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December 1988

Hot rolled steels for springs suitable for quenching and tempering

Technical delivery conditions

DIN 17 221

Warmgewalzte Stähle für vergütbare Federn; technische Lieferbedingungen

Supersedes December 1972 edition.

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

See Explanatory notes for connection with International Standard ISO 683/14 : 1973 published by the International Organization for Standardization (ISO) and with EURONORM 89 – 71 published by the European Coal and Steel Community (ECSC).

The clauses and subclauses marked • give specifications which are to be agreed upon at the time of ordering, those marked •• give specifications which are optional and may be agreed upon at the time of ordering.

1 Field of application

1.1 This standard applies to

hot rolled semi-finished products,

hot rolled and, where required, subsequently peeled or ground steel bars (rounds and flats),

hot rolled ribbed spring steel,

hot rolled wire,

hot rolled wide flats, and

hot rolled strip,

made of the spring steels listed in table 2, normally used for the production of quenched and tempered leaf springs, torsion bar springs, conical springs, helical springs, disc springs, spring washers, and any other springy components.

The heat treatment conditions in which the various product forms may be supplied are shown in table 1, and the possible surface finishes are given in subclause 7.2.2.

Note. DIN Standards covering steels that are to meet the same requirements regarding chemical composition as given in table 2, but are supplied in other product forms or other treatment conditions or are intended for particular applications, and other DIN Standards covering spring steels, are listed in the 'Other relevant standards' clause.

1.2 In addition to the requirements specified in this standard, the general technical delivery conditions for steel and steel products given in DIN 17 010 shall apply unless otherwise specified in this standard.

2 Concepts

2.1 Spring steels

Spring steels as defined in this standard are steels which, owing to their resilience in the quenched and tempered condition, are suitable for the production of any type of springy component. The resilience of the steels results from their elastic deformability which enables them to sustain loading to a specific limit without this causing permanent distortion after unloading. The typical characteristics of springs are obtained by increasing the carbon content, by adding alloying elements, such as silicon, manganese, chromium, molybdenum and vanadium, and by heat treatment, i.e. quench hardening in oil or water and subsequent tempering.

2.2 Product forms

The definitions given in EURONORM 79 shall apply for the product forms.

2.3 Types of heat treatment

The terminology used in DIN 17 014 Part 1 shall apply for the types of heat treatment referred to in this standard.

3 • Dimensions, limit deviations and form tolerances

The nominal sizes of the products, the limit deviations and, where applicable, form tolerances shall be agreed at the time of ordering, reference being made, if possible, to the appropriate dimensional standards (see appendix A).

4 Mass

The mass of the steels covered in this standard has been calculated taking the density as 7,85 kg/dm^3.

5 Designation

5.1 The standard designation for steels as covered in this standard shall give in the following order:

the name of product (steel);

the number of this standard;

the material designation or number identifying the steel grade (see table 2) [1];

the heat treatment condition (see subclause 7.2.1 and table 1), where required.

Example:

Steel DIN 17 221 – 50 CrV 4 U

or

Steel DIN 17 221 – 1.8159 U

[1] *DIN-Normenheft* (DIN Standardization booklet) No. 3 provides information on how the material designations and numbers for steels are formed.

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5.2 The specifications given in the relevant dimensional standard shall apply for the standard designation of products.

6 Steel grades

6.1 The specifications of this standard relate to alloyed high-grade steels.

6.2 • The steel grade is to be selected by the purchaser.

7 Requirements

7.1 Manufacturing process

The steelmaking process, the casting process and the forming process shall be at the manufacturer's discretion.

•• In special cases, however, an agreement on this may be made at the time of ordering.

7.2 Heat treatment condition and surface finish of material on delivery

7.2.1 •• Heat treatment condition

Possible heat treatment conditions are as listed in table 1. Unless otherwise agreed at the time of ordering, the products shall be supplied in the untreated condition.

7.2.2 •• Surface finish

Unless otherwise agreed at the time of ordering, the products shall be supplied with a surface as rolled.

If agreed at the time of ordering, the products shall be provided with one of the following surface finishes:

a) hot rolled and pickled;

b) hot rolled and abrasive blasted;

c) hot rolled and peeled or ground;

d) other surface finishes (with details to be agreed).

