

Procedure for inspection, testing and acceptance of wrought steels (other than plate, sheet, strip and tube)

ICS 49.025.10

Committees responsible for this British Standard

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- British Forging Industry Association
- British Investment Casting Trade Association
- British Iron and Steel Producers' Association
- British Non-ferrous Metals Federation
- British Steel Industry
- Copper Development Association
- Light Metal Founders' Association
- Ministry of Defence
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Foreword

This British Standard, prepared under the direction of the Aerospace Standards Policy Committee, covers the inspection, testing and acceptance requirements for wrought steels (other than plate, sheet, strip and tube) to be used for aerospace purposes. The procedures are for use in conjunction with the relevant material specifications in the British Standard Aerospace S series. The procedures are also applicable to other specifications for wrought steel products, where appropriate, including Ministry of Defence (Procurement Executive) DTD series standards or where this standard is referred to in an order, drawing or inspection schedule. This standard is a revision of BS 4S 100:1975 which is withdrawn.

The corresponding requirements for sheet and strip and for tubes are covered by the latest edition of BS S 500 and BS 3T 100.

In this revision the text has been extensively revised to bring it into line with modern steel-making practices and current testing procedures required by the Aerospace Industry. The individual clauses have been renumbered by section to facilitate future amendments. Section 1 has been expanded to incorporate some of the repetitive statements from the other sections. Additional and modified definitions appear in Section 1 which also includes for the first time provision for steel-making by continuous casting. Section 10 is now restricted to raw material and the inspection and testing requirements for springs have been transferred from Section 10 to a new Annex C.

Section 11, which incorporated the provisions of the former Annex E, has now been deleted. Annex A and Annex B have been completely revised and improved. The former Annex C and Annex D have been deleted as not being appropriate for an inspection and testing procedural document. A new Annex D has been introduced giving rules for the application of values given in material specifications.

NOTE Arising from these changes the sections and clause numbers in this standard are not all the same as those of the previous edition so that, where such numbers are given in current material specifications, they may not now be appropriate. The requirements in Section 8 of BS 3S 100 were placed in Section 7 of BS 4S 100, and Section 8 remains unallotted. The progressive review of the material specifications will rectify this matter.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 58, an inside back cover and a back cover.

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Section 1. General requirements

1.1 Scope

This British Standard specifies procedures for the inspection, testing and acceptance of wrought steel billet, bar, rod and forgings, of parts made from such forms and subsequently heat treated, and of spring steel rod for wire drawing, spring wire and springs, to be used for aerospace purposes. The standard is applicable to material specifications in the British Standard Aerospace S series, and the Ministry of Defence (Procurement Executive) DTD series.

1.2 General

This standard details the basic requirements for the inspection and testing of British Standard Aerospace series and DTD series wrought steels (other than plate, sheet, strip and tube).

In addition to the definitive requirements, this standard also requires the items detailed in **1.5** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

If the purchaser wishes to specify an inspection, testing or acceptance procedure for any property of any product, which differs from that specified in this standard, this shall be agreed between the purchaser and the manufacturer and shall be fully documented on the order, drawing or inspection schedule, provided that the purchaser is also the quality assurance authority. If the purchaser is not also the quality assurance authority, deviations from the requirements of this standard shall only be agreed and documented after written approval has been obtained from the quality assurance authority.

1.3 References

1.3.1 Normative references

This British Standard incorporates by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page 54. Subsequent amendments to, or revisions of, any of these publications apply to this British Standard only when incorporated in it by updating or revision.

1.3.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

1.4 Terms and definitions

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

1.4.1

air melting

the practice of melting, by an electric process, in air and casting in air

1.4.2

bar

a wrought product with a consistent solid cross-section supplied in straight lengths

1.4.3

bright bar

bar which has been finish ground or machined

1.4.4

bright drawn bar

bar which has been descaled and cold drawn

1.4.5

black bar

bar which has not had its finished surface improved by descaling or by either of the methods applicable to bright bar

1.4.6**batch**

products which are from the same cast; of the same form and manufactured under the same processing conditions; of the same nominal dimensions to within $\pm 10\%$ or of similar ruling section; and in the same heat treatment condition and from the same heat treatment charge or, in the case of continuous heat treatment, from a run of not more than 8 h except in the case of coil when the maximum time is that required to heat treat one full coil

1.4.7**billet**

a rolled, extruded, forged or continuously cast product which may be solid or hollow and which is intended for further hot working

1.4.8**cast**

mass of solid metal all resulting from the same final melting operation

1.4.9**consumable electrode**

an electrode, for subsequent remelting, produced from air melted, vacuum melted or vacuum refined material

1.4.10**consumable electrode remelting**

the process of remelting consumable electrodes of known analysis by one of the methods defined in 1.4.11, 1.4.12, 1.4.13 or 1.4.36

