BRITISH STANDARD

BS EN
10277-5:2008

Bright steel products — Technical delivery conditions —

Part 5: Steels for quenching and tempering

ICS 77.140.20; 77.140.60

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British Standards

National foreword

This British Standard is the UK implementation of EN 10277-5:2008. It supersedes BS EN 10277-5:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/31, Wrought steels.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN 10277-5:2008) has been prepared by Technical Committee ECISS/TC 23 “Steels for heat treatment, alloy steels and free-cutting steels - Qualities and dimensions”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2008, and conflicting national standards shall be withdrawn at the latest by September 2008.

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This document supersedes EN 10277-5:1999.

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This European Standard EN 10277 'Bright steel products - Technical delivery conditions' is subdivided as follows:

Part 1: General;

Part 2: Steels for general engineering purposes;

Part 3: Free-cutting steels;

Part 4: Case hardening steels;

Part 5: Steels for quenching and tempering.

During the preparation of the first edition of this European Standard there were not enough statistical data available concerning mechanical properties of bright bar products. Since then it has been recognized that the proof strength values in the cold drawn condition were too high. In addition, cyclic stresses that occur during straightening can reduce the proof strength (Bauschinger's effect), which was not taken into account when drafting the first edition of this standard. In this second edition the proof strength values of non-alloy and alloy grades in condition +QT+C in parts 3 and 5 have been adjusted downwards compared to the first edition.

Furthermore for this part the tensile strength values of different grades were amended in the condition +QT+C in the tables for the mechanical properties for non alloy and alloy steels.

1 Scope

This part of EN 10277 applies to bright steel bars in the drawn, turned or ground condition, in straight lengths of steels for quenching and tempering.

This EN 10277-5 is complemented by EN 10277-1.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10083-2, *Steels for quenching and tempering - Part 2: Technical delivery conditions for non alloy steels*

EN 10083-3, *Steels for quenching and tempering - Part 3: Technical delivery conditions for alloy steels*

EN 10277-1, *Bright steel products - Technical delivery conditions - Part 1: General*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 10277-1 and the following apply.

3.1
steels for quenching and tempering
engineering steels which because of their chemical composition are suitable for hardening and in the quenched and tempered condition have good toughness at a given tensile strength.

4 Classification and designation

4.1 Classification

Steel grades C35E, C35R, C40E, C40R, C45E, C45R, C50E, C50R, C60E and C60R are non-alloy special steels. All other steel grades covered by this European Standard are alloy special steels.

4.2 Designation

See EN 10277-1.

5 Information to be supplied by the purchaser

See EN 10277-1.

6 Manufacturing process

See EN 10277-1.

7 Requirements

7.1 Chemical composition

7.1.1 Cast analysis

The chemical composition of the steel according to the cast analysis shall be as specified in Table 1.

7.1.2 Product analysis

The permissible deviations from the chemical composition as specified in Table 1 for cast analysis and the product analysis of the steel shall be as specified in Table 2.

7.2 Mechanical properties

The mechanical properties of the steels shall be as specified in Table 3, Table 4 and Table 5.

7.3 Hardenability

Where steels are ordered with hardenability requirements, the requirements of EN 10083-2 shall apply for non alloyed steels and EN 10083-3 shall apply for alloyed steels.

7.4 Grain size

Unless otherwise agreed at the time of ordering the grain size of non-alloy steels shall be left to the discretion of the manufacturer. If a fine grain structure is required in accordance with a reference treatment, option B.2 of EN 10277-1 shall be ordered.

All alloy steels shall show an austenitic grain size of 5 or finer. Only for verification see B.2 of EN 10277-1.

7.5 Non-metallic inclusions

7.5.1 Microscopic inclusions

The steels shall have a cleanness corresponding to special steel quality. For details of the requirements for the verification of non-alloy steels see EN 10083-2, A.4 for and of alloy steels see EN 10083-3, A.3.

7.5.2 Macroscopic inclusions

As freedom from macroscopic inclusions cannot be guaranteed in any steel, any requirement to verify the level present shall be agreed at the time of enquiry and order (see EN 10277-1, 7.5.2 and B.3.2).

