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Inspector-in-Charge A.I.D.
Commercial Steels & Forge Pty. Ltd.
Lidcombe.

EMERGENCY STANDARD
No. (E)D.508—1940
Being British Standards Institution
Specification for Aircraft Material
No. 2 S. 28*
endorsed without amendment.

STANDARDS ASSOCIATION OF AUSTRALIA.

Headquarters :
Science House, Gloucester and Essex Streets, Sydney.

AUSTRALIAN STANDARD SPECIFICATION
(Emergency Series)

FOR

AIR HARDENING NICKEL-CHROME STEEL

This standard forms one of a series prepared by the Standards Association of Australia at the request of Departments of the Commonwealth Government for use in relation to the supply of materials required for defence purposes. In appropriate cases these specifications will be reviewed for inclusion in the normal series of Australian Standards.

NOTE.—The heat-treatment temperatures specified have been selected as representing an average figure for general practice for the particular class of material, and are given in the Specification as guides. Where variation from the specified figures is found to be necessary the exact temperature must be stated in the test report.

- Section I. Provisions applicable to all Sections of this Specification.
Section II. S.28—A. Bars and Billets for Forging and Drop Forging.
Section III. S.28—B. Bars for Machining.
Section IV. S.28—C. Forgings and Drop Forgings.
Section V. S.28—D. Finished Air Hardened Parts.

SECTION I.

Provisions applicable to all Sections of this Specification.

1. **Chemical Analysis.** (a) The steel shall contain :—

Carbon	-	-	-	between 0.25 and 0.32 per cent.
Silicon	-	-	-	not more than 0.30 per cent.
Manganese	-	-	-	between 0.35 and 0.60 per cent.
Sulphur	-	-	-	not more than 0.05 per cent.
Phosphorus	-	-	-	not more than 0.05 per cent.
Nickel	-	-	-	between 3.75 and 4.50 per cent.
Chromium	-	-	-	between 1.00 and 1.50 per cent.

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

Vanadium	-	-	-	not more than 0.25 per cent.
Molybdenum	-	-	-	not more than 0.65 per cent.
Tungsten	-	-	-	not more than 1.00 per cent.

- (b) The complete analysis of every cast shall be supplied to the Inspector.

2. **Mechanical Tests.** (a) The mechanical properties obtained from test pieces selected and prepared as specified in the appropriate Clause 7, 16 or 22 shall be as follows :—

Maximum Stress	-	-	-	not less than 100 tons per sq. inch.
Elongation	-	-	-	not less than 12 per cent.
Reduction of Area	-	-	-	not less than 25 per cent.
Izod Value	-	-	-	not less than 15 ft. lb.
Brinell Hardness Number	-	-	-	not less than 444 (2.90 mm.).

(b) *Tensile Test.* The test pieces shall be machined from the samples selected as specified in the appropriate Clause 7, 16 or 22 to the dimensions of the British Standard Tensile Test Piece, Fig. 1 of B.S. Specification 2 A. 4, or, if the samples are too small, machined to suitable test pieces as shown in Figs. 2 to 4.

* In order to avoid confusion it is recommended that this specification be referred to by its British classification No. 2 S. 28, by which it is already well known.

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With the concurrence of the Deputy Director of Aeronautical Inspection a B.S. Tensile Test Piece to Fig. 2, may be employed if required by the limitation of the available testing machine.

The testing appliances shall be such that the load when applied shall be axial.

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

(c) *Izod Test.* The test pieces shall be machined from the samples selected as specified in the appropriate Clause, 7, 16 or 22 to the dimensions of the British Standard Notched Bar Test Piece, Fig. 7 or 10 of B.S. Specification 2 A. 4, and tested in a 120 ft. lb. Izod machine.

(d) *Brinell Test.* (i) The test shall be made with a 10 mm. diameter ball and a load of 3,000 kg.,* which shall not be exceeded even momentarily, and shall be maintained for not less than 15 seconds. Prior to testing, the skin of the sample shall be removed by filing, grinding or machining the areas to be tested.

