
**Boron treated engineering steels for
quenching and tempering**

Aciers de construction mécanique traités au bore pour trempe et revenu



Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11637, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 17, *Steel* Subcommittee SC 4, *Heat treatable and alloy steels*.

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International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isos; s=central

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This document is being issued in the Technical Report (type 2) series of publications (according to subclause G.3.2.2 of part 1 of the ISO/IEC Directives, 1995) as a “prospective standard for provisional application” in the field of boron treated engineering steels because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this Technical Report (type 2) will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

Annex A forms an integral part of this Technical report. Annex B is for information only.

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Introduction

For the following two reasons the attempt to establish an International Standard for boron treated engineering steel for quenching and tempering has proved especially difficult.

- a) The number of types of these steels, applied until now mostly as company grades, is very great world-wide, so that concentration on a reasonable number of internationally standardized steels has caused problems.
- b) The hardenability of these steels can, even for types with the same specified chemical composition, vary greatly because of differences in the effectiveness of the boron and in the content of residual elements. Consequently, it seemed reasonable to specify tight limits for only the most important characteristic of these steels, namely the hardenability, and to permit relatively wide ranges for the carbon, manganese and chromium contents. In this way manufacturers have the possibility of complying with the tight hardenability requirements independent of the melting procedure applied.

For the reasons given under b) the proposals of the various members for the hardenability of the individual steels differed significantly. The hardenability scatterbands specified in table 5 and figure 1 were therefore mainly derived with the help of formulae established by what is considered world-wide as the greatest customer of boron treated steels and published in ASTM A 255.

It is to be expected that the application of the specifications in this document will not cause any problems. Nevertheless, it was agreed to publish this first edition not as an International Standard but as an ISO Technical Report of type 2 so that for a trial period of three years information and experience of its use in practice can be gathered.

Boron treated engineering steels for quenching and tempering

1 Scope

1.1 This Technical Report gives the technical delivery requirements for

- semi-finished products, for example blooms, billets, slabs (see note 3 below);
- bars (see note 3 below);
- wire rod;
- hot or cold rolled sheet/plate and strip (see note 2 below);
- hammer or drop forgings (see note 3 below).

These articles are manufactured from the boron alloy steels listed in table 3 and supplied in one of the heat-treatment conditions given for the different types of products in table 1, lines 2 to 5 for columns 4 to 8 and in one of the surface conditions given in table 2.

The steels are in general intended for the fabrication of quenched and tempered or austempered (see 3.3 and note 1 below) machine parts.

This Technical Report is not applicable for steels for cold heading which are covered by ISO 4954.

NOTES

- 1 For the purpose of simplification the term “quenched and tempered” is, unless otherwise indicated, used in the following also for the austempered condition.
- 2 The terms “plate” or “flat product” in the following also include, unless otherwise stated, wide flats.
- 3 Hammer-forged semi-finished products (blooms, billets, slabs, etc.) and hammer-forged bars are in the following covered under semi-finished products or bars and not under the term “hammer and drop forgings”.

1.2 In special cases, variations in these technical delivery requirements or additions to them may form the subject of an agreement at the time of enquiry and order (see annex A).

1.3 In addition to this Technical Report, the general technical delivery requirements of ISO 404 are applicable.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 148:1983, *Steel — Charpy impact test (V-notch)*.

ISO 377:1997, *Steel and steel products — Location and preparation of test pieces for mechanical testing*.

ISO 404:1992, *Steel and steel products — General technical delivery requirements*.

ISO 642:1979, *Steel — Hardenability test by end quenching (Jominy test)*.

ISO 643:1983, *Steels — Micrographic determination of the ferritic or austenitic grain size*.

ISO 1035-1:1980, *Hot-rolled steel bars — Part 1: Dimensions of round bars*.

ISO 1035-2:1980, *Hot-rolled steel bars — Part 2: Dimensions of square bars*.

ISO 1035-3:1980, *Hot-rolled steel bars — Part 3: Dimensions of flat bars*.

ISO 1035-4:1982, *Hot-rolled steel bars — Part 4: Tolerances*.

ISO 3887:1976, *Steel, non-alloy and low-alloy — Determination of depth of decarburization*.

ISO 4948-1:1982, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*.

ISO 4948-2:1981, *Steels — Classification — Part 2: Classification of unalloyed and alloy steels according to main quality classes and main property or application characteristics*.

ISO 4954:1993, *Steels for cold heading and cold extruding*.

ISO 4967:—¹⁾, *Steel — Determination of content of non-metallic inclusions — Micrographic method using standard diagrams*.

ISO 6506-1:—²⁾, *Metallic materials — Brinell hardness tests — Part 1: Test method*.

ISO 6892:—³⁾, *Metallic materials — Tensile testing at ambient temperature*.

ISO 6929:1987, *Steel products — Definitions and classification*.

ISO 7452:1984, *Hot-rolled structural steel plates — Tolerances on dimensions and shape*.