7.6 Options

See Annex B of EN 10277-1.

8 Inspection and testing

8.1 Types and contents of inspection documents

See EN 10277-1.

8.2 Specific inspection

See EN 10277-1.

8.3 Verification of hardenability

See 10.3.2 of EN 10083-2 and EN 10083-3.

9 Marking

See EN 10277-1.

Table 1 — Chemical composition (cast analysis) of steels for quenching and tempering

Designation		Steel grade according to	Chemical composition, % by mass[a,b,c]									
Steel name	Steel number		C[d]	Si max.	Mn	P max.	S	Cr	Mo	Ni	V	Cr+Mo+Ni max.[d]
C35E	1.1181	EN 10083-2	0,32 to 0,39	0,40	0,50 to 0,80	0,030	≤ 0,035	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C35R	1.1180	EN 10083-2	0,32 to 0,39	0,40	0,50 to 0,80	0,030	0,020 to 0,040	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C40E	1.1186	EN 10083-2	0,37 to 0,44	0,40	0,50 to 0,80	0,030	≤ 0,035	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C40R	1.1189	EN 10083-2	0,37 to 0,44	0,40	0,50 to 0,80	0,030	0,020 to 0,040	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C45E	1.1191	EN 10083-2	0,42 to 0,50	0,40	0,50 to 0,80	0,030	≤ 0,035	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C45R	1.1201	EN 10083-2	0,42 to 0,50	0,40	0,50 to 0,80	0,030	0,020 to 0,040	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C50E	1.1206	EN 10083-2	0,47 to 0,55	0,40	0,60 to 0,90	0,030	≤ 0,035	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C50R	1.1241	EN 10083-2	0,47 to 0,55	0,40	0,60 to 0,90	0,030	0,020 to 0,040	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C60E	1.1221	EN 10083-2	0,57 to 0,65	0,40	0,60 to 0,90	0,030	≤ 0,035	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
C60R	1.1223	EN 10083-2	0,57 to 0,65	0,40	0,60 to 0,90	0,030	0,020 to 0,040	≤ 0,40	≤ 0,10	≤ 0,40	-	0,63
34CrS4	1.7037	EN 10083-3	0,30 to 0,37	0,40	0,60 to 0,90	0,025	0,020 to 0,040	0,90 to 1,20	-	-	-	-
41CrS4	1.7039	EN 10083-3	0,38 to 0,45	0,40	0,60 to 0,90	0,025	0,020 to 0,040	0,90 to 1,20	-	-	-	-
25CrMoS4	1.7213	EN 10083-3	0,22 to 0,29	0,40	0,60 to 0,90	0,025	0,020 to 0,040	0,90 to 1,20	0,15 to 0,30	-	-	-
42CrMoS4	1.7227	EN 10083-3	0,38 to 0,45	0,40	0,60 to 0,90	0,025	0,020 to 0,040	0,90 to 1,20	0,15 to 0,30	-	-	-
34CrNiMo6	1.6582	EN 10083-3	0,30 to 0,38	0,40	0,50 to 0,80	0,025	≤ 0,035	1,30 to 1,70	0,15 to 0,30	1,30 to 1,70	-	-
39NiCrMo3	1.6510	EN 10083-3	0,35 to 0,43	0,40	0,50 to 0,80	0,025	≤ 0,035	0,60 to 1,00	0,15 to 0,25	0,70 to 1,00	-	-
51CrV4	1.8159	EN 10083-3	0,47 to 0,55	0,40	0,70 to 1,10	0,025	≤ 0,025	0,90 to 1,20	-	-	0,10 to 0,25	-

[a] Elements not quoted shall not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall be taken to prevent the addition of such elements from scrap or other material used in manufacture, which affect the hardenability, mechanical properties and applicability.

[b] Where requirements are made on hardenability (see 7.3) slight deviations from the limits for the cast analysis are permissible, except for the elements, carbon (see footnote d), phosphorus and sulphur; the deviations shall not exceed the specifications of Table 2.

