British Standard

BRITISH STANDARD

BS 1449-1.1: 1991

Steel plate, sheet and strip —

Part 1: Carbon and carbon-manganese plate, sheet and strip —

Section 1.1 General specification

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) to Technical Committee ISM/10, upon which the following bodies were represented:

British Railways Board
British Steel Industry
Cold Rolled Sections Association
Society of Motor Manufacturers and Traders Limited

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Welded Steel Tube Association
Institution of Mechanical Engineers
National Association of Steel Stockholders

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Contents

Foreword

This Section of BS 1449 has been prepared under the direction of the Iron and Steel Standards Policy Committee and is a new edition of section one of BS 1449-1:1983. This Section of BS 1449, together with BS 1449-1.2 to 1.15 and BS EN 10130, supersedes BS 1449-1:1983 which is withdrawn.

When EN 10130 "Cold rolled low carbon steel flat products for cold forming — Technical delivery conditions" became available, it was a requirement that it should be published as a British Standard and any conflicting national standards withdrawn. This meant that the requirements for cold rolled wide strip specified in section two of BS 1449-1:1983 had to be deleted with the exception of the requirements for sheets for vitreous enamelling.

In view of the fact that there was other European work in hand which would also affect BS 1449-1, the Technical Committee responsible considered that BS 1449-1 should be split into a number of separately published Sections, mirroring as far as possible European work in hand or projected. In this way, when the equivalent European Standard becomes available and is published as a British Standard, the appropriate Section of BS 1449-1 will be withdrawn.

In Europe the practice is to prepare separate standards for hot rolled and cold rolled products and also for wide strip and narrow strip. Tolerance standards are also prepared as separate publications. Consequently BS 1449-1:1983 has been split into 15 separately published Sections as listed below. The related draft European Standard, prEN, or Euronorm, EU, is indicated.

— Section 1.1, *General specification.*

— Section 1.2, *Specification for hot rolled wide steel plate, sheet and wide strip based on formability*. (Related. to EU 111)

— Section 1.3, *Specification for cold rolled steel plate, sheet and wide strip for vitreous enamelling based on formability.* (Related to prEN 10209)

— Section 1.4, *Specification for hot rolled wide material based on specified minimum strength*. (Related to EU 149)

— Section 1.5, *Specification for cold rolled wide material based on specified minimum strength*. (Related to EU 149)

— Section 1.6, *Specification for tolerances on dimensions and shape for hot rolled wide material.* (Related to prEN 10051)

— Section 1.7, *Specification for tolerances on dimensions and shape for cold rolled wide material*. (Related to prEN 10131)

— Section 1.8, *Specification for hot rolled narrow strip based on formability*. (Related to EU 46)

— Section 1.9, *Specification for cold rolled narrow strip based on formability.* (Related to EU 139)

— Section 1.10, *Specification for hot rolled narrow strip based on specified minimum strength*. (Related to EU 149)

— Section 1.11, *Specification for cold rolled narrow strip based on specified minimum strength*. (Related to EU 149)

— Section 1.12, *Specification for tolerances on dimensions and shape for hot rolled narrow strip*. (Related to EU 48)

— Section 1.13, *Specification for tolerances on dimensions and shape for cold rolled narrow strip.* (Related to EU 140)

— Section 1.14, *Specification for hot rolled narrow strip supplied in a range of conditions for heat treatment and general engineering purposes.*

— Section 1.15, *Specification for cold rolled narrow strip supplied in a range of conditions for heat treatment and general engineering purposes.*

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their 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 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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0 Introduction

0.1 Designation system

In this standard, symbols have been used to indicate all the conditions and surface finishes in which the various materials are available. The meaning of these symbols is given in Table 1 and Table 2 and their use is described in this Section of BS 1449 and in BS 1449-1.2 to BS 1449-1.15 as appropriate. Each of these appropriate Sections also includes a table which indicates the combinations of conditions and surface finishes that are available for a particular grade of material.

Attention is drawn to the fact that it is not obligatory for the purchaser of a fabricated component to specify the manufacturing method for the flat rolled material. However, when it is necessary to specify the manufacturing method, the symbols concerned with material conditions (see Table 1) precede the material grade number in the following manner:

a) the symbols R, B or K, signifying either a rimmed, balanced or killed steel;

b) the symbols HR, HS, CR or CS, signifying the type of rolling;

c) the symbol SP when the material is required in the skin passed condition;

d) any other symbol concerned with material condition and which is appropriate to the grade being ordered (see the tables on availability in the appropriate Sections of BS 1449).

Any symbols concerned with surface finish (see Table 2) appear after the material grade number, Thus, material K CSSP 34/20 BR designates a killed steel in the form of cold rolled, skin passed, grade 34/20 narrow strip, supplied with a bright finish.

Material 34/20 GP would be used to specify this material when the purchaser did not wish to be more precise about the manufacturing method.

NOTE When it is required to specify an edge condition (see **2.9** and clause **18**) it is sufficient to add, after the designation of the material, the symbol indicating the edge condition, e.g. edge E1.

0.2 Summary of material grades, chemical compositions and types of steel available

The material grades, chemical compositions and types of steel available in BS 1449-1.2 to BS 1449-1.5, BS 1449-1.8 to BS 1449-1.11, BS 1449-1.14 and BS 1449-1.15 are summarized in Table 3.

1 Scope

This Section of BS 1449 specifies general requirements for flat rolled carbon steel products, available in the hot or cold rolled conditions and in coil or cut length form, rolled as wide strip in nominal widths of 600 mm and wider or as narrow strip in nominal widths less than 600 mm, as specified in BS 1449-1.2 to BS 1449-1.15.

