

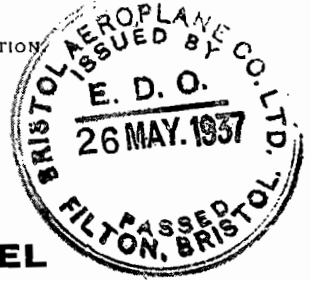
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NOTE.—The Institution desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the material herein referred to, but does not purport to comprise all the necessary provisions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

55-65 TON NICKEL CHROMIUM STEEL

FOR AIRCRAFT PURPOSES.

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

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

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

Section 2. S.11—A. Bars and Billets for Forging.

Section 3. S.11—B. Bars for Machining.

**Section 4. S.11—C. Forgings (other than for Crankshafts and
Airscrew Shafts).**

Section 5. (No Specification).

Section 6. S.11—E. Forgings for Crankshafts and Airscrew Shafts.

SECTION 1.

Provisions applicable to all Sections of this Specification.

1. Chemical Composition. (a) The chemical composition of the steel shall be:—

Carbon	-	-	not less than 0.25 nor more than 0.35 per cent.
Silicon	-	-	not more than 0.30 per cent.
Manganese	-	-	not less than 0.45 nor more than 0.70 per cent.
Sulphur	-	-	not more than 0.05 per cent.
Phosphorus	-	-	not more than 0.05 per cent.
Nickel	-	-	not less than 2.75 nor more than 3.75 per cent.
Chromium	-	-	not less than 0.50 nor more than 1.00 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) All tests shall be carried out to the satisfaction of the Inspector.

(b) The mechanical properties of the material shall be as follows:—

0·1 per cent Proof Stress	-	(see Footnote).*
Ultimate Tensile Stress	-	not less than 55 tons per sq. inch nor more than 65 tons per sq. inch.
Elongation	- - -	not less than 18 per cent.
Izod	- - - -	not less than 40 ft.-lb.

(Core test, as specified in Clauses 16 (b) (iii) and 25 A (c) (iii), not less than 30 ft.-lb.)

Brinell Hardness Number - not less than 248 nor more than 302
(see Clauses 20, 28 and 33).

Nicked Fracture - - - see paragraph (f) below.

(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 British Standard Specification No. 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 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) (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 British Standard Specification No. 2 A. 4, and tested in a 120 ft.-lb. Izod machine.

(ii) When the dimensions of a test sample are such that neither of the British Standard notched bar test pieces can be made from it, the nicked fracture test (see paragraph (f)) shall be substituted for the Izod test.

(iii) The fractures obtained from the Izod test pieces must be free from defects.

(e) *Hardness Test.* (i) The Brinell hardness test shall be carried out in accordance with the British Standard Specification No. 240.

(ii) Where the Brinell test is unsuitable, some other approved hardness test shall be adopted.

(f) *Nicked Fracture Test.* (i) 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 be free from defects when broken by a minimum number of blows.

(ii) For bars over 2 inches diameter or width across flats, the area of the portion to be fractured shall be approximately equivalent to 1½ inches square, and shall include the core.

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 passed previously on chemical composition and mechanical tests.

* When the Purchaser requests that the 0·1 per cent Proof Stress test shall be determined the tests shall be made on the tensile test samples selected and prepared as specified in Clause 7, 16 or 25 whichever is relevant. The value obtained shall be not less than 43 tons per sq. in.

SECTION 2.**S.11—A. Bars and Billets for 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.** Margins of manufacture, when required, shall be specified on the order.

6. **Heat Treatment.** (a) All bars and billets shall be delivered as rolled or forged, unless otherwise specified on the order.

(b) The test samples selected and prepared as specified in Clause 7 shall be hardened by heating to a temperature of 830° C. and quenching in oil. They shall then be tempered by heating to a suitable temperature of not less than 560° C. nor more than 660° C. and quenching in water or oil, at the option of the Manufacturer, to give the tensile and Izod values specified in Clause 2.

(c) No test sample shall be re-hardened more than three times.

