

BRITISH STANDARD 2 S. 500 : 1969

METRIC AND INCH UNITS

UDC 629.7 : 669.14.018.296-41 : 620.1

**Inspection and Testing Procedure
for Aerospace Material**

STEEL SHEET AND STRIP

BRITISH STANDARD : AEROSPACE SERIES

INSPECTION AND TESTING

PROCEDURE FOR STEEL SHEET AND STRIP

FOREWORD

This British Standard covers the general inspection and testing requirements for steel in the forms of sheet and strip.

The standard has been revised to include two new sections covering the supply of precipitation hardening steels and of heat treated parts, the introduction of metric dimensions and the necessary revision of the tables.

The procedure defined herein is primarily for use in conjunction with related material specifications in the 'S' series of British Standards and the Ministry of Technology D.T.D. series; it may also be used with other material specifications by agreement between the purchaser and the supplier. The inspection and testing procedure for billets, bars, forgings and wires is contained in British Standard S.100 and that for tubes in British Standard T.100.

This standard makes references to the following British Standards:

British Standard 4 A. 4.	Test pieces and test methods for metallic materials for aircraft. Part 1. Tensile tests and Part 3. Bend tests.
BS 240.	Method for Brinell hardness test. Part 1, Testing of metals.
BS 350.	Conversion factors and tables.
BS 427.	Method for Vickers hardness test. Part 1, Testing of metals.
BS 891.	Method for Rockwell hardness test. Part 1, Testing of metals.

NOTE. Where reference is made to British Standards or other specifications, the latest issue shall be used.

CONTENTS

Sections	Page	Section	Page
1. General requirements	3	TABLES	
2. Sheet and strip delivered in the normalized or softened condition for use without further heat treatment (excluding austenitic steel)	6	1. Tolerances on thickness of hot-rolled steel sheet and strip (Excluding mild steel)	
3. Sheet and strip delivered in the softened condition for use in the hardened and tempered condition	7	A. Metric dimensions (millimetres)	14
4. Sheet delivered in the hardened and tempered condition	9	B. Imperial dimensions (inches)	15
5. Strip delivered in the hardened and tempered condition	10	2. Tolerances on thickness of cold-rolled steel sheet and strip (Excluding mild steel)	
6. Corrosion and heat resisting austenitic steel sheet and strip (High temperature properties not verified)	11	A. Metric dimensions (millimetres)	16
7. Precipitation hardening steel sheet and strip	12	B. Imperial dimensions (inches)	17
8. Finally heat-treated parts (Made from sheet and strip delivered in other than the finally heat treated condition)	13	3. Tolerances on width of rotary-sheared material	
APPENDIX		A. Metric dimensions (millimetres)	18
A. Modified requirements for the acceptance of small quantities of steel	24	B. Imperial dimensions (inches)	18
		4. Tolerances on width and length of guillotine-sheared material	
		A. Metric dimensions (millimetres)	19
		B. Imperial dimensions (inches)	19
		5. Tolerances on thickness of hot-rolled mild steel sheet and strip	
		A. Metric dimensions (millimetres)	20
		B. Imperial dimensions (inches)	21
		6. Tolerances on thickness of cold-rolled mild steel sheet and strip	
		A. Metric dimensions (millimetres)	22
		B. Imperial dimensions (inches)	23

1. GENERAL REQUIREMENTS

1.1 DEFINITIONS

For the purposes of this British Standard the following definitions apply:

- (1) *Oxygen steelmaking process*. A steelmaking process using commercially pure oxygen (99% purity) excluding air or mixed air/oxygen blowing processes.
- (2) *Cast*. A complete melt or that portion of a melt intended for aircraft purposes.
- (3) *Billet*. Rolled billets, forged billets, slabs and sheet bars for re-rolling.
- (4) *Sheet and strip*. Hot or cold rolled products of rectangular section of dimensions covered by Tables 1-6.

1.2 CHEMICAL COMPOSITION

1.2.1 The chemical composition of the steel shall comply with that required by the material specification. An analysis of every cast shall be made for the specified elements and a certificate of analysis shall be supplied to the purchaser.

