

No guarantee can be given in respect of this translation
 In all cases the latest German-language version of this standard shall be taken as authoritative

Flame and Induction Hardening Steels Quality Specifications	DIN 17212
--	----------------------------

Stähle für Flamm- und Induktionshärten; Gütevorschriften

In accordance with the Act concerning Units of Measurement of 2nd July 1969 and the Implementation Orders relating to this Act and dated 26th June 1970, the units adopted in this Standard are N/mm² (Newtons per square millimetre) for tensile strength and the 0.2 limit, and J (Joule) for the notched bar impact strength. The numerical values stated in these units are definitive. According to § 3, paragraph (1).1 of the above Act, the units and numerical values appearing in brackets alongside are no longer permitted, since the kg is the base unit for mass.

This Standard is based on Stahl-Eisen Data Sheet 830 of the Verein Deutscher Eisenhüttenleute (Association of German Ferrous Metallurgists). For connection with international standards (ISO Recommendation and Euronorm) see Table 1 and Explanations.

Sections marked by a (●) contain information regarding agreements which are to be made, or which may be made, when ordering.

1. Scope

1.1. This Standard applies to flame and induction hardening steels according to Table 1 in the form of

- rolled or forged half-finished products (e.g. blooms, roughed slabs, billets),
- hot rolled or hot forged steel bars (round, square, hexagon, octagon and flat steel),
- hot rolled wire,
- hot rolled sheet, strip and wide flats,
- seamless tubes, rings and tyres,
- open-die forgings and drop forgings,

generally up to the diameters stated in Table 6, or in other equivalent dimensions.

2. Definition

2.
qu
qu
co
2.

usual
ng and
he

Anwenderinformation

3.
3.
at
3.
di

listed
ble

4.
4.
4.
we

5.
5.
Th
qu
lo
5.
st
5.
in

ent and
le
the

Die Originalfassung der Norm enthält **Elemente, z. B. farbige Abbildungen oder Tabellen**, die in dieser gescannten Form der Norm nicht originalgetreu darstellbar sind. Dies muß bei der Anwendung berücksichtigt werden. Maßgebend für das Anwenden jeder DIN-Norm ist deren Originalfassung mit dem neuesten Ausgabedatum. Vergewissern Sie sich bitte in den DIN-Mitteilungen, im aktuellen DIN-Katalog mit dem neuesten Ergänzungsheft oder in der aktuellen Ausgabe der PERINORM.

to 14
14

Translation Fachtechnisches Übersetzungsinstitut Henry G. Freeman, Düsseldorf
 Nachdruck, auch auszugsweise, nur mit Genehmigung des Deutschen Normenausschusses, Berlin 30, gestattet.

Flame and Induction Hardening Steels
Quality Specifications

DIN
17212

Stähle für Flamm- und Induktionshärten; Gütevorschriften

In accordance with the Act concerning Units of Measurement of 2nd July 1969 and the Implementation Orders relating to this Act and dated 26th June 1970, the units adopted in this Standard are N/mm² (Newtons per square millimetre) for tensile strength and the 0.2 limit, and J (Joule) for the notched bar impact strength. The numerical values stated in these units are definitive.

According to § 3, paragraph (1).1 of the above Act, the units and numerical values appearing in brackets alongside are no longer permitted, since the kg is the base unit for mass.

This Standard is based on Stahl-Eisen Data Sheet 830 of the Verein Deutscher Eisenhüttenleute (Association of German Ferrous Metallurgists). For connection with international standards (ISO Recommendation and Euronorm) see Table 1 and Explanations.

Sections marked by a (●) contain information regarding agreements which are to be made, or which may be made, when ordering.

1. Scope

1.1. This Standard applies to flame and induction hardening steels according to Table 1 in the form of

rolled or forged half-finished products (e.g. blooms, roughed slabs, billets),
hot rolled or hot forged steel bars (round, square, hexagon, octagon and flat steel),
hot rolled wire,
hot rolled sheet, strip and wide flats,
seamless tubes, rings and tyres,
open-die forgings and drop forgings,

generally up to the diameters stated in Table 6, or in other equivalent dimensions.

2. Definition

2.1. Flame and induction hardening steels are characterized by the fact that, when in the usual quenched and tempered condition, they are capable of being surface hardened by local heating and quenching without any appreciable impairment of the strength and toughness properties of the core.

2.2. For flame and induction hardening, see DIN 17014.

3. Dimensions and permissible dimension variations

3.1. Dimension standards covering the majority of the products mentioned in Section 1 are listed at the end of this Standard.

3.2. ● In the absence of dimension standards for particular forms of product, the permissible dimension variations are to be agreed when ordering.

4. Weight calculation and permissible weight variations

4.1. The density of the steels covered by this Standard is reckoned as 7.85 kg/dm³.

4.2. ● Unless specified to the contrary in the dimension standards listed, the permissible weight variations are to be agreed when ordering.

5. Grade classification

5.1. Steel grades

The steel grades listed in Table 1 are high-grade steels which, compared with the ordinary quenched and tempered steels according to DIN 17200, have a reduced spread of carbon content and lower maximum values of phosphorus content.

5.1.1. ● The choice of steel grade is the purchaser's responsibility. Consultation with the steelmaker is urged.

5.1.2. For flame or induction hardening, the use of fine-grained steels is recommended in the interests of reducing the susceptibility to cracking.

Continued on pages 2 to 14
Explanations on page 14

No guarantee can be given in respect
of this translation

In all cases the latest German-language version of this
standard shall be taken as authoritative

Nachdruck, auch auszugsweise, nur mit Genehmigung des Deutschen Normenausschusses, Berlin 30, gestattet.

Translation
Fachtechnisches Übersetzungsinstitut
Henry G. Freeman, Düsseldorf

Table 1. Chemical composition of flame and induction hardening steels (ladle analysis)

Steel grade		Comparable steel grade (designation) according to		Chemical composition in % by wt. ¹⁾							
Code number	Material number	Euronorm 86-70	ISO standard 683/XII-1972	C	Si	Mn	P maximum	S maximum	Cr	Mo	
Cf 35	1.1183	C 36	1	0,33 to 0,39	0,15 to 0,35	0,50 to 0,80	0,025	0,035	—	—	
Cf 45	1.1193	C 46	3	0,43 to 0,49	0,15 to 0,35	0,50 to 0,80	0,025	0,035	—	—	
Cf 53	1.1213	C 53	5	0,50 to 0,57	0,15 to 0,35	0,40 to 0,70	0,025	0,035	—	—	
Cf 70	1.1249	—	—	0,68 to 0,75	0,15 to 0,35	0,20 to 0,35	0,025	0,035	—	—	
45 Cr 2	1.7005	45 Cr 2	6	0,42 to 0,48	0,15 to 0,40	0,50 to 0,80	0,025	0,035	0,40 to 0,60	—	
38 Cr 4	1.7043	38 Cr 4	7	0,34 to 0,40	0,15 to 0,40	0,60 to 0,90	0,025	0,035	0,90 to 1,20	—	
42 Cr 4	1.7045	—	8	0,38 to 0,44	0,15 to 0,40	0,50 to 0,80	0,025	0,035	0,90 to 1,20	—	
41 CrMo 4	1.7223	41 CrMo 4	9	0,38 to 0,44	0,15 to 0,40	0,50 to 0,80	0,025	0,035	0,90 to 1,20	0,15 to 0,30	
49 CrMo 4	1.7238	—	—	0,46 to 0,52	0,15 to 0,40	0,50 to 0,80	0,025	0,035	0,90 to 1,20	0,15 to 0,30	

¹⁾ Elements not quoted in the Table shall not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the ladle. All reasonable precautions shall be taken to prevent the addition of such elements from scrap or other materials used in manufacture, which affect the hardenability, mechanical properties and utilization.