(ii) The diameter of the impression shall be measured to the nearest 0.05 mm.

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

(b) Any material may be rejected at any time for faults in manufacture notwithstanding that it has been previously passed on analysis and mechanical tests.

SECTION II.

S. 28-A. Bars and Billets for Forging and Drop Forging.

4. **Manufacture.** All bars and billets for forging and drop forging shall be rough-machined or made from rough-machined blooms or ingots.

5. **Margins of Manufacture.** No margins of manufacture are specified.

6. **Heat Treatment.** (a) All bars and billets for forging or drop forging shall be delivered in the softened condition having a Brinell Hardness Number not greater than 302 (3.50 mm.).

(b) *Hardening and Tempering.* The mechanical test samples shall be hardened by heating to a temperature of 820° C. and cooling in still air. They may then be tempered by heating to a temperature not exceeding 250° C. The test samples shall be machined before hardening and may be finished by wet grinding after heat-treatment.

7. **Selection and Preparation of Mechanical Test Samples.** (a) The bars or billets of each size and from the same cast shall be grouped in parcels of not more than :—

50 for sizes up to and including 1½ inches diameter or width across flats.

25 for sizes over 1½ inches diameter or width across flats.

The Inspector shall select one sample from each parcel for mechanical testing. A mechanical test sample shall be of sufficient length to allow of the preparation of the test pieces specified in Clause 2.

(b) The portion of the bar or billet selected for the preparation of the test samples shall be prepared in one of the following ways :—

(i) Test samples from bars 1½ inches diameter or width across flats and under shall be machined to the dimensions of the test pieces specified in Clause 2 (b) and (c) plus a grinding allowance, if required, and shall be heat-treated in that size.

(ii) Bars and billets over 1½ inches and up to 3 inches diameter or width across flats may be either forged and/or machined at the option of the Steelmaker to 1½ inches diameter and then machined to the dimensions of the test pieces specified in Clause 2 (b) and (c) plus a grinding allowance, if required, and heat-treated in that size.

(iii) Bars and billets over 3 inches diameter or width across flats may be forged and/or machined at the option of the Steelmaker to test samples 2½ inches diameter and then machined to the dimensions of the test pieces specified in Clause 2 (b) and (c), plus a grinding allowance if required, and heat-treated in that size.

(iv) When it is agreed between the Purchaser and the Deputy Director of Aeronautical Inspection that a special size of test sample more nearly represents the section of the designed part as heat-treated, that special test sample may be used for the mechanical tests. At the option of the Steelmaker it may be forged and/or machined to size and then machined to the dimensions of the test pieces specified in Clause 2 (b) and (c) plus a grinding allowance, if required, and heat-treated in that size. The size of the special test sample shall be stated on the order.

(c) The mechanical test samples shall be marked as directed by the Inspector before they are cut from the bar or billet, and shall be hardened and tempered as specified in Clause 6 (b).

8. **Mechanical Tests.** (a) The test pieces machined from the samples selected and prepared as specified in Clause 7 shall comply with the mechanical tests specified in Clause 2. These tests shall be carried out in the presence of the Inspector and to his satisfaction.

(b) If any test piece machined from the sample fails to give the mechanical tests specified in Clause 2 (a), the Inspector may reject the parcel represented by the test piece or at his discretion select two other samples for test, one of which must be from the bar or billet from which the original test sample was taken. If that bar or billet has been withdrawn by the Steelmaker one other bar or billet shall be selected. If both samples fulfil the test, the parcel from which the samples were selected will be accepted.

* It is recommended that the Brinell Hardness determination for small size bars be made with a suitably reduced load and/or ball in accordance with B.S. Specification No. 240.

