Provisional Specification for war-time use.

[2 L. 40. January, 1940.]

(Cancelling B.S. Specification L. 40 and replacing Air Ministry Material Specification D.T.D. 293.)

NOTE.—*The Institution desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the material herein referred to, but does not purport to comprise all the necessary provisions of a contract.*

British Standards Institution.
Incorporated by Royal Charter.
FORMED IN 1901 AS THE ENGINEERING STANDARDS COMMITTEE.
INCORPORATED IN 1918 AS THE BRITISH ENGINEERING STANDARDS ASSOCIATION.

BRITISH STANDARD SPECIFICATION

FOR

ALUMINIUM ALLOY BARS, EXTRUDED SECTIONS AND FORGINGS

(Not greater than 3 inches diameter or minor sectional dimension)

FOR AIRCRAFT PURPOSES.

(Specific Gravity not greater than 2·80).

NOTE.—The bars and forgings referred to in this Specification must not be greater than 3 inches diameter or minor sectional dimension. Larger sizes of bars and forgings must be ordered to the latest issue of B.S. Specification L.45.

The term " forging " in this Specification includes drop-forgings and pressings.

SECTION 1.

Provisions applicable to all Sections of this Specification.

1. **Quality of Material.** (*a*) The aluminium used for making this alloy shall be in accordance with the latest issue of British Standard Specification No. L. 31.

(*b*) The copper used for making this alloy shall assay not less than 99·8 per cent.

(*c*) No scrap shall be used other than that derived from the Manufacturer's own manufacture.

2. **Chemical Composition.** (*a*) The chemical composition of the alloy shall be :—

Copper	-	not less than 1·5 and not more than 4·0 per cent.
Magnesium	-	„ „ „ 0·3 „ „ „ „ 1·5 „ „
Iron	-	„ „ „ 0·3 „ „ „ „ 1·5 „ „
Aluminium	-	the remainder.

Price 1/- net. Post free 1/2d.

Any of the following elements may be present at the option of the Manufacturer :—

Silicon	-	-	not more than 1·5 per cent.
Nickel	-	-	,, ,, ,, 2·0 ,, ,,
Manganese	-	-	,, ,, ,, 1·0 ,, ,,
Cerium	-	-	,, ,, ,, 0·3 ,, ,,
Chromium	-	-	,, ,, ,, 0·2 ,, ,,
Titanium	-	-	,, ,, ,, 0·2 ,, ,,
Niobium (Columbium)	-	-	,, ,, ,, 0·3 ,, ,,

(*b*) The Manufacturer shall supply the complete analysis of each cast to the Inspector.

(*c*) A cast shall be defined as :—

(i) The product of one furnace melt.

(ii) The product of one crucible melt.

(iii) The product of a number of crucible or furnace melts where such are aggregated and mixed prior to casting.

(iv) Where a continuous melting process is employed, a cast shall be taken as the amount of metal tapped from the furnace without any further additions of metal having been made to the charge.

(v) Or as otherwise defined from time to time.

3. **Mechanical Tests.** (*a*) All tests shall be carried out to the satisfaction of the Inspector.

(*b*) The mechanical properties of the test pieces shall be :—

	Test Pieces representing :—	
	Bars and Billets for Forging (Section 2). Bars for Machining and Extruded Sections greater than ⅜ inch thickness (Section 3). Forgings (Section 4).	Extruded Sections not greater than ⅜ inch in thickness (Section 3).
	Not less than :—	Not less than :—
0·1 per cent Proof Stress	21 tons per sq. in.	20 tons per sq. in.
Ultimate Tensile Stress	27 ,, ,,	26 ,, ,,
Elongation ...	10 per cent.	10 per cent.

(*c*) *Tensile Test.* For bars, other than rectangular bars, less than 9/32 inch in thickness, and for test samples representing forgings, the tensile test pieces shall be turned to the dimensions of the British Standard Test Piece C (a suitable test piece is shown in Fig. 1), or if the samples are too small the test pieces shall be in accordance with the largest possible size of those shown in Figs. 2 and 3 of B.S. Specification 2A. 4.

Round, square and hexagonal bars less than 9/32 inch diameter or width across flats may be tested in the full section.