1.4.11**vacuum arc remelting**

the process of remelting consumable electrodes under vacuum

1.4.12**electroflux remelting**

the process of remelting consumable electrodes through a flux

1.4.13**electroslag remelting**

the process of remelting consumable electrodes under a protective slag layer

1.4.14**continuous casting**

the process whereby molten metal from a single melt is poured into a water cooled mould, through which it is passed slowly and continuously to emerge as solid metal in a regular shape ready for subsequent hot working

1.4.15**design authority**

the organization responsible for the detailed design of matériel and which has the responsibility for certifying designs and/or for sealing drawings and specifications

1.4.16**equivalent diameter**

the diameter at the time of heat treatment of a hypothetical very long bar (effectively of infinite length) of uniform circular cross-section, which, if subjected to the same cooling conditions as the product being heat treated, i.e. same initial and final temperatures and same cooling medium, would have a cooling rate at its axis equivalent to that at the slowest-cooling position in the product being heat treated

NOTE Further information is given in BS 5046.

1.4.17**forgemaster**

the company responsible for producing forgings

1.4.18**forging**

a product obtained by hot working under a press or hammer (including rolled rings) and not intended for further hot working

1.4.19**forging stock**

cast or wrought steel intended for the production of forgings

1.4.20**ingot**

material cast into static moulds prior to subsequent hot working or, in the case of continuously cast material, an individual continuously cast strand

1.4.21**limiting ruling section**

the largest diameter, for any given composition of steel, in which certain specified mechanical properties can be expected after a specified heat treatment

NOTE Further information is given in BS 5046.

1.4.22**manufacturer**

the company that produces the material in the form and condition in which it is supplied to the purchaser

1.4.23**parent cast**

a melt of known chemical composition which is to be subsequently remelted

1.4.24**procedure X**

a procedure for the initial approval and process control of forgings in which test samples are machined from specified locations in forgings and tested to establish the initial quality and demonstrate that the forgings continue to conform to specified requirements

NOTE 1 The forgings from which the samples are taken are destroyed.

NOTE 2 This procedure is used in conjunction with procedures A or C (see 6.4.1).

1.4.25**purchaser**

the company which orders and purchases the product

1.4.26**quality assurance authority**

the body responsible for authorizing the manufacturer or supplier to issue certification, when to certify means to attest as meeting a standard

1.4.27**rod**

a hot rolled wrought product with a consistent solid cross-section supplied in coil form

NOTE It may be a finished product or subsequently further processed.

1.4.28**ruling section**

the equivalent diameter of that portion of the product or part at the time of heat treatment that is most important in relation to mechanical properties

NOTE Further information is given in BS 5046.

1.4.29**strand**

the product of an individual continuous casting mould

1.4.30**secondary refining**

the process of carrying out a further refining operation in a separate vessel to that in which initial melting/converting was carried out, without intermediate solidification of the steel. The operation is carried out under vacuum and/or with inert gas bubbling facilities

1.4.31**supplier**

the organization which has not necessarily made the product but which supplies it to the purchaser

1.4.32**test piece**

a test sample or a portion of a test sample as finally prepared for testing

1.4.33**test sample**

that portion of the material selected for testing

1.4.34 tests**1.4.34.1****acceptance tests**

the tests carried out by the manufacturer on material which is to be delivered in the finally heat treated condition to show that the material conforms to the material specification

1.4.34.2**proving tests**

the mechanical tests carried out by the manufacturer on material which is to be delivered in a condition other than the finally heat treated condition. Suitable test samples are subjected to the specified final heat treatment to show that the material conforms to the material specification

1.4.35**vacuum degassing**

the treatment of an air melted liquid alloy in a vacuum for the purpose of removing volatile constituents, followed by casting in air or under vacuum

1.4.36**vacuum induction melting**

the process of melting, by induction heating, under vacuum and casting in a vacuum chamber

NOTE See also 1.4.11 vacuum arc remelting.

1.4.37**wire**

a product with a regular or consistent solid section obtained by the cold working of rod and normally supplied in coils

1.5 Information to be supplied by the purchaser

The following information to be supplied by the purchaser, which is specified in the clauses referred to, shall be fully documented on the order, drawing or inspection schedule, on which the number of this British Standard shall also be given.

