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DEUTSCHE NORM

October 1983

Creep resistant steel plate and strip

Technical delivery conditions

DIN 17 155

Blech und Band aus warmfesten Stählen; technische Lieferbedingungen

Supersedes
DIN 17 155 Part 1, January 1959 edition,
DIN 17 155 Part 2, January 1959 edition
and DIN 17 155 Part 2 Supplement,
June 1969 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.

For connection with International Standards, see Explanatory notes.

The clauses and subclauses marked with a dot • contain information on agreements to be made at the time of ordering. The subclauses marked with two dots •• contain information on agreements which may be made additionally at the time of ordering.

1 Field of application

1.1 This standard applies to hot rolled plate and strip made from the creep resistant steels listed in table 1, which are mainly used in steam boiler plants, pressure vessels, large diameter pressure pipelines and similar components.

If the products made from steels in accordance with this standard are manufactured or used for plants subject to regular inspection, then the relevant codes of practice shall be observed, e.g. the *Technische Regeln für Druckbehälter (TRB)* (Technical rules on pressure vessels), the *Technische Regeln für Dampfkessel (TRD)* (Technical rules on steam boilers) and the *Technische Regeln Druckgase (TRG)* (Technical rules on pressure gases). The same applies to other fields of application for which additional specifications exist.

1.2 This standard does not apply to creep resistant steel products in respect of which separate technical delivery conditions already apply, e.g. it does not apply to pipes in accordance with DIN 17 175 and DIN 17 177.

1.3 In addition to the specifications given in this standard, the general technical delivery conditions for steel and steel products specified in DIN 17 010 shall apply, unless anything to the contrary has been specified below.

2 Concepts

2.1 **Creep resistant** steels within the meaning of this standard are steels which exhibit long term stress properties at elevated temperatures, in some cases up to 600 °C.

2.2 The **forms of product** are governed by the definitions laid down in EURONORM 79.

3 • Dimensions and permissible dimensional deviations

The nominal sizes of the products and the permissible dimensional deviations shall be agreed at the time of ordering, with reference to Standards DIN 1016 or DIN 1543.

4 Weights

A density of 7,85 kg/dm^3 shall be taken as the basis for the weight calculation of all steels in accordance with this standard.

5 Classification of grades

5.1 This standard comprises the steel grades listed in table 1.

5.2 • The selection of steels is left to the purchaser's discretion.

6 Designation and ordering

6.1 Designation of steel grades

The symbols and material numbers of the steel grades are to be obtained from table 1. The symbol or the material number of the steel grade concerned shall be incorporated in the standard designation for the products in accordance with the examples given in the dimensional standards.

6.2 Designation for order purposes

The following information shall be included in the designation for order purposes: quantity, form of product, dimensional standard, symbol or material number of the required steel grade, as delivered condition in cases where the products have to be supplied in a condition other than the normalized condition, and dimensions.

7 Requirements

7.1 Steelmaking processes

7.1.1 The steels shall be produced either by the basic oxygen process, the open hearth process or in the electric furnace.

Subject to agreement with the purchaser, a different but equivalent process may also be used.

Continued on pages 2 to 16

7.1.2 Apart from UH I steel, which is to be supplied unkilled, all the steel grades in accordance with this standard shall be fully killed, i. e. they shall be neither unkilled nor semi-killed.

7.2 As delivered condition

UH I, H I, H II, 17 Mn 4, 19 Mn 6 and 15 Mo 3 steels are normally supplied in the normalized condition, whilst 13 CrMo 4 4 and 10 CrMo 9 10 steels are supplied in the air-hardened condition.

•• Subject to special agreement at the time of ordering, UH I, H I, H II, 17 Mn 4, 19 Mn 6 and 15 Mo 3 steels may also be supplied in the untreated condition, whilst 13 CrMo 4 4 and 10 CrMo 9 10 steels may be supplied in the normalized condition, and only in exceptional cases in the untreated condition.

7.2.2 For UH I, H I, H II, 17 Mn 4 and 19 Mn 6 steels, normalizing may be replaced by an equivalent temperature control during and after rolling. This implies that even after subsequent normalizing the requirements have to be satisfied [1].

7.3 Chemical composition

7.3.1 The data of table 1 are applicable to the chemical composition after the cast analysis. Minor deviations from these values are permitted if the mechanical properties satisfy the requirements of this standard, and if the weldability is not impaired.

7.3.2 During the check test of the chemical composition on the test piece in accordance with the instructions contained in subclauses 8.4.1 and 8.5.1 relating to sampling and to the analysis method, the results may deviate from the limiting values for the chemical composition given in table 1 by the amounts given in table 2.

7.4 Mechanical properties

7.4.1 The values specified in tables 3 and 4 shall apply to test pieces taken and prepared in accordance with subclause 8.4.2. After stress relieving in accordance with table 8.1, the values for yield strength and tensile strength specified in tables 3 and 4 may be fallen short of by up to 10 %; the long term creep and stress rupture properties are not adversely affected thereby.

7.4.2 If both ends of a rolled slab are subjected to a test, the maximum difference in tensile strength values determined at the two ends shall not exceed the following values, depending on the steel grades concerned:

70 N/mm² max. for UH I, H I, H II, 17 Mn 4, 19 Mn 6, 15 Mo 3 and 13 CrMo 4 4 steels,

80 N/mm² max. for 10 CrMo 9 10 steel.

7.4.3 The values listed in tables 3 and 4 shall apply to transverse test pieces.

7.4.4 •• At the time of ordering, compliance with one of the quality classes Z 1, Z 2 or Z 3 as specified in the *Stahl-Eisen-Lieferbedingungen* (Iron and steel delivery conditions) 096, as characterized by a minimum reduction in area after fracture of tensile test pieces perpendicular to the surface of the product, may be agreed.