This Section of BS 1449 covers plate, sheet and strip in nominal thicknesses up to and including 16 mm and the material grades, chemical compositions and types of steel summarized in Table 3.

NOTE The titles of the publications referred to in this standard are listed on page 16.

2 Definitions

For the purposes of this Section of BS 1449 the following definitions apply.

2.1
flat products

products of almost rectangular cross-section with a width much greater than the thickness

2.2
hot rolled flat products

flat products produced by hot rolling

NOTE The very light cold rolling pass called "skin pass' or "dressing pass", generally resulting in a reduction in thickness of less than 5 %, that is given to certain hot rolled flat products does not alter their classification as hot rolled products.

2.3
cold rolled flat products

flat products that have undergone a reduction in thickness of at least 25 % by cold rolling

NOTE In the case of flat products of nominal width less than 600 mm and for certain qualities of steel, material with a reduction of less than 25 % may be included in this category.

2.4
hot or cold rolled strip

a hot or cold rolled flat product which immediately after the final rolling pass is wound into regularly superimposed laps so as to form a coil with almost flat sides

NOTE 1 Strip as rolled normally has slightly convex edges (mill edges), but it may also be supplied with sheared or other edges (see **2.9**) or it may be obtained by slitting from wider strip. Strip may be subsequently cut and supplied as sheet or cut lengths, or as coils of any narrower width.

NOTE 2 According to its rolled nominal width, strip is classified as defined in **2.5** and **2.6**.

Table 1 — Symbols for material conditions

Condition	Symbol	Description
Rimmed steel	R	Low carbon steel in which deoxidation has been controlled to produce an ingot having a rim or skin almost free from carbon and impurities, within which is a core where the impurities are concentrated
Balanced steel	B	A steel in which processing has been controlled to produce an ingot with a structure between that of a rimmed and a killed steel. It is sometimes referred to as semi-killed steel
Killed steel	K	Steel that has been fully deoxidized
Hot rolled on wide mills Hot rolled on narrow mills	HR HS	Material produced by hot rolling. This will have an oxide scale coating, unless an alternative finish is specified (see Table 2)
Cold rolled on wide mills Cold rolled on narrow mills	CR CS	Material produced by cold rolling to the final thickness
Normalized	N	Material that has been normalized as a separate operation
Annealed	A	Material in the annealed last condition (i.e. which has not been subjected to a final light cold rolling)
Skin passed	SP	Material that has been subjected to a final light cold rolling
Temper rolled	 H1 H2 H3 H4 H5 H6	Material rolled to the specified temper and qualified as follows: H1 = eighth hard H2 = quarter hard H3 = half hard H4 = three-quarters hard H5 = hard H6 = extra hard
Hardened and tempered	HT	Material that has been continuously hardened and tempered in order to give the specified mechanical properties

Table 2 — Symbols for surface finishes and surface inspection

Finish	Symbol	Description
Pickled	P	A hot rolled surface[a] from which the oxide has been removed by chemical means
Mechanically descaled	D	A hot rolled surface[a] from which the oxide has been removed by mechanical means
Full finish	FF	A cold rolled skin passed material having one surface free from blemishes liable to impair the appearance of a high class paint finish[b]
General purpose finish	GP	A cold rolled material free from gross defects, but of a lower standard than FF[b]
Matt finish	M	A surface finish obtained when material is cold rolled on specially prepared rolls as a last operation
Bright finish	BR	A surface finish obtained when material is cold rolled on rolls having a moderately high finish. It is suitable for most requirements, but is not recommended for decorative electroplating
Plating finish	PL	A surface finish obtained when material is cold rolled on specially prepared rolls to give one surface which is superior to a BR finish and is particularly suitable for decorative electroplating
Mirror finish	MF	A surface finish having a high lustre and reflectivity. Usually available only in narrow widths in cold rolled material
Unpolished finish	UP	A blue/black oxide finish; applicable to hardened and tempered strip
Polished finish	PF	A bright finish having the appearance of a surface obtained by fine grinding or abrasive brushing; applicable to hardened and tempered strip
Polished and coloured blue	PB	A polished finish oxidized to a controlled blue colour by further heat treatment; applicable to hardened and tempered strip
Polished and coloured yellow	PY	A polished finish oxidized to a controlled yellow colour by further heat treatment; applicable to hardened and tempered strip
Vitreous enamel	VE	A surface finish for vitreous enamelling of material of specially selected chemical composition
Special finish	SF	Other finishes by agreement between the manufacturer and the purchaser

NOTE 1 Some of these finishes are available only from wide mills, others only from narrowmills. For availability see the specific requirements in BS 1449-1.2 to BS 1449-1.15 as appropriate.

NOTE 2 By special agreement between the supplier and the purchaser, cold rolled material can be supplied to surface texture specifications. The information to be given in statements about surface texture requirements is specified in BS 1134-1.

[a] A hot rolled surface supplied in the as-rolled condition, i.e. a non-descaled surface; some surface defects of steelmaking or rolling origin may be present, the proportion being greater with strip than with sheet or plate.

[b] GP and FF finishes are normally supplied with a matt appearance.