From extruded sections, where the dimensions of the section permit, the test pieces shall be in accordance with the largest possible size of those shown in Figs. 1, 2 and 3 of B.S. Specification 2A. 4. Material thinner than 9/32 inch shall be tested by means of a rectangular test piece of the maximum available thickness and ½ inch wide, or as nearly ½ inch wide as the section will permit. The elongation of flat test pieces shall be measured on a gauge length of 1 inch or $4\sqrt{\text{Area}}$, at the option of the Manufacturer.

The parallel portion of any test piece may be increased in length to accommodate the extensometer employed.

The load shall be applied axially.

Should a tensile test piece break outside the middle half of its gauge length the test may be discarded and another test made.

(*d*) *Hardness Test.* The hardness test shall be carried out by an approved method.

All hardness determinations made on test samples, bars, sections or forgings in a parcel shall be made under the same conditions of testing.

4. **Freedom from Defects.** (*a*) The material shall be free from defects.

(*b*) Any material may be rejected for faults in manufacture, notwithstanding that it has been passed previously on chemical composition and mechanical tests.

SECTION 2.

L. 40—A. Bars and Billets for forging.

5. **Manufacture.** The bars and billets may be supplied in the non-heat-treated condition, unless otherwise specified on the order.

6. **Margins of Manufacture.** Margins of manufacture, when required, shall be agreed between the Manufacturer and the Purchaser and shall be specified on the order.

7. **Heat-Treatment.** The test samples selected and prepared as specified in Clause 8 shall be solution-treated by being heated uniformly at a temperature of not less than 495° C. nor more than 535° C. and quenched in water or oil at the option of the Manufacturer. They shall then be aged by heating for the requisite period at a temperature between 155° C. and 185° C.

The heat-treatment temperatures and time of soaking employed shall be supplied by the Manufacturer to the Purchaser.

All material to be used for aeronautical purposes must give the required mechanical properties after heat-treatment at the temperature specified above. Material for other purposes may be heat-treated at different temperatures from those specified, provided that these temperatures are stated by the Manufacturer on the test certificate.

8. **Selection and Preparation of Mechanical Test Samples.** (*a*) Bars and billets from the same cast shall be grouped in a parcel and the Inspector shall select one test sample from the largest size of bar or billet in the parcel for mechanical testing.

The test samples shall be removed from the bars or billets by nicking and breaking off or they may be sawn and, after separation from the bar, fractured. The fractured surfaces must show freedom from pipe or other defect.

(*b*) The portion of the bar or billet selected for the preparation of the test samples shall be prepared as follows :—

(i) Test samples from bars up to and including 1⅛ inches diameter or width across flats shall not be machined or forged but shall be heat-treated in the full size.

(ii) Bars and billets over 1⅛ inches diameter or width across flats may be forged and/or machined at the option of the Manufacturer to test samples 1⅛ inches diameter and be heat-treated in that size.

(*c*) The tensile test piece shall be machined concentrically from the test sample.

(*d*) The test samples shall be marked as directed by the Inspector before they are removed from the bars or billets, and shall be heat-treated as specified in Clause 7.

9. **Tensile Test.** The mechanical properties of the test pieces machined from the samples selected and prepared as specified in Clause 8 must comply with the appropriate tensile test specified in Clause 3.

10. **Re-Tests.** If any test piece fails to comply with the tensile test specified in Clause 3 the Inspector shall select for test from the same parcel two other samples, one of which must be from the bar or billet from which the original test sample was taken, unless that bar or billet has been withdrawn by the Manufacturer. Test pieces prepared from these two further samples as specified in Clause 8 must comply with the appropriate tensile test specified in Clause 3.

11. **Identification.** (*a*) All bars ¾ inch diameter or width across flats and under and from the same cast, passed by the Inspector, shall be tied in bundles which shall bear a tag stamped with the mark of the Inspector and such other marking as shall ensure full identification of the material.

(*b*) All billets and all bars over ¾ inch diameter or width across flats, 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 at one extreme end of each bar or billet.

SECTION 3.