7.4.5 If the impact values can only be verified on test pieces exhibiting a width of less than 10 mm but at least 5 mm, because of the low thickness of the product concerned, the minimum values specified in table 3 will be reduced proportionately to the cross section of the test piece.

7.5 Surface finish and soundness

7.5.1 The products shall have a smooth surface commensurate with the shaping process used.

7.5.2 Surface defects exceeding the extent permitted for imperfections shall be eliminated by suitable means. The indentations formed as a result shall be flattened out.

•• Unless anything to the contrary has been agreed at the time of ordering, the permissible thickness deviations specified in the dimensional standards shall be adhered to.

Note. See also the *Stahl-Eisen-Lieferbedingungen* 071.

Surface defects may only be repaired by welding with the approval of the purchaser and of the inspector responsible for the acceptance test.

7.5.3 The products shall be free of any internal defects which might impair their usability more than marginally.

•• An agreement in accordance with *Stahl-Eisen-Lieferbedingungen* 072 may be made in respect of the ultrasonic testing of heavy plate for internal discontinuities.

8 Testing

8.1 Acceptance tests

Supplies in accordance with this standard shall be subjected to acceptance testing.

8.2 Tests to be carried out

At least the following tests shall be carried out:

- tensile test at room temperature;
- tensile test at elevated temperature;
- impact test at 0 or 20 °C for products with thicknesses equal to or exceeding 5 mm;
- visual inspection in respect of surface condition;
- dimensional check,
- any further tests specially agreed upon at the time of ordering, e. g. product analysis.

8.3 Scope of test programme

8.3.1 In cases where the verification of the chemical composition in accordance with the product analysis has been agreed at the time of ordering, this verification shall be carried out on one test piece per melt.

8.3.2 The following units shall be regarded as the test unit for verifying mechanical properties, with the exception of the determination of the 0,2 % proof stress at elevated temperatures:

- the as rolled plate, for plate;
- the coil, for strip and sheet cut therefrom.

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[1] If normalizing is replaced by an equivalent temperature control during and after rolling, the manufacturer shall carry out an initial verification to demonstrate that a condition equivalent to the normalized condition has been attained with adequate certainty, if the products are to be used for plants subject to regular inspection.

The specifications laid down in subclauses 8.3.2.1 to 8.3.2.3 shall apply as regards the number of samples to be taken per test unit for carrying out the tensile test at room temperature (15 to 35 °C) and of the impact test.

8.3.2.1 In the case of plate supplied in delivered product lengths not exceeding 7 m per as rolled plate, one sample shall be taken from one end of each as rolled plate.

8.3.2.2 In the case of plate supplied in delivered product lengths exceeding 7 m per as rolled plate, one sample shall be taken from both ends of each as rolled plate.

8.3.2.3 In the case of sheet cut from strip, one test sample each shall be taken from the inner and the outer end of the coil.

If the strip is supplied coiled, a test sample need only be taken from the outer end.

8.3.3 For the hot tensile test, either 30 t per melt or a smaller quantity submitted for testing shall qualify as test unit.

One test sample shall be taken per test unit.

8.3.4 All products made from the 15 Mo 3, 13 CrMo 4 4 and 10 CrMo 9 10 alloyed steels shall be subjected to an appropriate test by the manufacturer to ensure that no material mix-up has occurred.

8.3.5 The thickness of all products shall be measured.

8.3.6 All products shall be checked in respect of their surface condition.

8.4 Sampling and preparation of test pieces

8.4.1 In cases where verification of the chemical composition on the basis of the product analysis has been agreed at the time of ordering, the *Stahl-Eisen-Prüfblatt* (Iron and steel test sheet) 1805 shall apply in respect of sampling and of the preparation of the test pieces. In the case of arbitration chips shall be taken in a uniform manner over the entire cross section of the product.

8.4.2 For the mechanical tests, samples shall be taken from a position at one quarter of the product width (see figure 1). In the case of strip, samples shall be taken at an adequate distance from the end of the strip.

Note. If samples have to be taken from the middle zone in relation to the width of the product, because of requirements relating to the thickness, then the samples to be taken as specified in subclause 8.4.2 may also be taken from that zone.

8.4.2.1 The samples shall be sized in such a way that specimens for retests can be taken from them if necessary (see subclause 8.6).

8.4.2.2 For products which are not supplied in the normal delivery condition, the sample shall be converted to the normal delivery condition in accordance with the details given in subclause 7.2 and table B.1.

8.4.2.3 For the tensile test at room temperature, a transverse test piece shall be taken from each sample, and this shall normally be a flat test piece. As a general rule, both rolled surfaces shall be left on the test piece. In the case of flat test pieces from products with a width exceeding 40 mm, at least one rolled surface shall remain intact.

Round test pieces are permitted, but should only be provided in the case of product thicknesses exceeding 40 mm. Such test pieces shall be taken in such a way that their axis is situated at a distance of one quarter of the product thickness from the surface, or as close as possible to this position.

8.4.2.4 Three transverse test pieces each shall be taken from the samples for the impact test. In the case of product thicknesses not exceeding 40 mm, one side of the test piece shall be selected to lie as close as possible to the rolled surface. In the case of product thicknesses exceeding 40 mm, the test pieces shall be taken in such a way that their longitudinal axis is situated at a distance of one quarter of the product thickness from the surface, or as close as possible to this position.

The notch shall be situated at right angles to the surface of the product.

8.4.2.5 For the tensile test at elevated temperature, one test piece shall be taken from each test unit as described in subclause 8.3.3. The specifications laid down in subclause 8.4.2.3 shall apply as regards the direction and the position of the test piece.

8.5 Test methods to be applied

8.5.1 The chemical composition shall be examined using the methods specified by the Chemists' Committee of the *Verein Deutscher Eisenhüttenleute* (Society of German Ferrous Metallurgy Engineers) [2].