ISO 7788:1985, *Steel — Surface finish of hot-rolled plates and wide flats — Delivery conditions*.

ISO 9443:1991, *Heat-treatable and alloy steels — Surface quality classes for hot-rolled round bars and wire rods — Technical delivery conditions*.

ISO 10474:1991, *Steel and steel products — Inspection documents*.

ISO 14284:1996, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition*.

1) To be published. (Revision of ISO 4967:1979)

2) To be published. (Revision of ISO 6506:1981 and ISO 410:1982)

3) To be published. (Revision of ISO 6892:1984)

3 Definitions

For the purposes of this Technical Report the following definitions apply:

3.1 different forms of product: See ISO 6929 and the notes to 1.1.

3.2 ruling section: That section for which the specified mechanical properties shall apply.

NOTE — Independent of the actual shape and dimensions of the cross-section of the product the size of its ruling section is always given by a diameter. This corresponds to the diameter of an "equivalent round bar". That is a round bar which, at the position of its cross-section specified for taking the test pieces for the mechanical tests, will, when being cooled from austenitizing temperature, show the same cooling rate as the actual ruling section of the product concerned at its position for taking the test pieces.

3.3 austempering: Austenitization of a steel with subsequent cooling to a temperature in the bainite region and holding at this temperature until a desired degree of transformation is obtained.

The subsequent cooling to room temperature can be carried out in any manner desired.

3.4 alloy steel: See clause 3 of ISO 4948-1:1982.

3.5 special steel: See 4.2.4 of ISO 4948-2:1981.

4 Ordering and designation

The designation of the product in an order shall cover the following.

- a) The designation of the product form (bloom, bar, rod, etc.) followed by
 - either the designation of the dimensional standard and the dimensions and tolerances selected from this (see 5.7), or
 - in the case of drop forgings, by the designation of the drawing or any other document covering the dimensions and tolerances required for the product.
- b) If a surface condition other than "hot worked" or a special surface quality is required
 - the surface condition (see table 2);
 - the surface quality (see 5.6).
- c) A description of the steel comprising
 - 1) a reference to this Technical Report;
 - 2) the designation of the steel type given in table 3;
 - 3) if a heat-treatment condition other than the untreated condition is required, the symbol for this other condition (see table 1, column 3);

NOTE — If the quenched and tempered condition is ordered, the mechanical properties should also be agreed when ordering (see 5.2.3).

- 4) if an inspection document is required, the type of inspection document (see ISO 10474);
- 5) if any supplementary requirement shall be complied with, the symbol and, where necessary, the details of this supplementary requirement (see annex A).

EXAMPLE

To be ordered are:

Hot-rolled round bars:

— in accordance with ISO 1035-1,

with:

— a nominal diameter of 40,0 mm;

— a nominal length of 8 000 mm;

— a diameter tolerance of $\pm 0,40$ mm (= class S in accordance with ISO 1035-4:1982);

— a length tolerance of $\begin{smallmatrix} 0 \\ +100 \end{smallmatrix}$ mm (= class L2 of ISO 1035-4:1982);

— all other tolerances as given in ISO 1035-4 for normal cases.

Surface:

— blast cleaned (symbol +BC, see table 2).

Steel:

— in accordance with ISO/TR 11637;

— type 40MnCrB4-2;

— heat-treatment condition: treated for shearability (symbol +S, see table 1);

— with an inspection certificate 3.1.B according to ISO 10474;

— ultrasonically tested (supplementary requirement specified in clause A.3) in accordance with test sheet xy.

Designation:

— rounds: ISO 1035-1-40,0 S x 8 000 L2

— surface: +BC

— steel and heat treatment: ISO/TR 11637-40MnCrB4-2+S

— inspection document: ISO 10474-3.1.B

— supplementary requirement: A.3 — ultrasonic test —, see test sheet xy.

5 Requirements

5.1 Manufacturing process

5.1.1 General

The manufacturing process of the steel and of the products is, with the restrictions given by the requirements in 5.1.2 to 5.1.4, left to the discretion of the manufacturer.

5.1.2 Deoxidation

All steels shall be treated so that the boron improves hardenability.

5.1.3 Heat treatment and surface condition at delivery

5.1.3.1 Normal condition at delivery

Unless otherwise agreed at the time of enquiry and order, the products shall be delivered in the untreated, that means hot-worked, condition.

5.1.3.2 Particular heat-treatment condition

If so agreed at the time of enquiry and order, the products shall be delivered in one of the particular heat treatment conditions given in table 1, lines 3 to 5.

5.1.3.3 Particular surface condition

If so agreed at the time of enquiry and order, the products shall be delivered in one of the particular surface conditions given in table 2, lines 3 to 7.

5.1.4 Cast separation

The steels shall be delivered separated by casts.

5.2 Chemical composition, hardenability and mechanical properties

See figures 1 to 3 and tables 3 to 6.

