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Specification for Aircraft Material
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STANDARDS ASSOCIATION OF AUSTRALIA.

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

AUSTRALIAN STANDARD SPECIFICATION FOR AIRCRAFT MATERIAL
(Emergency Series)

**NICKEL-CHROMIUM 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 average figures 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. 82-A. Bars and Billets for Forging and Drop Forging.
Section III. S. 82-B. Bars for Machining.
Section IV. S. 82-C. Forgings and Drop Forgings.
Section V. S. 82-D. Finished Case-hardened Parts.

SECTION I.

Provisions applicable to all Sections of this Specification.

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

Carbon	...	...	not more than 0.18 per cent.
Silicon	...	...	not more than 0.30 per cent.
Manganese	...	...	not more than 0.50 per cent.
Sulphur	...	...	not more than 0.05 per cent.
Phosphorus	...	...	not more than 0.05 per cent.
Nickel	...	...	not less than 4.0 or more than 4.5 per cent.
Chromium	...	...	not less than 1.0 or more than 1.6 per cent.

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

Vanadium	...	...	not more than 0.25 per cent.
Molybdenum	...	...	not more than 0.50 per cent.
Tungsten	...	...	not more than 1.0 per cent.

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

2. Tests. (a) All tests shall be carried out in the presence and to the satisfaction of the Inspector.

(b) *Mechanical Tests.* The mechanical properties of the material shall be as follows :—

Maximum Stress	...	...	not less than 85 tons per square inch.
Elongation	...	...	not less than 12 per cent.
Reduction of Area	...	...	not less than 35 per cent.
Izod Value	...	...	not less than 25 ft. lb.
Nicked Fracture	...	...	See (e) below.

*In order to avoid confusion it is recommended that this specification be referred to by its British classification No. S.82, by which it is already well known.

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(c) *Tensile Test.* The tensile test pieces shall be machined from the selected samples 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, they shall be machined to the dimensions shown in Figs. 2, 3 or 4 thereof.

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

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

(d) (i) *Izod Test.* The Izod test pieces shall be machined from the selected samples 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.

(ii) When the dimensions of a test sample are such that one of the British Standard Notched Bar test pieces cannot be made from it, the Nicked Fracture test (*see* (e) below) shall be substituted for the Izod test.

(iii) The fractures obtained from the Izod test pieces must be entirely grey and fibrous, and free from any sign of pipe or other defect.

(e) *Nicked Fracture Test.* 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 original sectional area, must show an entirely grey and fibrous fracture, free from any sign of pipe or other defect, 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 for faults in manufacture, notwithstanding that it has been previously passed on analysis and mechanical tests.

SECTION II.

S. 82-A. Bars and Billets for Forging and Drop Forging.

4. **Rough-Machining.** All bars and billets shall be made from rough-machined ingots or blooms or shall themselves be rough-machined.

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

6. **Heat-Treatment.** (a) All bars and billets for forging and drop forging shall be delivered as rolled or forged.

(b) The mechanical test pieces selected and prepared as specified in Clause 7 shall be refined by heating to a temperature of 830° C. and cooling in air or quenching in oil. They shall then be hardened by heating to a temperature of 760° C., and quenching in oil, and may at the option of the Manufacturer be tempered at a temperature not exceeding 200° C. to give the mechanical tests specified in Clause 2.

7. **Selection and Preparation of Mechanical Test Samples.** (a) Bars or billets from the same cast and of the same diameter or width across flats 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 test sample shall be prepared as follows :—

(i) From bars 1½ inches diameter or width across flats and under the test samples 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.

(ii) From bars and billets over 1½ inches diameter or width across flats the test samples may be forged to 1½ inches diameter. The test samples 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.

(c) The mechanical test samples shall be marked as directed by the Inspector before they are cut from the bars or billets, and the test pieces after machining shall be heat-treated as specified in Clause 6 (b).

The test pieces may be finished by wet grinding after heat-treatment.