7. **Selection and Preparation of Mechanical Test Samples.** (a) The Inspector shall select one test sample from a bar or billet in each cast for mechanical testing. The sample shall be of sufficient length to allow of the preparation of the tensile and Izod test pieces specified in Clause 2. The diameter of the test sample shall be not less than the ruling thickness of the forgings which are to be manufactured from the bars or billets and this diameter shall be stated on the order. The test sample shall be prepared as specified in Clause 25 (A) (b). For the purpose of all subsequent orders this test sample will be accepted as representing all sizes of bars and billets from the same cast where the specified diameter of test sample does not exceed that of the sample already tested and approved under this Clause.

(b) The test pieces shall be machined from the test sample as specified in Clause 25 (A) (c).

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

9. **Sulphur Printing Test.** The Inspector may select one or more bars or billets from each cast of steel for sulphur printing. The resulting prints must not reveal the presence of defects or harmful segregations.

10. **Re-tests.** If any test piece fails to comply with the tensile or Izod test specified in Clause 2 the Inspector may reject the bars or billets represented by that test piece, or at the request of the Manufacturer select for test from the same cast of steel 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 tensile and Izod tests specified in Clause 2.

11. **Identification.** (a) All bars under ½ 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 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 $\frac{1}{2}$ inch diameter or width across flats 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 stamping shall be done at one extreme end of each bar or billet.

SECTION 3.

S.11—B. Bars for Machining.

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

13. **Margins of Manufacture.** The margins of manufacture shall be specified on the order.

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

(b) All bright bars shall be straight.

15. **Heat Treatment.** (a) All bars shall be delivered in the finally heat-treated condition.

(b) All black bars shall be hardened and tempered after rolling or forging.

All bright bars shall be hardened and tempered either before or after the bars are cold rolled, drawn or ground to size.

(c) All bars shall be hardened by heating to a temperature of 830° C. and quenching in oil. They shall then be tempered by heating to a suitable temperature of not less than 560° C., nor more than 660° C. and quenching in water or oil, at the option of the Manufacturer, to give the tensile, Izod and hardness values and the nicked fracture test specified in Clause 2.

(d) No bar shall be re-hardened more than three times.

16. **Selection and Preparation of Mechanical Test Samples.** (a) Bars from the same cast and heat-treated together shall be grouped in parcels.

The Inspector shall select one test sample from the largest size of bar in each parcel for mechanical testing. The sample shall be of sufficient length to allow of the preparation of the tensile and Izod test pieces specified in Clause 2.

(b) (i) For bars up to and including $1\frac{1}{8}$ inches diameter or minor sectional dimension the tensile and Izod test pieces shall be machined concentrically from the test samples.

(ii) For bars over $1\frac{1}{8}$ inches and up to and including $2\frac{1}{2}$ inches diameter or minor sectional dimension, the longitudinal axes of the tensile and Izod test pieces shall be not less than $\frac{3}{16}$ inch from the surface of the test sample.

(iii) For bars over $2\frac{1}{2}$ inches diameter or minor sectional dimension, the longitudinal axes of the tensile and Izod test pieces shall coincide with a position half-way between the centre and surface of the test sample. When bars are over 4 inches diameter or minor sectional dimension an additional Izod test piece shall be machined from the core of the test sample from all selected bars and this test piece must give the Izod values specified in Clause 2 for the core test. If the value obtained from this test piece is not less than 40 ft. lb. no further Izod test will be required from that selected bar.

(c) The test samples shall be marked as directed by the Inspector before they are cut from the bars and shall not be further heat-treated or mechanically worked before testing.

17. **Mechanical Tests.** The test pieces machined from the samples selected as specified in Clause 16 must comply with the tensile and Izod tests specified in Clause 2.

18. **Sulphur Printing Test.** The Inspector may select one or more bars from each cast of steel for sulphur printing. The resulting prints must not reveal the presence of defects or harmful segregations.

19. **Re-tests.** If any test piece fails to comply with the tensile or Izod test specified in Clause 2 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 16 must comply with the tensile and Izod tests specified in Clause 2.

(ii) Allow the parcel to be re-heat-treated and re-tested in accordance with Clauses 16 and 17.

20. **Hardness Test.** (a) All bars in each parcel shall be submitted to the hardness test specified in Clause 2 and the hardness number must be within the specified limits, the impression being made at one end of each bar. The Inspector, at his discretion, may require the hardness test to be made at both ends of each bar.