5.2.1 The chemical composition of the steel shall comply with the requirements given in tables 3 and 4.

5.2.2 If the steel is ordered in the untreated condition or in the condition "treated for shearability", the hardenability requirements given in table 5 shall apply.

5.2.3 If the steel is ordered in the quenched and tempered condition, the mechanical properties shall comply with the requirements agreed when ordering.

NOTE — In such a case the values of hardenability given in table 5 are for guidance purposes only.

5.3 Shearability

5.3.1 Under suitable shearing conditions (avoiding local stress peaks, preheating, application of blades with a profile adapted to that of the product, etc.) the manganese-boron steels and the steel 27MnCrB5-2 shall, in the untreated condition, be shearable.

5.3.2 The steels 40MnCrB4-2, 39MnCrB6-2 and 45MnCrB4-2 shall, when being ordered in the condition "treated for shearability", have a surface hardness of max. 250 HB. They are in such a case regarded as shearable, provided that suitable shearing conditions are applied.

5.4 Structure

5.4.1 Unless otherwise agreed at the time of enquiry and order, the grain size shall be left to the discretion of the manufacturer. If a fine grain structure is required, special requirement shall be ordered (see annex A, clause A.1).

NOTE — Sometimes, it might be difficult to achieve a fine grain structure as specified in 5.4.1 and A.1 and this should be checked by steel manufacturers and customers.

5.4.2 For the non-metallic inclusion content (see A.2).

5.5 Internal soundness

The steel shall be free from internal defects likely to have an adverse effect (see A.3).

5.6 Surface quality and decarburization

5.6.1 All products shall have a workmanlike finish.

5.6.2 Minor surface discontinuities, which may also occur under normal manufacturing conditions, such as scores originating in the case of black steel from rolled-in scale, shall not be regarded as defects.

5.6.3 Where appropriate, detailed requirements referring to the surface shall be agreed at the time of enquiry and order, if possible by reference to International Standards.

5.6.3.1 For bars and wire rods ISO 9443 contains surface quality classes.

5.6.3.2 The bars and wire rod for cold heading and cold extrusion are in total handled by ISO 4954.

5.6.3.3 It is more difficult to detect and eliminate surface discontinuities from coiled products than from cut lengths. This should be taken into account when agreements on surface quality are made.

5.6.3.4 For hot-rolled plates, the requirements for surface finish are specified in ISO 7788.

5.6.3.5 Requirements for the admissible surface decarburization should, where appropriate, be agreed at the time of enquiry and order and be based on one of the testing methods given in ISO 3887.

5.6.4 Removal of surface discontinuities by welding is not permitted.

Pending publication of a separate International Standard, the kind and permissible depth for removal of surface discontinuities should, where appropriate, be agreed at the time of enquiry and order.

5.7 Shape, dimensions and tolerances

The shape, dimensions and tolerances of the products shall comply with the requirements agreed at the time of enquiry and order. The agreements shall, as far as possible, be based on corresponding International Standards, otherwise on suitable national standards.

The following International Standards cover dimensions and/or tolerances for products included in this Technical Report:

- for bars: ISO 1035-1 to ISO 1035-4;
- for plates (except for wide flats): ISO 7452.

6 Inspection, testing and conforming of products

6.1 Inspection and testing procedures and types of inspection documents

6.1.1 Products complying with this Technical Report shall be ordered and delivered with one of the inspection documents specified in ISO 10474. The type of inspection document shall be agreed at the time of enquiry and order. If the order does not contain any specification of this kind, a test report shall be issued.

6.1.2 If a test report is to be provided this shall cover:

- a) the statement that the material complies with the requirements of the order;
- b) the results of the cast analysis for all elements specified for the steel type supplied.

6.1.3 If, in accordance with the agreements in the order, an inspection certificate or an inspection report is to be provided, the specific inspections and tests described in 6.2 shall be carried out and their results shall be certified in the inspection documents.

In addition the inspection document shall cover:

- a) for all elements specified for the steel type concerned the results of the cast analysis given by the manufacturer;
- b) the result of all inspections and tests ordered by supplementary requirements (see annex A);
- c) the symbol letters or numbers relating the inspection document, the test pieces and products to each other.

6.2 Specific inspection and testing

See table 7.

6.2.1 Verification of the hardenability, hardness and mechanical properties

The amount of testing, the sampling conditions and the test methods to be applied for the verification of the requirements shall be in accordance with the prescriptions given in table 7.

6.2.2 Visual and dimensional inspection

A sufficient number of products is to be inspected to ensure the compliance with the specification.

6.2.3 Retests

See ISO 404.

7 Marking

The manufacturer shall mark the products or the bundles or the boxes containing the products in a suitable way, so that the identification of the cast, the steel type and the origin of the delivery is possible (see A.5).