General

- a) the identity of the material specification with which this standard is to be used;
- b) if a particular method is required for surface inspection (see 1.10.1);
- c) if sulfur printing and/or deep etching tests are required also on samples corresponding to the bottoms of ingots (see 1.12.1);
- d) the required sampling frequency for sulfur printing and/or deep etching tests if different from the material specification and this standard (see 1.12.2);
- e) if a particular method of ultrasonic examination and level of acceptance are required (see 1.15.3);

- f) if the higher acceptance grade for ultrasonic testing given in Annex B is required (see 1.15.4 and B.6);
- g) the heat treatment condition in which the material and parts are to be supplied, if different from the material specification (see 1.16.1);
- h) the required heat treatment temperature (and tolerance) if different from the material specification (see 1.16.4);
- i) if the determination of transverse properties is required (see 1.18.2);
- j) the required condition of supply, if different from the material specification (see 1.28);
- k) the required dimensional tolerances for parts (see 1.29);
- l) if the material is required to be identifiable to the ingot and position within the ingot from which it came (see 1.30.1);

Forging stock, billet and bar

- m) the ruling section of heat treatment test samples, if required (see 5.2.1.2 and 5.2.3.2);

Forgings

- n) the method of ultrasonic examination to be used and the level of acceptance (see 1.15.3);
- o) if the identification marking is to be stamped in a particular position (see 1.31.4);
- p) whether procedure X is to be invoked, and if so the number of forgings to be selected for evaluation, the location, size and form of the test pieces, the minimum test properties, any additional test requirements and the procedure for selection of forgings during production (see 6.3);
- q) the sampling procedure for batch release testing, including details of integral test samples or test samples machined from the body of forgings, as applicable (see 6.4.1);
- r) the number of test samples to be heat treated with each batch of forgings, if applicable (see 6.4.2);
- s) if a heat treatment proving test is required (see 6.4.3), and the retest procedure, if applicable (see 6.5.2.2);
- t) the number of test samples to be supplied for heat treatment with each batch of forgings, if applicable (see 6.4.5);
- u) the mechanical tests to be carried out and the mechanical properties required, if different from the material specification (see 6.5.1);
- v) if more than one hardness test is to be carried out per forging, the required test positions and required hardness values (see 6.6.1.2 and 6.6.1.3);

Parts finally heat treated after machining

- w) the mechanical tests to be carried out and the mechanical properties required, if different from the material specification (see 7.2.4.1);
- x) the position for hardness testing, if applicable (see 7.2.5.1 and 7.5.5.1) and any special hardness requirements (see 7.2.5.1);
- y) the carburizing process to be applied, if applicable, the depth of case required and the final heat treatment to be applied (see 7.3.2 and 7.3.3.2);
- z) if a particular method is required for measuring the depth of case (see 7.3.3.2);
- aa) if hardness testing is to be carried out on the core of each part, and the hardness required (see 7.3.6);
- ab) the depth of case to be obtained from nitriding (see 7.4.2), and if a particular method is to be used for measuring depth of case (see 7.4.3.2);
- ac) if a hardness test is required on the core, and if a particular test position is required (see 7.4.5);

Spring steel rod and wire for springs

- ad) if ductility tests are required for wire (see 10.3.7.4);

Springs

ae) the required frequency of insertion of test lengths with springs heat treated in a continuous furnace or oven [see C.4b)];

af) the maximum permitted amount of decarburization if different from the material specification (see C.6.1);

1.6 Chemical composition

1.6.1

The chemical composition of the steel shall conform to the material specification. The values specified in the material specification shall be applied in accordance with Annex D. An analysis of every cast shall be made for the specified elements and a certificate of analysis shall be supplied to the purchaser unless the whole of the cast is to be remelted (see 1.6.2).

1.6.2

Each consumable electrode remelted cast shall be analyzed. Samples shall be taken from the top and bottom of each remelted ingot. The elements to be determined in each cast shall be as specified in the material specification.

NOTE If the manufacturer can show by statistical analysis that there is no significant difference between the top and bottom locations, only one position need be analyzed.

1.6.3

Analytical samples shall be selected and prepared in accordance with the relevant requirements given in BS 6200-2.1:1993 and BS 6200-2.2:1993. In the case of continuously cast material, if it is impracticable to sample the liquid steel, samples shall be taken from the cast product at positions corresponding to the beginning, middle and end of the cast.

1.6.4

Elements not quoted in the material specification shall not be intentionally added to the steel except for the purpose of finishing the melt. Reasonable precautions shall be taken to prevent their inclusion during manufacture. The maximum limits on residual elements shall be as given in Table 1.

Table 1 — Maximum limits on residual elements

Element	Carbon and carbon manganese, boron and alloy grades Wt %	Non-austenitic, corrosion resisting grades Wt %	Austenitic, corrosion resisting grades Wt %
Nickel	0.40	—	—
Chromium	0.30	—	—
Molybdenum	0.15	0.30	1.00
Niobium	—	—	0.20
Titanium	—	—	0.10
Copper	0.30	0.30	0.70

1.6.5

The deliberate addition of lead shall be permitted in certain low strength steels if it is specified as an alloying element in the material specification. Lead shall not be added to other steels.