8. **Mechanical Tests.** The test pieces machined from the samples selected and prepared as specified in Clause 7 must comply with the mechanical tests specified in Clause 2.

9. **Up-ending Test.** From each parcel specified in Clause 7, the Inspector shall select one bar or billet for the up-ending test. From the bar or billet so selected, a sample shall be cut equal in length to its diameter or width across flats and forged down at normal forging temperature to half its original length by a minimum number of blows. The sample must be tested as cut from the bar or billet and must not be further machined before testing. After up-ending it must not show any defect.

10. **Sulphur-Printing Test.** From each parcel specified in Clause 7 the Inspector may select one end of one bar or billet for sulphur printing. The resulting prints must not reveal the presence of defects or harmful segregations.

11. **Re-Tests.** If any test piece fails to give the mechanical tests specified in Clause 2 the Inspector may reject the parcel represented by that test piece or at his discretion 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 7 must comply with the mechanical tests specified in Clause 2.

12. **Identification.** (a) All bars under half-inch diameter or width across flats and from the same cast, passed by the Inspector, shall be wired up in bundles which shall bear a metal tag stamped with the identification mark of the Inspector and a symbol or such other marking which shall ensure full identification of the material.

(b) All billets and all bars half-inch diameter or width across flats and over, passed by the Inspector, shall be stamped with the identification mark of the Inspector and a symbol or such other marking which shall ensure full identification of the material. All such stamping shall be done at one extreme end of each bar or billet.

SECTION III.

S. 82-B. Bars for Machining.

13. **Rough-Machining.** All bars shall be made from rough-machined ingots or blooms.

14. **Margins of Manufacture.** Margins of manufacture, when required, shall be specified on the order.

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

(b) All bright bars shall be straight.

16. **Heat-Treatment.** (a) All bars shall be delivered in a softened condition with a Brinell Hardness Number not greater than 277 (3.65 mm.) unless otherwise specified on the order.

(b) The mechanical test pieces selected and prepared as specified in Clause 17 shall be refined by heating to a temperature of 830° C. and cooling in air or quenching in oil. They shall then be hardened by heating to a temperature of 760° C., and quenching in oil, and may at the option of the Manufacturer be tempered at a temperature not exceeding 200° C., to give the mechanical tests specified in Clause 2.

17. **Selection and Preparation of Mechanical Test Samples.** (a) Bars from the same cast and of the same diameter or width across flats 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 Clause 2.

(b) The portion of the bar selected for the test sample shall be prepared as follows :—

(i) From bars $1\frac{1}{2}$ inches diameter or width across flats and under the test samples 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.

(ii) From bars over $1\frac{1}{2}$ inches diameter or width across flats the test samples may be forged to $1\frac{1}{2}$ inches diameter. The test samples 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.

(c) The mechanical test samples shall be marked as directed by the Inspector before they are cut from the bars, and the mechanical test pieces after machining shall be heat-treated as specified in Clause 16 (b).

The test pieces may be finished by wet grinding after heat-treatment.

18. **Mechanical Tests.** The test pieces machined from the samples selected and prepared as specified in Clause 17 must comply with the mechanical tests specified in Clause 2.



19. **Sulphur-Printing Test.** From each parcel specified in Clause 17 the Inspector may select one end of one bar for sulphur printing. The resulting prints must not reveal the presence of defects or harmful segregations.

20. **Re-Tests.** If any test piece fails to give the mechanical tests specified in Clause 2 the Inspector may reject the parcel represented by that test piece, or at his discretion 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 17 must comply with the mechanical tests specified in Clause 2.

21. **Identification.** (a) All bars under half-inch diameter or width across flats, and from the same cast, passed by the Inspector, shall be wired up in bundles which shall bear a metal tag stamped with the identification mark of the Inspector and a symbol or such other marking which shall ensure full identification of the material.

(b) All bars, half-inch diameter or width across flats and over, passed by the Inspector, shall be stamped with the identification mark of the Inspector and a symbol or such other marking which shall ensure full identification of the material. All such stamping shall be done at one extreme end of each bar.