Table 1 — Combinations of usual heat-treatment conditions at delivery, product forms and requirements specified in tables 3 to 5

1	2	3	4	5	6	7	8	9		
1	Heat-treatment condition at delivery	Symbol	Billets, blooms, slabs	Bars	Wire rod	Flat products	Hammer and drop forgings	Applicable requirements		
								1	2	3
2	Untreated	none or +U	x	x	x	x	x	Chemical composition according to tables 3 and 4	Maximum Brinell hardness according to 5.3	Hardenability values according to table 5
3	Treated to improve shearability	+S	x	x	—	—	—			
4	Quenched and tempered	+QT	—	x	—	x			Mechanical properties according to 5.2.3	
5	Others	Other treatment conditions, for example certain annealing conditions to achieve a certain structure, may be agreed at the time of enquiry and order. The condition “annealed to achieve a spheroidization of the carbides”, as required for cold heading and cold extrusion, is covered in ISO 4954.								

Table 2 — Surface condition at delivery

1	2	3	4	5	6	7	8	9	10
1	Surface condition at delivery		Symbol	Semi-finished products as blooms, billets	Bars	Wire rod	Flat products	Hammer and drop forgings (see note 3 to 1.1)	Notes
2	Unless otherwise agreed	as hot worked	None or +HW	x ¹⁾	x	x	x	x	
3	Particular conditions supplied by agreement	HW + pickled	+PI	x	x	x	x	x	— 2)
4		HW + blast cleaned	+BC	x	x	x	x	x	
5		HW + rough machined	— 3)	—	x	x	—	x	
6		cold rolled	+CR	—	—	—	x	—	
7		others							

1) The term "hot worked" also includes in the case of the semi-finished products the continuously cast condition.

2) In addition, it may be agreed that the products be oiled or, where appropriate, limed or phosphated.

3) Until the term "rough machined" is defined by, for example, machining allowances, the details are to be agreed at the time of enquiry and order.

Table 3 — Types of steel and specified chemical composition (applicable to cast analysis)

Type of steel	Chemical composition ¹⁾ , (% m/m)						
	C	Si max.	Mn	P max.	S max.	Cr	B ²⁾
20MnB4	0,17 to 0,23	0,40	0,70 to 1,30	0,035	0,040		0,000 8 to 0,005 0
20MnB5	0,17 to 0,23	0,40	1,00 to 1,60	0,035	0,040		0,000 8 to 0,005 0
30MnB5	0,27 to 0,33	0,40	1,00 to 1,60	0,035	0,040		0,000 8 to 0,005 0
35MnB4	0,32 to 0,38	0,40	0,70 to 1,30	0,035	0,040		0,000 8 to 0,005 0
35MnB5	0,32 to 0,38	0,40	1,00 to 1,60	0,035	0,040		0,000 8 to 0,005 0
39MnB5	0,36 to 0,42	0,40	1,00 to 1,60	0,035	0,040		0,000 8 to 0,005 0
27MnCrB5-2	0,24 to 0,30	0,40	1,10 to 1,50	0,035	0,040	0,30 to 0,70	0,000 8 to 0,005 0
34MnCrB5-2	0,31 to 0,37	0,40	1,10 to 1,50	0,035	0,040	0,85 to 1,25	0,000 8 to 0,005 0
34CrB4	0,31 to 0,37	0,40	0,50 to 0,90	0,035	0,040	0,85 to 1,25	0,000 8 to 0,005 0
40MnCrB4-2	0,37 to 0,43	0,40	0,70 to 1,10	0,035	0,040	0,30 to 0,70	0,000 8 to 0,005 0
39MnCrB6-2	0,36 to 0,42	0,40	1,35 to 1,75	0,035	0,040	0,30 to 0,70	0,000 8 to 0,005 0
45MnCrB4-2	0,42 to 0,48	0,40	0,70 to 1,10	0,035	0,040	0,30 to 0,70	0,000 8 to 0,005 0

1) Small quantities of certain elements are present in steels which are not specified or required. These elements are considered as incidental and may be present to the following amounts:
Cr 0,30 %, Cu 0,40 %, Mo 0,08 %, Ni 0,30 %.

2) Boron contents down to 0,000 5 % are tolerated, if the requirements for hardenability are still obtained.

Table 4 — Permissible deviations between specified analysis and product analysis

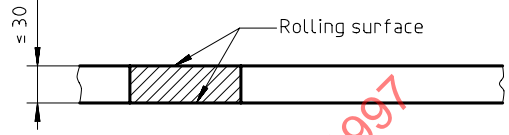
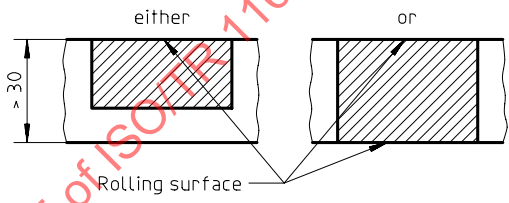
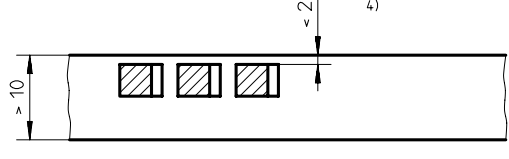
Element	Permissible maximum content according to cast analysis (% m/m)	Permissible deviation ¹⁾ (% m/m)
C	≤ 0,30 > 0,30 ≤ 0,48	± 0,02 ± 0,03
Si	≤ 0,40	+ 0,03
Mn	≤ 1,00 > 1,00 ≤ 1,75	± 0,04 ± 0,05
P	≤ 0,035	+ 0,005
S	≤ 0,040	+ 0,005
Cr	≤ 1,25	± 0,05
Cu	≤ 0,40	+ 0,02
Mo	≤ 0,08	+ 0,01
Ni	≤ 0,30	+ 0,02

