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High-temperature austenitic steel plate and sheet, cold and hot rolled strip, bars and forgings
Technical delivery conditions

DIN 17460

Hochwarmfeste austenitische Stähle; technische Lieferbedingungen für Blech, kalt- und warmgewalztes Band, Stäbe und Schmiedestücke

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.

The symbol • denotes items which shall, the symbol •• denoting items which may, be agreed upon at the time of ordering.

Contents

1 Scope and field of application

1.1 This standard specifies technical delivery conditions for hot rolled plate up to 75 mm thick, for cold and hot rolled strip (and plate up to 12 mm thick cut therefrom), and for bars and forgings in relevant sizes up to 160 mm. Such products are made from the high-temperature austenitic steels specified in table 1, which are suitable for high-pressure applications where elevated temperatures and high mechanical stresses are involved. Note that certain materials are not suitable for all products.

1.2 • This standard also applies to forged or rolled semi-finished products, intended to be subsequently hot formed, the heat treatment condition and testing of such products being the subject of agreement at the time of ordering.

1.3 Unless otherwise specified, the technical delivery conditions for steel and steel products specified in DIN 17 010 shall also be complied with. This also applies to the forgings covered here.

2 Concepts

2.1 High-temperature austenitic steel is austenitic steel which has a minimum chromium content of 13 % by mass and which, when exposed to long-term mechanical stress and temperatures over 550 °C, remains strong.

2.2 See DIN 17 014 Part 1 for heat treatment terminology.

2.3 See DIN EN 10 079 for concepts dealing with product forms.

3 • Dimensions and tolerances

Dimensions and tolerances shall be the subject of agreement at the time of ordering, based where possible on the relevant dimensional standards listed in appendix A.

4 Mass

4.1 Calculation of the design mass of products shall be based on the guideline values for density specified in table B.2.

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4.2 •• The tolerances on mass may be the subject of agreement at the time of ordering, where such are not specified in the dimensional standards listed in appendix A.

5 Designation and ordering

5.1 The standard designation shall give, in the following order:

a) name of material (steel);
b) DIN number (DIN 17 460);
c) material designation or number (cf. table 1);
d) symbol denoting heat treatment condition (cf. table 5).

Examples:

Steel DIN 17 460 – X 6 CrNi 18 11 c2
or
Steel DIN 17 460 – X 6 CrNi 18 11 IIa
or
Steel DIN 17 460 – 1.4948 c2
or
Steel DIN 17 460 – 1.4948 IIa

In the case of steel identified by material designation X 5 NiCrAlTi 31 20, supplied in the annealed for recrystallization condition, the symbol RK shall be added to the designation, as follows:

Steel DIN 17 460 –
X 5 NiCrAlTi 31 20 RK c2

5.2 The designation of semi-finished products shall be in accordance with the relevant dimensional standard.

5.3 For ordering purposes, the desired material, surface quality and requirements regarding testing shall be clearly stated. Information which is subject to agreement shall also be specified at the time of ordering (cf. subclauses marked • and ••).

6 Requirements

6.1 •• Manufacturing process

6.1.1 Unless otherwise agreed, the steelmaking process shall be at the manufacturer's discretion. If so agreed, the purchaser shall be informed of the steelmaking process used.

6.1.2 Unless otherwise agreed, the manufacturing process shall be at the manufacturer's discretion.

6.2 Heat treatment condition and surface quality

Steel shall be supplied in one of the heat treatment conditions specified in tables 3 and 4 (cf. also table B.3).

• The heat treatment condition and surface quality shall be agreed at the time of ordering.

6.3 Chemical composition

6.3.1 Ladle analysis

The chemical composition, as determined by ladle analysis, shall be in compliance with table 1.

6.3.2 Product analysis

Where a product is to be carried out, the results may deviate from the values given in table 1 by the amounts listed in table 2.

6.3.3 Subject to agreement, deviations from the specifications given in subclause 6.3.1 and 6.3.2 are permitted, provided the mechanical properties, weldability, and the performance of the finished product are not adversely affected.