1.6.6 Product analysis and permitted deviations

Product analysis may differ from the cast analysis due to heterogeneity arising during casting and solidification. Table 2 shows the deviations from the range specified for cast analysis permitted on product analysis.

The deviation may occur either above or below the individual element ranges but shall not apply both above and below the specified range for any one element in any one cast of steel.

Test specimens for product analysis shall be taken in accordance with BS 6200-3.

Product analysis deviations shall not be applied to cast analysis.

Table 2 — Permitted variations of product analysis from specified range

Element	Range in which maximum of specified element falls Wt %	Variation on specified range	
		Under min. Wt %	Over max. Wt %
Carbon	≤0.010	0.002	0.002
	>0.010 ≤0.03	0.005	0.005
	>0.03 ≤0.25	0.01	0.01
	>0.25 ≤0.50	0.02	0.02
	>0.50 ≤1.0	0.03	0.03
	>1.0 ≤1.3	0.04	0.04
Silicon	≤0.1	—	0.01
	>0.1 ≤0.25	0.02	0.02
	>0.25 ≤0.45	0.03	0.03
	>0.45 ≤1.0	0.05	0.05
	>1.0 ≤2.0	0.10	0.10
Manganese	≤0.70	0.03	0.03
	>0.70 ≤1.0	0.04	0.04
	>1.0 ≤2.0	0.05	0.05
Phosphorus	≤0.030	0.003	0.003
	>0.030 ≤0.045	0.004	0.004
	>0.045	0.005	0.005
Sulfur	≤0.030	—	0.003
Chromium	≤0.60	0.03	0.03
	>0.60 ≤1.25	0.04	0.04
	>1.25 ≤2.5	0.05	0.05
	>2.5 ≤10.0	0.10	0.10
	>10.0 ≤15.0	0.15	0.15
	>15.0 ≤20.0	0.20	0.20
	>20.0	0.25	0.25
Molybdenum	≤0.20	0.01	0.01
	>0.20 ≤0.50	0.02	0.02
	>0.50 ≤1.0	0.03	0.03
	>1.0 ≤2.0	0.05	0.05
	>2.0 ≤3.0	0.08	0.08
Nickel	≤1.0	0.03	0.03
	>1.0 ≤3.0	0.05	0.05
	>3.0 ≤5.0	0.07	0.07
	>5.0 ≤10.0	0.10	0.10
	>10.0 ≤20.0	0.15	0.15
	>20.0 ≤30.0	0.20	0.20
Aluminium	≤0.15	0.005	0.01
	>0.15 ≤0.50	0.03	0.03
	>0.50 ≤1.0	0.04	0.04
Boron	>0.0001 ≤0.01	0.0004	0.001
	>0.01 ≤0.05	0.005	0.005

Table 2 — Permitted variations of product analysis from specified range (*continued*)

Element	Range in which maximum of specified element falls Wt %	Variation on specified range	
		Under min. Wt %	Over max. Wt %
Cobalt	≤ 0.05	0.01	0.01
	>0.05 ≤ 1.0	0.03	0.03
	>1.0 ≤ 5.0	0.05	0.05
	>5.0 ≤ 10.0	0.10	0.10
	>10.0 ≤ 15.0	0.15	0.15
Copper	≤ 0.50	0.03	0.03
	>0.50 ≤ 5.0	0.04	0.04
	>5.0 ≤ 10.0	0.05	0.05
Nitrogen	≤ 0.02	0.005	0.005
	>0.02 ≤ 0.20	0.01	0.01
	>0.20 ≤ 0.25	0.02	0.02
Niobium	≤ 1.0	0.05	0.05
	>1.0 ≤ 3.0	0.10	0.10
	>3.0 ≤ 5.0	0.15	0.15
Tin	≤ 0.05	0.005	0.01
Titanium	≤ 1.0	0.05	0.05
	>1.0 ≤ 3.0	0.07	0.07
Vanadium	≤ 0.01	0.01	0.01
	>0.01 ≤ 0.25	0.02	0.02
	>0.25 ≤ 0.50	0.03	0.03
	>0.50 ≤ 1.0	0.04	0.04
	>1.0 ≤ 1.5	0.05	0.05
	>1.5 ≤ 5.0	0.10	0.10
Tungsten	≤ 1.0	0.03	0.03
	>1.0 ≤ 2.0	0.05	0.05
	>2.0 ≤ 5.0	0.07	0.07
Zirconium	≤ 0.1	—	0.01
	>0.1 ≤ 0.2	0.02	0.02

1.7 Manufacture

1.7.1

The steel shall be made by the melting process specified in the material specification. If, in addition to air melting, vacuum degassing and/or secondary refining is carried out by the manufacturer, and that treatment is not a requirement of the material specification or order, the release documentation shall state that vacuum degassing and/or secondary refining has been employed.