7.3 Chemical composition, maximum hardness and hardenability

Table 1 summarizes usual combinations of heat treatment conditions of the material on delivery, product forms and requirements regarding chemical composition, maximum hardness and hardenability. The requirements given in column 6 of table 1 shall apply for the relevant heat treatment condition of the material on delivery and for the particular product form.

7.3.1 Table 2 shall apply for the chemical composition determined by the ladle analysis.

7.3.2 The specifications given in table 3 (see also footnote 3 to table 9) shall apply for the limit deviations in the product analysis from the limiting values specified for the ladle analysis (see table 2).

7.3.3 •• It may be agreed at the time of ordering that the requirements given in table 5 be substituted for those given in table 4.

7.4 Shearability

7.4.1 In given circumstances, all steel grades specified in this standard are shearable in the softened condition (G).

7.4.2 54 SiCr 6, 60 SiCr 7, 55 Cr 3, 50 CrV 4 and 51 CrMoV 4 steels are shearable in given circumstances in the 'treated for shearability' condition (C) if their hardness complies with the values specified in table 6.

7.4.3 In given circumstances, 38 Si 7 steel is also shearable in the untreated condition.

7.5 •• Grain size

The steel shall, when tested as described in DIN 50 601, have a grain size index for the austenite of 5 or finer.

7.6 •• Nonmetallic inclusions

If requirements regarding the degree of cleanness (applicable to oxidic nonmetallic inclusions) determined microscopically as specified in DIN 50 602 have been agreed at the time of ordering, the values given in table 7 shall apply for the overall index, K, of the particular cast.

7.7 •• Soundness

Requirements regarding soundness, based, for example, on non-destructive testing, may be agreed at the time of ordering.

7.8 Surface condition

7.8.1 General

7.8.1.1 The products shall have a smooth surface consistent with the forming process used, EURONORM 163 applying for the requirements regarding the surface finish of wide flats.

7.8.1.2 When remedying surface defects, positive deviations from the dimensional tolerances given in the relevant dimensional standards are permitted only on approval of the purchaser or his representative.

7.8.2 •• Maximum depth of crack

It may be agreed at the time of ordering that a specified depth of crack shall not be exceeded.

Specification of a maximum depth of crack, in the case of steel bars and wire rod of circular cross section, should be in accordance with *Stahl-Eisen-Lieferbedingungen* (Iron and steel delivery conditions) 055.

7.8.3 Maximum depth of decarburization

7.8.3.1 •• Requirements regarding the maximum depth of decarburization may be agreed at the time of ordering, the requirements given in table 8 applying for the untreated condition and the 'treated for shearability' condition.

7.8.3.2 The values given in table 8 refer to the diameter in the case of products of circular cross section and to the middle third of the long side of the specimens in the case of products of rectangular cross section.

7.9 Separation of products by casts

Within one consignment, the products shall be separated by casts.

8 Testing

8.1 General

The manufacturer shall be responsible for devising and implementing a quality control system for his production so as to ensure that the requirements specified in clause 7 are met.

•• The issue of a certificate as specified in DIN 50 049 for materials testing carried out at the manufacturer's works or by independent inspectors may be agreed at the time of ordering.

8.2 •• Materials testing certificates issued by the manufacturer's works

8.2.1 If a test report (DIN 50 049 – 2.2) is to be issued in accordance with agreements made at the time of ordering, this report shall specify the results of the ladle analysis for all the elements listed in table 2 for the relevant steel grades.

8.2.2 If a manufacturer's test certificate (DIN 50 049 – 2.3) is to be issued, the required tests shall be agreed.

The document shall give the following details:

a) the results of a ladle analysis for all the elements listed in table 2 for the relevant steel grade;

b) the results of the agreed tests.

8.3 Materials testing certificates issued by independent inspectors

●● Inspection certificates (3.1 A, 3.1 B or 3.1 C) or inspection reports (3.2 A or 3.2 C) shall be issued on the basis of acceptance inspection.

● The required tests or the tests to be carried out in keeping with official regulations and the relevant codes of practice shall be subject to agreement.

●● If acceptance inspection is not to be carried out by a works expert, the body responsible for acceptance inspection or the inspector shall be named.

The document shall give the following details:

a) the information referred to in subclauses 8.2.2 a) and b);

b) the mark identifying the inspector.