L. 40—B. Bars for machining and Extruded Sections.

12. **Margins of Manufacture.** (*a*) The margins of manufacture for rolled or extruded bars and sections shall be in accordance with those given in the appropriate item of the Appendix (p. 9).

(*b*) The margins of manufacture for hammered bars shall not exceed plus or minus ⅛ inch.

13. **Straightness.** All bars and sections shall be straight.

14. **Heat-Treatment.** (*a*) Unless otherwise specified on the order, all bars and sections shall be delivered in the solution-treated, straightened and aged condition and in this condition must comply with the appropriate tensile test specified in Clause 3.

(*b*) All bars and sections shall be solution-treated by being heated uniformly at a temperature of not less than 495° C. nor more than 535° C., and quenched in water or oil at the option of the Manufacturer. They shall then be aged by heating for the requisite period at a temperature between 155° C. and 185° C.

The heat-treatment temperatures and the time of soaking employed shall be supplied by the Manufacturer to the Purchaser.

All material to be used for aeronautical purposes must give the required mechanical properties after heat-treatment at the temperature specified above. Material for other purposes may be heat-treated at different temperatures from those specified, provided that these temperatures are stated by the Manufacturer on the test certificate.

15. **Selection and Preparation of Mechanical Test Samples.** (*a*) Bars from the same cast and heat-treated (*i.e.* annealed, solution-treated or solution-treated and aged) together shall be grouped in a parcel and the Inspector shall select one test sample from the largest size of bar in the parcel for the tensile test specified in Clause 16.

(*b*) Sections not exceeding ⅜ inch in thickness from the same cast and heat-treated (*i.e.* annealed, solution-treated or solution-treated and aged) together shall be grouped in a parcel. Similarly, sections greater than ⅜ inch in thickness from the same cast and heat-treated (*i.e.* annealed, solution-treated or solution-treated and aged) together shall be grouped in a parcel. Where any such parcel contains only sections that are reasonably similar in shape and thickness, the Inspector shall select one test sample for the tensile test specified in Clause 16. Where, however, sections which differ sufficiently in shape and particularly in thickness as to be liable to respond differently to the heat-treatment operation are included in one parcel, the contents of such parcel shall be sub-divided into parcels each consisting of those sections that are reasonably similar in shape and thickness, and the Inspector shall select for the tensile test specified in Clause 16 one test sample from each such parcel.

(*c*) The test samples shall be marked as directed by the Inspector and shall then be removed from the bars by nicking and breaking off or they may be sawn and, after separation from the bar, fractured. The fractured surfaces must show freedom from pipe or other defect. The test samples shall be removed from the extruded sections by sawing.

(*d*) For bars up to and including 1⅛ inches diameter or width across flats, the tensile test piece shall be machined concentrically from the test sample.

For bars over 1⅛ inches diameter or width across flats, the longitudinal axis of the tensile test piece shall be not less than 9/16 inch from the surface of the test sample.

(*e*) Test samples representing parcels of annealed bars or sections shall be solution-treated and aged as specified in Clause 14 (*b*) before testing.

Test samples representing parcels of solution-treated bars or sections shall be aged as specified in Clause 14 (*b*) before testing.

Test samples representing parcels of solution-treated and aged bars or sections shall not be further heat-treated or mechanically worked before testing.

16. **Tensile Test.** (*a*) The mechanical properties of the test pieces machined from the samples selected and prepared as specified in Clause 15 must comply with the appropriate tensile test specified in Clause 3.

(*b*) A small flat shall be prepared on the shoulder of each tensile test piece for the hardness test specified in Clause 17.

(*c*) If any test piece fails to comply with the tensile test specified in Clause 3 the Inspector may reject the parcel represented by that test piece or at the request of the Manufacturer adopt either of the following procedures :—

(i) Select for test from the same parcel two other samples, one of which must be from the bar or section from which the original test sample was taken, unless that bar or section has been withdrawn by the Manufacturer. Test pieces prepared from these two further samples as specified in Clause 15 must comply with the appropriate tensile test specified in Clause 3.

(ii) Allow the parcel to be re-heat-treated in accordance with Clause 14 (*b*) and re-tested in accordance with Clauses 15, 16 and 17.