8.5.2 The tensile test at room temperature (15 to 35 °C) shall be carried out as described in DIN 50 145, normally using a short proportional test bar of gauge length $L_0 = 5{,}65\sqrt{S_0}$ (S_0 = test piece cross section) as specified in DIN 50 125.

The upper yield stress shall be determined as yield strength. If no pronounced yield strength is apparent, the 0,2 % proof stress shall be determined.

8.5.3 The impact test on ISO V-notch specimens shall be carried out as described in DIN 50 115, according to the specifications in table 3, at 0 or 20 °C. The minimum values of impact energy given in table 3 apply to the mean from three test pieces, and in this connection only one individual value may be allowed to fall below the specified minimum value by a maximum of 30 %.

If the above conditions are not fulfilled, the manufacturer may insist, except where retests are concerned, on the testing of three additional test pieces to be taken from the samples concerned. In such an event, the requirements relating to the impact energy shall be

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[2] *Handbuch für das Eisenhüttenlaboratorium* (Handbook for the Ferrous Metallurgy Laboratory), volume 2: *Die Untersuchung der metallischen Stoffe* (Investigation of metallic materials), *Verlag Stahleisen mbH*, Düsseldorf, 1966;

volume 5 (Supplementary volume): A 4.1 – *Aufstellung empfohlener Schiedsverfahren* (List of recommended arbitration procedures), B – *Probenahmeverfahren* (Sampling procedures), C – *Analysenverfahren* (Methods of analysis), *Verlag Stahleisen mbH*, Düsseldorf,

the most recent edition in each case.

deemed satisfied if the following conditions are complied with:

- The mean value of the impact energy from the total of six individual values of the two test series shall be equal to or greater than the specified minimum value of the impact energy ($A_{v,min}$).
- Note more than two of the six individual values may be lower than the specified minimum value ($A_{v,min}$), and of these not more than one shall be lower than $0,7 \cdot A_{v,min}$.

In the case of products with a thickness of less than 5 mm, the impact test shall be dispensed with.

8.5.4 The 0,2 % proof stress at elevated temperatures shall be determined in accordance with DIN 50 145. The verification shall be carried out at one of the temperatures specified in table 4.

•• This temperature may be specified at the time of ordering; if no test temperature is specified in the purchase order, the test shall be carried out at 300 °C.

8.5.5 The assessment of the surface finish shall be made by visual examination, viz. without any special optical aids.

8.5.6 If an ultrasonic test in respect of internal soundness has been agreed for heavy plate, the specifications in the *Stahl-Eisen-Lieferbedingungen* 072 shall apply for the ultrasonic test.

8.6 Retests

In accordance with DIN 17 010.

8.7 Documents on materials testing

One of the documents covered by DIN 50 049, July 1982 edition, clause 3, shall be issued for products conforming to this standard.

• At the time of ordering, the type of document shall be specified, and the inspector appointed for acceptance tests shall be named, unless these tests are to be carried out by the works inspector.

8.7.1 Details to be included in the document

The document shall include the following information:

a) the technical delivery conditions, the technical rules and all characteristic data, code numbers and letter symbols which are required to identify and associate the test results with the various test units and deliveries, and in certain cases with the different sampling and test conditions, also the identification mark of the inspector;
b) the melting process;
c) the results of the cast analysis in respect of the elements featured in table 1 with numerical values;
d) as delivered condition as specified in subclause 7.2 (in the case of quenched and tempered or of tempered products, the heat treatment temperatures shall be specified);
e) the results of the tests to be carried out as specified in subclause 8.2.

9 Marking

9.1 Plate and strip shall be marked with

- the mark of the manufacturing works;
- the symbol for the steel grade;
- the cast number;
- the test piece number, and
- the inspector's mark.

Plates up to 5 mm thick shall be marked by stamping or by painting, whilst plates over 5 mm thick shall be marked by stamping. Bundled plates and strip shall be marked by means of a securely attached tag.

9.2 Plates which are not supplied bundled shall be marked on one end in such a way that the marking is upright and thus indicates the main direction of rolling by virtue of its orientation. Markings applied by stamping shall be outlined with white paint.

9.3 •• Any further marking shall be agreed at the time of ordering.

10 Complaints

10.1 External and internal defects may only be objected to if they impair to an appreciable extent the processing and utilization of the steel grade and form of product ordered.

10.2 The purchaser shall give the manufacturer the opportunity of convincing himself that the complaint is justified, in so far as possible by submitting the material complained of, and specimens of the material as supplied.

Table 1. Chemical composition (cast analysis)

Steel grade		Percentage by mass												
Symbol	Material number	C	Si	Mn	P max.	S max.	Al_{gos}	Cr	Cu max.	Mo	Nb max.	Ni max.	Ti max.	V max.
UH I	1.0348	≤ 0,14	–	0,20 to 0,80	0,035	0,030	–	≤ 0,30[1]	–	–	–	–	–	–
H I	1.0345	≤ 0,16	≤ 0,35	0,40 to 1,20	0,035	0,030	≥ 0,020	≤ 0,25[1], [2]	0,30[1], [2]	≤ 0,10[1], [2]	0,01[1]	0,30[1], [2]	0,03[1]	0,03[1]
H II	1.0425	≤ 0,20	≤ 0,35	0,50 to 1,30	0,035	0,030	≥ 0,020	≤ 0,25[1], [2]	0,30[1], [2]	≤ 0,10[1], [2]	0,01[1]	0,30[1], [2]	0,03[1]	0,03[1]
17 Mn 4	1.0481	0,14 to 0,20	≤ 0,40	0,90 to 1,40	0,035	0,030	≥ 0,020	≤ 0,25[1], [2]	0,30[1], [2]	≤ 0,10[1], [2]	0,01[1]	0,30[1], [2]	0,03[1]	0,03[1]
19 Mn 6	1.0473	0,15 to 0,22	0,30 to 0,60	1,00 to 1,60	0,035	0,030	≥ 0,020	≤ 0,25[1], [2]	0,30[1]	≤ 0,10[1], [2]	0,01[1]	0,30[1], [2]	0,03[1]	0,03[1]
15 Mo 3	1.5415	0,12 to 0,20	0,10 to 0,35	0,40 to 0,90	0,035	0,030	[3]	≤ 0,25[1]	0,30[1]	0,25 to 0,35		0,30[1]		
13 CrMo 4 4	1.7335	0,08 to 0,18	0,10 to 0,35	0,40 to 1,00	0,035	0,030	[3]	0,70 to 1,10	0,30[1]	0,40 to 0,60				
10 CrMo 9 10	1.7380	0,06 to 0,15	≤0,50	0,40 to 0,70	0,035	0,030	[3]	2,00 to 2,50	0,30[1]	0,90 to 1,10				