[c] Steels with improved machinability as a result of the addition of higher sulphur contents up to around 0,10 % S (including resulphurized steels with controlled inclusion content (e.g. Ca-treatment)) (modern method) or lead may be supplied on request. In the first case the upper limit for the manganese content may be increased by 0,15 %.

[d] If the unalloyed steels are ordered without hardenability requirements (symbols +H, +HH, +HL) or without requirements on the mechanical properties in the quenched and tempered condition restriction in the carbon range to 0,05 % and/or the total sum of the elements Cr, Mo and Ni to ≤ 0,45 % may be agreed at the time of ordering.

Table 2 — Permissible deviations between the product analysis and the limiting values given in Table 1 for the cast analysis

Element	Permissible content in the cast analysis % by mass		Permissible deviations[a] % by mass
C		≤ 0,55	± 0,02
	> 0,55	≤ 0,65	± 0,03
Si		≤ 0,40	+ 0,03
Mn		≤ 1,00	± 0,04
	> 1,00	≤ 1,10	± 0,05
P		≤ 0,035	+ 0,005
S		≤ 0,040	+ 0,005[b]
Cr		≤ 1,70	± 0,05
Mo		≤ 0,30	± 0,03
Ni		≤ 1,70	± 0,05
V		≤ 0,25	± 0,02

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

[b] For steels with a specified sulphur range (0,020 % to 0,040 % according to cast analysis), the permissible deviation is ± 0,005 %

Table 3 — Mechanical properties in the cold drawn (+C) condition

Designation		Thickness mm	Mechanical properties [a]		
			Cold drawn (+C)		
Steel name	Steel number		Proof strength [b] $R_{p0,2}$ MPa min.	Tensile strength [b] R_m MPa	Elongation A % min.
C35E C35R	1.1181 1.1180	≥ 5 ≤ 10	510	650 to 1 000	6
		> 10 ≤ 16	420	600 to 950	7
		> 16 ≤ 40	320	580 to 880	8
		> 40 ≤ 63	300	550 to 840	9
		> 63	270	520 to 800	9
C40E C40R	1.1186 1.1189	≥ 5 ≤ 10	540	700 to 1 000	6
		> 10 ≤ 16	460	650 to 980	7
		> 16 ≤ 40	365	620 to 920	8
		> 40 ≤ 63	330	590 to 840	9
		> 63	290	550 to 820	9
C45E C45R	1.1191 1.1201	≥ 5 ≤ 10	565	750 to 1 050	5
		> 10 ≤ 16	500	710 to 1 030	6
		> 16 ≤ 40	410	650 to 1 000	7
		> 40 ≤ 63	360	630 to 900	8
		> 63	310	580 to 850	8
C50E C50R	1.1206 1.1241	≥ 5 ≤ 10	590	770 to 1 100	5
		> 10 ≤ 16	520	730 to 1 080	6
		> 16 ≤ 40	440	690 to 1 050	7
		> 40 ≤ 63	390	650 to 1 030	8
		> 63	-	-	-
C60E C60R	1.1221 1.1223	≥ 5 ≤ 10	630	800 to 1 150	5
		> 10 ≤ 16	550	780 to 1 130	5
		> 16 ≤ 40	480	730 to 1 100	6
		> 40 ≤ 63	-	-	-
		> 63	-	-	-

[a] For thickness < 5 mm, the mechanical properties may be agreed at the time of enquiry and order.

[b] For flats and special sections the proof strength ($R_{p0,2}$) may deviate by – 10 % and the tensile strength (R_m) by ± 10 %.