1) ± means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in table 3, but not both at the same time.

Table 5 — Hardness limits for the hardenability end quench test

Type of steel	Limits of range	Hardness HRC at a distance, in millimetres, from quenched end of test piece of:													End quench temperature °C
		1,5	3	5	7	9	11	13	15	20	25	30	35	40	
20MnB4	max.	47	47	46	44	38	32	27	24	-	-	-	-	-	880 ± 5
	min.	41	40	38	31	22	-	-	-	-	-	-	-	-	880 ± 5
20MnB5	max.	47	47	47	46	44	41	38	35	29	24	20	-	-	850 ± 5
	min.	41	40	39	36	31	24	-	-	-	-	-	-	-	850 ± 5
30MnB5	max.	53	53	53	52	51	49	46	42	35	29	26	25	24	850 ± 5
	min.	47	46	45	43	41	38	33	27	22	-	-	-	-	850 ± 5
35MnB4	max.	57	56	55	53	51	47	43	38	28	25	24	23	22	850 ± 5
	min.	51	50	48	45	37	31	27	23	-	-	-	-	-	850 ± 5
35MnB5	max.	56	56	56	55	54	52	50	46	38	32	28	26	24	850 ± 5
	min.	50	50	49	46	43	39	34	29	23	20	-	-	-	850 ± 5
39MnB5	max.	59	59	59	58	57	56	55	53	45	38	35	32	30	850 ± 5
	min.	53	53	52	50	48	45	41	35	28	24	20	-	-	850 ± 5
27MnCrB5-2	max.	53	53	53	53	52	51	50	49	45	42	38	35	33	850 ± 5
	min.	47	46	45	44	43	42	40	38	32	26	22	-	-	850 ± 5
34MnCrB5-2	max.	56	56	56	56	56	55	54	53	51	48	44	41	39	850 ± 5
	min.	50	50	49	48	47	46	45	43	38	33	27	24	22	850 ± 5
34CrB4	max.	56	56	56	56	56	55	54	53	51	48	44	41	39	850 ± 5
	min.	50	50	49	48	47	46	45	43	38	33	27	24	22	850 ± 5
40MnCrB4-2	max.	59	59	59	59	58	57	56	54	45	39	35	33	32	850 ± 5
	min.	53	53	53	52	50	46	41	37	28	24	21	-	-	850 ± 5
39MnCrB6-2	max.	59	59	59	59	58	58	58	58	57	55	53	51	50	850 ± 5
	min.	53	53	53	52	52	51	50	49	47	43	39	35	32	850 ± 5
45MnCrB4-2	max.	62	62	62	62	61	60	59	57	48	41	37	35	34	850 ± 5
	min.	56	56	56	54	52	49	44	38	31	27	25	22	21	850 ± 5

Table 6 — Position of the test pieces in plates with reference to the thickness of the product and with reference to the direction of rolling

Type of test	Thickness of product mm	Orientation of test piece ¹⁾ for width, <i>w</i>		Distance of test piece from rolling surface mm
		<i>w</i> < 600 mm	<i>w</i> ≥ 600 mm	
Tensile test ²⁾	≤ 30	longitudinal	transverse	
	> 30			
Impact test ³⁾	> 10 ⁴⁾	longitudinal	longitudinal	

NOTE — For products of a thickness between 5 and 10 mm, the width of the impact test piece is, generally, equal to the thickness of the product, the height remaining fixed at 10 mm. In case of dispute on V-notch impact test results from such subsize test pieces, subsize test pieces conforming to the dimensions given in ISO 148 (cross-section: 10 mm × 7,5 mm or 10 mm × 5 mm) shall be used.

1) Orientation of the longitudinal axis of the test piece with reference to the main rolling direction.

2) The test piece shall be in accordance with ISO 6892.

3) The notch axis shall be perpendicular to the product surface.

4) For products of a thickness greater than 30 mm, the impact test piece may, by agreement at the time of enquiry and order, be sampled at a quarter of the thickness.