8.4 Scope of testing, sampling, preparation of samples and test procedure

8.4.1 Chemical composition, hardness and hardenability

Where the chemical composition is to be analyzed and the hardness and hardenability to be tested, the test conditions specified in table 9 shall apply.

8.4.2 ●● Grain size

If verification of the grain size has been agreed at the time of ordering, one test piece per cast shall be tested.

Unless otherwise agreed at the time of ordering, sampling and sample preparation shall be carried out as described in DIN 50601, and the grain size be determined by the quenching method described in the same standard.

For this test, test pieces not exceeding 20 mm in diameter shall be heated in a furnace brought to heat treatment temperature (and not in a salt bath).

In cases of dispute, the test pieces shall be pretreated at 1150 °C, for 30 minutes, with subsequent cooling in air, to produce a standard initial condition.

8.4.3 Nonmetallic inclusions

The steel shall be checked for freedom from inclusions in accordance with DIN 50602.

8.4.4 ●● Soundness

In cases where testing of the products for their internal soundness (e.g. using ultrasonics) has been agreed, but the test procedure has not been specified, the scope of test, the test conditions and test criteria shall be at the manufacturer's discretion.

8.4.5 ●● Surface defects

Unless otherwise agreed at the time of ordering, the method of checking the products for surface defects, the scope of test and the test criteria shall be at the manufacturer's discretion.

8.4.6 ●● Decarburization

Normally, for determining the depth of decarburization, sufficient sharp-edged polished sections shall be prepared from products in their as delivered condition, in accordance with DIN 50192, and etched and examined microscopically. Unless otherwise agreed at the time of ordering, the scope of test shall be at the manufacturer's discretion.

In the case of products of circular cross section, the average of four measurements, perpendicular to each other and including the maximum depth of decarburization, shall be determined.

In the case of products of rectangular cross section, the middle third of the long side of the specimen shall be tested and the average of the maximum depth of decarburization, measured from the top and bottom faces, be determined.

8.4.7 ●● Visual examination and check of dimensions

Unless otherwise agreed at the time of ordering, the procedure for visual examination and check of dimensions shall be at the manufacturer's discretion.

8.4.8 Retests

The specifications given in DIN 17010 shall apply for retests.

9 Marking

9.1 The manufacturer shall mark the products or the bundles or packages, as far as possible in compliance with DIN 1599, so that the cast, the steel grade and the source of the consignment can be identified.

9.2 If the consignments are to be accompanied by documents covering acceptance inspection, the marking shall additionally include the test piece number and the inspector's mark.

9.3 ●● Any further requirements with regard to the marking of the products may be agreed at the time of ordering.

10 Complaints

10.1 Under current law, warranty claims may only be raised against defective products if the defects impair their processing and use to a more than negligible extent. This shall apply unless otherwise agreed at the time of ordering.

10.2 It is normal and practical for the purchaser to give the supplier the opportunity to judge whether the complaints are justified, if possible by submitting the product objected to or samples of the products supplied.

Table 1. **Heat treatment conditions and product forms in which steels are usually supplied and associated requirements as specified in tables 2 to 6**

No.	1		2	3	4	5	6		
1	Heat treatment condition of material on delivery		Product form				The following requirements given in tables 2 to 6 shall apply:		
		Code letter	Semi-finished product	Steel bars (rounds and flats) and ribbed spring steel	Wire rod	Wide flats; strip	6.1	6.2	6.3
2	Untreated	No code letter, or U	×	×	×	×	Chemical composition as in tables 2 and 3.	–	Hardenability as in table 4 or, if agreed at the time of ordering, as in table 5.
3	Treated for shearability	C	×	×	–	×		Maximum hardness as in table 6, column 2.	
4	Softened	G	×	×	×	×		Maximum hardness as in table 6, column 3.	
5	Spheroidized	GKZ	–	×	×	×		Maximum hardness as in table 6, column 4.	
6	•• If a treatment condition other than those given in lines 2 to 5 is required, this shall be specified in uncoded form in the order; in such cases, the product form and the requirements shall be agreed at the time of ordering.								