[1] Verification of compliance with these limiting values is subject to a particular agreement.
[2] The sum total of the percentages by mass of Cr, Cu, Mo and Ni shall not exceed 0,70 %.
[3] The Al content of the cast shall be determined and stated in the certificate.

Table 2. **Permissible deviations of the chemical composition determined by the product analysis from the limiting values specified in the cast analysis** (see table 1)

Element	Limiting values according to the cast analysis of table 1 Percentage by mass	Permissible deviations of the results of the product analysis from the upper or lower limiting values for the cast analysis [1] Percentage by mass
C	≤ 0,22	0,02
Si	≤ 0,35	0,05
	> 0,35 to ≤ 0,60	0,06
Mn	≤ 1,00	0,05
	> 1,00 to ≤ 1,60	0,10
P	≤ 0,035	0,005
S	≤ 0,030	0,005
Al	≥ 0,020	0,005
Cr	≤ 1,00	0,05
	> 1,00 to ≤ 2,50	0,10
Cu	≤ 0,30	0,05
Mo	≤ 0,35	0,03
	> 0,35 to ≤ 1,10	0,04
Nb	≤ 0,01	0,005
Ti	≤ 0,03	0,01
V	≤ 0,03	0,01

[1] If several product analyses are carried out on one cast, and if contents outside the range of chemical composition permitted by the cast analysis are determined for one single element, then only either values exceeding the permitted maximum value or only values falling short of the permitted minimum value shall be allowed, but not the two simultaneously for one and the same cast.

Table 3. Mechanical properties [1]

Steel grade		Upper yield stress R_{eH} [2]					Tensile strength R_m			Elongation at fracture ($L_0 = 5\,d_0$)		Impact energy (ISO V-notch test pieces) Mean value from three test pieces			
		for product thicknesses, in mm													
		≤ 16	> 16 to ≤ 40	> 40 to ≤ 60	> 60 to ≤ 100	> 100 to ≤ 150	≤ 60	> 60 to ≤ 100	> 100 to ≤ 150	≤ 60	> 60 to ≤ 150	≤ 60	> 60 to ≤ 150	≤ 60	> 60 to ≤ 150
		N/mm² min.					N/mm²			% min.		at 0 °C J min.		at + 20 °C J min.	
Symbol	Material number														
UH I	1.0348	195	185	175	–	–	280 to 400	–	–	25	–	–	–	–	–
H I	1.0345	235	225	215	200	185	360 to 480	360 to 480	350 to 480	24	23	31	31	–	–
H II	1.0425	265	255	245	215	200	410 to 530	410 to 530	400 to 530	22	21	31	31	–	–
17 Mn 4	1.0481	290	285	280	255	230	460 to 580	450 to 570	440 to 570	21	20	31	31	–	–
19 Mn 6	1.0473	355	345	335	315	295	510 to 650	490 to 630	480 to 630	20	20	31	31	–	–
15 Mo 3	1.5415	275 [3]	270	260	240	220	440 to 590	430 to 580	420 to 570	20	19	–	–	31	27
13 CrMo 4 4	1.7335	300	295	295	275	255	440 to 590	430 to 580	420 to 570	20	19	–	–	31	27
10 CrMo 9 10	1.7380	310	300	290	270	250	480 to 630	460 to 630	460 to 630	18	17	–	–	31	27

[1] The values for product thicknesses exceeding 150 mm are subject to agreement.

[2] If no clearly defined yield strength can be ascertained, these values shall apply to the 0,2 % proof stress.

[3] A minimum value of 285 N/mm² shall apply to product thicknesses not exceeding 10 mm.

Table 4. 0,2 % proof stress at elevated temperatures [1], [2]

Steel grade		Product thickness	0,2 % proof stress at a temperature of						
			200 °C	250 °C	300 °C	350 °C	400 °C	450 °C	500 °C
Symbol	Material number	mm	N/mm² min.						
UH I	1.0348	≤ 60	135	115	95	80	70	–	–
H I	1.0345	≤ 16	185	165	140	120	110	105	–
		> 16 to ≤ 40	180	165	135	120	110	105	–
		> 40 to ≤ 60	175	165	135	120	110	105	–
		> 60 to ≤ 100	165	155	125	115	105	100	–
		> 100 to ≤ 150	155	145	115	110	100	95	–
H II	1.0425	≤ 60	205	185	155	140	130	125	–
		> 60 to ≤ 100	195	175	145	135	125	120	–
		> 100 to ≤ 150	185	165	135	130	120	115	–
17 Mn 4	1.0481	≤ 60	245	225	205	175	155	135	–
		> 60 to ≤ 100	230	210	190	165	135	115	–
		> 100 to ≤ 150	215	195	175	155	135	115	–
19 Mn 6	1.0473	≤ 60	265	245	225	205	175	155	–
		> 60 to ≤ 100	250	230	210	190	165	145	–
		> 100 to ≤ 150	235	215	195	175	155	135	–
15 Mo 3	1.5415	≤ 10	240	220	195	185	175	170	165
		> 10 to ≤ 40	225	205	180	170	160	155	150
		> 40 to ≤ 60	210	195	170	160	150	145	140
		> 60 to ≤ 100	200	185	160	155	145	140	135
		> 100 to ≤ 150	190	175	150	145	140	135	130
13 CrMo 4 4	1.7335	≤ 10	255	245	230	215	205	195	190
		> 10 to ≤ 40	240	230	215	200	190	180	175
		> 40 to ≤ 60	230	220	205	190	180	170	165
		> 60 to ≤ 100	220	210	195	185	175	165	160
		> 100 to ≤ 150	210	200	185	175	170	160	155
10 CrMo 9 10	1.7380	≤ 40	245	240	230	215	205	195	185
		> 40 to ≤ 60	235	230	220	205	195	185	175
		> 60 to ≤ 100	225	220	210	195	185	175	165
		> 100 to ≤ 150	215	210	200	185	175	165	155