Table 4 — Mechanical properties of non alloy steels for quenching and tempering

Designation		Thickness[a,b] mm	Mechanical properties[b]							
			As rolled + turned[c] (+SH) or annealed + turned (+A +SH)		Cold drawn + quenched and tempered[d] (+C +QT)			Quenched and tempered + cold drawn (+QT +C)		
Steel name	Steel number		Hardness HBW	R_m MPa	$R_{p0,2}$ MPa min.	R_m MPa	A % min.	$R_{p0,2}$ MPa min.	R_m MPa	A % min.
C35E C35R	1.1181 1.1180	≥ 5 ≤ 10	-	-	-	-	-	525	750 to 950	9
		> 10 ≤ 16	-	-	-	-	-	490	700 to 900	9
		> 16 ≤ 40	154 to 207	520 to 700	370	600 to 750	19	455	650 to 850	10
		> 40 ≤ 63	154 to 207	520 to 700	320	550 to 700	20	400	570 to 770	11
		> 63 ≤ 100	154 to 207	520 to 700	320	550 to 700	20	385	550 to 750	12
C40E C40R	1.1186 1.1189	≥ 5 ≤ 10	-	-	-	-	-	560	800 to 1 000	8
		> 10 ≤ 16	-	-	-	-	-	525	750 to 950	8
		> 16 ≤ 40	163 to 211	550 to 710	400	630 to 780	18	490	700 to 900	9
		> 40 ≤ 63	163 to 211	550 to 710	350	600 to 750	19	435	620 to 820	10
		> 63 ≤ 100	163 to 211	550 to 710	350	600 to 750	19	420	600 to 800	11
C45E C45R	1.1191 1.1201	≥ 5 ≤ 10	-	-	-	-	-	595	850 to 1 050	8
		> 10 ≤ 16	-	-	-	-	-	565	810 to 1 010	8
		> 16 ≤ 40	172 to 242	580 to 820	430	650 to 800	16	525	750 to 950	9
		> 40 ≤ 63	172 to 242	580 to 820	370	630 to 780	17	455	650 to 850	10
		> 63 ≤ 100	172 to 242	580 to 820	370	630 to 780	17	455	650 to 850	11
C50E C50R	1.1206 1.1241	≥ 5 ≤ 10	-	-	-	-	-	610	870 to 1 070	7
		> 10 ≤ 16	-	-	-	-	-	580	830 to 1 030	7
		> 16 ≤ 40	181 to 269	610 to 910	460	700 to 850	15	555	790 to 990	8
		> 40 ≤ 63	181 to 269	610 to 910	400	650 to 800	16	510	730 to 930	9
		> 63 ≤ 100	181 to 269	610 to 910	400	650 to 800	16	475	680 to 880	9
C60E C60R	1.1221 1.1223	≥ 5 ≤ 10	-	-	-	-	-	630	900 to 1 100	6
		> 10 ≤ 16	-	-	-	-	-	615	880 to 1 080	6
		> 16 ≤ 40	198 to 278	670 to 940	520	800 to 950	13	580	830 to 1 030	7
		> 40 ≤ 63	198 to 278	670 to 940	450	750 to 900	14	545	780 to 980	8
		> 63 ≤ 100	198 to 278	670 to 940	450	750 to 900	14	525	750 to 950	8

a For non-round products in the quenched and tempered conditions, see EN 10277-1, Figure A.1.

b For thicknesses < 5 mm the mechanical properties may be agreed at the time of enquiry and order.

c “As rolled + turned” for unalloyed steels, “annealed + turned” for alloyed steels.

d These values are also valid for the “quenched and tempered + turned” condition.