17. **Hardness Test.** (*a*) The hardness value of the tensile test piece selected as specified in Clause 15 shall be determined by an approved method and all bars and sections ¾ inch diameter or width and over in each parcel represented by this test piece shall be tested for hardness by the same method and under identical conditions of testing.

The minimum hardness value allowable on any bar or section in the parcel is X per cent below that of the tensile test piece, where the value of X depends on the ultimate tensile stress of the test piece as shown in the following table :—

When the Ultimate Tensile Stress of the Test Piece is :—	Value of X.
26 to under 27 tons per sq. in.	Nil
27 ,, 28 ,, ,,	5 per cent.
28 ,, 29 ,, ,,	7½ ,,
29 ,, 30 ,, ,,	10 ,,
30 and over ,, ,,	12½ ,,

(*b*) If any bar or section is below the specified hardness it may be rejected, or at the request of the Manufacturer be submitted to the tensile test specified in Clause 16. Alternatively, bars which do not give the specified hardness value may be re-heat-treated in accordance with Clause 14 (*b*) and re-tested in accordance with Clauses 15, 16 and 17.

18. **Identification.** (*a*) All sections and all bars ¾ inch diameter or width across flats and under, and from the same cast, passed by the Inspector, shall be tied in bundles which shall bear a tag stamped with the mark of the Inspector and such other marking as shall ensure full identification of the material.

(*b*) All bars over ¾ inch diameter or width across flats, 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 at one extreme end of each bar.

SECTION 4.

L. 40—C. Forgings (made from bars or billets not greater than 3 inches diameter or minor sectional dimension or by direct manipulation of the cast ingot.)

NOTE.—Attention is called to the difficulty of specifying tensile test values which will accurately represent the tensile properties of forgings. The test samples only indicate the quality of the material and it must not be assumed that the properties of the forgings and the test samples are similar.

19. **Heat-Treatment.** (*a*) Unless otherwise specified on the order the forgings shall be delivered in the solution-treated and aged condition.

(*b*) The test samples selected and prepared as specified in Clause 20 and the forgings shall be heat-treated together. They shall be heat-treated by being heated uniformly at a temperature of not less than 495° C. nor more than 535° C. and quenched in water or oil at the option of the Manufacturer. They shall then be aged by heating for the requisite period at a temperature between 155° C. and 185° C.

The heat-treatment temperatures and the time of soaking employed shall be supplied by the Manufacturer to the Purchaser.

All material to be used for aeronautical purposes must give the required mechanical properties after heat-treatment at the temperatures specified above. Material for other purposes may be heat-treated at different temperatures from those specified, provided that these temperatures are stated by the Manufacturer on the test certificate.

20. **Selection and Preparation of Mechanical Test Samples.** (*a*) One test sample shall be provided from the same cast of alloy as the forgings are made, to represent the forgings from that cast in each batch heat-treated together.

This test sample may be forged from the bars or billets from which the forgings are made or, if the forgings are made by direct manipulation of a cast ingot, the sample shall be forged from an ingot of the same cast.

Whichever method of preparation is used, the diameter of the test sample shall be not less than 1⅛ inches, unless the diameter of the original bar is less than 1⅛ inches in which case the test samples shall be heat-treated full size.

The test sample shall be marked as directed by the Inspector.

(*b*) The tensile test piece shall be machined concentrically from the test sample.

(*c*) If the forgings are not delivered in the finally heat-treated and aged condition a test sample from the same size of bars or billets and from the same cast as the forgings were made (or from an ingot of the same cast) shall be prepared as specified in paragraph (*a*) above and heat-treated as specified in Clause 19 (*b*). Test pieces machined from the test samples as specified in Clause 3 (*c*) must comply with the appropriate tensile test specified in Clause 3 before the forgings are finally delivered.

(*d*) When the heat-treatment is carried out after delivery the test samples prepared as specified in paragraph (*a*) above and the forgings shall be heat-treated together as specified in Clause 19 (*b*). Test pieces machined from the test samples as specified in Clause 3 (*c*) must comply with the appropriate tensile test specified in Clause 3.

(*e*) The test samples after being heat-treated as specified in Clause 19 (*b*) shall not be further heat-treated or mechanically worked before testing.