[1] The yield strength values specified in table 3 for room temperature are to be applied as characteristic values to be used for calculation if the temperature does not exceed 50 °C. For temperatures between 50 and 200 °C, a linear interpolation should be made, using the values featured in tables 3 and 4 for room temperature and for 200 °C. The room temperature shall be adopted as the starting point, using the yield strength value specified in table 3 for the product thickness concerned.

[2] The values shall be agreed for thicknesses exceeding 60 mm for steel UH I, and for thicknesses exceeding 150 mm for the other steel grades.

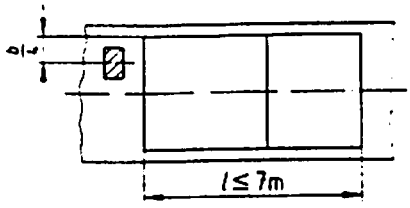
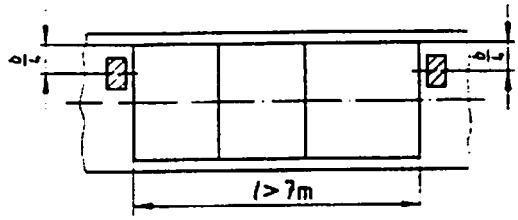
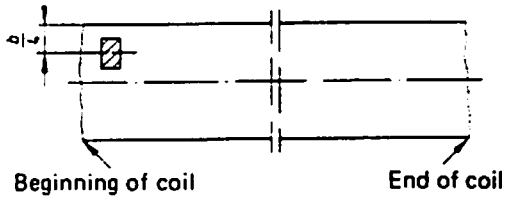
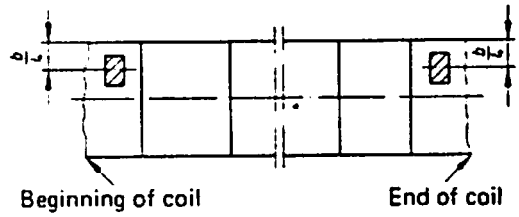
Product		Sampling	
		For the preparation of the test pieces described in subclause 8.3, there shall be taken from each test unit	
		for	one sample from the positions marked by ▨
Plate		supply in product lengths per as rolled plate with $l \leq 7$ m	
		supply in product lengths per as rolled plate with $l > 7$ m	
Strip	supplied as coil		
	supplied as plate		

Figure 1. Synopsis of positions for taking test pieces

Appendix A

Preliminary reference data relating to long term creep and stress rupture properties [1]

The 1 % time yield limits and creep strength values given in table A.1 for elevated temperatures do not signify that the steels can be subjected in continuous operation to these temperatures. The limitations will be governed by the overall stresses during operation, and in particular by the scaling conditions.

Table A.1

Steel grade	Temperature	1 % time yield limit [2] for		Creep strength [3] for		
		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Symbol	°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
H I H II	380	164	118	229	165	145
	390	150	106	211	148	129
	400	136	95	191	132	115
	410	124	84	174	118	101
	420	113	73	158	103	89
	430	101	65	142	91	78
	440	91	57	127	79	67
	450	80	49	113	69	57
	460	72	42	100	59	48
	470	62	35	86	50	40
	480	53	30	75	42	33
17 Mn 4 19 Mn 6	380	195	153	291	227	206
	390	182	137	266	203	181
	400	167	118	243	179	157
	410	150	105	221	157	135
	420	135	92	200	136	115
	430	120	80	180	117	97
	440	107	69	161	100	82
	450	93	59	143	85	70
	460	83	51	126	73	60
	470	71	44	110	63	52
	480	63	38	96	55	44
	490	55	33	84	47	37
	500	49	29	74	41	30
15 Mo 3	450	216	167	298	245	228
	460	199	146	273	209	189
	470	182	126	247	174	153
	480	166	107	222	143	121
	490	149	89	196	117	96
	500	132	73	171	93	75
	510	115	59	147	74	57
	520	99	46	125	59	45
	530	84	36	102	47	36

[1] The table gives preliminary reference data on the long term creep and stress rupture properties of plate and strip made from high temperature creep resistant steels. The values listed in the table represent the mean values of the scatter range covered up to the present, and these values will be checked from time to time when the results of further tests become available, and they will be corrected if necessary. It can be assumed on the basis of the data from long term creep tests which are already available that the lower limit of this scatter range for the temperatures listed here is situated approx. 20 % lower than the mean value listed, for the steel grades featured.

[2] This is the stress, related to the initial cross section, which results in a 1 % permanent elongation after 10 000 or 100 000 hours.

[3] This is the stress, related to the initial cross section, which leads to rupture after 10 000, 100 000 or 200 000 hours.

