inspector, shall be either individually marked as required in **3.7.1** or, at the option of the supplier, tied securely in bundles, each of which shall have attached a durable label bearing the mark of the inspector and such other marking as shall ensure full identification of the material.