Table 7 — Test conditions for the verification of the requirements given in column 2

1	2	3	4	5	6	7
No.	Requirements	See:	Amount of testing		Sampling 2)	Test method
			Test unit 1)	Number of sample products per test unit	Number of tests per sample products	
1	Chemical composition	Tables 3 and 4	C	The cast analysis is given by the manufacturer (for product analysis see clause A.4 in annex A)	See ISO 14284	
2	Hardenability (for deliveries in condition +U or +S)	Table 5	C	1	1	In case of dispute, if possible, the sampling method given in ISO 642:1979 under a or b1 shall be applied. In all other cases, the sampling method including the method which starts from separately cast and subsequently hot-worked test ingots or from cast and non hot-worked samples is, unless otherwise agreed at the time of enquiry and order, left to the discretion of the manufacturer.
3	Hardness in the condition +S	5.3.2	C+D+T	1	1	In case of dispute, the hardness shall be measured, if possible, at the circumference of the product at a distance of $1 \times$ thickness from one end and, in cases of products with square or rectangular cross-section, at a distance of $0,25 \times w$, where w is the width of the product from one longitudinal edge. If for example for hammer and drop forgings the above prescriptions prove unrealistic, a more appropriate position of the hardness indentations shall be agreed at the time of enquiry and order
4	Mechanical properties of quenched and tempered products	5.2.3	C+D+T	1	Tensile and 3 ISO V-notch 4) impact tests	The test pieces for tensile test and, where applicable, the test pieces for ISO V-notch impact tests shall be taken as follows. For bars and wire rod in accordance with figure 2. For flat products in accordance with figure 3 and table 6. For hammer and drop forgings, the test pieces shall be taken with their longitudinal axis parallel to the direction of principal grain flow from a position to be agreed at the time of enquiry and order. The tensile test shall, in cases of dispute, be carried out in accordance with ISO 6892 on proportional test pieces having a gauge length of $L_0 = 5,65 \sqrt{S_0}$ where S_0 is the area of the cross-section of the test piece. Where this is not possible — that means for flat products with thickness of < 3 mm — a test piece with constant gauge length in accordance with ISO 6892 shall be agreed at the time of enquiry and order. In this case the minimum elongation value to be obtained for these test pieces shall also be agreed. The impact test, where required, shall be made in accordance with ISO 148.

NOTE — Verification of the requirements is only necessary if an inspection certificate or an inspection report is ordered and if the requirements is applicable according to table 1, column 9.

- 1) The tests shall be carried out separately for each cast as indicated by "C", each dimension as indicated by "D" and each heat treatment batch as indicated by "T". Products with different thickness may be grouped if the differences in thickness do not affect the properties. In cases of doubt the thinnest and the thickest products shall be tested.
- 2) Unless otherwise specified the general conditions for selection and preparation of test samples and test pieces for mechanical tests shall be in accordance with ISO 377.
- 3) If agreed at the time of enquiry and order verification of the hardenability may be provided by calculation instead of hardenability end quench tests. Indication of the calculation method may also be agreed in this case.
- 4) Only applicable if values for the impact strength have been agreed (see 5.2.3).