Table 5 — Mechanical properties of alloy steels for quenching and tempering

Designation		Thickness [a,b] mm	Mechanical properites[b]							
			As rolled + turned[c] (+SH) or annealed + turned (+A +SH)	Cold drawn + quenched and tempered[d] (+C +QT)			Quenched and tempered + cold drawn (+QT +C)			Annealed + Cold drawn (+A +C)
Steel name	Steel number		Hardness HBW max.	$R_{p0,2}$ MPa min.	R_m MPa	A % min.	$R_{p0,2}$ MPa min.	R_m[e] MPa	A % min.	Hardness HBW max.
34CrS4	1.7037	≥ 5 ≤ 10	-	-	-	-	700	900 to 1 100	8	285
		> 10 ≤ 16	-	-	-	-	700	900 to 1 100	9	275
		> 16 ≤ 40	223	590	800 to 950	14	580	800 to 1 000	9	270
		> 40 ≤ 63	223	460	700 to 850	15	510	700 to 900	10	265
		> 63 ≤ 100	223	460	700 to 850	15	480	700 to 900	11	265
41CrS4	1.7039	≥ 5 ≤ 10	-	-	-	-	770	1 000 to 1 200	8	295
		> 10 ≤ 16	-	-	-	-	750	1 000 to 1 200	8	285
		> 16 ≤ 40	241	660	900 to 1 100	12	670	900 to 1 100	9	280
		> 40 ≤ 63	241	560	800 to 950	14	570	800 to 1 000	10	270
		> 63 ≤ 100	241	560	800 to 950	14	570	800 to 1 000	11	270
25CrMoS4	1.7213	≥ 5 ≤ 10	-	-	-	-	700	900 to 1 100	9	270
		> 10 ≤ 16	-	-	-	-	700	900 to 1 100	9	260
		> 16 ≤ 40	212	600	800 to 950	14	600	800 to 1 000	10	255
		> 40 ≤ 63	212	450	700 to 850	15	520	700 to 900	11	250
		> 63 ≤ 100	212	450	700 to 850	15	450	700 to 900	12	250
42CrMoS4	1.7227	≥ 5 ≤ 10	-	-	-	-	770	1 000 to 1 200	8	300
		> 10 ≤ 16	-	-	-	-	750	1 000 to 1 200	8	290
		> 16 ≤ 40	241	750	1 000 to 1 200	11	720	1 000 to 1 200	9	285
		> 40 ≤ 63	241	650	900 to 1 100	12	650	900 to 1 100	10	280
		> 63 ≤ 100	241	650	900 to 1 100	12	650	900 to 1 100	10	280
34CrNiMo6	1.6582	≥ 5 ≤ 10	-	-	-	-	770	1 000 to 1 200	8	308
		> 10 ≤ 16	-	-	-	-	750	1 000 to 1 200	8	298
		> 16 ≤ 40	248	900	1 100 to 1 300	10	720	1 000 to 1 200	9	293
		> 40 ≤ 63	248	800	1 000 to 1 200	11	650	1 000 to 1 200	10	288
		> 63 ≤ 100	248	800	1 000 to 1 200	11	650	1 000 to 1 200	10	288

Table 5*(continued)*

Designation		Thickness[a,b] mm	Mechanical properties[b]							
			As rolled + turned[c] (+SH) or annealed + turned (+A +SH)	Cold drawn + quenched and tempered[d] (+C + QT)			Quenched and tempered + cold drawn (+QT +C)			Annealed + Cold drawn (+A +C)
Steel name	Steel number		Hardness HBW max.	$R_{p0,2}$ MPa min.	R_m MPa	A % min.	$R_{p0,2}$ MPa min.	R_m[e] MPa	A % min.	Hardness HBW max.
39NiCrMo3	1.6510	≥ 5 ≤ 10	-	-	-	-	735	980 to 1 180	8	295
		> 10 ≤ 16	-	-	-	-	700	930 to 1 130	8	290
		> 16 ≤ 40	240	735	930 to 1 130	11	700	930 to 1 130	9	285
		> 40 ≤ 63	240	735	880 to 1 080	12	625	880 to 1 080	10	280
		> 63 ≤ 100	240	735	880 to 1 080	12	600	880 to 1 080	10	280
51CrV4	1.8159	≤ 16	248	900	1 100 to 1 300	9	-	-	-	311
		> 16 ≤ 40	248	800	1 000 to 1 200	10	-	-	-	293
		> 40 ≤ 80	248	700	900 to 1 100	12	-	-	-	287

a For non-round products in the quenched and tempered conditions, see EN 10277-1, Figure A.1.

b For thicknesses < 5 mm the mechanical properties may be agreed at the time of enquiry and order.

c "As rolled + turned" for unalloyed steels, "annealed + turned" for alloyed steels.

d These values are also valid for the "quenched and tempered and turned" condition.

e For flats and special sections the tensile strength (R_m) may deviate by ± 10 %.

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