1.7.2

Except as permitted in 1.7.3 for vacuum arc remelted casts, at no time during remelting shall material of any other composition or type be introduced into the melting chamber i.e. starter material and electrode stub ends shall conform to the same material specification as the steel being remelted. Not more than one parent cast shall be used to produce a single electrode or remelted ingot.

1.7.3

For vacuum arc remelted casts produced under automated conditions with equipment enabling quantitative control of electrode consumption, it is permissible to use electrode stubs which differ in composition from the material being re-melted, provided that the welding of the stub to the electrode takes place outside the furnace and sufficient unmelted electrode remains on the stub after completion of remelting to ensure freedom from contamination of the ingot by the stub material. Remelting shall be terminated not less than 20 mm from the electrode/stub interface and, after completion of the remelting cycle, the electrode/stub interface shall be examined to verify that the stub and weld are intact.

1.7.4

For electroslag remelted casts, the use of electrode stub ends of different material to the steel being remelted shall be permitted provided that the remelted steel is not contaminated with material from the stub ends. Not more than one parent cast shall be used to produce a single electrode or remelted ingot.

1.7.5

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

1.7.6

The ingots, unless charged hot into the mill or forge reheating furnace, shall be cooled in a manner that will prevent cracking.

1.7.7

Reheating for hot working and cooling after hot working shall be controlled to avoid deleterious effects.

1.7.8

At some stage, or stages, in the manufacture of the product, adequate discard shall be removed from the portions corresponding to the top and the bottom of each ingot or the beginning and end of each strand.

1.7.9

For products made by continuous casting, the minimum hot working reduction ratio from as cast bloom or billet to finished product shall be 6:1.

1.7.10

All products shall be manufactured from material conforming to all the relevant requirements of this section.

1.8 Temporary identification up to the cast approval stage

1.8.1

Ingots from each cast shall be identified serially and wrought products shall be identifiable to the particular ingots from which they were made and shall be marked to maintain their identity relative to the tops and bottoms of the ingots (beginnings and ends of strands). These markings shall be maintained until it has been shown that the cast conforms to **1.12**, **1.13**, **1.14** and **1.15**.

NOTE The identification of ingots within a cluster is arbitrary. In the case of directly rolled small section bar (i.e. < 100 mm section), it is not necessary to identify every piece to its location in the ingot provided that sufficient lengths from the top and bottom of the ingot are identified to ensure adequate discard.

1.8.2

Continuously cast products shall be identified serially and shall be identifiable to the strand from which they were made. The position corresponding to the beginning and end of each strand shall be marked.

1.9 Surface dressing

1.9.1 Overall dressing

When overall dressing is specified in the material specification, the material shall be machined, ground or scarfed all over at a suitable stage. Sufficient material shall be taken off to remove surface imperfections which might produce any defect which is likely to be detrimental to the end use.

1.9.2 Local dressing

When local dressing is specified in the material specification, surface defects shall be removed by local machining, chipping, grinding or scarfing.

1.10 Surface inspection

1.10.1

The surfaces of bars and forgings shall be inspected for defects which might be detrimental to the end use, using the method specified on the order [see 1.5b)]. If not specified on the order, the method of inspection shall be at the discretion of the manufacturer.

1.10.2

Forgings and black bar for machining shall be descaled by a suitable method to enable the surface to be inspected. If acid pickling is used the release documentation shall be endorsed to that effect.

1.10.3

The presence of any surface defect which is likely to be detrimental to the end use shall be a cause for rejection.

1.10.4

Bar supplied for the manufacture of aerospace fasteners shall be such that when processed in accordance with BS 3A 100:1991, the bar conforms to the surface defect requirements given in 9.5 of BS 3A 100:1991.

1.11 Freedom from defects

1.11.1

All material shall be free from any defect which is likely to be detrimental to the end use.

1.11.2

Certain defects (e.g. “fish tailing”) can occur at the ends of bars due to rolling. Appropriate steps shall be taken to ensure that such end defects are completely removed.

1.11.3

Notwithstanding prior acceptance of a material as conforming to this standard, any defect in the material which is found at a later stage, and which is likely to be detrimental to subsequent use, shall be a cause for rejection.

1.12 Sulfur printing and deep etching tests

1.12.1

Sulfur printing and/or deep etching tests shall be carried out, at a suitable stage during manufacture, on full section samples corresponding to the top of ingots (or both ends of each strand) and, when required by the material specification or order [see 1.5c)], to the bottoms of ingots selected from each cast in accordance with 1.12.2. Additionally for narrow end-up ingots, samples corresponding to the middle portions of the ingots shall be selected from each cast in accordance with 1.12.2.

NOTE Suitable methods for sulfur printing and deep etching tests are given in BS 6285:1982 and BS 6533:1984, respectively.