Table 3 — Summary of material grades, chemical compositions and types of steel available

Section of BS 1449	Material grade	Rolled condition (See Table 1)	Chemical composition								Types of steel
			C		Si		Mn		S	P	
			min.	max.	min.	max.	min.	max.	max.	max.	
	Materials having specific requirements based on formability										
1.2 1.3			%	%	%	%	%	%	%	%	
1.8 1.9	1	HR, HS, —, —	—	0.08	—	—	—	0.45	0.030	0.025	Extra deep drawing aluminium-killed steel
	1	—, —, CR, CS	—	0.08	—	—	—	0.45	0.030	0.025	Extra deep drawing aluminium-killed stabilized steel
	2	HR, HS, CR, CS	—	0.08	—	—	—	0.45	0.035	0.030	Extra deep drawing
	3	HR, HS, CR, CS	—	0.10	—	—	—	0.50	0.040	0.040	Deep drawing
	4	HR, HS, CR, CS	—	0.12	—	—	—	0.60	0.050	0.050	Drawing or forming
	14	HR, HS, —, —	—	0.15	—	—	—	0.60	0.050	0.050	Flanging
	15	HR, HS, —, —	—	0.20	—	—	—	0.90	0.050	0.060	Commericial
	Materials having specific requirements based on minimum strengths										
1.4 1.5	*Carbon-manganese steels*										
1.10	34/20	HR, HS, CR, CS	—	0.15	—	—	—	1.20	0.050	0.050	Available as rimmed (R) balanced (B) or killed (K) steels
1.11	37/23	HR, HS, CR, CS	—	0.20	—	—	—	1.20	0.050	0.050	
	43/25	HR, HS, —, —	—	0.25	—	—	—	1.20	0.050	0.050	
	50/35	HR, HS, —, —	—	0.20	—	—	—	1.50	0.050	0.050	Grain-refined balanced (B) or killed (K) steel
	Micro-alloyed steels										
	40/30	HR, HS, —, CS	—	0.15	—	—	—	1.20	0.040	0.040	Grain-refined niobium- or titanium-treated fully killed steels having high yield strength and good formability
	43/35	HR, HS, —, CS	—	0.15	—	—	—	1.20	0.040	0.040	
	46/40	HR, HS, —, CS	—	0.15	—	—	—	1.20	0.040	0.040	
	50/45	HR, HS, —, CS	—	0.20	—	—	—	1.50	0.040	0.040	
	60/55	—, HS, —, CS	—	0.20	—	—	—	1.50	0.040	0.040	
	40F30	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	The steels including F in their designations in place of the oblique line offer superior formability for the same strength levels
	43F35	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	46F40	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	50F45	HR, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	60F55	—, HS, —, CS	—	0.12	—	—	—	1.20	0.035	0.030	
	68F62	—, HS, —, —	—	0.12	—	—	—	1.50	0.035	0.030	
	75F70	—, HS, —, —	—	0.12	—	—	—	1.50	0.035	0.030	
	Narrow strip supplied in a range of conditions for heat treatment and general engineering purposes										
1.14 1.15	4	—, HS, —, CS	—	0.12	—	—	—	0.60	0.050	0.050	Low carbon steel available hot rolled, annealed, skin passed or cold rolled to controlled hardness ranges H1 to H6 inclusive
	10	—, HS, —, CS	0.08	0.15	0.10	0.35	0.60	0.90	0.045	0.045	For case hardening
	12	—, HS, —, CS	0.10	0.15	—	—	0.40	0.60	0.050	0.050	A range of carbon steels available in the hot rolled or annealed condition
	17	—, HS, —, CS	0.15	0.20	—	—	0.40	0.60	0.050	0.050	
	20	—, HS, —, CS	0.15	0.25	0.05	0.35	1.30	1.70	0.045	0.045	
	22	—, HS —, CS	0.20	0.25	—	—	0.40	0.60	0.050	0.050	
	30	—, HS, —, CS	0.25	0.35	0.05	0.35	0.50	0.90	0.045	0.045	
	40	—, HS, —, CS	0.35	0.45	0.05	0.35	0.50	0.90	0.045	0.045	A range of carbon steels for use in the hot rolled, normalized, annealed and (except for grade 95) in the temper rolled (half hard) conditions. Grades 40 and 50 may be induction or flame hardened and grades 60, 70, 80, and 95 may be supplied in the hardened and tempered condition
	50	—, HS, —, CS	0.45	0.55	0.05	0.35	0.50	0.90	0.045	0.045	
	60	—, HS, —, CS	0.55	0.65	0.05	0.35	0.50	0.90	0.045	0.045	
	70	—, HS —, CS	0.65	0.75	0.05	0.35	0.50	0.90	0.045	0.045	
	80	—, HS, —, CS	0.75	.0.85	0.05	0.35	0.50	0.90	0.045	0.045	
	95	—, HS, —, CS	0.90	1.00	0.05	0.35	0.30	0.60	0.040	0.040	

2.5
hot or cold rolled narrow strip

strip rolled in nominal widths less than 600 mm

NOTE After decoiling and cutting to length, narrow strip may be supplied as cut lengths or in folded bundles. Thicknesses over 3 mm may be rolled in flat lengths.

2.6
hot or cold rolled wide strip

strip rolled in nominal widths equal to or greater than 600 mm

2.7
hot or cold rolled sheet or plate

a flat rolled product cut from hot rolled or cold rolled strip, rolled on a continuous mill with the edges being allowed to deform freely during rolling, supplied flat and generally square or rectangular, the edges as rolled or sheared

according to thickness, sheet or plate is traditionally classified as:

a) sheet: nominal thickness less than 3 mm;

b) plate: nominal thickness equal to or greater than 3 mm and up to and including 16 mm

2.8
slit wide strip

strip that has been slit from wide strip

NOTE It may have a nominal width less than 600 mm.

2.9 edge conditions

NOTE See clause **18**.