(b) Bars which fail to comply with the hardness test may be rejected by the Inspector or at the request of the Manufacturer either of the following procedures may be adopted:—

(i) If the hardness numbers of the bars are below the minimum value specified the softest bar shall be submitted to the tensile test; if this bar complies with the tensile test all the bars represented will be accepted. If the hardness numbers of the bars are above the maximum value specified the hardest bar shall be submitted to tensile and Izod tests; if this bar complies with the tensile and Izod tests all the bars represented will be accepted.

(ii) The bars may be re-heat-treated in accordance with Clause 15. The largest size of bar in each parcel of bars re-heat-treated together must comply with the Izod test specified in Clause 2, and each bar must comply with the hardness test specified in paragraph (a) above.

21. **Nicked Fracture Test.** (a) All bars in each parcel shall be submitted to and must comply with the nicked fracture test specified in Clause 2 (f).

(b) (i) Any bars which exhibit defects may be rejected or be submitted to a further nicked fracture test at both ends. If the fractures are satisfactory the bars will be accepted.

(ii) Any bars the fractures of which are such as to indicate that the heat treatment may not have been satisfactory but are free from defects may be submitted to the Izod test. If the specified values are obtained the bars will be accepted. Alternatively, the bars may be re-heat-treated in accordance with Clause 15. The largest bar in each parcel of bars re-heat-treated together shall be tested and must comply with the Izod test specified in Clause 2 and each bar must comply with the hardness test specified in Clause 20 (a) and the nicked fracture test specified in Clause 2 (f).

22. **Identification.** (a) All bars under $\frac{1}{2}$ 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 tag stamped with the mark of the Inspector and such other marking as shall ensure full identification of the material.

(b) All bars $\frac{1}{2}$ inch diameter or width across flats 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 stamping shall be done at one extreme end of each bar.

SECTION 4.

S.11—C. Forgings (other than for Crankshafts and Airscrew Shafts).

23. **Rough-machining.** The forgings shall be made from bars or billets which have been rough-machined or from bars or billets made from rough-machined ingots or blooms.

24. **Heat Treatment.** (a) The forgings shall be delivered in the heat-treated condition, unless otherwise specified on the order.

(b) Large forgings shall preferably be rough-machined before heat-treatment.

(c) The forgings and the test samples selected and prepared as specified in Clause 25 shall be heat-treated together. They shall be hardened by heating to a temperature of 830°C . and quenching in oil. They shall then be tempered by heating to a suitable temperature of not less than 560°C . nor more than 660°C . and quenching in water or oil, at the option of the Manufacturer, to give the tensile, Izod and hardness values specified in Clause 2.

(d) No forging or test sample shall be re-hardened more than three times.

25. **Selection and Preparation of Mechanical Test Samples.** (A.) *General Procedure.* (a) The test samples shall be prepared from the bars or billets from which the forgings are made. They shall be marked as directed by the Inspector and shall be heat-treated with the forgings they represent. They shall be of sufficient length to allow of the preparation of the tensile and Izod test pieces specified in Clause 2 and shall be selected as follows:—

Forgings under 10 lb. One test sample, unless more are specified on the order, shall be provided for testing from each parcel of forgings of the same type, from the same cast and heat-treated together.

Forgings of 10 lb. and over. One test sample, unless more are specified on the order, shall be provided for testing from each parcel of 50 forgings of the same type, from the same cast and heat-treated together.

(b) The test samples may be heat-treated in the size as cut from the bars or billets, or they may be forged and/or machined to the ruling thickness of the forgings and heat-treated in that size. Where it is necessary to remove the surface, they shall be heat-treated as near that size as possible.

(c) (i) For test samples up to and including $1\frac{1}{4}$ inches diameter or minor sectional dimension, the tensile and Izod test pieces shall be machined concentrically from the test samples.

(ii) For test samples over $1\frac{1}{4}$ inches and up to and including $2\frac{1}{2}$ inches diameter or minor sectional dimension, the longitudinal axes of the tensile and Izod test pieces shall be not less than $\frac{3}{16}$ inch from the surface of the test sample.

(iii) For test samples over $2\frac{1}{2}$ inches diameter or minor sectional dimension, the longitudinal axes of the tensile and Izod test pieces shall coincide with a position half-way between the centre and surface of the test sample. When the test samples are over 4 inches diameter or minor sectional dimension an additional Izod test shall be machined from the core of the test sample and this test piece must give the Izod value specified in Clause 2 for the core test. If the value obtained from this test piece is not less than 40 ft. lb. no further Izod test will be required from that selected test sample.