1.2.2 Elements not quoted in the material specification shall not be intentionally added to the steel without the agreement of the purchaser*, except for the purpose of finishing the heat; reasonable precautions shall be taken to prevent their inclusion during manufacture. For special applications the purchaser*, by agreement with the manufacturer, may set a limit to the amount of one or more such elements and may require the amount of such elements to be stated in the certificate of analysis.

1.2.3 The deliberate addition of lead is permitted, by agreement, in certain low strength steels only where it is explicitly mentioned in the individual material specification. The addition of lead to other steels is not permitted.

1.2.4 The specified ranges of chemical composition are based on cast analyses. Any subsequent analytical checks shall take into consideration the heterogeneity normal to the steel.

1.3 MANUFACTURE

1.3.1 The steel shall be made by a process required by the material specification, unless the manufacturer and the purchaser* agree beforehand to the use of a different process. If a specification permits alternative processes, the manufacturer shall decide which of them shall be used, unless the purchaser* requires a particular process on the order. In all instances the process by which the steel was made shall be stated in the release note.

1.3.2 The size, shape and method of production of the ingots shall be so selected as to minimize segregation and axial unsoundness.

1.3.3 The ingots, unless charged hot into a re-heating furnace, shall be cooled in a manner that will ensure freedom from any internal or external cracks.

*The purchaser is responsible for securing the concurrence of the parent design firm.

1.3.4 Re-heating for hot working and cooling after hot working shall be controlled to avoid deleterious effects.

1.3.5 At some stage or stages in the manufacture of the sheet or strip adequate discard shall be removed from the portions corresponding to the top and the bottom of each ingot.

1.4 TEMPORARY IDENTIFICATION UP TO THE CAST APPROVAL STAGE

Ingots from each cast shall be identified serially, the products shall be identifiable with the particular ingots from which they were made, and the portions corresponding to the tops and bottoms of the ingots shall be suitably marked. These markings shall be maintained until the cast has been proved satisfactory on sulphur printing (and/or deep etching) and metallurgical examination as specified in 1.8.2, 1.8.3 and 1.8.4.

NOTE. The identification of ingots within a cluster is arbitrary.

1.5 SURFACE DRESSING

1.5.1 If overall dressing is required by the material specification or the order, the material shall be machined, ground or de-seamed all over at a suitable stage. Sufficient material shall be taken off to remove surface imperfections which might produce harmful defects in sheet or strip made from the material.

1.5.2 If local dressing is required by the material specification, surface defects shall be removed by local machining, chipping, grinding or de-seaming.

1.6 PREPARATION FOR SURFACE INSPECTION OF SHEET AND STRIP SUPPLIED BLACK

Unless otherwise agreed between the manufacturer and the purchaser, sheet or strip shall be de-scaled if necessary to enable the surface to be inspected to the satisfaction of the Inspecting Authority.

1.7 SURFACE FINISH

The surface finish shall be in accordance with the material specification or as agreed between the manufacturer and the purchaser and stated on the order.

1.8 FREEDOM FROM DEFECTS

1.8.1 All material shall be free from harmful defects.

1.8.2 Unless otherwise specified in the material specification, sulphur printing or deep etching tests shall be carried out at a suitable stage during manufacture on samples corresponding to the tops of ingots selected from each cast as required by 1.8.2.1 or 1.8.2.2. The tests shall reveal no harmful defects.

1.8.2.1 If required by the material specification, one sample shall be taken from each ingot.

1.8.2.2. If required by the material specification, samples shall be selected as follows:

(1) For ingots cast individually and weighing up to 5000 kg (5 ton) each, the minimum number of samples to be selected shall be as follows:

Number of ingots in cast	Number of ingots to be selected
Up to 5	1
6 to 10	2
Over 10	3

The selected ingots shall be as widely separated in order of production as is practicable.

(2) For ingots cast individually and weighing over 5000 kg (5 ton) each, a sample shall be taken from each ingot.