2.9.1
mill edge (E1)

the natural edge produced when strip is rolled

2.9.2
sheared edge or slit edge (E2)

the edge of strip that has been cut to size by guillotine or rotary cutters. The burr is not eliminated

2.9.3
dressed edge (E3)

the edge obtained when the sheared, slit or mill edge has been removed to produce a regular form, usually square or round

2.9.4
rolled round edge (E4)

a rounded edge produced by edge rolling either the natural edge of rolled strip or sheared or slit edge strip. This edge is produced when an approximately round edge is desired and when the finish of the edge is not important

2.9.5
sheared or slit and deburred edge (E5)

an approximately square edge produced by rolling or filing sheared or slit strip, for the purpose of removing the shearing or slitting burr only

2.9.6
rolled square edge (E6)

the edge produced by edge rolling to give an approximately square edge

3 General

The material shall comply with the general requirements of this Section of BS 1449 and with the appropriate specific requirements of BS 1449-1.2 to BS 1449-1.15.

NOTE Particular attention is drawn to the fact that material produced on narrow mills (which has the letters HS or CS included in the designation) will always have different dimensional tolerances and sometimes different mechanical properties from material produced on wide mills (which has the letters HR or CR included in the designation). References are made to the differences in appropriate places in the standard but some grades are available only as narrow mill products.

4 Steelmaking process

Unless otherwise required and stated on the order, the steel may be made by any process except that the air, and mixed air-oxygen, bottom-blown basic converter processes shall not be used.

5 Chemical composition

NOTE **Residual elements.** For special applications the purchaser, by agreement with the supplier, may set a limit to the amount of one or more residual elements and/or may require the amount of such elements to be stated on the certificate of analysis

5.1 Cast analysis

The chemical composition of the steel shall be determined by cast analysis and shall comply with the appropriate requirements of BS 1449-1.2 to BS 1449-1.5, BS 1449-1.8 to BS 1449-1.11, BS 1449-1.14 and BS 1449-1.15.

If specified on the order, the supplier shall state on a test certificate the cast analysis of the material supplied. Any subsequent analytical checks shall take into consideration the heterogeneity normal to the steel (see **5.2**), and shall not be used as a basis for rejection unless the supply of an incorrect grade is clearly indicated.

5.2 Product check analysis

For killed steels complying with BS 1449-1.4, BS 1449-1.5, BS 1449-1.10, BS 1449-1.11, BS 1449-1.14 and BS 1449-1.1.5, the permitted variations on product analysis shall be in accordance with appendix A.

Samples for product analysis shall be taken in accordance with BS 1837 and, in the event of dispute, analysed in accordance with the appropriate method of British Standard Handbook No. 19.

6 Freedom from defects

The steel shall be free from amounts of segregation, laminations, surface flaws and other defects which are detrimental to appropriate processing and, where specified, the end use.

NOTE Where coil is supplied, the degree or amount of surface defects may be expected to be more than in cut lengths because of the impossibility of rejecting portions of a coil. This should be taken into account by the purchaser in his assessment of the material.

7 Condition of material on delivery

The condition of material on delivery shall be in accordance with the appropriate requirements specified in BS 1449-1.2 to BS 1449-1.15 as appropriate. Unless otherwise stated on the enquiry and order, all materials other than hot rolled materials shall be supplied with an oil or other protective coating.

NOTE By agreement between manufacturer and purchaser a particular protective coating may be available.

8 Number of tests

The manufacturer shall carry out sufficient tests in accordance with the relevant clauses of this standard in order to ensure that the material complies with the requirements of this specification.

For wide mill products and narrow mill hot rolled products, when a test certificate is required, a minimum of one test of each type specified by the purchaser or required by the relevant material specification in this standard shall be taken for each 30 t or parts thereof for each item.

For products cold rolled on narrow mills, the test unit shall be 5 t.

NOTE A coil greater than 5 t in mass may be regarded as one test unit.

For the purposes of this standard, a test unit shall consist of one grade and finish, of a given nominal width and thickness, from one cast, processed as a single batch.

9 Tensile properties

The test for stabilization shall apply to skin passed stabilized steels only.

When tested in accordance with **B.1**, the tensile strength, yield strength and elongation shall comply with the requirements given in BS 1449-1.2 to BS 1449-1.15, as appropriate.

10 Bending

When tested in accordance with **B.2**, the outer convex surface of the bend shall be free from cracks.

11 Strain-age-embrittlement

When tested in accordance with **B.3**, the test piece shall flatten without breaking.

12 Stabilization

When tested in accordance with **B.4**, the percentage increase in load shall not exceed 6 %.

13 Formability

NOTE Aluminium-stabilized grades CR/CS 1 are superior to steel grades CR/CS 2 to 4 for drawing applications.

The Erichsen cupping test shall apply to the formability grades specified in BS 1449-1.3 and BS 1449-1.9, having a nominal thickness of up to and including 2 mm only.

When tested in accordance with **B.5** the Erichsen cupping test values shall comply with the values given in BS 1449-1.3 and BS 1449-1.9, as appropriate.

14 Hardness

When tested in accordance with **B.6**, the hardness shall comply with the requirements given in BS 1449-1.2 to BS 1449-1.15, as appropriate.

15 Decarburization test

In cases of dispute, the extent of decarburization shall be determined by examination of a carefully prepared cross section of a copper-plated and normalized sample of the steel strip at a magnification of × 200 diameters (see BS 6617).

NOTE Care should be taken to avoid additional decarburization during normalizing.

16 Retests

If a test fails to meet the requirements of this standard and the manufacturer decides to retest, he shall perform two additional tests from the material represented, one of which shall be from the original bundle or coil. If either of these additional tests fails to meet the specified requirements, the material shall be deemed not to comply with the standard.