The tests shall reveal no feature likely to be detrimental to the end use.

1.12.2

Samples shall be selected as specified in the material specification, or order or [see 1.5d)]. If not specified, samples shall be selected as follows.

- a) For ingots cast individually up to 5 000 kg each, the minimum number of samples to be selected shall be as given in Table 3. The selected ingots shall be as widely separated in order of casting as is practicable.
- b) For ingots cast individually over 5 000 kg each, one sample shall be taken from each ingot.
- c) For ingots cast in clusters, one sample shall be taken from one ingot in each cluster.
- d) For continuously cast material, one sample shall be selected from each end of each strand.

Table 3 — Sampling of ingots of up to 5 000 kg mass for sulfur printing and deep etching tests

Number of ingots in cast	Number of ingots to be selected
Up to 5	1
6 to 10	2
11 to 25	3
26 to 40	4
Over 40	5

1.13 Lead segregation

If lead is added to the steel (see 1.6.5), the billet adjacent to the bottom discard of each ingot, or each end of each continuously cast strand shall be shown to be free from lead segregation. Where ingots are cast in a cluster, one ingot shall be shown to be free from lead segregation.

1.14 Cleanness

When applicable (see note), the material shall be assessed for cleanness by measurement of the non-metallic inclusion content using the method specified in the material specification. If the material specification does not specify a method, the assessment shall be carried out in accordance with Annex A.

The material shall meet the acceptance criteria given in the material specification or the relevant acceptance criteria given in Annex A, as applicable.

NOTE Cleanness assessment is only applicable to certain steels (see A.1).

1.15 Ultrasonic examination

1.15.1 All materials, except continuously cast material which is manufactured directly into coil, shall be subjected to ultrasonic examination and shall meet the requirements of Annex B. Testing shall be carried out at an intermediate (billet) stage with diameter or minor sectional dimension less than or equal to 200 mm or, when this is not practicable, at a suitable subsequent stage of manufacture.

1.15.2 In the case of continuously cast steel which is manufactured directly into coil, an alternative means of assessing the material for internal defects shall be employed. This shall be at the discretion of the manufacturer and acceptable to the quality assurance authority.

1.15.3 For bar exceeding 200 mm in diameter or minor sectional dimension and for all products in austenitic corrosion resisting steel and free-machining steels, irrespective of the melting route, the method of examination and level of acceptance shall be as stated on the order or inspection schedule [see 1.5e)]. If not stated on the order or inspection schedule, the method of examination and level of acceptance shall be at the discretion of the manufacturer. For forgings, the method of examination and the level of acceptance shall be as stated on the order [see 1.5n)].

1.15.4 If the form and/or surface condition of billet or bar supplied for subsequent hot working does not permit ultrasonic examination in accordance with the full requirements of Annex B, the manufacturer shall endorse the release documentation with the details of the level to which the product has been examined. It shall then be the responsibility of the company producing the product in its final form to demonstrate conformity to the ultrasonic requirements of this standard.

1.15.5 If the higher grade acceptance standard given in Annex B (see Table B.1) is specified in the material specification or on the drawing or order [see 1.5f)] the material shall meet the acceptance criteria for this grade as given in Annex B. If the higher grade is not specified, the material shall meet the acceptance criteria for the standard grade as given in Annex B.

NOTE Attention is drawn to the limitations which class AA imposes regarding the type of product which can be examined to this level (see B.6).

1.16 Heat treatment

1.16.1 Material and parts shall be supplied in the heat treatment condition specified in the material specification, drawing or order [see 1.5g)].

1.16.2 No material, part or test sample shall be subjected to refining, hardening, normalizing, softening, solution treatment, primary hardening or precipitation, or a combination thereof, more than three times in total.

1.16.3 Temperature control during heat treatment shall be in accordance with BS 2M 54:1991, except in the case of material destined for further hot working.

1.16.4 If a specific temperature (value and tolerance) is given in the material specification, drawing or order [see 1.5h)], that temperature shall be used. If a temperature range is given in the material specification, drawing or order, a temperature within that range, shall be selected that will give the properties specified in the material specification.

NOTE Special provisions for the heat treatment of test samples are given in 1.18.3 and 1.18.4.

1.17 Mechanical properties

NOTE 1 In the material specifications which make reference to this standard, the specified mechanical properties refer to tests taken in the longitudinal direction, except where transverse properties are specified. The specified properties relate to test pieces machined from defined positions and they will not necessarily be realized when tests are carried out on test pieces selected from other positions in the material. (See 1.4.16, 1.4.21 and 1.4.28).

NOTE 2 Where the material specification specifies only the mechanical properties for the longitudinal direction, it is permissible to release material tested in the transverse direction, provided that the test results conform to the requirements specified for the longitudinal direction (see 1.18.2).