5.2. Treatment condition

● The steels are ordered and supplied in accordance with the treatment conditions indicated in Table 2 (note Sections 6.1 and 7.2.2).

6. Designations

6.1. Designation of steel grades and of treatment conditions

6.1.1. The code numbers have been formed according to Section 2.1.2.1 of the Explanations in Standards Book 3, and the material numbers according to DIN 17007 Sheet 2. To the code number must be appended, as necessary, the code letter, and to the material number the appended number for the treatment condition according to Table 2.

Example for steel 45 Cr 2, material number 1.7005 in the quenched and tempered condition (V or .05): 45 Cr 2 V or 1.7005.05.

Appended numbers for marking the treatment condition (in conjunction with a material number) shall be used only in those cases for which, according to DIN 17007 Sheet 2, September 1961 issue, Section 4.3, there is an unambiguous correlation between the appended number and the treatment condition.

6.1.2. The code number or the material number for the steel grade and the code letter or the appended number for the treatment condition are to be appended to the symbols for the product as given in the examples of designations in the dimension standards.

Example: Designation of hot rolled round steel with diameter 85 mm in the steel grade 45 Cr 2 in the quenched and tempered condition (see Example in Section 6.1.1):

Round 85 DIN 1013 - 45 Cr 2 V
or Round 85 DIN 1013 - 1.7705.05

Table 2. Treatment conditions

Treatment condition	Code letter	Appended numbers in the material number ¹⁾
untreated (hot-worked)	U	00
quenched and tempered (see Section 9.4)	V	05
normalized (see Section 9.2)	N	01
soft annealed (see Section 9.3)	G	02
treated for cold shearability (see Section 7.6.3)	C	²⁾

¹⁾ The first appended number which, according to the issue of DIN 17007 Sheet 2 at present in force, is intended to mark the melting process and deoxidation method, should also be written and in the present case appears as 0.
²⁾ Not yet specified in DIN 17007 Sheet 2.

Table 3. Extent of guarantee and symbols for modes of delivery

The horizontal crosses (x) appearing in each column mark the extent of guarantee of the mode of delivery concerned, for which the symbol is listed in the column heading.

Guarantee ¹⁾ of	Extent of guarantee and symbols for mode of delivery ²⁾													
	1	1b	1c	2	2b	2c	4	4b	4c	5	10	11	11i	11k
Chemical composition	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hardenability in the end quench test ³⁾ 4)				x	x	x							x	
Hardness in the hot worked condition (U) in the soft annealed condition (G)		x	x		x	x		x	x					
Cold shearability (C)												x	x	x
Mechanical properties of the quenched and tempered ruling cross-section (V) ⁵⁾							x	x	x					x
of the quenched and tempered product in the delivery dimensions (V)										x				
of the normalized product in the delivery dimensions (N) ⁶⁾											x			

- 1) The code letters for the treatment condition are given in brackets.
- 2) The numbers and letters are largely in agreement with the markings used in ISO Standard 683/XII-1972 and in Euronorm 86.
- 3) For the steel grades listed in Table 5.
- 4) The order should state whether the scatter band to be guaranteed is the one with limits according to Figures 1 a to 1 e or another having defined, closer limits (see Section 7.4.1.1).
- 5) In the case of modes of delivery 4, 4 b and 4 c, hardenability testing by the end quench test may be agreed to as a simplified verification for the mechanical properties guaranteed for the quenched and tempered ruling cross-section (see Section 7.5.2 a).
- 6) Only for unalloyed steels (see Table 8).

Examples of application:

- a) If an order states the mode of delivery by quoting the symbol 1 c, the following must be guaranteed: chemical composition from the product analysis and hardness in the soft annealed condition.
- b) If the chemical composition as determined from the ladle analysis, the hardenability and the hardness in the soft annealed condition are to be guaranteed, the mode of delivery should be denoted by the symbol 2 c when ordering.

6.2. Designation of modes of delivery

The example quoted in Section 6.1.2 for symbols is to be written as follows when combined with particulars specifying a required mode of delivery (e.g. 5, see Table 3):

- Round 85 DIN 1013 - 45 Cr 2 V - mode of delivery 5
- or Round 85 DIN 1013 - 1.7705.05 - mode of delivery 5

7. Requirements

7.1. Melting process

• The steels are made in the open hearth furnace or electric furnace or by the oxygen lancing process. Subject to this range of methods, the choice of melting process is left to the manufacturer, unless agreed otherwise when ordering.

7.2. Modes of delivery (extent of guarantee)

7.2.1. Steels according to this Standard are supplied in one of the modes of delivery (combination of guaranteed properties) listed in Table 3.

7.2.2. • The treatment condition (see Table 2) and the mode of delivery (see Table 3) must be agreed when ordering.

7.2.3. The steels are to be supplied segregated according to ladles.

7.3. Chemical composition

7.3.1. With regard to the chemical composition, it is the product analysis values which are guaranteed in the case of the modes of delivery 1 to 1 c, and the ladle analysis values in the case of the other modes of delivery (2 to 11 k).

7.3.2. • In the case of modes of delivery 1 to 1 c agreement can be reached when ordering regarding verification that the product analysis values have been complied with subject to the values quoted in Table 4 for the permissible variations from the limiting values for the ladle analysis (Table 1).

7.3.3. In the case of modes of delivery 2 to 11 k, minor variations from the limiting values for the ladle analysis in Table 1 are permissible, provided that the hardenability values or mechanical properties stated for these modes of delivery are maintained.

7.4. Hardenability

7.4.1. For the modes of delivery 2 to 2 c and, where applicable, for 4 to 4 c (see Section 7.5.2 a) when requirements regarding hardenability in the end quench test are made, the provisional hardness values according to Table 5 and the provisional scatter bands according to Figures 1 a to 1 e are guaranteed.

7.4.1.1. • When ordering it may be agreed that the scatter bands of hardenability in the end quench test be narrowed to not less than 2/3 of the original spread, the actual position relative to the limits of the original scatter band being optional, provided that the relationship remains the same throughout the length of the scatter band. When agreements of this kind are made, however, the spread of hardness must be not less than 6 HRC units (e.g. 51 to 57 HRC).

7.4.2. The hardness ranges hold good at the hardening temperatures indicated in Table 11 for the end quench test.

7.5. Mechanical properties

7.5.1. For the modes of delivery 4 to 4 c, 5 and 11 k, the values quoted in Table 6 for the mechanical properties of quenched and tempered cross-sections are guaranteed for specimens taken from round, hexagonal or octagonal bars in the rolling direction in the manner of Figure 2.

7.5.1.1. For rectangular cross-sections the appropriate regions of the equivalent diameter should be found from Figure 3.

7.5.1.2. • For other cross-sectional forms (including tubes) the equivalent diameter should be agreed when ordering.

7.5.1.3. • If specimens are taken at right angles to the deformation fibre (e.g. in the case of steel bars in diameters over 100 mm or in the case of sheets) or disposed in some other way (e.g. obliquely) to the deformation fibre, then the values to be guaranteed for elongation, reduction of area and notched bar impact strength are to be specially agreed.