The supplier shall have the right to reprocess and resubmit the material for inspection and testing.

17 Surface finish and surface inspection

The material shall be supplied in the as-rolled finish or, subject to availability as indicated in BS 1449-1.2 to BS 1449-1.15, as appropriate and if stated on the order, in one of the finishes given in Table 2. Only one surface shall be inspected to the appropriate requirements and that surface shall be identified in one of the following ways (see clause **21**):

a) by marking with the manufacturer's brand;

b) by another method agreed between the manufacturer and purchaser.

NOTE By agreement between the manufacturer and the purchaser, other finishes to those specified may be available.

18 Edge conditions

NOTE The availability of the edge conditions is indicated in Table 4.

The following requirements shall apply to the edge condition specified.

a) *Mill edges* (E1). The edges of narrow strip shall be free from defects greater than 1.5 mm depth normal to the edge.

NOTE 1 By agreement between the manufacturer and the purchaser, more stringent requirements to those specified may be available.
NOTE 2 The requirements applicable to edges of wide strip should be by agreement between the manufacturer and purchaser.

b) *Sheared edges or slit edges* (E2). It is permissible for edges to exhibit transverse cutting marks, but they shall show no evidence of chipped cutting tools or edge cracks.

c) *Dressed edges* (E3). The process used to dress the edges shall not be detrimental to the metallurgical structure of the strip. The strip shall not show edge defects.

d) *Rolled round edges* (E4). The edges shall be free from defects greater than 1.5 mm depth normal to the edge.

e) *Sheared or slit and deburred edges* (E5). It is permissible for edges to exhibit transverse cutting marks, but they shall show no evidence of chipped cutting tools, or edge cracks, burr or turn-down.

f) *Rolled square edges* (E6). The edges shall be free from defects greater than 1.5 mm depth normal to the edge.

19 Inspection

The purchaser or his representative shall have reasonable access to the works of the manufacturer for the purpose of inspection. If such inspection is to be carried out, this shall be stated when placing the order.

NOTE In continuous mill practice, all orders are subject to a detailed internal system of inspection and testing. Because the period between inspection, or testing, and despatch may be only a few hours, it is desirable that, whenever possible, the external inspection should use the records available.

20 Tolerances on dimensions and shape

The tolerances on dimensions and shape shall be in accordance with BS 1449-1.6, BS 1449-1.7, BS 1449-1.12 and BS 1449-1.13 as appropriate.

NOTE By agreement between the purchaser and manufacturer closer tolerances may be available.

21 Marking

Material shall be identified. Material which is too small for individual marking shall be bundled and identified by a tag or label. No supplier's brand marks (see clause **17**) to the material shall interfere with subsequent normal processing. In the case of sheet and strip, the material shall be identified either by individual marking or by a label.

Table 4 — Edge conditions

Material	Edge condition[a]					
	Mill edge (E1)	Sheared or slit edge (E2)	Dressed edge (E3)	Rolled round edge (E4)	Sheared or slit and deburred edge (E5)	Rolled square edge (E6)
Wide mill	X	X	—	—	—	—
Narrow mill	X	X	X	X	X	X

NOTE 1 X indicates availability of edge condition.
NOTE 2 Edge conditions E1 to E6 may not be available in all combinations of nominal width and thickness.
[a] See **2.9**.

Appendix A Product analysis and permitted variations

[Applicable only to the killed steels in BS 1449-1.4, BS 1449-1.5, BS 1449-1.10, BS 1449-1.11, BS 1449-1.14 and BS 1449-1.15 (see **5.2**)].

A.1 Analysis of the product can vary from the cast analysis due to heterogeneity arising during the casting and solidification of the ingot. Table 5 gives the variations in permitted product analysis.

Table 5 applies only to killed (K) steels and not to rimmed (R) or balanced (B) steels (see Table 1).

The variations are permitted to occur either above or below the individual element ranges but shall not be applied both above and below the specified range for any one element in any one cast of steel.

A.2 In the event of the results of the analysis of a single sample falling outside the permitted variations on the product analysis further samples shall be selected for check analysis from the remainder of the consignment, as follows:

a) at least two samples from the same cast for delivered masses up to 5 t;

b) at least five samples from the same cast for delivered masses over 5 t up to 20 t; and

c) at least eight samples from the same cast for delivered masses over 20 t.

The results of the analysis of these samples shall fall within the permitted variations. If any of these further samples are proved to be outside the permitted variations for any significant element the consignment shall be deemed not to comply with the requirements of this Section of BS 1449.

Appendix B Methods of test

B.1 Tensile test

B.1.1 *Selection of test samples*

Tensile test samples shall, where possible, be taken from a position at least 20 mm from the edge of the material. They shall be taken parallel to, or at 90° to, the direction of rolling, except in the case of material rolled on narrow mills, when they shall be taken parallel to the direction of rolling.

B.1.2 *Test pieces*

The appropriate test pieces shall comply with BS EN 10002-1.

B.1.3 *Test method*

Determine the tensile strength, yield strength and elongation, as appropriate, in accordance with BS EN 10002-1.

For the purposes of this British Standard, the yield strength. (R_e) shall be either the lower yield stress (R_{eL}) or the 0.5 % total elongation proof stress ($R_{t0.5}$).

NOTE If a test piece breaks outside the middle third of the gauge length, the result may, at the option of the supplier, be discarded and another test made from the same material. In acceptance testing, however, the test results may be regarded as valid, irrespective of the fracture position in the gauge length, if the minimum specified values are obtained.