1.17.1 The minimum frequency of sampling for mechanical testing shall be one sample per batch.

1.17.2 The values for mechanical properties specified in the material specification shall be applied in accordance with Annex D.

1.18 Selection and preparation of test samples

1.18.1 Test samples shall be selected and prepared in accordance with the relevant section of this standard, and, for products supplied finally heat treated, shall be fully representative of the material in its delivery condition.

1.18.2 If transverse properties for billet or bar are specified in the material specification or order [see 1.5i)], test samples shall be cut in the form of transverse slices. This shall only apply to billet and bar not less than 75 mm in diameter or major sectional dimension. The results of transverse testing shall be identified as such on the release documentation.

1.18.3 Except for precipitation hardening steels (see 1.18.4), it shall be permissible for test samples for steels for which the specified minimum tensile strength is 1 300 MPa or more to be machined to test piece size, plus a grinding allowance if required, and heat treated at that size.

1.18.4 It shall be permissible for test samples for precipitation hardening steels for which the specified minimum tensile strength is 1 250 MPa or more to be machined after solution treatment (and primary hardening if applicable) to test piece size, plus a grinding allowance if required, and precipitation hardened at that size.

1.19 Location of longitudinal test pieces for mechanical tests

1.19.1 For products and test samples up to and including 30 mm in diameter or minor sectional dimension, the test pieces shall be machined coaxially with the test sample.

1.19.2 For products and test samples over 30 mm in diameter or minor sectional dimension the longitudinal axis of the test pieces shall be 12.5 mm from the surface of the product or test sample.

1.20 Location of transverse test pieces for mechanical tests

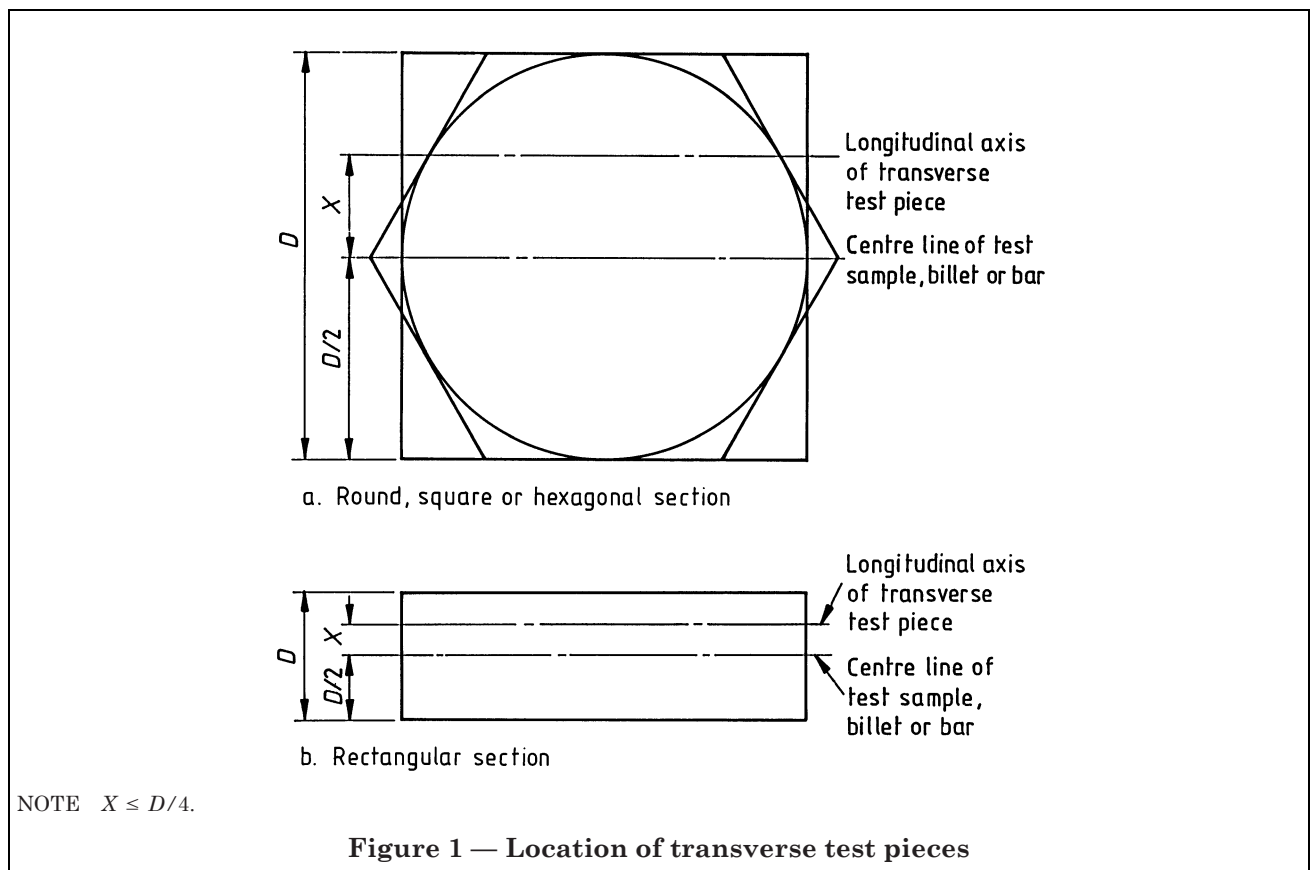
The test pieces shall be located as shown in Figure 1 or, if specified in the material specification, the longitudinal axis of the test piece shall intersect the longitudinal axis of the product or test sample.