Table A.1 (continued)

Steel grade	Temperature	1 % time yield limit [2] for		Creep strength [3] for		
		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Symbol	°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
13 CrMo 4 4	450	245	191	370	285	260
	460	228	172	348	251	226
	470	210	152	328	220	195
	480	193	133	304	190	167
	490	173	116	273	163	139
	500	157	98	239	137	115
	510	139	83	209	116	96
	520	122	70	179	94	76
	530	106	57	154	78	62
	540	90	46	129	61	50
	550	76	36	109	49	39
	560	64	30	91	40	32
	570	53	24	76	33	26
10 CrMo 9 10	450	240	166	306	221	201
	460	219	155	286	205	186
	470	200	145	264	188	169
	480	180	130	241	170	152
	490	163	116	219	152	136
	500	147	103	196	135	120
	510	132	90	176	118	105
	520	119	78	156	103	91
	530	107	68	138	90	79
	540	94	58	122	78	68
	550	83	49	108	68	58
	560	73	41	96	58	50
	570	65	35	85	51	43
	580	57	30	75	44	37
	590	50	26	68	38	32
	600	44	22	61	34	28

For [2] and [3], see page 10.

Appendix B

Heat treatment and further processing

B.1 Heat treatment

B.1.1 Reference data in respect of the temperatures to be adopted for the heat treatment are given in table B.1.

B.1.2 For sequential annealing, the annealing temperature adopted shall be situated at the lower end of the permissible ranges given in table B.1.

B.2 Hot working

B.2.1 Hot working within the meaning of this standard shall be understood to mean a forming operation at temperatures above the maximum permitted temperature for stress relief annealing.

B.2.2 Hot working can as a general rule be accomplished without any difficulty.

The rules applying to hot working shall also be observed for in situ fitting and alignment work. In such cases the temperature control shall be inspected.

B.2.3 The plates shall be heated to between 920 and 1050 °C for hot working processes. Any grain coarsening due to excessive holding time or to the exceeding of the upper limiting temperature shall be avoided.

After hot working, the steels shall be heat treated again unless the measures mentioned below are taken.

For UH I, H I, H II, 17 Mn 4, 19 Mn 6 and 15 Mo 3 steels, subsequent normalizing may be dispensed with, and for 13 CrMo 4 4 and 10 CrMo 9 10 steels tempering will be only necessary in the following circumstances:

in the case of hot working in a single operation, or prior to the final stage of hot working, if the material has been heated above the normalizing temperature, but not to more than 1000 °C, and if the working process has been completed at a temperature above 750 °C, or, in cases where the degree of deformation during the final stage of forming does not exceed 5 %, at a temperature above 700 °C.

For repeated hot forming operations and/or hot forming operations which require a long time, at temperatures of about 1000 to 1050 °C, it will be necessary to cool down the workpiece before the final stage of forming to temperatures below 350 °C for 13 CrMo 4 4 and 10 CrMo 9 10 steels, and to temperatures below 550 °C for the other grades of steel. The temperature during the final hot forming stage shall not exceed 1000 °C for the steels listed in the table, if it is desired to dispense with normalizing or with quenching and tempering.

B.3 Cold working

B.3.1 Cold working within the meaning of this standard shall be understood to mean a forming operation which can include heating of the workpiece to temperatures not exceeding the maximum permissible stress relief annealing temperature.

B.3.2 Cold working can as a general rule be accomplished without any difficulty.

After cold working involving normal degrees of cold deformation of the workpiece, a subsequent heat treatment will as a general rule [3] not be necessary.

After cold working involving high degrees of cold deformation of the workpiece, a subsequent heat treatment of the steels will be necessary.

B.4 Weldability

The steel grades specified in this standard are suitable for all fusion welding processes and also for flash butt welding (see also DIN 8528 Part 1).

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3) See also *AD-Merkblatt* (AD instruction sheet) HP 7/72 – *Wärmebehandlung; ferritische Stähle* (Heat treatment; ferritic steels).

Table B.1 **Reference data relating to heat treatment**

Steel grade		Temperature range for			
		normalizing [1]	quenching and tempering		stress relief annealing [3], [4]
Symbol	Material number		austenizing	tempering [2]	
		°C	°C	°C	°C
UH I	**1.0348**	900 to 950	–	–	520 to 580
H I	**1.0345**	890 to 950	–	–	520 to 580
H II	**1.0425**	890 to 950	–	–	520 to 580
17 Mn 4	**1.0481**	890 to 950	–	–	520 to 580
19 Mn 6	**1.0473**	890 to 950	–	–	520 to 580
15 Mo 3	**1.5415**	890 to 950.	–	– [5]	530 to 620
13 CrMo 4 4	**1.7335**	–	890 to 950	630 to 730	600 to 700
10 CrMo 9 10	**1.7380**	–	920 to 980	680 to 750	650 to 750

[1] In the case of normalizing, a further period of holding after the specified temperatures have been attained over the entire cross section is not required and should, as a general rule, be avoided.

[2] In the case of tempering, the specified temperatures, after having been attained over the entire cross section, shall be held for at least 20 minutes for 13 CrMo 4 4 steel, and for at least 30 minutes for the remaining steel grades, and in this connection the annealing time shall be reckoned from the moment the lower limit of the permissible temperature range has been attained.

[3] The required duration for the annealing temperatures specified here includes heating through and holding within the temperature range, and it will be governed by the thickness of the components concerned. If the annealing temperature is measured at the surface of the component, the following annealing times are recommended:

for thicknesses not exceeding 15 mm, at least 15 minutes;

for thicknesses between 15 and 30 mm, at least 30 minutes;

for thicknesses exceeding 30 mm, approx. 60 minutes.

[4] Subclause B.1.2 shall also be observed.

[5] For thin plates, tempering at 590 to 650 °C may be necessary.

Appendix C

Physical properties

A *Stahl-Eisen-Werkstoffblatt* (Iron and steel material sheet) giving reference data on the physical properties, is in course of preparation (and will be published by the *Verein Deutscher Eisenhüttenleute*, Postfach 8209, D-4000 Düsseldorf).