B.2 Bend test

B.2.1 *Selection of test samples*

Bend test samples shall, where possible, be taken from a position at least 20 mm from the edge of the material. They shall be cut so that the axis of the bend is parallel to the direction of final rolling (see Figure 1). In the case of material too narrow to permit this, the axis of the bend shall be at 90° to the direction of rolling (see Figure 2).

B.2.2 *Test pieces*

If the material dimensions permit, a rectangular test piece not less than 75 mm long by 25 mm wide shall be used for thicknesses less than 3 mm, and not less than 40 mm wide for thicknesses of 3 mm and over. For smaller sizes, the maximum width obtainable shall be used.

The test pieces shall have edges that are rounded or smoothed longitudinally to an approximately semicircular contour.

B.2.3 *Test method*

Carry out the bend test in accordance with BS 1639. Bend the test pieces cold through the angle and to the mandrel diameter (both specified for the grade in the appropriate Section of BS 1449) by pressure or hammer blows, optionally over a former.

Occasionally it is difficult to ensure that the material is accurately following the specified diameter and, in cases of dispute, a test piece shall be pushed into a block of soft material by a former in accordance with method 3 of BS 1639.

B.3 Strain-age-embrittlement test

B.3.1 *Selection of test samples*

Where possible, test samples shall be taken from a position at least 20 mm from the edge of the material and shall be cut so that the axis of the bend is parallel to the direction of final rolling (see Figure 1). In the case of material too narrow to permit this, the axis of bend shall be at 90° to the direction of rolling (see Figure 2).

Table 5 — Permitted variations of product analysis from specified range. Applicable to killed (K) steels only

Element	Range in which maximum of specified elements falls	Variation on specified range	
		Over maximum	Under maximum
	%	%	%
Carbon[a]	Up to and including 0.25	0.02	0.02
	Over 0.25 up to and including 0.50[a]	0.03	0.03
	Over 0.50 up to and including 1.05	0.04	0.04
Silicon	Up to and including 0.40	0.03	0.03
Manganese	Up to and including 1.0	0.04	0.04
	Over 1.0 up to and including 1.5	0.08	0.08
	Over 1.5	0.10	0.10
Sulphur	Up to and including 0.025	0.005	
	Over 0.025 up to and including 0.040	0.006	
	Over 0.040 up to and including 0.060	0.008	
Phosphorus	Up to 0.025	0.005	
	Over 0.025 up to and including 0.040	0.006	
	Over 0.040 up to and including 0.060	0.008	

[a] When required by the purchaser, and subject to agreement with the suppplier, smaller variations for the carbon range over 0.25 % up to and including 0.50 % may be agreed.

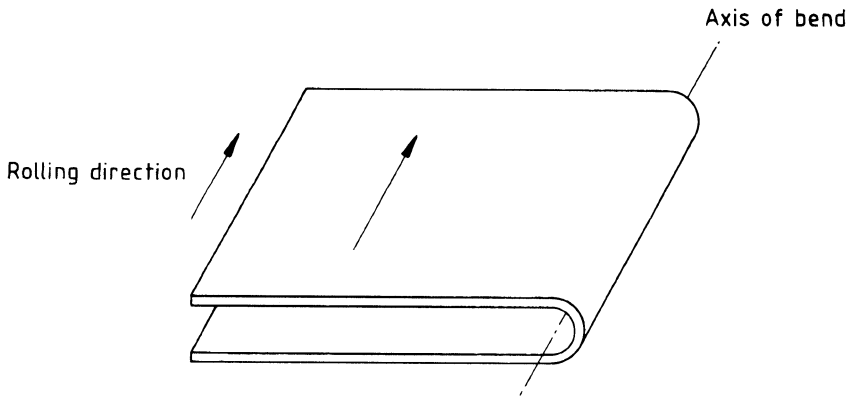

Figure 1 — Bend test with the axis of the bend parallel to the direction of rolling

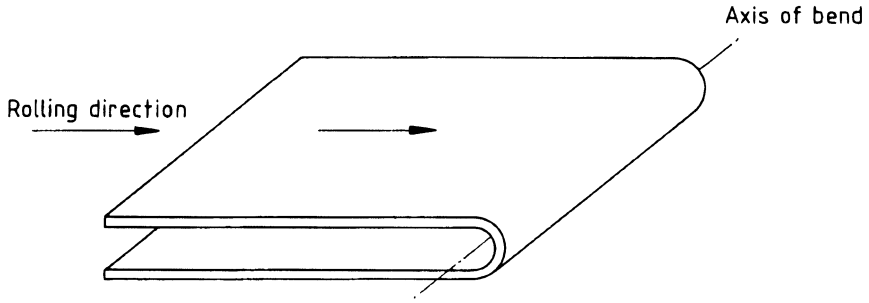

Figure 2 — Bend test with the axis of the bend at 90° to the direction of rolling

B.3.2 ***Test pieces***

If the material dimensions permit, a rectangular test piece of not less than 75 mm long by 25 mm wide shall be used for nominal thicknesses less than 3 mm, and not less than 40 mm wide for nominal thicknesses of 3 mm and over. For smaller sizes, the maximum width obtainable shall be used.

The test pieces shall have edges that are rounded or smoothed longitudinally to an approximately semicircular contour.

B.3.3 ***Test method***

Bend the test piece cold through 90° over a diameter equal to three times its thickness. Bending shall be about an axis at right angles to the length of the test piece.

Heat the test piece within the range 320 °C to 350 °C for 15 min and cool it to room temperature in still air.

Straighten the test piece by hammer blows on the apex of the bend.