9. **Up-ending Test.** From each parcel of bars or billets the Inspector shall select at least one bar or billet and up to five per cent. of the bars or billets, for the up-ending test. From the bars or billets so selected, samples shall be cut equal in length to their diameter or width across flats and forged down at normal forging temperature to half their original length by a minimum number of blows. The samples must be tested as cut from the bars or billets and must not be further machined before testing. After testing they must not reveal the presence of any defect.

10. **Sulphur-Printing Test.** The Inspector may at his discretion require the cut ends of one-half of the bars or billets from which the samples used for the up-ending tests are taken to be suitably prepared for sulphur-printing and the resulting prints must not reveal the presence of any defects or harmful segregations in the material so tested.

11. **Identification.** (a) All bars or billets half-inch diameter or width across flats and over, shall be stamped with the number S. 28, the cast number and the Steelmaker's trade mark or symbol. All such stamping must be done at one extreme end of each bar or billet.

(b) All bars or billets under half-inch diameter or width across flats, from the same cast, shall be wired up in bundles which shall bear a metal tag stamped with the number S. 28, the cast number and the Steelmaker's trade mark or symbol.

SECTION III.

S. 28—B. Bars for Machining.

12. **Manufacture.** All bars for machining shall be made from rough-machined blooms or ingots.

13. **Margins of Manufacture.** The margins of manufacture shall be in accordance with the order to the Steelmaker.

14. **Straightness.** (a) All black bars shall be commercially straight.

(b) All bright bars shall be straight.

15. **Heat Treatment.** (a) The bars shall be delivered in the softened condition and shall then have a Brinell Hardness Number not greater than 285 (3.60 mm.).

(b) *Hardening and Tempering.* The mechanical test samples shall be hardened by heating to a temperature of 820° C. and cooling in still air. They shall then be tempered by heating to a temperature not exceeding 250° C. The test samples shall be machined before hardening and may be finished by wet grinding after heat-treatment.

16. **Selection and Preparation of Mechanical Test Samples.** (a) The bars of each size and from the same cast shall be grouped in parcels of not more than 25.

(b) The mechanical test samples shall be marked as directed by the Inspector before they are cut from the bars.

(c) From the selected samples test pieces shall be machined to the dimensions of the test pieces specified in Clause 2, plus a grinding allowance, if required, and shall be heat-treated in that size.

17. **Mechanical Tests.** (a) The test pieces machined from the samples selected as specified in Clause 16 (a) shall comply with the Tensile and Izod tests specified in Clause 2. These tests shall be carried out in the presence of the Inspector and to his satisfaction.

(b) If any test piece machined from the samples fails to give the mechanical tests specified in Clause 2 (a) the Inspector may reject the parcel represented by the test piece, or at his discretion select two other samples for test, one of which must be from the bar from which the original test sample was taken. If that bar has been withdrawn by the Steelmaker one other bar shall be selected. If both samples fulfil the tests the parcel from which the samples were selected will be accepted.

18. **Sulphur-Printing Test.** The Inspector may at his discretion, require the ends of the test samples to be prepared for sulphur-printing. The resulting prints must not reveal the presence of defects or harmful segregations.

19. **Identification.** (a) All bars, half-inch diameter or width across flats and over, shall be stamped with the number S. 28, the cast number and the Steelmaker's trade mark or symbol. All such stamping must be done at one extreme end of each bar.

(b) All bars under half-inch diameter or width across flats, from the same cast, shall be wired up in bundles which shall bear a metal tag stamped with the number S. 28, the cast number and the Steelmaker's trade mark or symbol.

SECTION IV.

S. 28-C. Forgings and Drop Forgings.

20. **Material.** The forgings and drop forgings shall be made from bars or billets which have been inspected and passed as complying with Section II of this Specification.

21. **Heat Treatment.** (a) The forgings and drop forgings shall be delivered in the softened condition for machining, and must show in all parts a Brinell Hardness number not greater than 285 (3.60 mm.).