6.4 Mechanical properties

6.4.1 Table 3 shall apply for the mechanical properties, at ambient temperature, of materials supplied in the heat treated condition, except for material supplied in condition a1 or a2 as specified in table 5.

6.4.2 The values of elevated temperature 0,2 % and 1 % proof stress shall comply with the values given in table 4. Additional information regarding the heat resistance of X 5 NiCrAlTi 31 20 and X 8 NiCrAlTi 32 21 steels at temperatures over 600 °C is provided in table B.4.

6.4.3 The mechanical properties of materials supplied in condition a1 or a2 shall comply with tables 3 and 4. Verification of such compliance, as determined on reference test pieces, may be agreed at the time of ordering.

6.4.4 Guideline values for rupture stress are given in table B.1.

6.5 •• Soundness

Non-destructive testing, to establish internal and external soundness, may be agreed at the time of ordering (cf. subclause 7.2.8).

7 Testing

7.1 Inspection documents

7.1.1 Material complying with this standard shall be supplied with a DIN 50 049 (EN 10 204) inspection certificate or test report, unless otherwise specified in subclause 7.1.2 for semi-finished products.

• The type of inspection document shall be the subject of agreement. In the case of third-party inspection, the purchaser shall name his representative.

The certificate or report shall include the following particulars:

a) confirmation that the material complies with the information given in the order;
b) results of ladle analysis;
c) results of the tests described in subclauses 7.2.1 to 7.2.7, where required or agreed;
d) results of any additional tests;
e) marking (cf. clause 8).

7.1.2 Semi-finished products as specified in clause 1, supplied in condition a1 or a2 as specified in table 5, shall be supplied with an EN 10 204–2.2 inspection document, it not being necessary to verify the mechanical properties on reference test pieces, nor to determine the chemical composition based on a product analysis of a manufactured product. The document shall include the following particulars:

a) confirmation that the product complies with the information given in the order;
b) results of ladle analysis;
c) marking (cf. clause 8).

7.2 Scope of testing

7.2.1 •• Determination of and the scope of testing for the chemical composition based on a product analysis of the manufactured product may be agreed at the time of ordering.

7.2.2 One tensile test at ambient temperature shall be carried out on the test units specified in table 6.

7.2.3 •• It may be agreed to verify compliance with the impact energy values specified in table 3, in which case the scope of testing specified in table 6 shall apply, unless otherwise agreed.

7.2.4 •• It may be agreed to verify compliance with the 0,2 % and 1 % proof stress values specified in table 4, the test temperature and scope of testing also being subject to agreement.

7.2.5 All products shall be checked for dimensional accuracy.

7.2.6 All products shall be visually checked for their surface quality.

7.2.7 It shall be the manufacturer's responsibility to check all products for materials identity.

7.2.8 • The method of non-destructive testing to establish the internal and external soundness, and the method of assessment, shall be the subject of agreement (cf. subclause 6.5).

7.3 Sampling and sample preparation

7.3.1 The method of sampling specified in *Stahl-Eisen-Prüfblatt* (Iron and steel test sheet) 1805 shall be used for the determination of chemical composition by product analysis.

7.3.2 Test pieces for tensile testing and notched bar impact testing shall be taken from the products in their as delivered condition as specified in subclauses 7.3.2.1 and 7.3.2.3.

•• It may be agreed to take test pieces before the products has been straightened.

7.3.2.1 •• Unless otherwise agreed, test pieces shall be taken from plate and hot rolled strip and shall be so that their axis coincides with a line running at half the distance between longitudinal edge and centreline (cf. figure 1).

7.3.2.2 In the case of cold rolled strip that is 300 mm wide or more, tensile test pieces shall be taken at right angles to the direction of rolling, so that their axis coincides with a line at least one-fourth of the strip width away from the strip edge.

Where strip is less than 300 mm wide, longitudinal test pieces whose axes coincide with the line defined in the previous sentence shall be taken.