B.4 Test for stabilization

Subject a tensile test piece to a total strain of 10 % and note the load (P_1) required to produce this strain. Subject the test piece to an accelerated ageing treatment by heating at a nominal temperature of 100 °C for 30 min. Subject the test piece again to a strain of 10 %, calculated on the original (unstrained) gauge length. Note the load (P_2).

Calculate the percentage increase in load using the following equation:

$$\text{Percentage increase in load} = \frac{P_2 - P_1}{P_1} \times 100$$

B.5 Formability tests

NOTE 1 Formability is normally assessed by means of the elongation, as determined in the tensile test given in clause **9**, and the modified Erichsen cupping test.

NOTE 2 Tests for formability vary widely and involve two major components: stretch and draw.

The stretching properties are assessed by measurements such as elongation and the Erichsen cupping test values.

Drawability requires separate consideration and the determination of r values, or simulative cup-draw tests, are appropriate for this purpose. In the absence of British Standards covering these tests, the test method given in appendix C may be used to determine r values.

Carry out the modified Erichsen cupping test in accordance with BS 3855.

The surface of the cup shall be smooth and the fracture shall not exhibit any undue directionality. The lubricant for the test shall be graphited grease or polyethylene sheet complying with BS 3855. In cases of dispute, the reference method shall employ polyethylene sheet as lubricant.

B.6 Hardness test

For narrow strip, the method of testing shall be one of the following:

a) the Vickers hardness test, which shall be carried out on the surface of the material in accordance with BS 427;

NOTE 1 Attention is drawn to the recommendations for the minimum thicknesses for test pieces given in appendix C of BS 427:1990.

NOTE 2 Vickers hardness values (HV) are specified for certain of the steels included in BS 1449-1.14 and BS 1449-1.15.

b) at the purchaser's request, the Rockwell hardness test in accordance with BS 891;

c) at the purchaser's request, the Brinell hardness test in accordance with BS 240.

NOTE 3 When item b) or c) is requested, the appropriate value should be agreed at the time of ordering.

NOTE 4 There are several methods for testing the hardness of flat rolled steel, but as there is no general procedure for accurately converting one scale of hardness to another, it is recommended that such conversions should be avoided.

Appendix C
Determination of r values

Using a standard flat tensile test piece, accurately mark a 25 mm length in the centre of the parallel section. Measure the width of the test piece at five positions along the 25 mm gauge length and record the mean width.

Strain the test piece to approximately 15% elongation, measured on the 25 mm gauge length.

Remove the test piece from the tensile testing machine and determine accurately the r value in one of the following ways.

a) by calculation using the equation:

$$r = \frac{E_w}{E_t} = \frac{\log_e\left(\frac{W_o}{W_f}\right)}{\log_e\left(\frac{L_f \times W_f}{L_o \times W_o}\right)}$$

where

W_o is the initial gauge width in mm;

W_f is the final gauge width in mm;

L_o is the initial gauge length = 25 mm;

L_f is the final gauge length in mm;

b) from the nomogram shown in Figure 3 using the ratios:

$$\frac{L_f}{L_o} \text{ and } \frac{W_o}{W_f}$$

Example calculation

L_o = 25 mm

L_f = 28.75 mm

W_o = 20 mm

W_f = 18.45 mm

Using these data in the equation:

$$r = \frac{\log_e\left(\frac{20}{18.45}\right)}{\log_e\left(\frac{28.75 \times 18.45}{25 \times 20}\right)}$$