(3) For ingots cast in clusters, a sample shall be taken from one ingot in each cluster.

1.8.3 If lead is added to the steel by agreement with the purchaser* and when permitted by the material specification (see 1.2.3), the billet adjacent to the bottom discard of each ingot shall be tested for freedom from lead segregation.

1.8.4 The steelmaker or steel supplier shall satisfy himself, by examination for cleanness, that the cast is free from harmful inclusions. A standard of acceptance may be agreed between the steelmaker and the parent design firm.

1.8.5 The steelmaker or steel supplier shall verify by visual examination that the billets are free from harmful surface defects.

1.8.6 Non-destructive tests for the detection of flaws may be required by the material specification or by agreement between the manufacturer and the purchaser, who shall mutually determine the stage at which they are to be applied, the method of testing to be employed and the standards of acceptance.

1.8.7 Notwithstanding the previous acceptance of material as complying with the requirements of this British Standard, any material that is found at a later stage to contain harmful defects may be rejected.

1.9 HEAT TREATMENT TEMPERATURES

If a temperature with a tolerance is stated in the material specification, that temperature shall be mandatory. If a temperature range is stated, a temperature within that range shall be selected to give the required properties.

1.10 SELECTION AND PREPARATION OF MECHANICAL TEST SAMPLES

1.10.1 Test samples shall be selected and prepared in accordance with the requirements of the relevant section of this British Standard.

*The purchaser is responsible for securing the concurrence of the parent design firm.

1.10.2 The longitudinal axis of tensile test pieces cut from material 200 mm (8 in) wide or over shall be transverse to the direction of final rolling. The longitudinal axis of test pieces cut from material less than 200 mm (8 in) wide shall be parallel to the direction of final rolling.

1.10.3 The longitudinal axis of bend test pieces cut from material 50 mm (2 in) wide or over shall be transverse to the direction of final rolling. The longitudinal axis of test pieces cut from material less than 50 mm (2 in) wide shall be parallel to the direction of final rolling.

1.11 TENSILE TEST

1.11.1 The test pieces shall be prepared and tested in accordance with British Standard 4 A. 4, Part 1, and the following clauses.

1.11.2 The tensile strength, proof stress and elongation shall be determined for material 0.46 mm (0.018 in) and thicker.

1.11.3 For material thinner than 0.46 mm (0.018 in) the tensile strength only shall be determined unless otherwise agreed between the manufacturer and the purchaser.

1.11.4 For proof stress determination the following procedure shall be applied:

(1) On at least one test piece from each cast the proof stress shall be obtained from an accurately determined load-extension or stress-extension diagram. The test piece shall be broken in tension and the tensile strength and the elongation shall be recorded.

(2) On all remaining tensile test pieces it shall be verified by one of the methods stipulated in British Standard 4 A. 4, Part 1, that the proof stress complies with the requirements of the material specification. The test piece shall be broken in tension and the tensile strength and the elongation shall be recorded.

1.11.5 Elongation values shall be determined on a gauge length of 50 mm (2 in).

1.11.6 The fractures shall be free from defects.

1.12 BEND TEST

Single-bend tests shall be prepared and tested in accordance with British Standard 4 A. 4, Part 3.

1.13 HARDNESS TEST

1.13.1 Hardness tests shall be carried out as follows:

(1) If a minimum Brinell number or a range is specified, the test shall be made in accordance with BS 240, Part 1; the ratio of F/D^2 to be used shall be 30. Alternatively, a Vickers hardness test in accordance with BS 427, Part 1, shall be used.

(2) If a maximum hardness only is specified, the Brinell or Vickers hardness test may be replaced by a Rockwell test in accordance with BS 891, Part 1, (Rockwell principle).