(B.) (a) *Master Connecting Rods having integral lugs or flanges for the attachment of articulated rods.* (i) The test sample for the Izod test specified in Clause 2 shall be forged integrally with each forging. The thickness of this sample shall be not less than the ruling thickness of the forging and an impact test piece shall be machined from every sample for the Izod test specified in Clause 2. The sample shall be of sufficient length to allow of the preparation of the test piece and shall not be cut off before heat-treatment.

(ii) The test sample for the tensile test specified in Clause 2 shall be selected as specified in paragraph (A) above.

(b) *All other Connecting Rods.* The test samples for the tensile and Izod tests specified in Clause 2 shall be selected as specified in paragraph (A) above, or shall be cut from a selected forging as specified in paragraph (C) below. The procedure to be adopted shall be specified on the order. In addition a fracture test shall be made on a test sample forged integrally with each forging.

(c) *Forgings (other than connecting rods) for which integral test samples are specified.* The testing procedure shall be in accordance with paragraph (a) or (b) above. The procedure required shall be specified on the order.

(d) The test samples shall be marked as directed by the Inspector and shall not be further heat-treated or mechanically worked before testing.

(C.) *Test Samples cut from Forgings.* (i) When the order states that test samples shall be cut from the actual forgings, the test samples shall be of sufficient length to allow of the preparation of the tensile and Izod test pieces specified in Clause 2, and shall be taken from a part of the forging representing the ruling thickness and prepared as specified in paragraph A above.

(ii) When the forgings are under 10 lb. in weight one forging shall be provided for testing from each parcel of forgings of the same type, from the same cast and heat-treated together.

(iii) When the forgings are 10 lb. and over in weight one forging shall be provided for testing from each parcel of 50 forgings of the same type, from the same cast and heat-treated together.

(iv) The test samples shall not be further heat-treated or mechanically worked before testing.

26. **Mechanical Tests.** The test pieces machined from the samples selected and prepared as specified in Clause 25 must comply with the tensile and Izod tests specified in Clause 2.

27. **Re-tests.** (A.) *General Procedure.* (i) If any test piece selected and prepared as specified in Clause 25 (A) fails to comply with the tensile or Izod test specified in Clause 2, the Inspector may reject the parcel represented by that test piece or at the request of the Manufacturer adopt either of the following procedures:—

(a) Select for test two other test samples which have been heat-treated with the parcel of forgings. Test pieces prepared from these two further samples as specified in Clause 25 (A) must comply with the tensile and Izod tests specified in Clause 2.

(b) Allow the parcel to be re-heat-treated and re-tested in accordance with Clauses 25 (A) and 26.

(ii) Failing the provision of the necessary test samples to permit of the re-tests in paragraph (A) above, the re-tests may be made on test samples cut from forgings as specified in paragraph (C) below.

(B.) *Connecting Rods and other Forgings for which integral test samples are specified.* (i) If any test piece machined from a test sample integral with a forging fails to comply with the Izod test specified in Clause 2, the Inspector may reject the forging or at the request of the Manufacturer allow the forging to be re-heat-treated and re-tested in accordance with Clauses 25 (B) and 26.

(ii) Failing the provision of the necessary test sample to permit of the re-test in paragraph B (i) above, the forging shall be rejected.

(iii) If any test piece fails to comply with the tensile test specified in Clause 2, the Inspector may reject the parcel represented by that test piece or at the request of the Manufacturer adopt either of the following procedures :—

(a) Select for test two other test samples which have been heat-treated with the parcel of forgings. Test pieces prepared from these two further samples as specified in Clause 25 (A) must comply with the tensile test specified in Clause 2.

(b) Allow the parcel to be re-heat-treated and re-tested in accordance with Clauses 25 (B) and 26.

(iv) Failing the provision of the necessary test samples to permit of the re-tests in paragraph (iii) above, the re-tests may be made on test samples cut from forgings as specified in paragraph (C) below.

(C.) *Test Samples cut from Forgings.* If any test piece machined from a test sample cut from the actual forging fails to comply with the tensile or Izod test specified in Clause 2, the Inspector may reject the forgings represented by the test piece or at the request of the Manufacturer adopt either of the following procedures :—

(i) Select for test two other forgings from the same parcel. Test pieces prepared from these two further forgings as specified in Clause 25 (C) must comply with the tensile and Izod tests specified in Clause 2.