Table 2. **Chemical composition (ladle analysis)**

Steel grade		% by mass [1]							
Material designation	Material number	C	Si	Mn	P max.	S max.	Cr	Mo	V
38 Si 7	**1.5023**	0,35 to 0,42	1,50 to 1,80	0,50 to 0,80	0,030	0,030	–	–	–
54 SiCr 6	**1.7102**	0,51 to 0,59	1,20 to 1,60	0,50 to 0,80	0,030	0,030	0,50 to 0,80	–	–
60 SiCr 7	**1.7108**	0,57 to 0,65	1,50 to 1,80	0,70 to 1,00	0,030	0,030	0,20 to 0,40	–	–
55 Cr 3	**1.7176**	0,52 to 0,59	0,25 to 0,50	0,70 to 1,10	0,030	0,030	0,70 to 1,00	–	–
50 CrV 4	**1.8159**	0,47 to 0,55	0,15 to 0,40	0,70 to 1,10	0,030	0,030	0,90 to 1,20	–	0,10 to 0,20
51 CrMoV 4	**1.7701**	0,48 to 0,56	0,15 to 0,40	0,70 to 1,10	0,030	0,030	0,90 to 1,20	0,15 to 0,25	0,08 to 0,15

[1] Elements not listed in this table shall not be deliberately added to the steel except for finishing the cast, without the purchaser's approval. In cases of doubt, the limits given in EURONORM 20 shall apply.

Table 3. **Amounts by which the chemical composition as determined by product analysis may deviate from the limiting values specified in table 2 for the ladle analysis**

Element	Maximum permissible content in the ladle analysis % by mass	Limit deviations in the product analysis from the limiting values specified for the ladle analysis [1] % by mass
C	≤ 0,55 > 0,55 ≤ 0,65	0,02 0,03
Si	≤ 0,40 > 0,40 ≤ 1,80	0,03 0,05
Mn	≤ 1,00 > 1,00 ≤ 1,10	0,04 0,05
P	≤ 0,030	0,005
S	≤ 0,030	0,005
Cr	≤ 1,20	0,05
Mo	≤ 0,25	0,03
V	≤ 0,20	0,02

[1] If several product analyses are to be carried out, the deviations shown by one element within one cast shall lie either only above the upper limit or below the lower limit of the range specified for the ladle analysis.

Table 4. **Limiting values of Rockwell C hardness determined in the end quench test (quench hardening from 850 °C)**

Steel grade		Limits of scatterband	Hardness, in HRC, at a distance from quenched end, in mm														
Material designation	Material number		1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
54 SiCr 6 [1]	**1.7102** [1]	Maximum	67	66	65	63	62	60	57	55	47	43	40	38	37	36	35
		Minimum	57	56	55	50	44	40	37	35	32	30	28	26	25	24	24
60 SiCr 7 [1]	**1.7108** [1]	Maximum	68	68	67	65	63	61	60	58	51	46	43	41	39	39	38
		Minimum	60	59	57	54	48	45	42	39	35	32	31	30	29	28	28
55 Cr 3 [1]	**1.7176** [1]	Maximum	67	67	66	65	64	63	62	61	56	53	49	46	43	41	40
		Minimum	59	58	56	55	53	49	44	39	32	30	28	26	25	24	23
50 CrV 4	**1.8159**	Maximum	65	65	64	64	63	63	63	62	62	62	61	60	60	59	58
		Minimum	57	56	56	55	53	52	50	48	44	41	37	35	34	33	32
51 CrMoV 4 [1]	**1.7701** [1]	Maximum	67	67	67	67	67	67	67	67	66	66	66	65	65	65	64
		Minimum	58	58	58	57	57	57	57	57	56	56	56	55	54	53	52

[1] The limiting values of Rockwell C hardness are to be regarded as provisional.

Table 5. **Maximum product dimensions ensuring hardenability** (see subclause 7.3.3)

1		2		3			4		
Steel grade		Quench hardening		Minimum hardness in the core after quenching [1), 2)]	Maximum size, in mm, for		Minimum hardness in the core after quenching [1), 3)]	Maximum size, in mm, for	
Material designation	Material number	from a temperature of, in °C	in	HRC	flat products (thickness)	round steel (diameter)	HRC	flat products (thickness)	round steel (diameter)
38 Si 7	1.5023	830 to 860	water	47	10	12	56	–	–
54 SiCr 6	1.7102	830 to 860	oil [4)]	54	[5)]	20 [6), 7)]	56	12 [7)]	18 [7)]
60 SiCr 7	1.7108	830 to 860	oil [4)]	54	18 [7)]	25 [7)]	56	14 [7)]	22 [7)]
55 Cr 3	1.7176	830 to 860	oil [4)]	54	16 [7)]	25 [7)]	56	14 [7)]	22 [7)]
50 CrV 4	1.8159	830 to 860	oil [4)]	54	25 [7)]	40 [7)]	56	20 [7)]	30 [7)]
51 CrMoV 4	1.7701	830 to 860	oil [4)]	54	45 [7)]	65 [7)]	56	35 [7)]	60 [7)]

[1)] Applies to the quench hardening temperatures given in column 2.