Table 4. Values by which product analyses are allowed for permissible variations from the limiting values for the ladle analysis

(Applying to cross-sections up to 10 000 mm² in the case of unalloyed steels, and to cross-sections up to 62 500 mm² in the case of alloy steels)

Element	Permissible maximum content in the ladle analysis % by wt.	Permissible variation of product analysis from limiting values of ladle analysis ¹⁾ % by wt.
C	> 0,55 ≤ 0,55 ≤ 0,75	±0,02 ±0,03
Si	≤ 0,40	±0,03
Mn	≤ 0,90	±0,04
P	≤ 0,025	+0,005 0
S	≤ 0,035	+0,005 0
Cr	≤ 1,20	±0,05
Mo	≤ 0,30	±0,03

¹⁾ When a single ladle is concerned, the variation of an element in the case of two or more product analyses must be either all below the minimum value or all above the maximum value of the range stated for the product analysis, but not both at once.

Table 5. Provisional limiting values of Rockwell C hardness when testing for hardenability by the end quench

For the time being, the limiting values of Rockwell C hardness are only provisionally specified; they course on the basis of experience accumulated by manufacturers and users.

Hardness values not indicated in this Table can be obtained from Figures 1 a to 1 e.

Steel grade		Limits of spread	Hardness in HRC at a distance from the quenched end fa									
Code number	Material number		1,5	3	5	7	9	11	13	15	20	25
45 Cr 2	1.7005	maximum	62	60	57	52	46	42	40	38	35	33
		minimum	54	49	40	32	28	25	23	22	20	—
38 Cr 4	1.7043	maximum	58	58	58	57	55	52	50	48	42	39
		minimum	51	50	48	44	39	36	33	31	26	24
42 Cr 4	1.7045	maximum	60	60	60	59	58	56	54	52	46	42
		minimum	53	52	50	47	44	40	37	35	30	27
41 CrMo 4	1.7223	maximum	60	60	60	60	60	59	59	58	56	53
		minimum	53	53	52	51	50	48	45	43	38	35
49 CrMo 4	1.7238	maximum	63	63	63	63	63	62	61	60	59	57
		minimum	56	55	54	53	51	50	48	46	42	40

Table 6. Guaranteed mechanical properties of the steels in the quenched and tempered condition (code letter: V

Steel grade		up to 16 mm diameter ¹⁾					above 16 to 40 mm diameter ²⁾			
Code number	Material number	Yield point (0.2 limit) N/mm ²) (kg/mm ²) minimum	Tensile strength N/mm ²) (kg/mm ²)	Elongation ($L_0 = 5 d_0$) %	Reduction of area %	Notched bar impact strength J ³⁾ (kgm/cm ²)	Yield point (0.2 limit) N/mm ²) (kg/mm ²) minimum	Tensile strength N/mm ²) (kg/mm ²)	Elongation ($L_0 = 5 d_0$) %	Reduction of an %
Cf 35	1.1183	420 (43)	620 to 760 (63 to 78)	17	40	42 (6)	360 (37)	580 to 730 (59 to 74)	19	45
Cf 45	1.1193	480 (49)	700 to 840 (71 to 86)	14	35	28 (4)	410 (42)	660 to 800 (67 to 82)	16	40
Cf 53	1.1213	510 (52)	740 to 880 (75 to 90)	12	25	—	430 (44)	690 to 830 (70 to 85)	14	35
Cf 70	1.1249	560 (57)	780 to 930 (80 to 95)	11	25	—	480 (49)	740 to 880 (75 to 90)	13	30
45 Cr 2	1.7005	640 (65)	880 to 1080 (90 to 110)	12	40	35 (5)	540 (55)	780 to 930 (80 to 95)	14	45
38 Cr 4	1.7043	740 (75)	930 to 1130 (95 to 115)	11	40	35 (5)	630 (64)	830 to 980 (85 to 100)	13	45
42 Cr 4	1.7045	780 (80)	980 to 1180 (100 to 120)	11	40	35 (5)	670 (68)	880 to 1080 (90 to 110)	12	45
41 CrMo 4	1.7223	880 (90)	1080 to 1270 (110 to 130)	10	40	35 (5)	760 (78)	980 to 1180 (100 to 120)	11	45
49 CrMo 4 ²⁾	1.7238	—	—	—	—	—	—	—	—	—

¹⁾ Note Sections 7.5.1.1 and 7.5.1.2

²⁾ This steel is used mainly for relatively large dimensions and simple parts.

³⁾ See preamble

ability by the end quench test

provisionally specified; they are to be re-examined in due

a to 1 e.

Hardness in HRC										
Distance from the quenched end face (in mm) of										
9	11	13	15	20	25	30	35	40	45	50
46	42	40	38	35	33	31	29	28	27	26
48	25	23	22	20	—	—	—	—	—	—
55	52	50	48	42	39	37	36	35	34	33
59	36	33	31	26	24	22	20	—	—	—
58	56	54	52	46	42	40	38	37	36	35
64	40	37	35	30	27	25	23	22	21	20
60	59	59	58	56	53	51	48	47	46	45
60	48	45	43	38	35	34	33	32	32	32
63	62	61	60	59	57	55	54	53	52	52
61	50	48	46	42	40	39	38	37	36	36

condition (code letter: V) (valid for longitudinal specimens)

above 16 to 40 mm diameter ¹⁾				above 40 to 100 mm diameter ¹⁾					above 100	
Tensile strength N/mm ² ²⁾ (kg/mm ²)	Elongation ($L_0 = 5 d_0$) %	Reduction of area %	Notched bar impact strength J ³⁾ (kgm/cm ²)	Yield point (0.2 limit) N/mm ² ²⁾ (kg/mm ²)	Tensile strength N/mm ² ²⁾ (kg/mm ²)	Elongation ($L_0 = 5 d_0$) %	Reduction of area %	Notched bar impact strength J ³⁾ (kgm/cm ²)	Yield point (0.2 limit) N/mm ² ²⁾ (kg/mm ²)	Tensile strength N/mm ² ²⁾ (kg/mm ²)
		minimum		minimum			minimum		minimum	
580 to 730 (59 to 74)	19	45	42 (6)	320 (33)	540 to 690 (55 to 70)	20	50	42 (6)	—	—
660 to 800 (67 to 82)	16	40	28 (4)	370 (38)	620 to 760 (63 to 78)	17	45	28 (4)	—	—
690 to 830 (70 to 85)	14	35	—	400 (41)	640 to 780 (65 to 80)	15	40	—	—	—
740 to 880 (75 to 90)	13	30	—	—	—	—	—	—	—	—
780 to 930 (80 to 95)	14	45	42 (6)	440 (45)	690 to 830 (70 to 85)	15	50	42 (6)	—	—
830 to 980 (85 to 100)	13	45	42 (6)	510 (52)	740 to 880 (75 to 90)	14	50	42 (6)	—	—
880 to 1080 (90 to 110)	12	45	42 (6)	560 (57)	780 to 930 (80 to 95)	14	50	42 (6)	—	—
980 to 1180 (100 to 120)	11	45	42 (6)	640 (65)	880 to 1080 (90 to 110)	12	50	42 (6)	560 (57)	780 to 930 (80 to 95)
—	—	—	—	690 (70)	880 to 1080 (90 to 110)	12	50	35 (5)	640 (65)	830 to 980 (85 to 100)

bar th (mm ²)	above 100 to 160 mm diameter ¹⁾					above 160 to 250 mm diameter ¹⁾				
	Yield point (0.2 limit) N/mm ² ³⁾ (kg/mm ²)	Tensile strength N/mm ² ³⁾ (kg/mm ²)	Elongation (L ₀ = 5 d ₀) %	Reduction of area %	Notched bar impact strength J ³⁾ (kgm/cm ²)	Yield point (0.2 limit) N/mm ² ³⁾ (kg/mm ²)	Tensile strength N/mm ² ³⁾ (kg/mm ²)	Elongation (L ₀ = 5 d ₀) %	Reduction of area %	Notched bar impact strength J ³⁾ (kgm/cm ²)
	minimum			minimum		minimum			minimum	
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—
	560 (57)	780 to 930 (80 to 95)	13	55	42 (6)	510 (52)	740 to 880 (75 to 90)	14	55	42 (6)
	640 (65)	830 to 980 (85 to 100)	13	50	35 (5)	590 (60)	780 to 930 (80 to 95)	13	50	35 (5)

7.5.2. The mechanical properties in the quenched and tempered condition according to Table 6 are to be verified

- a) ● in the case of modes of delivery 4 to 4 c and 11 k for a ruling cross-section¹⁾ which is to be agreed when ordering and which is to be quenched and tempered according to the data in Table 11;
 - as an alternative to verification of the mechanical properties in the ruling cross-section, verification of hardenability by the end quench test according to Table 5 may be agreed when ordering.
 In cases of dispute, however, the guaranteeing of the mechanical properties in the ruling cross-section remains decisive;
- b) in the case of mode of delivery 5, for the product to be supplied in the quenched and tempered condition in the delivery dimensions concerned.