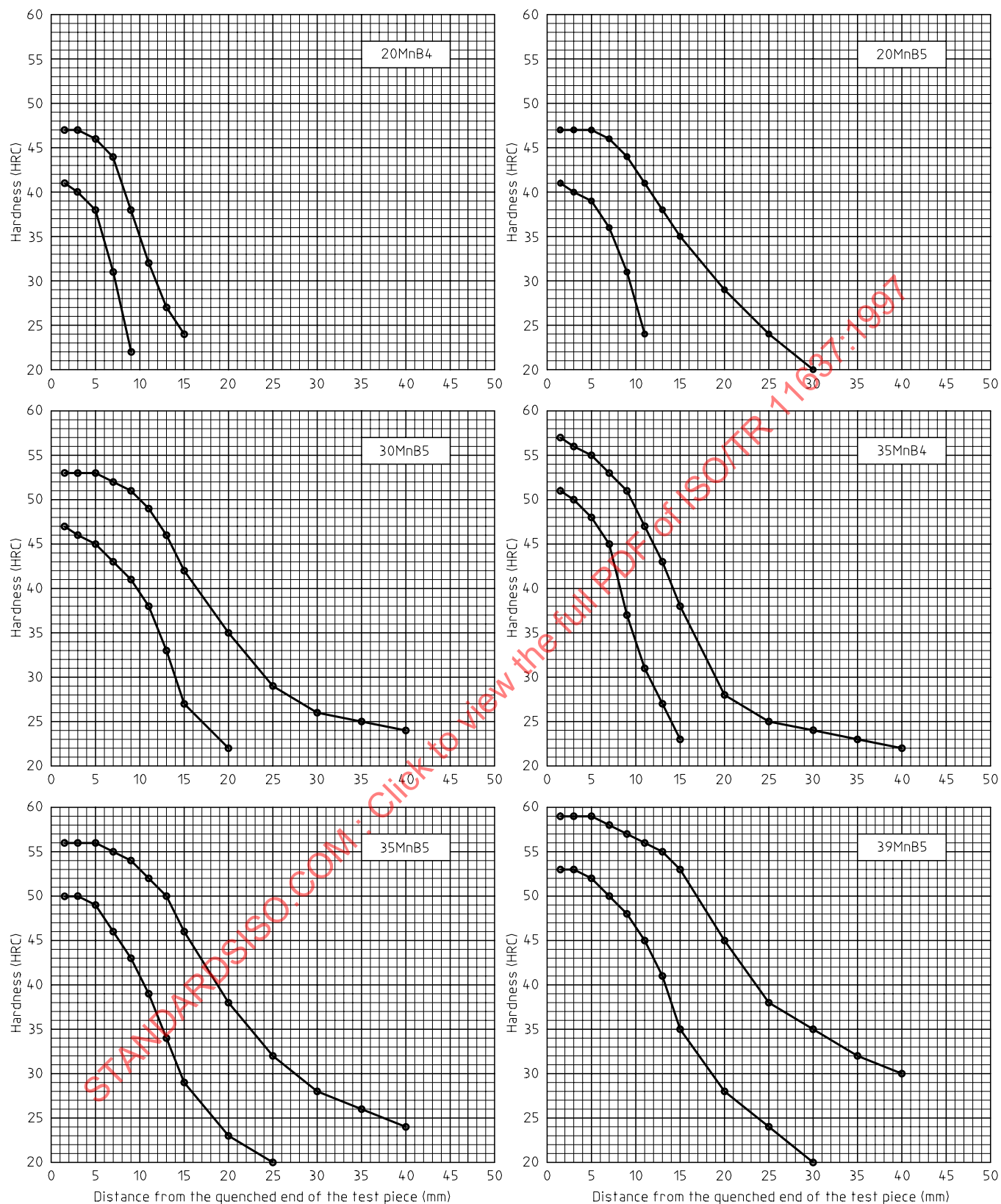
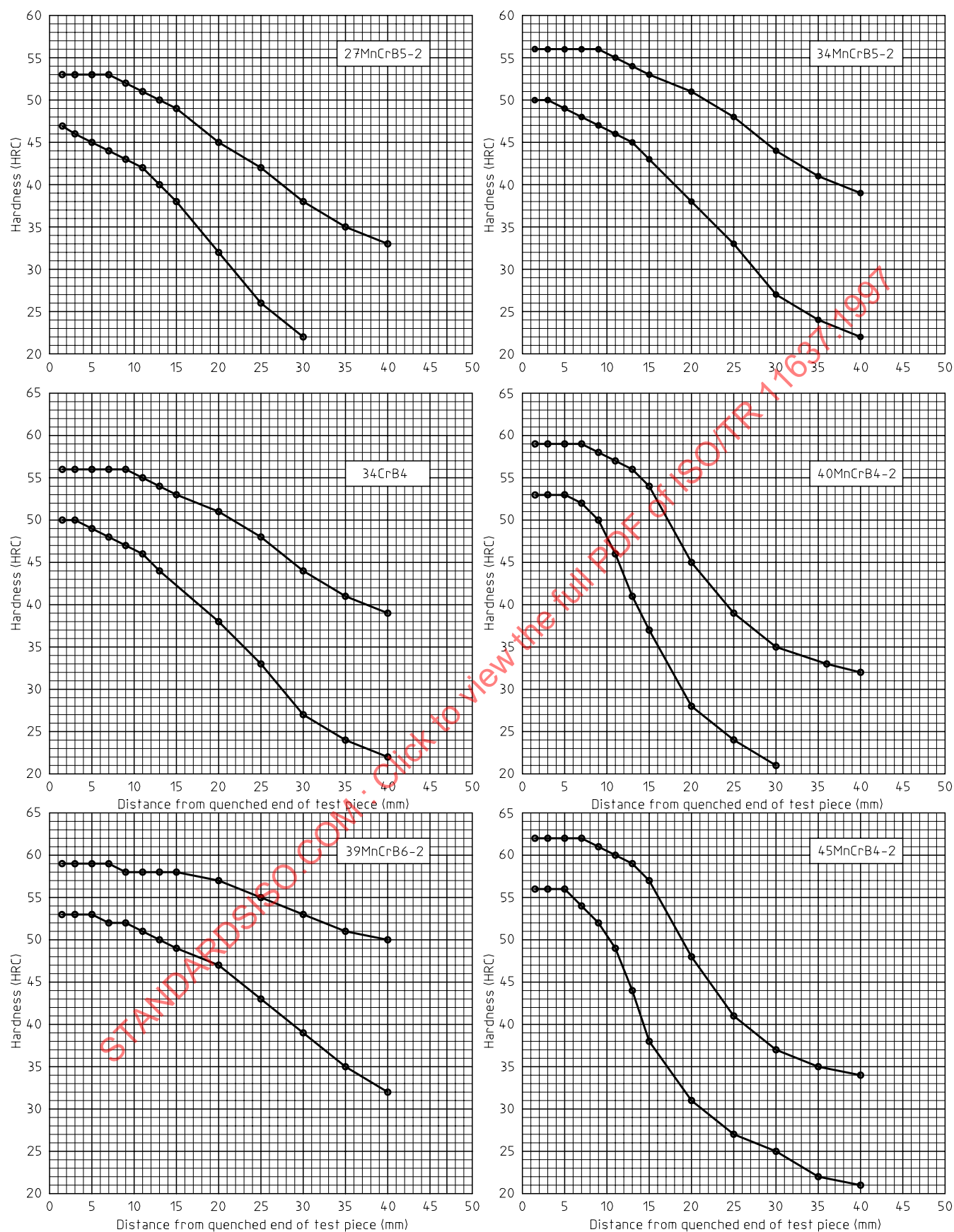
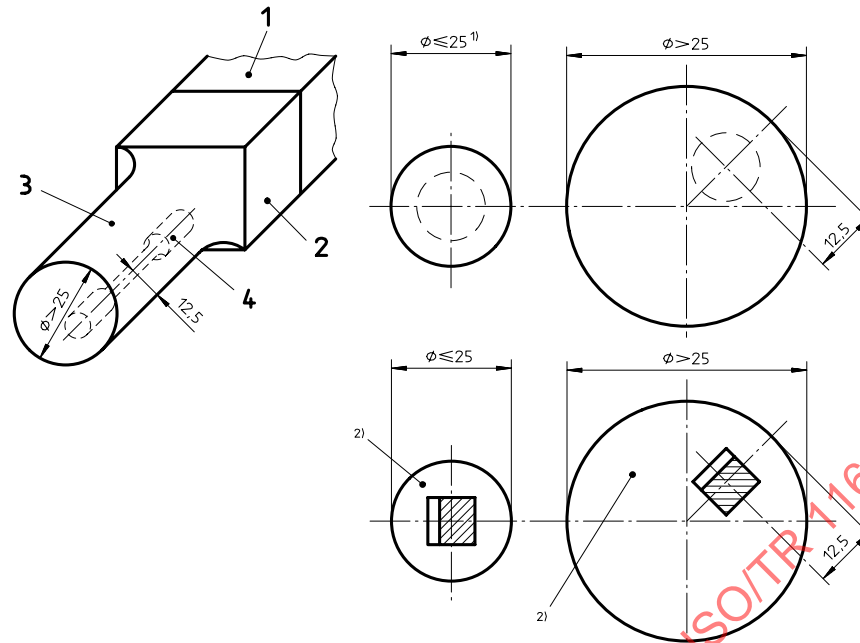


