

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.

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### BRITISH STANDARD SPECIFICATION

FOR

## ALUMINIUM ALLOY BARS AND FORGINGS

(Greater than 3 inches diameter or width across flats or minor sectional dimension)

FOR AIRCRAFT PURPOSES.

(Specific Gravity not greater than 2.80).

**Section 1. Provisions applicable to all Sections of this Specification.**

**Section 2. L. 45—A. Bars and Billets for forging (over 3 inches diameter or width across flats).**

**Section 3. L. 45—B. Bars for machining (over 3 inches and up to 6 inches diameter or minor sectional dimension).**

**Section 4. L. 45—C. Forgings (made from bars or billets over 3 inches diameter or minor sectional dimension or by direct manipulation of the cast ingot).**

**Section 5. L. 45—D. Bars for machining (over 6 inches and up to 8 inches diameter or minor sectional dimension).**

NOTE.—The bars and forgings referred to in this Specification are greater than 3 inches diameter or minor sectional dimension. Extruded sections and smaller sizes of bars and forgings must be ordered to the latest issue of B.S. Specification L. 40.

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 <sup>4.5</sup> <del>4.0</del> per cent. | See note 2 |
| Magnesium | - | " " " 0.3 " " " " 1.5 " "   |            |
| Iron      | - | " " " <del>0.5</del> " " " " 1.5 " "  |            |
| Aluminium | - | the remainder!  | 1.5        |

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) *Tensile Test.* From test samples representing bars or billets and forgings, the test pieces shall be machined to the dimensions of British Standard Test Piece C (a suitable test piece is shown in Fig. 1). 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.

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

All hardness determinations made on test samples, bars, 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. 45—A. Bars and Billets for forging (over 3 inches diameter or width across flats.).

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.

P.D. 385

**Amendment No. 2: August, 1945**

to

B.S. L 45—January, 1940.

**War Emergency Revision**

*Clause 2. Chemical Composition.*

*Copper.* The upper limit for copper of 4.0 per cent to be amended to read 4.5 per cent.

*Iron.* The minimum limit for iron of 0.3 per cent to be amended to 0.15 per cent.

**British Standards Institution.**

**BRITISH STANDARD**

**SPECIFICATION**

FOR

**L. 45. ALUMINIUM ALLOY BARS AND FORGINGS**

(Greater than 3 inches diameter or width across flats or minor sectional dimension).

**REVISION.**

*Clause 2. Chemical Composition.* Minimum iron content to be 0.3 per cent in place of 0.5 per cent.

[B.S. No. L. 45, facing p. 2.]

square bars shall be as follows:—

Tolerance on width  $\pm (0.007 + 0.006 W)$  inch.

Tolerance on thickness  $\pm (0.007 + 0.003 (W + t))$  inch.

where  $W$  = width and  $t$  = thickness.

(d) The margins of manufacture for hammered bars shall not exceed plus or minus  $\frac{1}{4}$  inch.

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of soaking employed shall be

give the required mechanical above. Material for es from that specified, manufacturer on the test

es. (a) Bars and billets pector shall select one for mechanical testing. es diameter and shall

taken shall be etched

in Clause 7, but shall esting.

test pieces machined e 8 must comply with

s per sq. in.

” ” ” cent.

e tensile test specified me parcel two other hich the original test awn by the Manufac- s specified in Clause 8

e Inspector, shall be arking as shall ensure e at one extreme end

d up to 6 inches on).

e of the dimensions

nal bars shall be not eter or width across

l rectangular, flat or

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 the time of soaking employed shall be supplied by the Manufacturer to the Purchaser.

All material 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 that 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. This test sample shall be forged and/or machined to 1½ inches diameter and shall be marked as directed by the Inspector.

(b) The end of the bar from which the test sample was taken shall be etched and must show freedom from pipe or other defect.

(c) The test samples shall be heat-treated as specified in Clause 7, but shall not be further heat-treated or mechanically worked before testing.

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 following tensile test:—

|                           |   |                                   |
|---------------------------|---|-----------------------------------|
| 0.1 per cent Proof Stress | - | not less than 21 tons per sq. in. |
| Ultimate Tensile Stress   | - | " " " " 27 " " " "                |
| Elongation                | - | " " " " 10 per cent.              |

10. **Re-Tests.** If any test piece fails to comply with the tensile test specified in Clause 9 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 tensile test specified in Clause 9.

