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EMERGENCY STANDARD

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Being British Standards Institution
Specification for Aircraft Material

B.S. No. 3 S. 15*

endorsed without amendment

(C.A. 110)

STANDARDS ASSOCIATION OF AUSTRALIA.

Headquarters :

Science House, Gloucester and Essex Streets, Sydney.

AUSTRALIAN STANDARD SPECIFICATION

(Emergency Series)

FOR

**3 PER CENT. NICKEL CASE-HARDENING
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. 15—A. Bars and Billets for Forging and Drop Forging.

Section III. S. 15—B. Bars for Machining.

Section IV. S. 15—C. Forgings and Drop Forgings.

Section V. S. 15—D. Finished Case-Hardened Parts.

SECTION I.

Provisions applicable to all Sections of this Specification.

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

| | | | | | |
|------------|---|---|---|---|---------------------------------|
| Carbon | - | - | - | - | between 0.10 and 0.15 per cent. |
| Silicon | - | - | - | - | not more than 0.30 per cent. |
| Manganese | - | - | - | - | between 0.20 and 0.60 per cent. |
| Sulphur | - | - | - | - | not more than 0.05 per cent. |
| Phosphorus | - | - | - | - | not more than 0.05 per cent. |
| Nickel | - | - | - | - | between 2.75 and 3.5 per cent. |
| Chromium | - | - | - | - | not more than 0.30 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, 15, 21 or 25 shall be as follows :—

| | | | | |
|-------------------|---|---|---|--|
| Maximum Stress | - | - | - | between 45 and 60 tons per sq. in. for material $1\frac{1}{8}$ inches diameter or width across flats at the time of heat-treatment, and not less than 45 tons per sq. in. for material under $1\frac{1}{8}$ inches diameter or width across flats at the time of heat-treatment. |
| Elongation | - | - | - | not less than 18 per cent. |
| Reduction of Area | - | - | - | not less than 45 per cent. |
| Izod Value | - | - | - | not less than 40 ft. lb. |
| Nicked Fracture | - | - | - | See Clause 2 (d). |

(b) **Tensile Test.** The test pieces shall be machined from the samples selected as specified in the appropriate Clause 7, 15, 21 or 25 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. 3 S. 15, by which it is already well known.

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, 15, 21 or 25 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) *Nicked Fracture Test (See Clauses 8 (a) ii and 16 (a) ii).* A test piece or bar nicked or sawn so that the area of the portion to be fractured is not less than one-half of the sectional area of the bar, shall show a grey fibrous fracture when broken by a minimum number of blows.

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. 15-A. Bars and Billets for Forging and Drop Forging.

4. **Manufacture.** All bars and billets for forging or 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 as rolled or forged unless otherwise stated on the order.

(b) *Refining and Hardening.* The mechanical test samples shall be refined by heating to a temperature of 860° C. and suitably cooled in air, oil or water. They shall then be hardened by heating to a temperature of 770° C., and quenching in water to give the mechanical tests specified in Clause 2 (a).

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 Clauses 2 and 25 (c).

(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 not be forged or machined, but shall be heat-treated in the full size. Where it is necessary to remove the surface, they shall be heat-treated as near full size as possible.

(ii) Bars and billets over 1½ inches diameter or width across flats may be forged and/or machined at the option of the Steelmaker to test samples 1½ inches diameter and be heat-treated in that size.

(iii) 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 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 refined and hardened as specified in Clause 6 (b).

8. **Mechanical Tests.** (a) (i) 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.

(ii) When the dimension of the test sample is such that one of the British Standard Notched Bar Test Pieces cannot be made from it, the Nicked Fracture Test shall be substituted for the Izod Test.

(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 taken 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.

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 billet 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 test 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. 15, 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. 15, the cast number, and the Steelmaker's trade mark or symbol.

SECTION III.

S. 15-B. Bars for Machining.

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

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

(b) All bright bars shall be straight.

14. **Heat Treatment.** (a) All bars shall be delivered as rolled or cold drawn.

15. **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.

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 Clauses 2 and 25 (c).

(b) The portion of the bar selected for the preparation of the test samples shall be prepared in accordance with Clause 7 (b) and (c).

16. **Mechanical Tests.** (a) (i) The test pieces machined from the samples selected and prepared as specified in Clause 15 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.

(ii) When the dimension of the bar is such that one of the British Standard Notched Bar Test Pieces cannot be made from it, the Nicked Fracture Test shall be substituted for the Izod Test.

(b) If any test piece machined from the sample fails to give the mechanical test 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.

17. **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.

18. **Identification.** (a) All bars, half-inch diameter or width across flats, and over, shall be stamped with the number S. 15, 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. 15, the cast number and the Steelmaker's trade mark or symbol.

SECTION IV.

S. 15-C. Forgings and Drop Forgings.

19. **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.

20. **Heat Treatment.** All forgings and drop forgings and mechanical test samples shall be normalised at a temperature between 850° and 880° C., unless otherwise stated on the order.

21. **Selection and Preparation of 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. 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 Clauses 2 and 25 (c).

(b) The portion of the bar or billet selected for the preparation of the test sample 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 in the full size.

(ii) Bars and billets over $1\frac{1}{8}$ inches diameter or width across flats may be either forged or machined to $1\frac{1}{8}$ inches diameter and supplied in that size.

(iii) 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 heat-treated in that size. The size of the special 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. 15-D. Case-Hardened Parts.

22. **Material.** The parts shall be made from bars or forgings which have been inspected and passed as complying with Sections III and IV, respectively of this Specification.

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

24. **Heat Treatment.** The heat treatment to be given to the parts shall be as follows :—

(a) Carburised at a temperature between 880° C. and 930° C.

(b) The parts and mechanical test samples provided as specified in Clause 25 shall be refined by heating to a temperature of 860° C. They shall then be hardened by heating to a temperature of 770° C. and quenching in water or oil and may be tempered at a temperature not exceeding 200° C.

(c) No finished parts shall be refined or re-hardened more than twice.

25. **Selection and Preparation of Test Samples for Case-Hardened Parts.** (a) The Contractor shall obtain with all forgings and drop forgings the test samples specified in Clause 21.

(b) For parts made from bars the Contractor shall supply one mechanical test sample as specified in Clause 7 to represent each batch of parts made from the same cast and refined and hardened at the same time. This test sample shall be quenched in water.

(c) A separate piece of a test sample shall be supplied for the carburising test and shall be carburised, refined and hardened with the parts.

(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. If both samples fulfil the tests the batch from which the samples were selected will be accepted.

(ii) Allow the batch to be refined and/or re-hardened and re-tested.

(e) Failing the provision of the necessary test samples to permit of the re-tests in paragraph (d) above, the re-tests may be made where possible, on test samples cut from finished parts selected by the Inspector.

26. **Mechanical Tests.** The test pieces specified in Clause 25 after refining and hardening with the finished parts they represent must comply with the mechanical tests specified in Clause 2 (a) of Section I which shall be carried out in the presence of the Inspector and to his satisfaction.

27. **Carburising Test.** The test pieces prepared as specified in Clause 25 (c) shall be available for fracture by the Inspector.

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.