21. **Tensile Test.** (*a*) The mechanical properties of the test pieces machined from the samples selected and prepared as specified in Clause 20 must comply with the appropriate tensile test specified in Clause 3.

(*b*) A small flat shall be prepared on the shoulder of each tensile test piece for the hardness test specified in Clause 22.

(*c*) If any test piece fails to comply with the tensile test specified in Clause 3, the Inspector may reject the parcel represented by that test piece or at the request of the Manufacturer adopt either of the following procedures :—

(i) Select for test two other samples which have been heat-treated with the parcel from which the original sample was taken. Test pieces prepared from these two further samples as specified in Clause 20 must comply with the appropriate tensile test specified in Clause 3.

(ii) Allow the parcel to be re-heat-treated in accordance with Clause 19 (*b*) and re-tested in accordance with Clauses 20, 21 and 22.

22. **Hardness Test.** (*a*) The hardness value of the tensile test piece selected as specified in Clause 20 shall be determined by an approved method and all forgings ¾ inch diameter or thickness and over in each parcel represented by this test piece shall be tested for hardness by the same method and under identical conditions of testing.

The hardness value of each forging in the parcel must be at least 92½ per cent of that of the tensile test piece.

(*b*) If any forging is below the specified hardness it may be rejected, or at the request of the Manufacturer, be re-heat-treated in accordance with Clause 19 (*b*) and re-tested in accordance with Clauses 20, 21 and 22.

23. **Identification.** (*a*) *Forgings under 5 lb.* All forgings under 5 lb. each in weight, passed by the Inspector, shall be made into parcels which shall bear a tag stamped with the mark of the Inspector and such other marking as shall ensure full identification of the material.

(*b*) *Forgings* 5 *lb. and over.* All forgings 5 lb. in weight and over, 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 such stamping must be done wherever it is least liable to be detrimental to the forging.

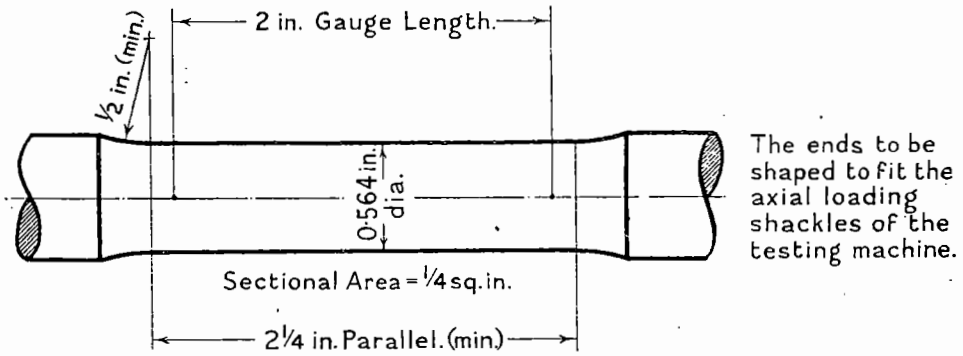

FIG. 1. TENSILE TEST PIECE.

(Cancelling B.S. Specification L. 40 and replacing Air Ministry Material Specification D.T.D. 293.)

APPENDIX

MARGINS OF MANUFACTURE

1.—Round Bars.

1	2
Nominal Diameter of Bar.	Margin of Manufacture.
Inch	Inch
¼ (0·25) 5/16 (0·3125) ⅜ (0·375) 7/16 (0·4375)	±0·002
½ (0·5) 9/16 (0·5625) ⅝ (0·625) ¾ (0·75) ⅞ (0·875)	±0·003
1 1⅛ (1·125) 1¼ (1·25) 1⅜ (1·375)	±0·004
1½ (1·5) 1⅝ (1·625) 1¾ (1·75)	±0·005
1⅞ (1·875) 2	±0·006
Over 2 to 2⅝	±0·008
Over 2⅝ to 3	±0·010

(Cancelling B.S. Specification L. 40 and replacing Air Ministry Material Specification No. D.T.D. 293.)

2.—Hexagonal Bars.