11. **Identification.** All bars and billets, 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. 45—B. Bars for machining (over 3 inches and up to 6 inches diameter or minor sectional dimension).

12. **Margins of Manufacture.** (a) The bars shall be of the dimensions specified on the order.

(b) The margins of manufacture for round and hexagonal bars shall be not greater than plus or minus 1 per cent of the nominal diameter or width across flats.

(c) The margins of manufacture for rolled or extruded rectangular, flat or square bars shall be as follows:—

|                                    |                                 |
|------------------------------------|---------------------------------|
| Tolerance on width                 | ± (0.007 + 0.006 W) inch.       |
| Tolerance on thickness             | ± (0.007 + 0.003 (W + t)) inch. |
| where W = width and t = thickness. |                                 |

(d) The margins of manufacture for hammered bars shall not exceed plus or minus ¼ inch.

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

14. **Heat-Treatment.** (a) Unless otherwise specified on the order all bars shall be delivered in the solution-treated, straightened and aged conditions and in this condition must comply with the mechanical tests specified in Clauses 16 and 17.

(b) All bars 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 temperature and the time of soaking employed shall be supplied by the Manufacturer to the Purchaser.

All material 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 these 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) The test samples shall be marked as directed by the Inspector and shall then be removed from the bars. The end of the test sample which shall include the core of the bar shall be etched and must show freedom from pipe or other defect.

(c) The longitudinal axis of the tensile test pieces shall be not less than  $\frac{1}{16}$  inch from the surface of the test sample.

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

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

Test samples representing parcels of solution-treated and aged bars 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 following tensile test :—

|                           |   |                                   |
|---------------------------|---|-----------------------------------|
| 0.1 per cent Proof Stress | - | not less than 19 tons per sq. in. |
| Ultimate Tensile Stress   | - | " " " 25 " " " "                  |
| Elongation                | - | " " " 8 per cent.                 |

(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 paragraph (a) above, 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 taken from the bar from which the original test sample was taken, unless that bar has been withdrawn by the Manufacturer. Test pieces prepared from these two further samples as specified in Clause 15 must comply with the tensile test specified in paragraph (a) above.

(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 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 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. |
|--|-------------|
| 25 to under 26 tons per sq. in.                          | 5 per cent. |
| 26 " 27 " "  | 7½ "        |
| 27 " 28 " "  | 10 "        |
| 28 and over " "  | 12½ "       |

(b) If any bar 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 and re-tested in accordance with Clauses 15, 16 and 17.

**18. Identification.** All bars passed by the Inspector shall be stamped with the mark of the Inspector and such other markings as shall ensure full identification of the material. All stamping shall be done at one extreme end of each bar.

#### SECTION 4.

#### L. 45—C. Forgings (made from bars or billets over 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 test samples are similar.

**19. Heat-Treatment.** (a) Unless otherwise specified on the order the forgings shall be supplied 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 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 test 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  $1\frac{1}{8}$  inches.

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 (a) must comply with the tensile test specified in Clause 21 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 (a) must comply with the tensile test specified in Clause 21.

(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 following tensile test :—

|                           |   |                                   |
|---------------------------|---|-----------------------------------|
| 0.1 per cent Proof Stress | - | not less than 21 tons per sq. in. |
| Ultimate Tensile Stress   | - | " " " 27 " " " "                  |
| Elongation                | - | " " " 10 per cent.                |

(b) If any test piece fails to comply with the tensile test specified in Clause 21, 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 tensile test specified in paragraph (a) above.

(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) A hardness test shall be carried out by an approved method on all forgings. The part of the forging on which the hardness impression is made shall be agreed between the Manufacturer and the Purchaser and the hardness number shall be specified on the order or drawing. The hardness number obtained shall be not less than a value to be agreed between the Manufacturer and the Purchaser and shall be stated on the order and/or drawing.

(b) If any forging fails to comply with the hardness test as agreed in paragraph (a) above, the forging may be rejected or, at the request of the Manufacturer, be re-heat-treated in accordance with Clause 19 and re-tested in accordance with Clauses 20, 21 and 22.

23. **Identification.** All forgings 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 must be done wherever it is least liable to be detrimental to the forging.