$$r = \frac{\log_e 1.08}{\log_e(1.15 \times 0.9225)}$$

$$r = \frac{\log_e 1.08}{\log_e 1.061} = \frac{0.0807}{0.0592} = 1.363$$

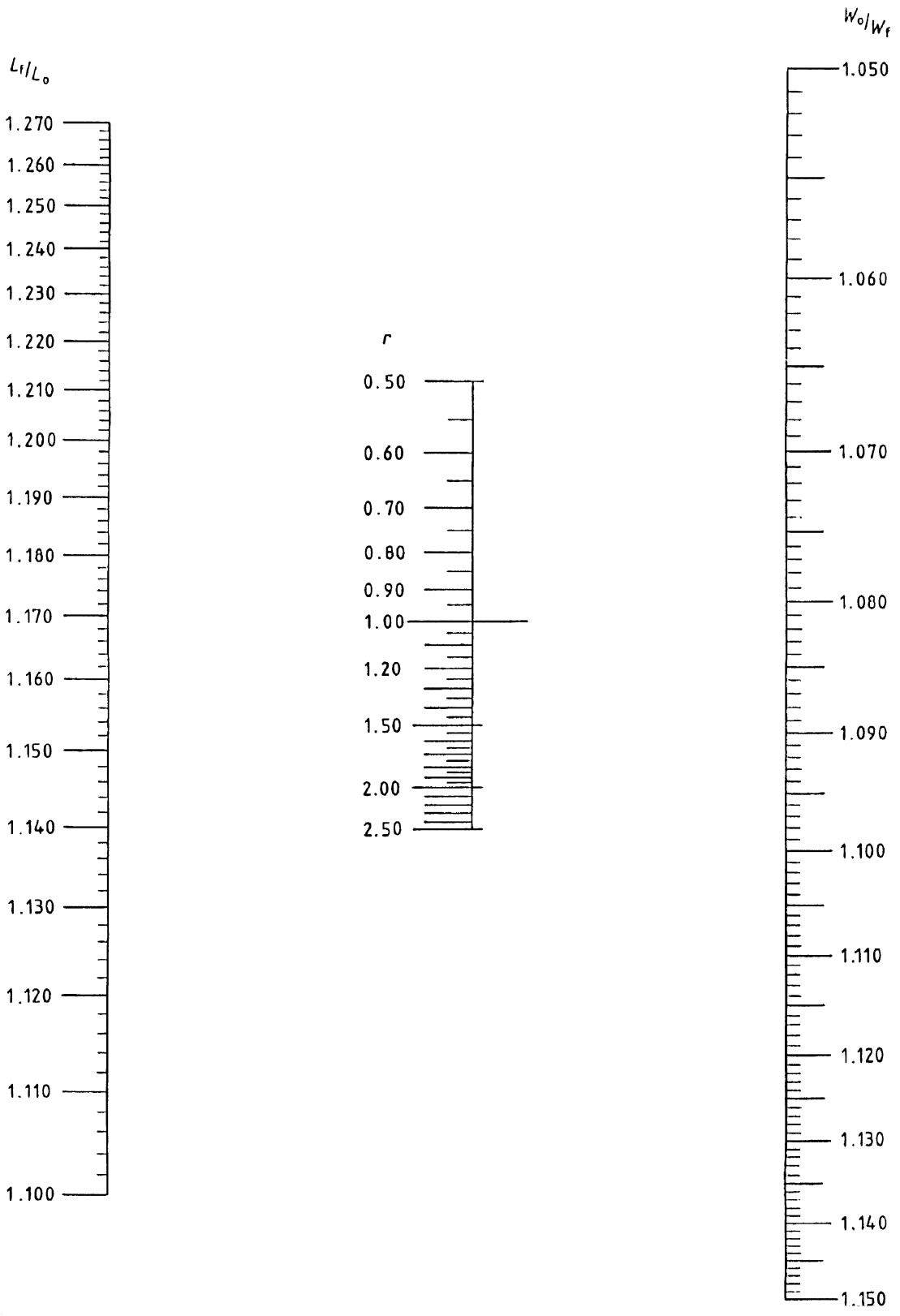

Figure 3 — Nomogram for determination of r values

Publication(s) referred to

BS 240, *Method for Brinell hardness test and for verification of Brinell hardness testing machines.*

BS 427, *Method for Vickers hardness test and for verification of Vickers hardness testing machines.*

BS 891, *Method for hardness test (Rockwell method) and for verification of hardness testing machines (Rockwell method).*

BS 1134, *Assessment of surface texture Part 1 Methods and instrumentation.*

BS 1449, *Steel plate, sheet and strip.*

BS 1449-1.2, *Specification for hot rolled steel plate, sheet and wide strip based on formability.*

BS 1449-1.3, *Specification for cold rolled steel plate, sheet and wide strip for vitreous enamelling based on formability.*

BS 1449-1.4, *Specification for hot rolled wide material based on specified minimum strength.*

BS 1449-1.5, *Specification for cold wide material based on specified minimum strength.*

BS 1449-1.6, *Specification for tolerances on dimensions and shape for hot rolled wide material.*

BS 1449-1.7, *Specification for tolerances on dimensions and shape for cold rolled wide material.*

BS 1449-1.8, *Specification for hot rolled narrow strip based on formability.*

BS 1449-1.9, *Specification for cold rolled narrow strip based on formability.*

BS 1449-1.10, *Specification for hot rolled narrow strip based on specified minimum strength.*

BS 1449-1.11, *Specification for cold rolled narrow strip based on specified minimum strength.*

BS 1449-1.12, *Specification for tolerances on dimensions and shape for hot rolled narrow strip.*

BS 1449-1.13, *Specification for tolerances on dimensions and shape for cold rolled narrow strip.*

BS 1449-1.14, *Specification for hot rolled narrow strip supplied in a range of conditions for heat treatment and general engineering purposes.*

BS 1449-1.15, *Specification for cold rolled narrow strip supplied in a range of conditions for heat treatment and general engineering purposes.*

BS 1639, *Methods for bend testing of metals.*

BS 1837, *Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys.*

BS 3855, *Method for modified Erichsen cupping test for sheet and strip metal.*

BS 6617, *Determination of decarburization in steel.*

BS EN 10002-1, *Tensile testing of metallic materials.*

BS EN 10002-1, *Method of test at ambient temperature.*

BS EN 10130, *Cold rolled low carbon steel flat products for cold forming: technical and delivery conditions*[1)].

BS Handbook No. 19, *Methods for the sampling and analysis of iron, steel and other ferrous metals.*

prEN 10021, *General technical conditions of delivery of iron and steel products*[1)].

prEN 10025, *Hot rolled products of non-alloy structural steels*[1)].

prEN 10051, *Continuously hot rolled non-coated sheet and strip. Tolerances*[1)].

prEN 10113, *Hot rolled products in weldable fine grain stuctural steels*[1)].

prEN 10131, *Cold rolled uncoated non-alloy steel flat products for cold forming. Tolerances*[1)].

prEN 10209, *Cold rolled low carbon steel flat products for vitreous enamelling*[1)].

EU 46, *Hot rolled narrow strip in mild unalloyed steel. Qualities*[1)].

EU 48, *Hot rolled narrow strip. Tolerances*[1)].

EU 111, *Continuously hot rolled non-coated mild unalloyed steel sheet and strip for cold forming. Quality standard*[1)].

EU 139, *Cold rolled uncoated non-alloy narrow strip for cold forming. Qualities*[1)].

EU 140, *Cold rolled narrow strip. Tolerances*[1)].

EU 149, *Flat products in high yield strength steels for cold forming. Wide flats, sheet/plate, wide and narrow strip*[1)].

[1)] Referred to in the foreword only.

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