Standards and other documents referred to

DIN 1016	Steel flat products; hot rolled strip, hot rolled sheet less than 3 mm thick, dimensions, permissible dimensional deviations, deviations of form and weight
DIN 1543	Steel flat products; hot rolled plate, 3 to 150 mm thick; permissible dimensional deviations, deviations of weight and form
DIN 8528 Part 1	Weldability; metallic materials, terminology
DIN 17 010	General technical delivery conditions for steel and steel products
DIN 17 175	Seamless tubes of heat resistant steels; technical delivery conditions
DIN 17 177	Electric pressure welded steel tubes for elevated temperatures; technical delivery conditions
DIN 50 049	Documents on materials testing
DIN 50 115	Testing of metallic materials; impact test
DIN 50 125	Testing of metallic materials; tensile test specimens, rules for their preparation
DIN 50 145	Testing of metallic materials; tensile test
EURONORM 79	*Benennung und Einteilung von Stahlerzeugnissen nach Formen und Abmessungen* (Nomenclature and classification of steel products according to shape and dimensions)

Stahl-Eisen-Lieferbedingungen 071 [4])
Oberflächenbeschaffenheit von warmgewalztem Gross- und Mittelblech sowie Breitflachstahl (Surface finish of hot rolled heavy plate and medium plate, also of wide flats)

Stahl-Eisen-Lieferbedingungen 072 [4])
Ultraschallgeprüftes Grobblech; Technische Lieferbedingungen (Ultrasonically tested heavy plate; technical delivery conditions)

Stahl-Eisen-Lieferbedingungen 096 [4])
Blech, Band und Breitflachstahl mit verbesserten Eigenschaften für Beanspruchungen senkrecht zur Erzeugnisoberfläche (Plate, strip and wide flats with improved properties for stressing at right angles to the surface of the product)

Stahl-Eisen-Prüfblatt 1805 [4])
Probenahme und Probenvorbereitung für die Stückanalyse bei Stählen (Sampling and test piece preparation for the product analysis of steels)

Handbuch für das Eisenhüttenlaboratorium, volume 2 [4]):
Die Untersuchung der metallischen Stoffe, Düsseldorf 1966

Handbuch für das Eisenhüttenlaboratorium, volume 5 (supplementary volume): [4])
A 4.1 – *Aufstellung empfohlener Schiedsverfahren*,
B – *Probenahmeverfahren*,
C – *Analysenverfahren*,
the most recent edition in each case.

AD-Merkblatt HP 7/72
Wärmebehandlung; Ferritische Stähle (Heat treatment; ferritic steels) [5])

Previous editions

DIN 17 155 Part 1: 10.51, 01.59; DIN 17 155 Part 2: 10.51, 01.59x; Supplement to DIN 17 155 Part 2: 03.64, 06.69

Amendments

Compared with the January 1959 edition, the following amendments have been made:

a) DIN 17 155 Part 1 and Part 2 and the Supplement to DIN 17 155 Part 2 have been combined to form this standard.

b) The content has been revised in their entirety. The layout of the standard corresponds to DIN DIN 820 Part 22 (December 1980 edition).

c) In addition to plate, the standard now also applies to strip.

d) H III, H IV and 19 Mn 5 steels have been dropped. UH I, 19 Mn 6 and 10 CrMo 9 10 steels have been adopted for the first time (see also Explanatory notes).

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[4]) Obtainable from:
Verlag Stahleisen mbH, Breite Strasse 27, D-4000 Düsseldorf 1.

[5]) Obtainable from:
Beuth Verlag GmbH, Kamekestrasse 2–8, D-5000 Köln 1.

Explanatory notes

This standard is related to International Standard ISO 2604/4 – 1975 "Steel products for pressure purposes; quality requirements. Part 4: Plates", published by the International Organization for Standardization (ISO) and also to EURONORM 28–69 *Stahlblech und Stahlband aus unlegierten Stählen für Druckbehälter; Gütevorschriften* (Steel plate and steel strip for unalloyed steels for pressure vessels; quality specifications) and to EURONORM 43–72 *Blech und Band aus legierten Stählen für Druckbehälter; Gütevorschriften* (Plate and strip of alloyed steels for pressure vessels; quality specifications) (these EURONORMS are published by the European Coal and Steel Community). We would refer you to the comparison table at the end of these Explanatory notes for a comparison of the elevated temperature ferritic martensitic steel as specified in ISO 2604/4 and in EURONORM 28 and EURONORM 43 with the German steel grades. The above-mentioned international standards are at present in the process of being revised. According to the results of the consultations on the revised versions of EURONORM 28 and EURONORM 43 which are available to date, it would appear that the selection of steel grades featured in these two standards will harmonize to a considerable extent with this DIN Standard; this can largely be attributed to the fact that the work on DIN 17 155 was carried out at approximately the same time and in parallel with the work on EURONORM 28 and EURONORM 43. In the revised version of EURONORM 28 and EURONORM 43, UH I steel, which is relatively insignificant as fas as quantities used are concerned, but which is however important for enamelling and for galvanizing kettles, will be dropped; in comparison with the present standard, these EURONORMS will on the other hand feature additional standardized steel grades, viz. a coarse-grained variant of H I steel and a variant of 19 Mn 6 steel which includes the possible addition of niobium and vanadium.