SECTION IV.

S. 82-C. Forgings and Drop Forgings.

22. **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.

23. **Heat-Treatment.** (a) All forgings and drop forgings and mechanical test samples shall be delivered in a softened condition with a Brinell Hardness of not more than 277 (3.65 mm.) unless otherwise specified on the order.

(b) The mechanical test samples shall be softened with the forgings and drop forgings which they represent.

24. **Selection and Preparation of Mechanical Test Samples.** (a) The Manufacturer shall supply sufficient test samples representing forgings or drop forgings made from the same cast to meet the requirements specified in Clause 28. 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, and of the test piece for the carburising test specified in Clause 30.

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

(i) From bars $1\frac{1}{8}$ inches diameter or width across flats and under the test samples shall be supplied in the full size.

(ii) From bars and billets over $1\frac{1}{8}$ inches diameter or width across flats, the test samples may be forged and/or machined to $1\frac{1}{8}$ inches diameter and supplied in that size.

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

25. **Identification.** (a) *Forgings and Drop Forgings under 6 lb.* All forgings and drop forgings under 6 lb., passed by the Inspector, shall be made into parcels which shall bear a metal tag, stamped with the identification mark of the Inspector and a symbol or such other marking which shall ensure full identification of the material.

(b) *Forgings and Drop Forgings of 6 lb. and over.* All forgings and drop forgings 6 lb. and over, passed by the Inspector, shall be stamped with the identification mark of the Inspector and a symbol or such other marking which shall ensure full identification of the material. All such stamping must be done wherever it is least liable to be detrimental to the serviceableness of the forging or drop forging.

SECTION V.

S. 82-D. Finished Case-hardened Parts.

26. **Material.** The parts shall be made from bars, forgings or drop forgings which have been inspected and passed as complying with Sections I to IV of this Specification.

27. **Heat-Treatment.** The parts, and the mechanical test pieces, selected and prepared as specified in Clause 28, shall be heat-treated as follows:—

(a) The parts shall be carburised at a uniform temperature between 850° C. and 900° C.

(b) The parts and mechanical test pieces shall then be heat-treated together as follows :—They shall be refined by heating to a temperature of 830° C. and cooling in air or quenching in oil and be hardened by heating to a temperature of 760° C. and quenching in oil. They may then at the option of the Manufacturer be tempered at a temperature not exceeding 200° C. to give the mechanical tests specified in Clause 2.

(c) The parts shall not be recarburised nor shall they be refined or re-hardened more than twice.

28. Selection and Preparation of Mechanical Test Samples. (a) (1) The Manufacturer shall obtain with all forgings and drop forgings the test samples specified in Clause 24.

(ii) The test samples 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. The test pieces may be finished by wet grinding after heat-treatment.

(b) For parts made from bars the Manufacturer shall supply at least one mechanical test sample which shall be selected and prepared in the same manner as that specified in Clause 17.

(c) A separate piece of a test sample for the carburising test specified in Clause 30 shall be carburised, refined and hardened with each box of parts.

29. Mechanical Tests. The test pieces machined from the samples selected as specified in Clause 28, must after heat-treatment as specified in Clause 27, comply with the mechanical tests specified in Clause 2.

30. Carburising Test. The test pieces prepared as specified in Clause 28 (c) shall be fractured as directed by the Inspector. The fracture so obtained must be to the satisfaction of the Inspector.

31. Re-Tests. (a) If any test piece fails to give the mechanical tests specified in Clause 2, the Inspector may reject the parts represented by the test piece or at his discretion adopt either of the following procedures :—

(i) Select for test two other samples, which have been heat-treated with the same batch of parts as the test sample which failed. The test pieces prepared from these two further samples must comply with the mechanical tests specified in Clause 2.

(ii) Allow the batch to be re-heat-treated in accordance with Clause 27 and re-tested in accordance with Clause 29.

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

For the purposes of this specification as an Australian standard the term "Inspector" 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 17th February, 1942.

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.