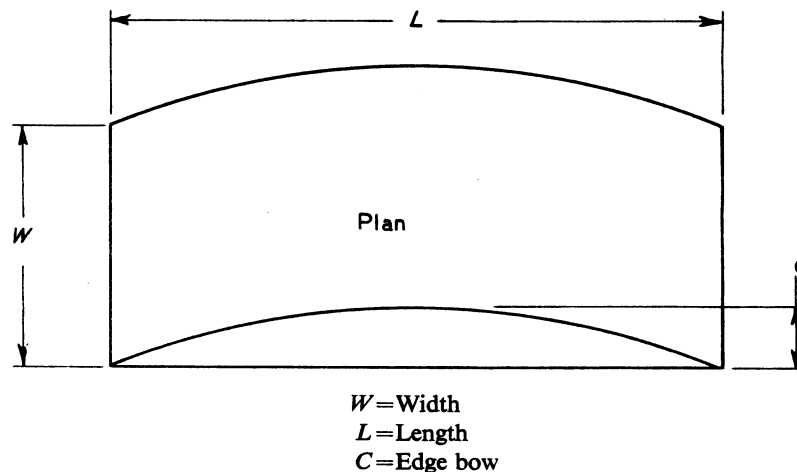


Fig. 1. Edge straightness.

1.13.2 All tests on the same batch of material, and on the tensile test samples, shall be made by the same method and under the same conditions of loading.

1.14 WELDABILITY TEST

If the purpose for which the steel is to be used indicates that the weldability is important, tests may be agreed between the manufacturer and the purchaser* and stated on the order.

1.15 EXAMINATION FOR DECARBURIZATION

1.15.1 A sample shall be selected in accordance with the requirements of the relevant section of this British Standard. The sample shall be suitably mounted to protect the edge of the section and shall be examined microscopically with bright field illumination on a polished and etched transverse section at a magnification of approximately 200 diameters. An alternative method of determination of depth of decarburization may be agreed with the Inspecting Authority.

1.15.2 Any decarburization shall not exceed the maximum depth permitted in the material specification.

1.16 DIMENSIONAL TOLERANCES

1.16.1 Thickness. The actual thickness of the sheet and strip shall comply with Table 1, Table 2, Table 5 or Table 6, as required by the material specification.

1.16.2 Width. The actual width of sheared sheet and strip shall comply with the requirements of Table 3 or Table 4, as stated on the order. If Table 4 tolerances are specified the order shall also state the class of tolerance required.

1.16.3 Edge straightness

1.16.3.1 Sheet. The edge straightness (edge bow), i.e. the lateral departure of the edge from a straight line forming a 2 m (6 ft) chord (see Fig. 1), shall not exceed the following amount:

Sheet up to 1200 mm (48 in) wide and	
not exceeding 3 m (10 ft) long	1.5 mm ($\frac{1}{16}$ in)

*The purchaser is responsible for securing the concurrence of the parent design firm.

Sheet over 1200 mm (48 in) wide or
over 3 m (10 ft) long 3 mm ($\frac{1}{8}$ in)

1.16.3.2 Strip. The edge straightness (edge bow) i.e. the lateral departure of the edge from a straight line forming a 3 m (10 ft) chord, shall not exceed 6 mm ($\frac{3}{4}$ in).

1.17 MAINTENANCE OF IDENTITY

1.17.1 The material shall be kept identifiable as to its cast and, if appropriate, its heat treatment test batch, to enable final identification marking to be made in accordance with 1.18.

1.17.2 Test samples shall be kept identifiable with the material that they represent.

1.18 FINAL MARKING

1.18.1 Each sheet and each coil of strip passed by the inspector shall bear the mark of the inspector and such other markings as shall ensure full identification of the material.

1.18.2 Each flat strip over 19 mm ($\frac{3}{4}$ in) wide passed by the inspector shall be marked as required by 1.18.1.

1.18.3 Flat strip not exceeding 19 mm ($\frac{3}{4}$ in) wide passed by the inspector shall be marked as required by 1.18.1 or, at the option of the manufacturer, flat strip from the same batch shall be made into bundles each of which shall bear a durable label stamped with the mark of the inspector and such other marking as shall ensure full identification.