**SECTION 5.****L. 45—D. Bars for machining (over 6 inches and up to 8 inches diameter or minor sectional dimension).**

24. **Margins of Manufacture.** (a) The bars shall be of the dimensions specified on the order.

(b) The margin of manufacture for round and hexagonal bars shall be not greater than plus or minus 1 per cent of the nominal diameter or width across flats.

(c) The margin of manufacture for rolled or extruded rectangular, flat or square bars shall be as follows:—

Tolerance on width  $\pm (0.007 + 0.006 W)$  inch.

Tolerance on thickness  $\pm (0.007 + 0.003 (W + t))$  inch.

where  $W$  = width and  $t$  = thickness.

(d) The margins of manufacture for hammered bars shall not exceed plus or minus  $\frac{1}{8}$  inch.

25. **Straightness.** All bars shall be straight.

26. **Heat-Treatment.** (a) Unless otherwise specified on the order all bars shall be delivered in the solution-treated, straightened and aged condition and in this condition must comply with the mechanical tests specified in Clauses 28 and 29.

(b) All bars shall be heat-treated as specified in Clause 14 (b).

27. **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 28.

(b) The test samples shall be marked as directed by the Inspector and shall then be removed from the bars. The end of the test sample which shall include the core of the bar shall be etched and must show freedom from pipe or other defect.

(c) The longitudinal axis of the tensile test piece shall be not less than 1 inch from the surface of the test sample.

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

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

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

28. **Tensile Test.** (a) The mechanical properties of the test pieces machined from the samples selected and prepared as specified in Clause 27 must comply with the following tensile test:—

|                           |   |                                   |
|---------------------------|---|-----------------------------------|
| 0.1 per cent Proof Stress | - | not less than 17 tons per sq. in. |
| Ultimate Tensile Stress   | - | " " " 23 " " " "                  |
| Elongation                | - | " " " 6 per cent.                 |

(b) A small flat shall be prepared on the shoulder of each tensile test piece for the hardness test specified in Clause 29.



(c) If any test piece fails to comply with the tensile test specified in paragraph (a) above, 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 from which the original test sample was taken unless that bar has been withdrawn by the Manufacturer. Test pieces prepared from these two further samples as specified in Clause 27 must comply with the tensile test specified in paragraph (a) above.

(ii) Allow the parcel to be re-heat-treated in accordance with Clause 14 (b) and re-tested in accordance with Clauses 27, 28 and 29.

29. **Hardness Test.** (a) The hardness value of the tensile test piece selected as specified in Clause 27 shall be determined by an approved method and all bars 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 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.  |
|--|--------------|
| 23 to under 24 tons per sq. in.                          | 7½ per cent. |
| 24 " 25 " "  | 10 " "       |
| 25 and over " "  | 12½ " "      |

(b) If any bar 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 28. Alternatively, bars which do not give the specified hardness value may be re-heat-treated in accordance with Clause 26 and re-tested in accordance with Clauses 27, 28 and 29.

30. **Identification.** All bars 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.

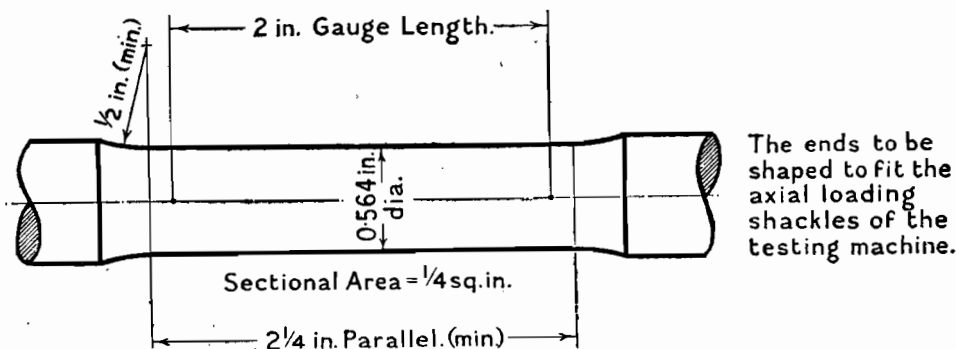


FIG. 1. TENSILE TEST PIECE.

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 15th 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.*