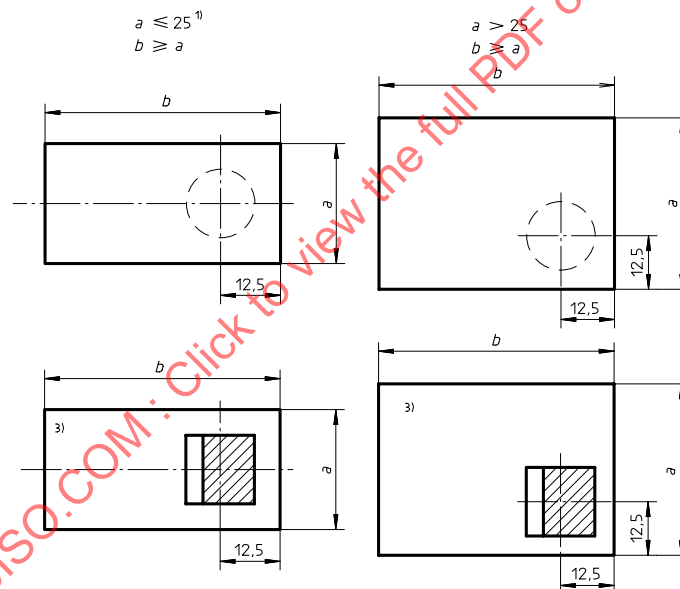
Figure 1 — Scatterbands for end quench hardenability

**Figure 1 — Scatterbands for end quench hardenability (concluded)**

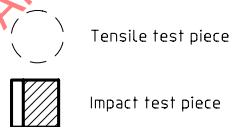
Dimensions in millimetres



Circular and similar shaped sections



Rectangular sections including squares

**Key**

- 1 Sample product
- 2 Test sample
- 3 Test bar (after reduction to the size in which it is to be heat treated)
- 4 Test piece

- 1) For small products (a or $b \leq 25$ mm), the test piece shall, if possible, consists of an unmachined part of the bar.
- 2) For round bars the direction of the notch axis shall be about parallel to the direction of the diameter running through the cross-section of the test piece.
- 3) For rectangular bars, the notch axis shall be perpendicular to the widest rolling surface.

Figure 2 — Location of the test pieces in bars and wire rods