7.5.3. For molybdenum-free steels the impact values stated in Table 6 cannot be guaranteed if, following tempering, cooling in air has to be adopted in order to achieve a low-stress condition.

7.5.4. ● For the modes of delivery 1 c, 2 c and 4 c, hardness values to be determined following normal preparation of the surface may be agreed according to Table 7 for the soft annealed condition (G).

7.5.5. ● In the case of modes of delivery 1 b, 2 b and 4 b, determination of hardness in the hot worked (untreated) condition on the normally prepared surface may be required by the purchaser. The hardness values to be guaranteed in such cases are to be agreed.

7.5.6. The mechanical properties in the normalized condition are guaranteed according to Table 8 for unalloyed steels in accordance with mode of delivery 10.

7.5.7. ● The hardness values of surface-hardened zones according to Table 9 apply subject to the conditions stated in Footnote 1 of the same Table in conjunction with the particulars in Table 11. Verification of these hardness values must be especially agreed and should only be carried out - if necessary at all - on the quenched and tempered ruling cross-section (modes of delivery 4 to 4 c and 11 k) or on quenched and tempered or normalized products in the delivery dimensions (modes of delivery 5 and 10).

7.6. Technological properties

7.6.1. Suitability for welding

Subject to the observance of proven welding conditions, all the steels in this Standard are suitable for flash welding. In some cases special precautions may be needed, e.g. pre-heating.

7.6.2. Workability

To obtain improved workability (when machining) the steels can be subjected to soft annealing (see Section 9.3) controlled according to the steel grade and dimensions concerned. For steels in this treatment condition (G) the hardness values stated in Table 7 apply.

¹⁾ In the selection of a steel an important consideration is whether the mechanical properties required can be achieved in the steel in the dimensions in which it exists at the time of heat-treatment. The cross-section which is definitive for this purpose is termed the ruling cross-section and this should always be expressed in terms of the diameter of a round steel which responds to heat-treatment in the same manner.

Table 7. Hardness after soft annealing

Steel grade		Hardness after soft annealing (code letter G) HB 30 maximum
Code number	Material number	
Cf 35	1.1183	183
Cf 45	1.1193	207
Cf 53	1.1213	223
Cf 70	1.1249	223
45 Cr 2	1.7005	207
38 Cr 4	1.7043	217
42 Cr 4	1.7045	217
41 CrMo 4	1.7223	217
49 CrMo 4	1.7238	235

Table 8. Guaranteed mechanical properties of normalized unalloyed steels (code letter N)

(valid for diameters > 16 ≤ 100 mm)

Steel grade		Yield point (0.2 limit) N/mm ² ¹⁾ (kg/mm ²) minimum	Tensile strength N/mm ² ¹⁾ (kg/mm ²)	Elongation (L ₀ = 5 d ₀) % minimum
Code number	Material number			
Cf 35	1.1183	270 (28)	490 to 640 (50 to 65)	21
Cf 45	1.1193	330 (34)	590 to 740 (60 to 75)	17
Cf 53	1.1213	340 (35)	610 to 760 (62 to 77)	16

¹⁾ See preamble

Table 9. Hardness of surface-hardened zones

Steel grade		Hardness of surface-hardened zones ¹⁾ HRC minimum
Code number	Material number	
Cf 35	1.1183	51
Cf 45	1.1193	55
Cf 53	1.1213	57
Cf 70	1.1249	60
45 Cr 2	1.7005	55
38 Cr 4	1.7043	53
42 Cr 4	1.7045	54
41 CrMo 4	1.7223	54
49 CrMo 4	1.7238	56

¹⁾ The above values apply to the condition existing after quenching and tempering and surface hardening according to the particulars in Table 11, followed by stress relieving at 150 to 180 °C for about 1h, and they relate to cross-sections up to 40 mm diameter for the steel Cf 70, up to 100 mm diameter for the steels 45 Cr 2, 38 Cr 4 and 42 Cr 4, and up to 250 mm diameter for the steels 42 CrMo 4 and 49 CrMo 4. For the steels Cf 35, Cf 45 and Cf 53 the same values may also be agreed for the condition after normalizing and surface hardening, subject to the same conditions, for cross-sections up to 100 mm diameter. It should be noted that surface decarburization may lead to lower hardness values in the surface-hardened zones.

7.6.3. Cold shearability

7.6.3.1. Cold shearability in all dimensions concerned is possessed by all the steels in this Standard in treatment condition G (see Table 7) but only by the unalloyed steels in treatment condition N (see Table 8).

7.6.3.2. In the rolled or forged condition cold shearability is possessed in general in all dimensions by the unalloyed steels (including the steel Cf 70), and the steel 45 Cr 2.

7.6.3.3. ● For the other steels and dimension ranges, cold shearability should if necessary be agreed when ordering (modes of delivery 11 to 11 k).

7.7. Non-metallic inclusions

● For these steels a maximum allowable content of non-metallic inclusions may be agreed when ordering (see Section 8.4.6).

7.8. Surface condition

7.8.1. The products shall have a smooth surface consistent with the forming method employed.

7.8.1.1. Products intended for machining are allowed to have surface defects, e.g. shells, grooving, rolling laps, cracks and surface decarburization within the machining allowance; such defects may be removed by suitable means provided that the usefulness of the material is not thereby impaired.

7.8.1.2. ● If products intended for noncutting shaping (e.g. drop forging or rod drawing) are required to meet special standards of surface condition, it is necessary, except in the case of primary material for drop forging, that this should be expressly noted in the order. In this case, surface defects which would burst open during shaping must be levelled out by suitable means. It is permissible in this case for the material to go slightly below the minimum thickness allowed in the dimension standard, provided that its usefulness is not thereby impaired.

7.8.2. It is not permissible for surface defects to be corrected by welding.

Table 10. Provisions regarding extent of test (test units and number of specimens)

8. Testing

8.1. Delivery testings

● For all steel grades in this Standard the purchaser can arrange for delivery testings which will generally be carried out by the manufacturer's inspectors, but may also, subject to special agreement when ordering, be performed by inspectors acting on behalf of the purchaser and unconnected with the manufacturer.

8.2. Extent of test

8.2.1. For testing all the steel grades are to be segregated according to ladles and, if necessary, into heat-treatment lots and dimension ranges.

8.2.2. Information on the extent of test, i.e. on the size of test units and on the number of specimens to be taken, is contained in Table 10.

● The extent of test shall be agreed when ordering in cases where no details are laid down in Table 10.

8.3. Sampling

8.3.1. For the product analysis, cuttings are to be removed evenly from the whole cross-section of the product to be tested. If this is not practicable, the cuttings should be taken from a suitable place which is characteristic of the whole cross-section.