1	2		3
Width across Flats.			Margin of Manufacture.
Max.		Min.	
Inch		Inch	Inch
0·193		0·189	0·004
0·248		0·244	0·004
0·324		0·320	0·004
0·413		0·409	0·004
0·445		0·441	0·004
0·525		0·521	0·004
0·600		0·596	0·004
0·710		0·706	0·004
0·820		0·815	0·005
0·920		0·915	0·005
1·010		1·005	0·005
1·100		1·095	0·005
1·200		1·195	0·005
1·300		1·295	0·005
1·480		1·474	0·006
1·670		1·664	0·006
1·860		1·854	0·006
2·050		2·042	0·008
2·220		2·212	0·008
2·410		2·402	0·008
2·580		2·570	0·010
2·760		2·750	0·010

3.—Rectangular, Flat and Square Bars.

Tolerance on width $= \pm (0{\cdot}007 + 0{\cdot}006\ W)$ inch.

Tolerance on thickness $= \pm (0{\cdot}007 + 0{\cdot}003\ (W + t))$ inch.

where W = width and t = thickness of the cross section.

4.—Sections.

(including standard angles, channels, tees, etc., and special sections)

Tolerance on overall width $= \pm (0{\cdot}007 + 0{\cdot}006\ W)$ inch.

Tolerance on Thickness.

Nominal Thickness (up to and including 3 inches overall width).	Tolerance.
in.	in.
Up to and including ... 0·08	± 0·008
Over 0·08 and including 0·125	± 0·009
,, 0·125 ,, ,, 0·187	± 0·010
,, 0·187 ,, ,, 0·250	± 0·012
,, 0·250 ,, ,, 0·375	± 0·015
,, 0·375 ,, ,, 0·500	± 0·018
,, 0·500 ,, ,, 0·625	± 0·022
,, 0·625	± 3·0 per cent

(Cancelling B.S. Specification L. 40 and replacing Air Ministry Material Specification D.T.D. 293.)

Tolerance on thickness to be increased for sections having overall widths greater than 3 inches in ratio to width, thus :—

For overall widths greater than 3 inches and including 4 inches, multiply above tolerances by ⅓.

For overall widths greater than 4 inches and including 5 inches, multiply above tolerances by ⅔, and so on.

For all sections :—

Maximum tolerance on thickness shall be ± 0·050 inch.

Minimum tolerance on thickness shall be ± 0·008 inch.

Tolerance on angles to be ± 2°.

5.—Deep Channels.

(Channels having an internal depth to width ratio greater than 1.)

If D = nominal depth in inches, and W = nominal width of gap in inches, then :—

The tolerance on overall dimensions, internal or external, across the ends of the flanges shall be :—

(*a*) *Where D/W is greater than 1 and not greater than 2*

$$\pm 2(0{\cdot}007 + 0{\cdot}006\ W) \text{ inch.}$$

(*b*) *Where D/W is greater than 2 and not greater than 3*

$$\pm 2{\cdot}5(0{\cdot}007 + 0{\cdot}006\ W) \text{ inch.}$$

(*c*) *Where D/W is greater than 3*

$$\pm 3(0{\cdot}007 + 0{\cdot}006\ W) \text{ inch.}$$

NOTE :—The above tolerances apply only to dimensions across the *open end of the channel*; for tolerances on width *across the base* of the flanges the tolerance shall be ± (0·007 + 0·006 W) inch.

Tolerance on thickness shall be as for standard sections given in Item 4.

6.—Tapered Sections.

(including sections of varying thickness.)

The tolerance on thickness at any point shall be that given by the table in Item 4 for the nominal thickness at the point to be measured.

This Specification having been approved by the Aircraft Industry Committee and endorsed by the Chairman of the Engineering Divisional Council was published under the authority of the General Council of the Institution as a British Standard on 29th January, 1940.

NOTE.

In order to keep abreast of progress in the Industries concerned, the British Standards are subject to periodical review.

Suggestions for improvements, addressed to the British Standards Institution, 28 Victoria Street, London, S.W.1, will be welcomed at all times. They will be recorded and in due course brought to the notice of the Committees charged with the revision of the Publications to which they refer.

G.&S.(GA)L660. 1000/1/40.