7.3.2.3 See figure 2 for location and orientation of test pieces taken from bars.

7.3.2.4 See figure 3 for location and orientation of test pieces taken from forgings.

7.4 Test procedure

7.4.1 The chemical composition shall be tested using a method specified in the *Handbuch für das Eisenhüttenlaboratorium* (Handbook for the ferrous metallurgy laboratory) and developed by the Chemists' Committee of the *Verein Deutscher Eisenhüttenleute* (Society of German Ferrous Metallurgy Engineers).

7.4.2 In the case of plate and strip with a nominal thickness of less than 3 mm, tensile testing shall be carried out as described in DIN EN 10 002 Part 1, on test pieces that are 80 mm long and 20 mm wide (large, flat ISO test pieces). In all other cases, proportional test pieces in accordance with DIN EN 10 002 Part 1 shall be used.

7.4.3 For the impact test, ISO-V notch test pieces as specified in DIN EN 10 045 Part 1 shall be used, evaluation of test results being based on DIN 17 010.

7.4.4 Products shall be checked for dimensional accuracy (i.e. compliance with the relevant dimensional standards given in appendix A, or with the specifications given in the order).

7.4.5 A visual check of the surface quality shall be made by a person with normal vision under sufficient light.

7.5 Retests

DIN 17 010 shall apply for retests.

8 Marking

8.1 Scope of marking

8.1.1 •• Unless otherwise agreed, products shall be marked with the manufacturer's mark, the material designation or number and, if specified, the cast number. Flats may also be marked with the symbol denoting heat treatment condition and thickness and, if specified, the number of the strip from which they originate.

8.1.2 Products supplied with an inspection document shall also be marked with the cast number, the batch number or number of the strip from which they originate, and with the inspector's mark. Unless the batch number is used for marking, the sample from which the test pieces are taken shall be marked with the test pieces number.

8.2 Type of marking

Marking is normally to be carried out in the following manner.

a) Flats shall be marked by coloured stamping, at right angles to the direction of rolling.

b) Bars that are 35 mm thick or more shall be marked by coloured stamping or hammering.

c) Bars less than 35 mm in thickness shall bear a tag attached to the bundle.

•• Other methods of marking may be agreed at the time of ordering.

9 Complaints

DIN 17 010 shall apply for complaints.

Table 1. **Steel grades and their chemical composition as determined by ladle analysis [1]**

Material designation	number	Percentage by mass C	Si	Mn max.	P max.	S max.	N	Cr	Mo	Ni	Others
X 6 CrNi 18 11	1.4948	0,04 to 0,08	≤ 0,75	2,0	0,035	0,015		17,0 to 19,0		10,0 to 12,0	
X 3 CrNiN 18 11	1.4949	≤ 0,04	≤ 0,75	2,0	0,035	0,015	0,10 to 0,18	17,0 to 19,0	0,20 to 0,50	9,5 to 11,5	
X 8 CrNiTi 18 10	1.4941	0,04 to 0,10	≤ 0,75	2,0	0,035	0,015		17,0 to 18,5	≤ 0,60	9,5 to 11,5	Ti: ≥ 5 × %C to ≤ 0,80 B: 0,0015 to 0,0050
X 6 CrNiMo 17 13	1.4919	0,04 to 0,08	≤ 0,75	2,0	0,035	0,015		16,0 to 18,0	2,0 to 2,5	12,0 to 14,0	
X 3 CrNiMoN 17 13	1.4910	≤ 0,04	≤ 0,75	2,0	0,035	0,015	0,10 to 0,18	16,0 to 18,0	2,0 to 2,8	12,0 to 14,0	B: 0,0015 to 0,0050
X 8 CrNiNb 16 13	1.4961	0,04 to 0,10	0,30 to 0,60	1,5	0,035	0,015		15,0 to 17,0		12,0 to 14,0	Nb: ≥ 10 × %C to ≤ 1,2 [2]
X 8 CrNiMoNb 16 16	1.4981	0,04 to 0,10	0,30 to 0,60	1,5	0,035	0,015		15,5 to 17,5	1,6 to 2,0	15,5 to 17,5	Nb: ≥ 10 × %C to ≤ 1,2 [2]
X 8 CrNiMoVNb 16 13	1.4988	0,04 to 0,10	0,30 to 0,60	1,5	0,035	0,015	0,06 to 0,14	15,5 to 17,5	1,10 to 1,50	12,5 to 14,5	Nb: ≥ 10 × %C to ≥ 1,2 [2] V: 0,60 to 0,85
X 5 NiCrAlTi 31 20	1.4958	0,03 to 0,08	≤ 0,70	1,5	0,015	0,010		19,0 to 22,0		30,0 to 32,5	Al: 0,20 to 0,50 Ti: 0,20 to 0,50 (Al + Ti): ≤ 0,70 Co: ≤ 0,5 (Ni + Co): 30,0 to 32,5 Cu: ≤ 0,5 Nb: ≤ 0,1
X 8 NiCrAlTi 32 21	1.4959	0,05 to 0,10	≤ 0,70	1,5	0,015	0,010		19,0 to 22,0		30,0 to 34,0	Al: 0,25 to 0,65 Ti: 0,25 to 0,65 Co: ≤ 0,5 (Ni + Co): 30,0 to 34,0 Cu: ≤ 0,5