8.3.2. The specimen for the end quench test shall be taken according to DIN 50191.

8.3.3. ● The specimens for the tensile and notched bar impact bending test are to be taken in the longitudinal direction of the product according to Figure 2 (the instructions in the caption of Figure 2 and in Section 8.4.4.1 should be observed). Details concerning the removal of specimens in the case of products with other cross-sectional forms and dimensions or involving other specimen positions relative to the deformation fibre are to be agreed when ordering (see Section 7.5.1.3).

8.3.4. ● Sampling for determining hardness is subject to agreement (see Sections 7.5.4, 7.5.5 and 7.5.7).

Guaranteed property	Mode of delivery according to Table 3	Number of specimens to be taken per test unit
Chemical composition determined from the product	1 to 1c	by agreement
Hardenability in the end quench test	2 to 2c; 11i	one specimen per ladle
Hardness in the hot worked condition (U)	1b; 2b; 4b	generally one specimen per ladle and dimension range
in the soft annealed condition (G) acc. to surface hardening	1c; 2c; 4c 2)	one specimen per ladle and heat-treatment lot ¹⁾
Mechanical properties of the quenched and tempered ruling cross-section	4 to 4c; 11k	one specimen per ladle
of the quenched and tempered product in the delivery dimensions	5	one specimen per ladle, diameter range and heat-treatment lot ¹⁾
of the normalized product in the delivery dimensions	10	
¹⁾ Applies to batchwise heat-treatment; if heat-treatment is performed in continuous furnaces, then, in the case of unalloyed steels, one test piece shall be taken for every 25 t or fraction of 25 t, whilst in the case of alloy steels one test piece shall be taken for every 15 t or fraction of 15 t, subject, however, to a minimum of one test piece per ladle. ²⁾ See Section 7.5.7.		

8.3.5. The removal of specimens for determining the content of non-metallic inclusions is covered by the directions contained in Stahl-Eisen Test Sheets 1580 or 1584²⁾.

8.4. Test methods to be used

8.4.1. • The chemical composition is to be determined by the methods³⁾ given by the Chemists' Committee of the Verein Deutscher Eisenhüttenleute (Association of German Ferrous Metallurgists). The methods not specified by the Chemists' Committee are subject to special agreement.

8.4.2. The end quench test is to be carried out according to DIN 50191. The quench temperatures are given in Table 11.

• If necessary, agreement should be reached when ordering regarding the distances from the quenched end face at which the hardness is to be determined or regarding the acceptability of other ways of verifying hardenability by the end quench test⁴⁾.

8.4.3. The tensile test is to be carried out according to DIN 50145*) using the short proportional bar with a gauge length of $L_0 = 5 d_0$ (for rectangular specimens $d_0 = 1.13 \sqrt{F_0}$ according to DIN 50125).

In the absence of a pronounced yield point, the 0.2 limit shall be determined according to DIN 50145*).

8.4.4. The notched bar impact bending test is to be carried out on DVM specimens according to DIN 50115.

8.4.4.1. • In general, the notched bar impact value is to be determined as the average of three tests on specimens which should all lie side by side at the same distance from the surface or - if this is impracticable - directly in line in the same test piece; when ordering, however, it may be agreed that the notched bar impact strength shall be determined on only one or two specimens. In cases of dispute the average must be found from three specimens.

8.4.4.2. The lowest value from three notched bar impact tests must not be less than 2/3 of the minimum mean value of the notched bar impact strength according to Table 6.

8.4.4.3. • In the case of products having dimensions such that a notched bar impact specimen with standard dimensions cannot be taken, special agreement shall be reached when ordering regarding procedure of the notched bar impact bending test.

8.4.5. Brinell hardness shall be determined according to DIN 50351 and Rockwell hardness according to DIN 50103.

8.4.5.1. • The special conditions applying to the determination of Rockwell hardness on the surface-hardened zones are to be agreed, if necessary, when ordering.

8.4.6. • The content of non-metallic inclusions is to be determined subject to agreement when ordering according to Stahl-Eisen Test Sheets 1580 or 1584²⁾.

8.4.7. • Agreement shall be reached when ordering regarding the method to be used for verifying cold shearability.

8.5. Retestings

8.5.1. If the unsatisfactory outcome of a testing is obviously due to deficiencies in the test procedure or to defective manufacture of the specimen and not to deficiencies in the steel itself, such unsatisfactory result shall be left out of account when the decision is being made regarding fulfilment of the requirements, and the test concerned shall be repeated.

8.5.2. If the unsatisfactory outcome of a testing is due to incorrect heat-treatment, the heat-treatment can be repeated whereupon the entire testing must be performed again.

8.5.3. If the results of a properly conducted testing do not meet the specified requirements, a retesting can be carried out. The procedure for this purpose is that for each unsatisfactory testing two further testings are made on another test piece from the same test unit. Test pieces giving unsatisfactory results are to be segregated.

8.5.4. The test unit is deemed to be in conformity with the conditions if both retestings have a satisfactory outcome. The test unit may be rejected if one of the retestings is unsatisfactory.

8.6. Test certificates

• Delivery testing is certificated by one of the certificates according to DIN 50049. The type of certificate must be agreed when ordering.

9. Hot working and heat-treatment

9.1. Forging

The pieces are to be carefully heated. Suitable temperature ranges for forging purposes are indicated in Table 11. To facilitate drop forging, careful heating to temperatures not more than 50 °C higher than those indicated is permissible, but these higher temperatures must not be held for long. The forged pieces should cool as slowly as possible and if necessary should then be heat-treated.

^{*)} At present still circulating as draft

²⁾ Stahl-Eisen Test Sheet 1580 - Stepped turning test for the macroscopic testing of steels for non-metallic inclusions - (November 1960). Stahl-Eisen Test Sheet 1584 - Blue brittleness test for testing steels for macroscopic non-metallic inclusions - (in course of preparation).

³⁾ Handbuch für das Eisenhüttenlaboratorium (Handbook for the Ferrous Metallurgical Laboratory), Vol. 2: Die Untersuchung der metallischen Stoffe (The Investigation of Metallic Materials); Vol. 4: Schiedsanalysen (Arbitration Analyses), Düsseldorf, Verlag Stahleisen mbH, using the latest edition.

⁴⁾ See, e.g., Section 8 in DIN 50191 - Testing of steel; end quench test for testing hardenability, specimen length 100 mm, specimen diameter 25 mm - or Section 7 in ISO Recommendation ISO/R 642-1967 - End quench hardness testing of steel (according to Jominy).

9.2. Normalizing (treatment condition N)

The pieces are to be carefully heated to the temperatures indicated in Table 11 until the core region also has been adequately converted to austenite, whereupon they should be cooled in still air. Delivery in the normalized condition only applies to the unalloyed steels (see Table 8).

9.3. Soft annealing (treatment condition G)

The pieces are to be annealed for up to several hours, depending on cross-section, at the temperatures indicated in Table 11 and then slowly cooled.

9.4. Quenching and tempering (treatment condition V)

The pieces are to be heated uniformly and throughout, i.e. for different lengths of time according to cross-section, to the quenching temperatures indicated in Table 11. In the case of steels for water and oil hardening, the method of hardening should be selected to suit the shape and dimensions of the workpiece concerned. Of these steels, Cf 53, Cf 70, 41 CrMo 4 and 49 CrMo 4 are susceptible to cracking when quenched in water. The tempering temperature should be chosen to give the required strength properties. The duration of tempering is governed mainly by the dimensions of the parts. To avoid temper brittleness in molybdenum-free steels, cooling from tempering temperature should be performed in oil although water may also be used if the dimensions of the piece or the steel grade allow this; otherwise, cooling can be performed in air.