22. **Selection and Preparation of Mechanical Test Samples.** (a) The Contractor shall supply one test sample, unless more are specified on the order, to represent each batch of forgings or drop forgings made from the same cast and heat-treated at the same time. The test samples shall be cut from the material from which the forgings or drop forgings were made, and shall be of sufficient length to allow of the preparation of the test pieces specified in Clause 2.

(b) The portion of the bar or billet selected for the preparation of the test samples shall be prepared in one of the following ways:—

(i) Test samples from bars $1\frac{1}{8}$ inches diameter or width across flats and under shall not be forged or machined but shall be supplied full size.

(ii) Bars and billets over $1\frac{1}{8}$ inches and up to 3 inches diameter or width across flats may be forged and/or machined, at the option of the Contractor, to test samples $1\frac{1}{8}$ inches diameter and supplied in that size.

(iii) Bars and billets over 3 inches diameter or width across flats may be forged and/or machined, at the option of the Contractor, to test samples $2\frac{1}{2}$ inches diameter and be supplied in that size.

(iv) When it is agreed between the Purchaser and the Deputy Director of Aeronautical Inspection that a special size of test sample more nearly represents the section of the designed part as heat-treated, that special test sample may be used for the mechanical tests. At the option of the Contractor it may be forged and/or machined to size and supplied in that size. The size of the special test sample shall be stated on the order to the Contractor.

(c) The mechanical test samples shall be marked as directed by the Inspector.

SECTION V.

S. 28-D. Finished Air Hardened Parts.

23. **Material.** The finished parts shall be made from bars which have been produced in accordance with Section III of this Specification, or from forgings and drop forgings which have been inspected and passed as complying with Section IV of this Specification.

24. **Freedom from Defects.** The parts shall be free from defects.

25. **Heat Treatment.** (a) An allowance for grinding may be left on the finished machine parts if desired.

(b) The parts and the test pieces shall be hardened by heating to a temperature of 820° C. and cooling in still air. They shall then be tempered by heating to a temperature not exceeding 250° C. The test samples shall be machined before hardening and may be finished by wet grinding after heat-treatment.

(c) No finished part shall be re-hardened more than twice.

26. **Selection and Preparation of Test Samples for Finished Parts.** (a) The Contractor shall obtain for all forgings and drop forgings the test pieces specified in Clause 22.

(b) For parts made from bars the Contractor shall supply one test sample, unless otherwise stated on the order, to represent each batch of finished machined parts made from the same cast and heat-treated at the same time.

(c) The test samples shall be machined to the test pieces specified in Clause 3 plus a grinding allowance, if required, and shall be heat-treated in that size as specified in Clause 25 (b).

(d) If any test piece machined from the sample fails to give the mechanical tests specified in Clause 2 (a) the Inspector may reject the parcel represented by the test piece or at his discretion adopt either of the following procedures:—

(i) Select two other samples for test which have been heat-treated with the batch of finished parts. If both samples fulfil the tests the batch from which the samples were selected will be accepted.

(ii) Allow the batch to be re-heat-treated and re-tested.

27. **Brinell Test.** The Inspector may require Brinell Hardness tests to be made on as many of the finished machined parts as he may consider necessary to ensure that they comply with the tensile strength specified, provided that the Brinell impression does not affect the serviceableness of the part.

In the British Standard Specification with which this specification is identical, the terms "Deputy Director of Aeronautical Inspection" and "Inspector" refer to officers within the organisation of the British Air Ministry. For the purposes of this specification as an Australian Standard such references shall be interpreted in the manner directed by the Australian Airworthiness Authority concerned.

This Specification, prepared by the Special Committee on Aircraft Materials and Components, was approved on behalf of the Council of the Association on 19th April, 1940.

NOTE.

In order to keep abreast of progress in the industries concerned, Australian Standards are subject to periodical review. Suggestions for improvement, addressed to the Headquarters of the Association, will be welcomed.