The following points arising from the discussions which led to the publication of the present standard should also be mentioned in particular:

a) The revision of DIN 17 155 Part 1 and Part 2 and of the Supplement to DIN 17 155 Part 2 was long overdue, and had been postponed at the time in order to proceed with the revision or with the new elaboration of the technical delivery conditions for seamless (DIN 17 175) and for welded tubes (DIN 17 177) of creep resistant steels. On the other hand, once the consultations relating to the revised version of DIN 17 155 were initiated, it became possible to bring this work to a satisfactory conclusion fairly rapidly, because the agreements reached in respect of the specifications of the high temperature yield limit values and of the long term creep and stress rupture values for DIN 17 175 and DIN 17 177, which had caused a great deal of argument and had wasted a great deal of time, could be referred to and adopted.

b) In accordance with present day practice, H I, H II, 17 Mn 4 and 19 Mn 6 steels shall in principle be melted in fine grain form; consequently, a minimum total aluminium content of 0,020 % was specified for these steel grades. In order to demarcate these grades from the special fine grained structural steels in accordance with DIN 17 102, the niobium, titanium and vanadium contents have been limited in addition to comparably low maximum values.

c) It was initially intended to differentiate between a fine grained and a coarse grained variant for each of the alloyed steel grades. The differentiation appeared necessary, on the one hand so as to be able to meet existing ductility requirements in certain cases, and on the other hand so as not to have to undertake an across-the-board reduction of the long term creep and rupture stress values, as seemed necessary on the basis of foreign documentation. However, the most recent evaluations of German experimental results on these steel grades have shown that aluminium has no influence on the long term behaviour of these steels in the case of aluminium contents not exceeding 0,040 %; it was therefore considered possible to renounce the need to differentiate in accordance with the aluminium content. However, the aluminium content of the alloyed steel grades shall be determined and stated in the certificate.

d) Because of the wide range of thicknesses in respect of which the data for the chemical composition apply, it became necessary to widen the range of analyses in certain cases in comparison with the steel grades of the same name in accordance with DIN 17 175 and DIN 17 177; on the other hand, the permitted sulfur content was reduced to 0,030 % max.

e) Because of the transition to fine grained melting and because of the uncertainties about the correlation of yield strength values at room temperature and at elevated temperatures which are still associated therewith, it was agreed to carry out the hot tensile test in principle once per every 30 t of material delivered. It is hoped that sufficient data will become available at a future date to enable this ruling to be dropped.

f) There was a difference of opinion concerning the specifications relating to the permissible differences in tensile strength between the two ends of as rolled plates of more than 7 m length. The steel manufacturers wanted any references to these permissible differences to be deleted in their entirety, pointing out that foreign standards do not contain any such specifications; for their part, the technical inspectorate considered that the range could be narrowed, pointing to the increasing use of continuous casting. The users desired a range to be specified, and would have agreed to a widening thereof. In the event, agreement was reached on a specification of 80 N/mm^2 for 10 CrMo 9 10 steel and 70 N/mm^2 for all remaining steel grades, irrespective of their length.

g) It was agreed in principle that the data contained in Appendix B on heat treatment and further processing could not indefinitely continue to form part of DIN 17 155, and that they should in due course form the subject matter of a separate *Stahl-Eisen-Werkstoffblatt*, together with the corresponding specifications at present contained in DIN 17 175 and DIN 17 177.

h) Temperature-controlled rolled products are not subject to any special marking. The users had expressed a wish that such products should at least be provided with a temporary marking, until sufficient experience

had been gathered on the further processing of these products. The steel manufacturers ascertained that up to now they had not been allowed to supply temperature-controlled rolled products made from steels in accordance with DIN 17 155 for plants subject to regular inspection, but they would of course make sure that these products were equivalent to normalized products before release for delivery. The technical inspectorate pointed out that a first-time approval was required according to *VdTUV-Merkblatt* (VdTUV instruction sheet) 1263 in respect of the supply of temperature-controlled rolled products for plants subject to regular inspection; thereafter, a running random check of the products was also specified.

Comparison table of ferritic and martensitic steels for elevated temperature use as specified in ISO 2604/4 – 1975 and also in EURONORM 28–69 and EURONORM 43–72 and comparable German documents

German document			ISO 2604/IV – 1975		EURONORM 28–69		EURONORM 43–72	
Source [1]	Symbol	Material number	Symbol	[2]	Symbol	[2]	Symbol	[2]
17 155	UH I	1.0348	–		–		–	
–	–	–	P 3		Fe 37-1 KW [3]		–	
17 155	H I	1.0345	P 5	●	Fe 37-2 KW	●	–	
–	–	–	P 7		Fe 42-1 KW [3]		–	
17 155	H II	1.0425	P 9	●	Fe 42-2 KW	●	–	
SEL	H IV	1.0445	P 11	○	Fe 47-1 KW [3]	○	–	
17 155	17 Mn 4	1.0481	P 13	○	Fe 47-2 KW	○	–	
SEL	19 Mn 5	1.0482	P 16	○	Fe 52-1 KW [3]	○	–	
SEL	19 Mn 5	1.0482	P 18	○	–		–	
17 155	19 Mn 6	1.0473	–		Fe 52-2 KW	○	–	
17 155	15 Mo 3	1.5415	P 26	●	–		16 Mo 3	○
SEL	16 Mo 5	1.5423	P 28	●	–		16 Mo 5 [3]	●
–	–	–	P 30		–		14 MnMo 5 5 [3]	
17 155	13 CrMo 4 4	1.7335	P 32	○	–		14 CrMo 4 5	○
SEL	14 MoV 6 3	1.7715	P 33	○	–		13 MoCrV 6 [3]	●
17 155	10 CrMo 9 10	1.7380	P 34	○	–		12 CrMo 9 10	○

[1] 17 155 = specified in DIN 17 155.
SEL = specified in the *Stahl-Eisen-Liste* (Iron and steel list), 7th edition 1981 (published by *Verlag Stahleisen mbH*, Düsseldorf).

[2] In this column, the degree of conformity of the chemical composition of the German steels on the one hand with the steels specified in ISO 2604/4 – 1975, EURONORM 28–69 and EURONORM 43–72 on the other hand is indicated. Key to symbols: ● = minor variations; ○ = important variations.

[3] This steel grade will no longer be included in the next edition of the EURONORM.

International Patent Classification

B 21 B 1-26