Pieces with abrupt changes of cross-section and made of the steels Cf 53, Cf 70, 41 CrMo 4 and 49 CrMo 4 should be tempered immediately after hardening.

Table 11. Temperatures for quenching in the end quench test, for hot working and heat-treating¹⁾

Steel grade Code number	Hardening temperature for end quench test °C ± 5	Hot working °C	Soft annealing °C	Normalizing °C	Quenching and tempering		Tempering °C
					Hardening ²⁾ in water ³⁾ °C	in oil ³⁾ °C	
Cf 35 Cf 45 Cf 53 Cf 70	— — — —	1100 to 850 1100 to 850 1050 to 850 1000 to 800	} 650 to 700 650 to 700	860 to 890 840 to 870 830 to 860 820 to 850	840 to 870 820 to 850 805 to 835 790 to 820	850 to 880 830 to 860 815 to 845 —	} 550 to 660
45 Cr2	850	1100 to 850	650 to 700	840 to 870	820 to 850	830 to 860	550 to 660
38 Cr4 42 Cr4	850 850	} 1050 to 850	} 680 to 720	845 to 885 840 to 880	825 to 855 820 to 850	835 to 865 830 to 860	} 540 to 680
41 CrMo 4 49 CrMo 4	} 850	} 1050 to 850	} 680 to 720	} 840 to 880	} 820 to 850	} 830 to 860	} 540 to 680

¹⁾ Apart from the hardening temperatures for the end quench test, the temperatures indicated above are reference values.
²⁾ ● For verifying the hardness of surface-hardened zones, the hardening temperature should, if necessary, be agreed.
³⁾ The quench medium should be chosen to suit the shape and dimension of the workpiece.

9.5. Surface hardening

For flame and induction hardening, the hardening temperatures (which are best measured with radiation pyrometers) lie in the range indicated for "hardening in water", but with the limits raised by about 50 °C. Quenching is usually effected in water; in special cases, however, less drastic quench media may also be used. With rising carbon and alloy content the risk of cracking during surface hardening increases and therefore steels like Cf 53, Cf 70, 41 CrMo 4 and 49 CrMo 4 must be treated with due care when undergoing surface hardening.

Generally speaking, stress relieving at 150 to 180 °C, or tempering at a suitable temperature, should be performed as soon as possible after surface hardening, the duration of stress relieving or tempering being not less than 1 h.

10. Complaints⁵⁾

10.1. External and internal defects may only be objected to if they appreciably impair the processing and use of the material in a manner appropriate to the steel grade and form of product concerned.

10.2. The purchaser must give the supplier an opportunity of convincing himself of the justification of the complaints and, where possible, should do this by presenting the material objected to as well as actual samples of the material supplied.

⁵⁾ For Explanations regarding this complaints clause in quality standards for iron and steel, see DIN Mitteilungen Vol. 40 (1961), No. 2, pp. 111/12.

Dimension standards for the steels covered by this Standard

For hot rolled wire:

- DIN 59110 Steel wire rod; dimensions, permissible variations, weights
 DIN 59115 Steel wire rod for bolts, nuts and rivets; dimensions, permissible variations, weights

For hot rolled and hot forged bars:

- DIN 1013 Steel bars, hot rolled round steel; dimensions, weights, permissible variations
 DIN 59130 Hot rolled round steel for bolts and rivets; dimensions, weights, permissible variations
 DIN 1014 Steel bars, hot rolled square steel; dimensions, weights, permissible variations
 DIN 1015 -, hot rolled hexagon steel; dimensions, weights, permissible variations
 DIN 1017 Sheet 1 -, hot rolled flat steel for general purpose; dimensions, weights, permissible variations
 Sheet 2 -, hot rolled flat steel for special purpose (in bar drawing mills, bolt and screw factories etc.); dimensions, weights, permissible variations
 DIN 7527 Sheet 6 Steel forgings, technical directions for delivery, shape and manufacture; forged bars

For hot rolled sheet, plate, strip and hot rolled wide flats:

- DIN 1541 Sheet 1 and Sheet 2 Steel sheets under 3 mm thick (thin sheets); thicknesses, sizes, dimension and weight variations
 DIN 1542 Steel plate 3 to 4.75 mm thick (medium plate); thicknesses, sizes, dimension and weight variations
 DIN 1543 Steel plate over 4.75 mm (heavy plate); dimension and weight variations
 DIN 59200 Hot rolled wide flats; dimensions, permissible variations, weights
 DIN 1016 Strip steel; hot rolled

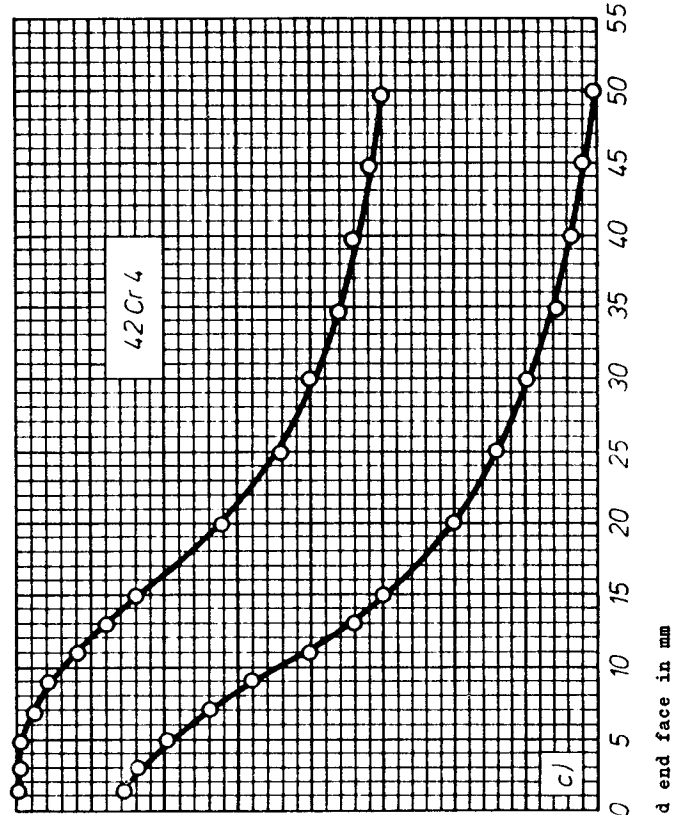
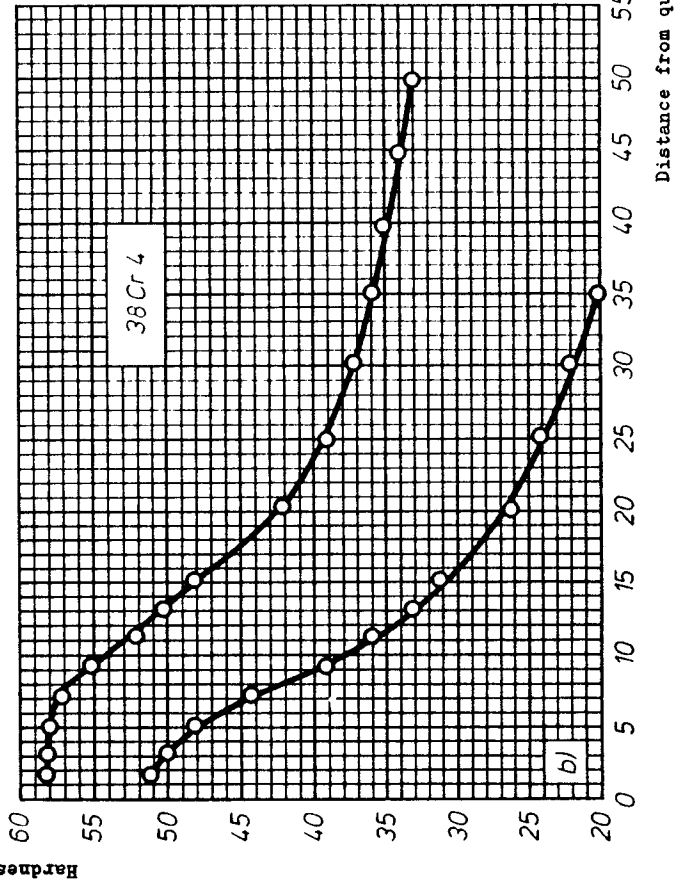
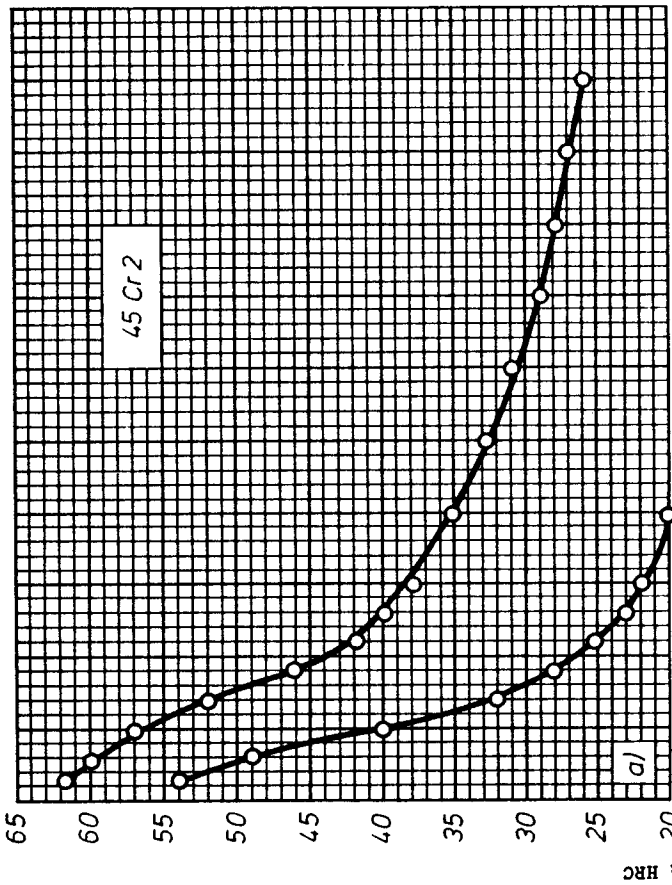
For tubes:

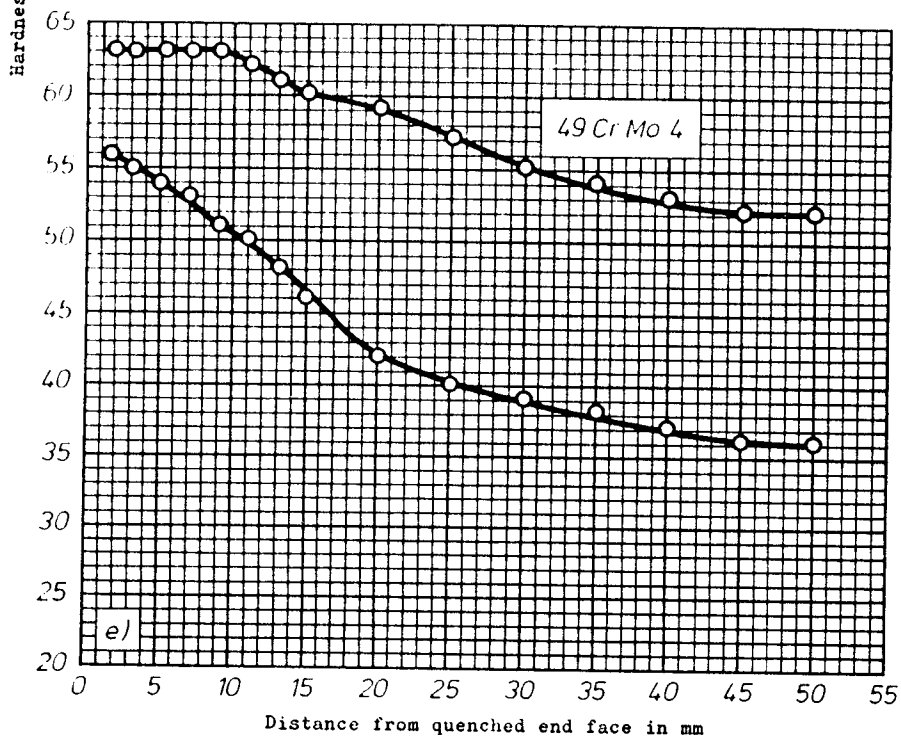
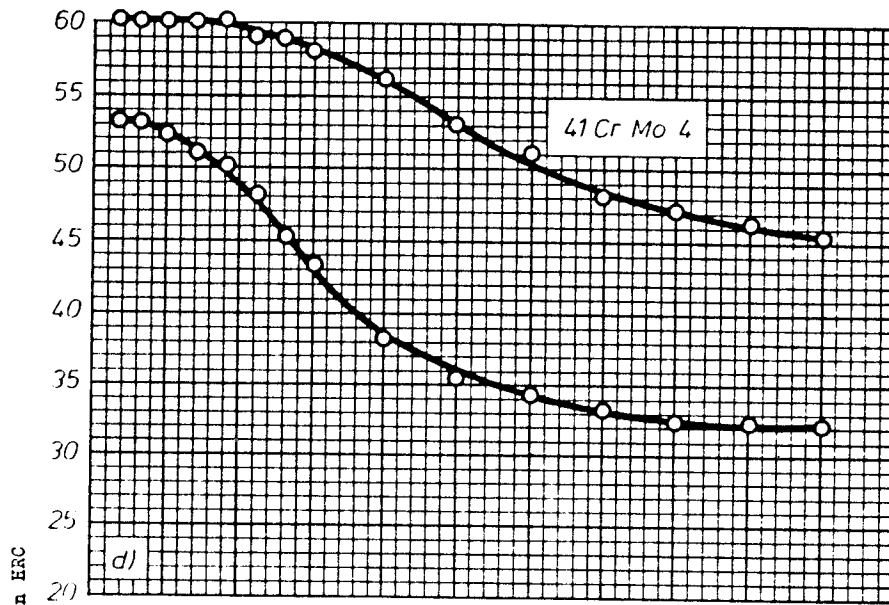
- DIN 2448 Seamless steel tubes; dimensions and weights
 Particulars about permissible dimension variations are also stipulated in
 DIN 1629 Sheet 3 and Sheet 4 Seamless tubes in unalloyed steels for supply purposes, process plant and tanks
 DIN 17175 Sheet 1 Seamless tubes of high-temperature steels; technical conditions of delivery

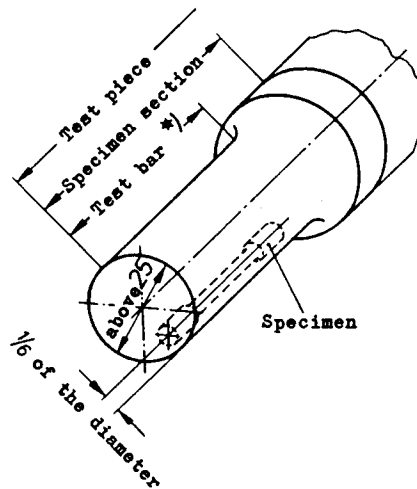
For forgings:

- DIN 7525 Sheet 1 Steel forgings, technical directions for delivery, shape and manufacture; drop-forged, machine-forged and rolled rings
 DIN 7526 -, tolerances and permissible variations for drop forgings
 DIN 7527 Sheet 1 to Sheet 6 -, machining allowances and permissible variations for open-die forged discs and pierced discs, seamless open-die forged rings and bushes, open-die forged rolled and welded rings, forged bars

Figures 1 a to 1 e
Provisional scatter bands of Rockwell C hardness on
testing for hardenability in the end quench test







- *) The test bar produced by hot working of the test piece or specimen section is used
 a) for testing the quenched and tempered ruling cross-section,
 b) for manufacturing specimens for the end quench test (to rough dimension including machining allowance)

Circular cross-sections		Square and rectangular cross-sections	
d to 25 mm	d above 25 mm	a to 25 mm $b \leq a$	a above 25 mm $b \leq a$
Tensile specimen		Notched bar impact specimen	

Figure 2. Position of tensile and notched bar impact specimens
 The condition "position of specimen axis at 1/6 of diameter or of the cross-section diagonal of the specimen section or test bar" is fulfillable for
 t e n s i l e s p e c i m e n s with a head diameter of 10 mm:
 - in the case of round steel from diameters of about 33 mm and upwards
 - in the case of rectangular steel from a length of side of about 39 mm and upwards.
 For n o t c h e d b a r i m p a c t s p e c i m e n s with a 10 mm x 10 mm cross-section the corresponding dimensions are in each case about 3 mm longer. The axis of the notch in the notched bar impact specimen shall be made as nearly perpendicular as possible to the fibre of the material.
 The specified location for removal of the specimen shall be complied with as closely as possible.

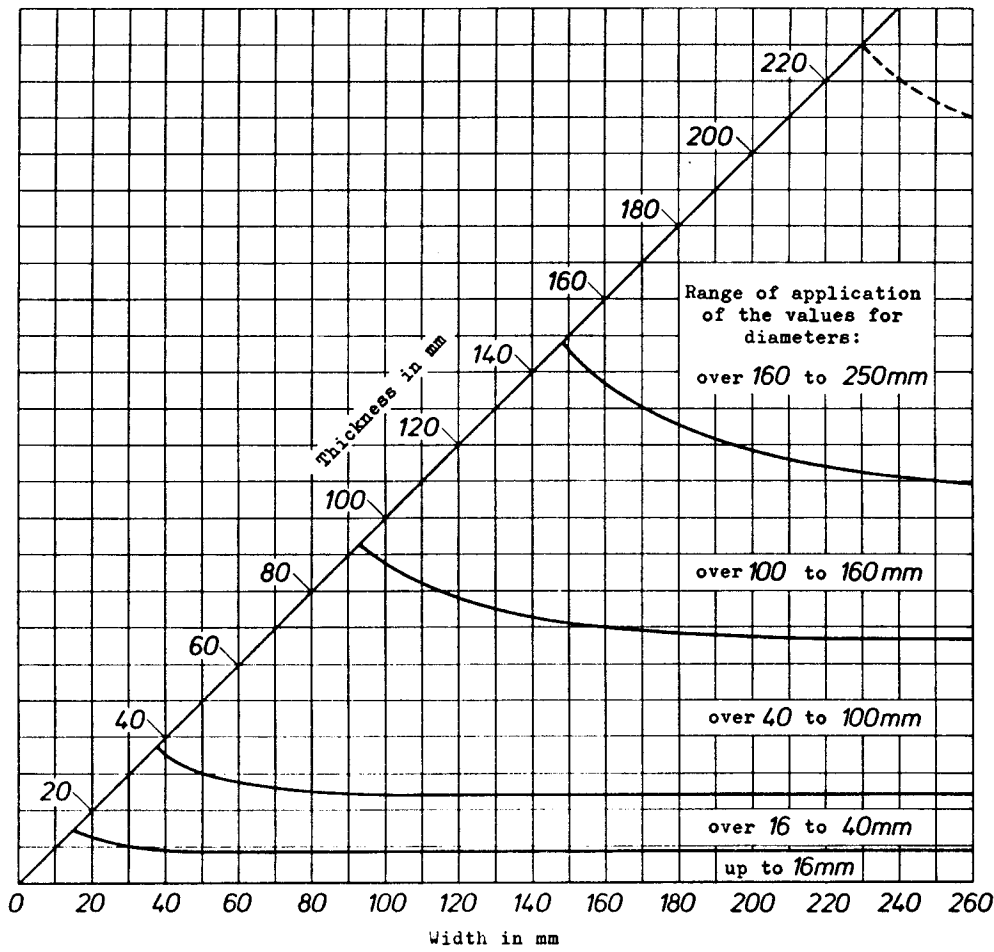


Figure 3. Applicability to square and rectangular cross-sections of the values given for circular cross-sections in the quenched and tempered condition.

Example for application of Figure 3:

For a flat steel with a thickness of 20 mm and a width of 120 mm the mechanical properties stated in Table 6 for the diameter range over 16 and up to 40 mm apply.

Explanations

This first edition of DIN 17212 is based on Stahl-Eisen Data Sheet 830 (3rd edition June 1955) of the Verein Deutscher Eisenhüttenleute (VDEh) (Association of German Ferrous Metallurgists) which has been due for conversion into a DIN standard with the approval of the VDEh, for some years past⁶⁾. Publication of the Standard has been delayed through efforts to secure agreement with the following international standards which have been published in the meantime:

- a) ISO Standard 683/XII - Flame and induction hardening steels - 1972 issue.
- b) Euronorm 86-70 - Flame and induction hardening steels; quality specifications - of March 1971.

Basically, all the unalloyed steels and the alloy steels 38 Cr 4, 42 Cr 4, 41 CrMo 4 and 49 CrMo 4 have been incorporated in the DIN Standard from Stahl-Eisen Data Sheet 830. In addition, the steel 45 Cr 2 has been included. In some cases it was necessary to change the code numbers to allow differentiation from the quenched and tempered steels. Apart from the steel Cf 70, which owes its significance to the fact that it is water-hardenable with high work-hardening and comparatively slight depth-hardening capability, all the steels in DIN 17212 very closely resemble the grades according to DIN 17200 (December 1969 issue). They differ from them only in regard to certain additional guarantees made necessary for ensuring suitability for flame and induction hardening, particularly in respect of closer spreads of carbon content and lower maximum values of phosphorus content.

In its general provisions, formulation and wording also, this Standard has been closely aligned with the new issue of DIN 17200, which was the subject of detailed comments in DIN-Mitteilungen (Vol. 49 (1970) No. 2).

As appears from Table 1, all the steels covered by DIN 17212 - with the exception of Cf 70 and 49 CrMo 4 - are matched by equivalent or comparable grades in the international standards. In addition, the two international delivery conditions contain an alloy steel with about 0.40 % by wt. C, about 0.75 % by wt. Cr, 0.15 to 0.30 % by wt. Mo and 0.70 to 1.0 % by wt. Ni. Moreover, the ISO Standard contains two further unalloyed steels with about 0.41 and about 0.51 % by wt. C plus a further alloy steel with about 0.50 % by wt. Cr, 0.15 to 0.30 % by wt. Mo and 0.40 to 0.70 % by wt. Ni. In Germany there is no requirement for these grades. The other differences between the DIN Standard and the international specifications arise from the aligning of DIN 17212 to the new issue of DIN 17200 and are of no great significance overall.

⁶⁾ See "DIN-Mitteilungen" 40 (1961), p. 490