(ii) Allow the parcel to be re-heat-treated and re-tested in accordance with Clauses 25 (C) and 26.

28. **Hardness Test.** (a) Each forging shall be submitted to the hardness test specified in Clause 2 and the hardness number must be within the limits specified.

(b) Forgings which fail to comply with the hardness test may be rejected by the Inspector or at the request of the Manufacturer be re-heat-treated in accordance with Clause 24. They must then comply with the hardness and Izod tests specified in Clause 2. Failing the provision of the necessary integral test samples a piece of bar or billet of the same cast from which the forgings were made and of the ruling thickness of the forgings shall be heat-treated at the same time and used for the Izod test.

29. **Identification.** (a) *Forgings under 10 lb.* All forgings under 10 lb., 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 of 10 lb. and over.* All forgings 10 lb. 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 stamping must be done wherever it is least liable to be detrimental to the forging.

SECTION 5.

(No Specification).

SECTION 6.**S.11—E. Forgings for Crankshafts and Airscrew Shafts.**

30. **Manufacture.** (a) Forgings for crankshafts and airscrew shafts shall be made by an approved process.

(b) The forgings shall be made from billets which have been inspected and passed as complying with Section 2 of this Specification.

31. **Heat Treatment.** (a) The forgings shall be delivered in the finally heat-treated condition.

(b) The forgings shall preferably be rough-machined before heat-treatment.

(c) The forgings shall be hardened by heating to a temperature of 830° C. and quenching in oil. They shall then be tempered by heating to a suitable temperature of not less than 560° C. nor more than 660° C. and quenching in water or oil, at the option of the Manufacturer, to give the tensile, Izod and hardness values and the nicked fracture test specified in Clause 2.

(d) No forging shall be re-hardened more than three times.

32. **Selection and Preparation of Mechanical Test Samples.** (a) Each crankshaft and airscrew shaft forging shall have a test sample forged on one end the diameter of which shall be equal to that of the crankshaft journal as forged or the ruling thickness of the airscrew shaft as forged and of sufficient length to allow of the preparation of all the test pieces specified in Clause 2. A test sample of sufficient length to allow of the preparation of the nicked fracture test piece shall be forged on the other end.

The Inspector at his discretion may require test samples of sufficient length to allow of the preparation of all the test pieces specified in Clause 2 to be forged on both ends of each forging.

(b) For test samples up to and including 2 inches diameter, the tensile and Izod test pieces shall be machined concentrically from the test sample.

For test samples over 2 inches diameter the longitudinal axes of the tensile and Izod test pieces shall be not less than one inch from the surface of the test sample.

(c) The test samples shall be heat-treated on the forgings and shall be marked as directed by the Inspector before they are cut off. After removal from the forgings the test samples shall not be further heat-treated or mechanically worked before testing.

33. **Hardness Test.** (a) Each forging shall be submitted to the hardness test specified in Clause 2 throughout its length, and the hardness numbers must be within the limits specified.

(b) Forgings which fail to comply with the hardness test may be rejected by the Inspector or at the request of the Manufacturer be re-heat-treated in accordance with Clause 31. They must then comply with the hardness test specified in paragraph (a) above and with the tensile and Izod tests specified in Clause 34 (b).

34. **Mechanical Tests.** (a) Each end of each forging shall be submitted to and must comply with the requirements of the nicked fracture test specified in Clause 2 (f).

(b) The test pieces machined from the samples selected and prepared as specified in Clause 32 must comply with the tensile and Izod tests specified in Clause 2.

35. **Re-tests.** If any test piece fails to comply with the tests specified in Clause 34 (b) the forging may be rejected by the Inspector or at the request of the Manufacturer be re-heat treated in accordance with Clause 31 and re-tested in accordance with Clauses 32, 33 (a) and 34 (b).

36. **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.

This Specification having been approved by the Aircraft Industry Committee and endorsed by the Chairman of the Engineering Divisional Council, was published by the authority of the General Council of the Institution as a British Standard on 10th May, 1937.

NOTE.

In order to keep abreast of progress in the Industries concerned, the British Standard Specifications are subjected 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 Specifications to which they refer.