[2)] A higher percentage of bainite is to be expected.

[3)] A lower percentage of bainite is to be expected.

[4)] A heavy-duty quenching oil shall be used for quench hardening.

[5)] •• Where applicable, the dimension is to be agreed at the time of ordering.

[6)] Provisional value.

[7)] The maximum dimensions listed in this table can only be achieved if the range of limit deviations specified for the ladle analysis is more restricted so that the Jominy curves lie within the upper two-thirds of the scatterband given in table 4.

Table 6. **Maximum hardness of products supplied in different heat treatment conditions**

1		2	3	4
Steel grade		Maximum Brinell hardness in the		
Material designation	Material number	'treated for shearability' condition C	softened condition G	spheroidized condition GKZ
38 Si 7	1.5023	–	217	200
54 SiCr 6	1.7102	280	248	230
60 SiCr 7	1.7108	280	248	230
55 Cr 3	1.7176	280	248	200
50 CrV 4	1.8159	280	248	210
51 CrMoV 4	1.7701	280	248	225

Table 7. **Microscopic degree of cleanness**
(applies to oxidic nonmetallic inclusions; cf. subclause 7.6)

Steel bars, diameter, d, or cross section of equal area, in mm	Overall index, K (oxides), for the individual cast
$70 < d \leq 100$	$K4 \leq 40$
$35 < d \leq 70$	$K4 \leq 35$
$17 < d \leq 35$	$K3 \leq 40$
$8 < d \leq 17$	$K3 \leq 30$
$d \leq 8$	$K2 \leq 35$

Table 8. **Maximum depth of decarburization** [1])

Steel grade		Flat products		Round steel	
Material designation	Material number	Thickness, s, in mm	Maximum depth of decarburization [1]), in mm	Diameter, d, in mm	Maximum depth of decarburization [1]), in mm
38 Si 7 54 SiCr 6 60 SiCr 7	1.5023 1.7102 1.7108	$5 \leq s \leq 25$	$0{,}01 \cdot s + 0{,}25$	$\leq 14{,}5$	0,25
				$> 14{,}5$	$0{,}017 \cdot d$
55 Cr 3 50 CrV 4 51 CrMoV 4	1.7176 1.8159 1.7701	$5 \leq s \leq 80$	$0{,}01 \cdot s + 0{,}15$	≤ 10	0,15
				> 10	$0{,}015 \cdot d$

[1]) Partial decarburization cannot always be avoided for 38 Si 7, 54 SiCr 6 and 60 SiCr 7 steels. On the lines of the Explanatory notes, 55 Cr 3, 50 CrV 4 and 51 CrMoV 4 steels shall be free from decarburization.

Table 9. **Test conditions for verifying compliance with the requirements** [1]

No.	1 Property	See table(s)	2 Test unit [2]	3 Number of test pieces per test unit	4 Number of tests per test piece	5 Sampling and sample preparation	6 Test method to be used
1	Chemical composition	2 and 3	S	The manufacturer shall inform the customer of the results of the ladle analysis. See footnote 3 as to whether a product analysis is to be carried out.			
2	Hardenability in end quench test	4	S	1	1	As described in DIN 50191; ladle analysis also permitted.	The test shall be carried out as described in DIN 50191. The quench hardening temperature shall conform to the specifications given in table 4. The hardness values shall be determined as described in DIN 50103 Part 1, method C.
3	Hardenability (core hardness)	5	S	1	1	Depending on the core hardness required, the test piece shall have the cross-sectional dimensions given in table 5 for 54 HRC or 56 HRC and a length of not less than 2 d (d being the diameter or thickness). It shall be quench hardened in accordance with the specifications given in table 5 and cut through the middle perpendicular to the fibre. The test pieces shall be tested with their as delivered dimensions. If these dimensions exceed the maximum dimensions specified in table 5, they shall be reduced by machining down to the relevant maximum dimension.	The hardness shall be determined as described in DIN 50103 Part 1, method C.
4	Hardness in the C, G or GKZ condition	6	S+W	1	1	In cases of arbitration, the hardness shall be determined, where possible on the product surface, at a distance equal to one diameter or one (smaller) side length from one end, and, in the case of square and flat products, in addition at a distance equal to 0,25 times the product thickness or width from a longitudinal edge. ●● If the above specifications cannot be complied with, appropriate agreements shall be made at the time of ordering. Sample preparation as described in DIN 50351.	As described in DIN 50351.