1.21 Tensile test at room temperature

1.21.1 For products exceeding 16 mm in diameter or major sectional dimension the test piece shall be prepared from the test sample (see 1.18, 1.19 and 1.20) in accordance with BS 4A 4-1.1:1966. The largest practicable section proportional round test piece shall be used and the test piece dimensions shall conform to BS 4A 4-1.1:1966.

1.21.2 In the case of bar, section and wire not exceeding 16 mm in diameter or major sectional dimension, it shall be permissible to use a full section test sample as the test piece. For these test pieces, the elongation shall be measured on a gauge length equal to five times the original diameter of the test piece or, for material of other than circular section, on a gauge length of 50 mm.

1.21.3 Testing shall be carried out as specified in the relevant section of this standard. If not specified in this standard, testing shall be carried out in accordance with BS 4A 4-1.1:1966.



1.21.4 If a value for the proof stress is given in the material specification, on at least one test piece from each cast, the proof stress shall be obtained from accurately determined load-extension or stress-strain data. For all remaining test pieces, either the proof stress shall be determined from load-extension or stress-strain data, or conformity to the material specification shall be verified by one of the alternative methods given in BS 4A 4-1.1:1966.

1.21.5 The fracture faces shall be free from defects.

1.21.6 The values obtained shall conform to the material specification and the results of each test shall be reported in accordance with BS 4A 4-1.1:1966.

1.22 Tensile test at elevated temperature

1.22.1 The test piece shall be prepared from the test sample (see **1.18**, **1.19** and **1.20**) in accordance with BS 4A 4-1.2:1967.

1.22.2 The test piece shall be tested in accordance with BS 4A 4-1.2:1967.

1.22.3 If a value for the proof stress is given in the material specification, the proof stress shall be obtained from accurately determined load-extension or stress-strain data.

1.22.4 The fracture faces shall be free from defects.

1.22.5 The values obtained shall conform to the material specification and the results of each test shall be reported in accordance with BS 4A 4-1.2:1967.

1.23 Creep and rupture test

1.23.1 The test piece shall be prepared from the test sample (see **1.18**, **1.19** and **1.20**) to the dimensions of one of the test pieces given in BS 4A 4-1.3:1967.

1.23.2 The test piece shall be tested in accordance with BS 4A 4-1.3:1967.

1.23.3 The stress applied shall be equal to or greater than that specified in the material specification. A stress greater than that specified in the material specification shall only be used provided that the minimum life specified in the material specification is obtained. The stress shall not be increased after the test has been commenced. The actual stress used shall be stated on the release documentation.

1.23.4 The duration of the test shall be not less than the minimum specified in the material specification.

1.23.5 The fracture faces shall be free from defects.

1.23.6 The values obtained shall conform to the material specification and the results of each test shall be reported in accordance with BS 4A 4-1.3:1967.

1.24 Impact test

1.24.1 The test piece(s) shall be prepared from the test sample (see **1.18**, **1.19** and **1.20**) to the dimensions of the appropriate type of test piece called up in BS 4A 4-2:1966. The type of test (Izod, Charpy V-notch or Charpy U-notch) shall be as specified in the material specification. Conversions from one type of impact test result to another shall not be permitted.

1.24.2 The test shall be carried out on a minimum of three notches. When the Izod test is specified, the three notch test piece shall be prepared, unless the test sample is of insufficient length, in which case the single notch test pieces shall be prepared.

1.24.3 In the case of impact test pieces from actual forgings, the test samples shall be taken from the forgings in accordance with procedure D as specified in **6.4.1c**.

1.24.4 If the test sample is machined to test piece size prior to heat treatment (see **1.18**), the notches shall be machined after heat treatment, or partly machined before heat treatment, in such a manner that at least 0.2 mm of material remains to be removed from the radius of the root of each notch after heat treatment.

1.24.5 The test piece(s) shall be tested in accordance with BS 4A 4-2:1966.