1.18.4 All marks for the purposes of identification shall be as agreed by the Inspecting Authority.

1.19 METRIC AND IMPERIAL UNITS

The tables governing dimensional tolerances are provided in two forms based on metric and imperial units respectively. These two sets of requirements are not interchangeable: the relevant set shall be applied, depending on whether the dimensions stated on the drawing/order are expressed in metric or imperial units. Hence, for example, if the drawing/order states the nominal dimensions of the material in metric units, the appropriate 'metric' table(s) shall be applied and not values obtained by conversion from or to the requirements governing dimensions in imperial units.

2. SHEET AND STRIP DELIVERED IN THE NORMALIZED OR SOFTENED CONDITION FOR USE WITHOUT FURTHER HEAT TREATMENT (EXCLUDING AUSTENITIC STEEL)

2.1 CONDITION

2.1.1 Sheet and strip shall be supplied in the normalized or softened condition as required by the material specification.

2.1.2 No sheet or strip shall be subjected to the specified normalizing or softening treatment more than three times.

2.2. SELECTION OF MECHANICAL TEST SAMPLES

2.2.1 Material from the same cast, of the same nominal thickness and normalized or softened together, shall be grouped into batches.

2.2.2 The inspector shall select as follows test samples, which shall not be further heat-treated or mechanically worked, for the test or tests specified in the material specification.

(1) *Coils and material cut from coils.* One sample from every 2000 kg (2 ton) weight or part thereof in the batch. If a single coil exceeds 2000 kg (2 ton) in weight one sample from each end of the coil.

(2) *Material rolled by other than a continuous process.* Three samples from every 2000 kg (2 ton) weight or part thereof in the batch, selected as far as practicable to represent the distribution of the material in the heat-treatment furnace, except that if the total weight in the batch is 1000 kg (1 ton) or under, two samples shall be selected.

2.3 MECHANICAL PROPERTIES

2.3.1 The mechanical properties of test pieces prepared and tested in accordance with 1.10, 1.11 and 1.12 from the test samples selected as specified in 2.2 shall comply with the requirements of the material specification.

2.3.2 If the material specification requires a maximum hardness the tests shall be made in accordance with 1.13 as follows:

(1) *Coil.* Each end of each heat-treated coil shall be tested.

(2) *Sheet and strip produced from one coil.* The top and bottom sheet or strip of each heat-treatment batch shall be tested.

(3) *Material rolled by other than a continuous process.* Each heat-treated sheet or flat strip shall be tested unless otherwise agreed by the Inspecting Authority.

The hardness numbers shall comply with the requirements of the material specification.

2.4 RETESTS

2.4.1 Tensile and bend tests. If any test piece prepared from the test samples selected in accordance with 2.2 fails to comply with the requirements of the material specification, the inspector shall adopt one or both of the procedures required by 2.4.1.1 or 2.4.1.2.

2.4.1.1 Samples for retesting shall be selected as follows:

(1) *Sheet and flat strip*

a. Select from the batch twice the number of test samples originally selected, one of which shall be from the sheet or flat strip which originally failed on mechanical test unless that item has been withdrawn by the manufacturer.

b. These additional test samples shall be selected as far as practicable to represent the distribution of the material in the heat-treatment furnace.

(2) *Coils*

a. *Coils up to and including 2000 kg (2 ton) weight.* Select from the batch twice the number of test samples originally selected, one of which shall be from the same end of the coil which failed on mechanical test, unless that coil has been withdrawn by the manufacturer.

b. *Single coils exceeding 2000 kg (2 ton) weight.* Select a further test sample from the same end of the coil which originally failed on mechanical test.

c. Coils may be cropped before selecting retest samples.

The test pieces prepared from these further test samples shall be tested in accordance with 2.3.1.

2.4.1.2 Allow the material to be re-heat treated in accordance with the material specification and tested in accordance with 2.2 and 2.3.

2.4.2 Hardness tests. Allow any material of incorrect hardness to be re-heat-treated in accordance with the material specification and tested to the requirements of 2.2. and 2.3.