[1] Verification is only necessary for products for which the relevant requirement referred to in column 6 of table 1 is deemed to apply and the relevant method of test has been agreed.

[2] S = cast, W = heat treatment batch.

[3] ●● If checking of the chemical composition has been agreed at the time of ordering, one product analysis per cast shall be made, unless otherwise specified. The specifications given in *Stahl-Eisen-Prüfblatt* (Iron and steel test sheet) 1805 shall apply for sampling and sample preparation. The analytical procedure shall be in compliance with the specifications given in *Handbuch für das Eisenhüttenlaboratorium* (Handbook for the ferrous metallurgy laboratory).

Appendix A

Dimensional standards relating to products covered in this standard

Hot rolled wire

DIN 59110	Steel wire rod; dimensions, permissible deviations and mass
DIN 59115	Steel wire rod for bolts, nuts and rivets; dimensions, permissible deviations and mass

Hot rolled bars

DIN 1013 Part 1	Steel bars; hot rolled round steel for general purposes; dimensions, permissible dimensional deviations and deviations of form
DIN 1013 Part 2	Steel bars; hot rolled round steel for special purposes; dimensions, permissible dimensional deviations and deviations of form
DIN 1017 Part 1	Steel bars; hot rolled flats for general purposes; dimensions, mass and permissible deviations
DIN 1017 Part 2	Steel bars; hot rolled flats for special applications (for use in bar drawing shops, screw works, etc.); dimensions, mass and permissible deviations
DIN 1570	Hot rolled ribbed spring steel; dimensions, mass, permissible deviations and static values
DIN 2077	Hot rolled round spring steel; dimensions, permissible deviations and form deviations
DIN 4620	Hot rolled spring steel for laminated leaf springs
DIN 59130	Steel bars; hot rolled round steel for bolts and rivets; dimensions, permissible dimensional and form deviations
DIN 59145	Hot rolled steel strip with semicircular edges for leaf springs; dimensions, permissible deviations, mass and moment of inertia

Hot rolled strip and hot rolled wide flats

DIN 1016	Steel flat products; hot rolled sheet and strip; limit deviations, form and mass tolerances
DIN 59200	Steel flat products; hot rolled wide flats; dimensions, permissible deviations, deviations of form and in mass

Bright round steel

DIN 668	Bright round steel; dimensions and permissible deviations according to ISO tolerance zone h11
DIN 670	Bright round steel; dimensions and permissible deviations according to ISO tolerance zone h8
DIN 671	Bright round steel; dimensions and permissible deviations according to ISO tolerance zone h9
DIN 59360	Ground and polished bright round steel; dimensions and permissible deviations according to ISO tolerance zone h7
DIN 59361	Ground and polished bright round steel; dimensions and permissible deviations according to ISO tolerance zone h6

Standards and other documents referred to

DIN 1599	Identification markings for steel
DIN 17010	General technical delivery conditions for steel and steel products
DIN 17014 Part 1	Heat treatment of ferrous materials; terminology
DIN 50049	Materials testing certificates
DIN 50103 Part 1	Testing of metallic materials; Rockwell hardness tests; C, A, B, F scales
DIN 50191	Hardenability testing of steel by end quenching
DIN 50192	Determination of depth of decarburization
DIN 50351	Testing of metallic materials; Brinell hardness test
DIN 50601	Metallographic examination; determination of the ferritic or austenitic grain size of steel and ferrous materials
DIN 50602	Metallographic examination; microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions
EURONORM 20	Definition and classification of steel grades
EURONORM 79	Definition and classification of steel products by shape and dimensions
EURONORM 163	Delivery conditions for surface finish of hot rolled plates and wide flats

Stahl-Eisen-Lieferbedingungen 055 *) (at present at the stage of draft) *Warmgewalzter Stabstahl und Walzdraht mit rundem Querschnitt und nicht profilierter Oberfläche; Oberflächen-Güteklassen; technische Lieferbedingungen* (Hot rolled steel bars and wire rod of circular cross section and non-profiled surface; surface quality classes; technical delivery conditions)

Stahl-Eisen-Prüfblatt 1805 *) *Probenahme und Probenvorbereitung für die Stückanalyse bei Stählen* (Sampling and sample preparation for product analysis of steels)

Handbuch für das Eisenhüttenlaboratorium *) (in loose-leaf form)

*) Obtainable from *Verlag Stahleisen mbH*, Postfach 8229, D-4000 Düsseldorf 1.

DIN-Normenheft 3 *Kurznamen und Werkstoffnummern der Eisenwerkstoffe in DIN-Normen und Stahl-Eisen-Werkstoffblättern* (Material designations and material numbers for ferrous materials dealt with in DIN Standards and iron and steel materials sheets)

Other relevant standards

DIN 17200	Steels for quenching and tempering; technical delivery conditions
DIN 17222	Cold rolled steel strip for springs; technical delivery conditions
DIN 17223 Part 1	Round steel wire for springs; patented cold drawn carbon steel wire for springs; technical delivery conditions
DIN 17223 Part 2	Round steel wire for springs; quality specifications; quenched and tempered spring wire and quenched and tempered valve spring wire made from unalloyed steels
DIN 17224	Stainless steel wire and strip for springs; technical delivery conditions

Previous editions

DIN 1669: 02.42x; DIN 17221: 04.55, 12.72.

Amendments

The following amendments have been made to the December 1972 edition.

a) 51 Si 7 steel is no longer specified. 54 SiCr 6 steel has been included.
b) 38 Si 7 and 60 SiCr 7 steels have been included as high-grade steels.
c) The specifications regarding chemical composition have been amended.
d) The 'spheroidized' as delivered condition (GKZ) has been included.
e) Only code letters have been specified to identify the various treatment conditions.
f) The previous system of conditions in which the products are to be supplied (requirement classes) has been dropped.
g) Limiting values of Rockwell C hardness for Cr alloyed steels when tested for hardenability in the end quench test have been included.
h) The limit deviations for the hardenability of steels have been amended and limit deviations for a core hardness of 56 HRC have been included.
i) Specifications regarding chemical properties of products in the quenched and tempered condition are no longer included since products complying with this standard are not supplied in the quenched and tempered condition.
j) The maximum values of hardness of products in the softened condition have been amended. Guideline values for the hardness of products in the untreated condition have been deleted.
k) The specifications regarding the maximum permissible content of oxidic nonmetallic inclusions have been quantified.
l) New specifications have been made for the permissible depth of decarburization, including values for Si alloyed steels.
m) Detailed information on hot forming and heat treatment has been omitted.
n) No examples of use referring to a particular steel grade have been given.
o) The standard has been editorially revised.

Explanatory notes

Steel grades and chemical composition

51 Si 7 steel, which has been approved by the *Deutsche Bundesbahn* (German Federal Railways) for the production of buffers and leaf springs, are no longer specified in this standard since there is only limited demand for this steel grade.

By way of departure from DIN 17200 (specifying a maximum Si content of 0,40 %), this standard specifies an Si content ranging from 0,15 to 0,40 % for 50 CrV 4 steel (although the lower limit is irrelevant to the deoxidation of the steel), the lower limit being considered indispensable by the spring manufacturers to ensure adequate spring elasticity. Normally, such a departure would have involved a change of the material designation; the proposed amendment was, however, rejected by users as this would necessitate costly alterations to existing documentation.

Current studies carried out by the automobile industry seem to suggest the advisability of a reduction of the phosphorus and sulfur contents to a minimum if the steel is to have a high strength. Such a reduction will be considered in a future edition of this standard, pending completion of these studies. In this context, however, the car manufacturers indicated that some of their customers required a minimum sulfur content in order to improve machinability and that the sulfur distribution was more important than the sulfur content, other factors (strength and tempering temperature) also requiring consideration. A further reduction of the phosphorus content was found to be premature taking into account the fact that the degree of cleanness and the amount of trace elements also affect the service life of springs.

Hardenability

The limiting values specified for the hardenability of 50 CrV 4 steel in table 4 comply with those given in DIN 17200, the hardenability scatterbands specified for 54 SiCr 6, 60 SiCr 7, 55 Cr 3 and 51 CrMoV 4 steels are not based on statistically reliable figures and do not represent the full ranges of chemical composition specified in table 2; thus, these values are to be regarded as provisional. At present no corresponding values are available for 38 Si 7 steel.

It may be agreed at the time of ordering that the limit deviations for a core hardness of 54 HRC (or 47 HRC for 38 Si 7 steel) or of 56 HRC be substituted for the hardenability scatterbands specified in table 4. Most of the values associated with 54 HRC have been verified on the basis of hardenability scatterbands, whereas those associated with 56 HRC have been extrapolated, starting from the lower limiting curve and covering the upper two-thirds of the respective scatterband. Values associated with a minimum core hardness of 56 HRC have been included, owing to a certain demand for high-stress springs with a virtually martensic structure.

Decarburization

The permissible depths of decarburization specified in table 8 apply to the untreated and treated for shearability conditions. When comparing the values given in table 7 of the 1972 edition for the untreated condition with those specified in table 8 of this edition, it should be taken into account that more stringent requirements have been specified here (cf. subclauses 7.8.3 and 8.4.6).

There was general agreement that partial decarburization may occur over the entire circumference of Si alloyed steels, and that complete decarburization at so-called contact points could not always be prevented when rolling steel containing alloying elements other than Si. Such decarburization is not thought to pose a substantial problem, as the products are peeled or ground during further processing.

As already described in the December 1972 edition of this standard, the decarburization depth is to be measured in the middle third of the long side in the case of products of rectangular cross section, as only measurements in this zone provide reliable results. In this context, it should be noted that the 'crucial measuring point', i.e. the zone exhibiting the maximum depth of decarburization, is not material-related but depends on the shape of the section and on other factors, such as on the position of the original edges of the billet. Such details could only be covered in the relevant dimensional standard, which would require further research and documentation.

In the discussions leading to the revised edition of this standard, the spring manufacturers considered it feasible to restrict the depth of decarburization to 1,0 % or, at the most, to 1,2 % of the diameter of circular steel products containing alloying elements other than Si. This view was founded on an analysis of orders received and on an increasing demand for high-quality springs of smaller diameters, requiring a further reduction of the permissible depth of decarburization, in particular for the diameter range from 10 to 20 mm. The steel manufacturers, whilst appreciating the spring manufacturers' request, felt it to be impossible to comply with it, pointing out that the values specified already constitute more stringent requirements and that inter-laboratory measurements of the maximum depth of decarburization had shown differing results. Furthermore, chassis springs, for example, would be machined prior to quenching and tempering, and strength blasting could partly compensate for decarburization. The results of an investigation published in *Z. Werkstofftechnik*, 1986: 17, 350–356, suggested that specimens subjected to a specific decarburization treatment under defined laboratory conditions and subsequently blasted, did not exhibit any signs of reduced service life.

It was proposed that comparative tests be made on circular and flat steel products to provide a standard method of measuring the carburization depth and that hardness measurements as described in DIN 1654 be performed in cases of arbitration.

Connection with EURONORM 89-71 and ISO 683/14 : 1973

Since EURONORM 89-71 requires revision and ISO 683/14 : 1973 is being revised, the following gives only a summary of differences or agreements regarding the selection of steel grades.

Steel grades comparable with 55 Cr 3, 50 CrV 4 and 51 CrMoV 4 are specified in EURONORM 89-71 and in the ISO document. The latter covers steel grades comparable with 54 SiCr 6 and 60 SiCr 7 steels and only one Si alloyed steel. EURONORM 89-71 specifies four Si alloyed steels; but the carbon content is higher than that of the 38 Si 7 steel specified in this standard. The present standard does not specify a steel grade that is comparable with 60 SiCr 8 and 45 SiCrMo 6 steels listed in EURONORM 89-71 or with 60 SiCr 4 2, 60 Cr 3, 60 CrB 3 and 60 CrMo 3 as given in the ISO document.

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