[1] Any elements for which values have not been specified may be present, provided the properties of the steel and its weldability are not adversely affected.

[2] The content specified represents niobium and tantalum together.

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

Element	Maximum content as determined by ladle analysis, as a percentage by mass	Limit deviations in the product analysis from the limiting values specified for the ladle analysis, as a percentage by mass [1]
C	≤ 0,04 > 0,04 to ≤ 0,10	+ 0,01 ± 0,01
Si	≤ 0,75	± 0,05
Mn	≤ 2,0	+ 0,04
P	≤ 0,035	+ 0,005
S	≤ 0,010 > 0,010 to ≤ 0,015	+ 0,003 + 0,005
N	≤ 0,18	± 0,01
Al	≥ 0,20 to ≤ 0,75	± 0,05
B	≥ 0,0015 to ≤ 0,0050	± 0,0005
Co	≤ 0,5	+ 0,05
Cr	≥ 15,0 to ≤ 22,0	± 0,20
Cu	≤ 0,5	+ 0,05
Mo	≥ 0,20 to ≤ 0,60 > 0,60 to ≤ 2,0 > 2,0 to ≤ 2,8	± 0,03 ± 0,05 ± 0,10
Ni	≥ 9,5 to ≤ 20,0 > 20,0 to ≤ 34,0	± 0,15 ± 0,20
Nb	≤ 1,20	± 0,05
Ti	≤ 0,80	± 0,05
V	≥ 0,60 to ≤ 0,85	± 0,03

[1] If a number of product analyses are to be carried out, the deviations shown by an element within one cast shall either be above the upper limit or below the lower limit of the range specified for the ladle analysis, but not both at the same time.

Table 3. **Mechanical properties at ambient temperature**

Material		Heat treatment condition	Min. 0,2 % proof stress, in N/mm²	Min. 1 % proof stress, in N/mm²	Tensile strength, in N/mm²	Min. elongation at fracture (L_0=5,65 · $\sqrt{S_0}$) as a percentage		Min. impact energy [1] (ISO-V), in J	
designation	number					Longitudinal [2]	Transverse and tangential	Longitudinal [2]	Transverse and tangential
X 6 CrNi 18 11	**1.4948**	Solution heat treated	185	225	500 to 700	40	30	90	60
X 3 CrNiN 18 11	**1.4949**	Solution heat treated	240	275	500 to 700	35	30	90	60
X 8 CrNiTi 18 10	**1.4941**	Solution heat treated	195	235	490 to 680	35	30	90	60
X 6 CrNiMo 17 13	**1.4919**	Solution heat treated	205	245	490 to 690	35	30	90	60
X 3 CrNiMoN 17 13	**1.4910**	Solution heat treated	260	300	550 to 750	35	30	120	80
X 8 CrNiNb 16 13	**1.4961**	Solution heat treated	205	245	510 to 690	35	22	65	45
X 8 CrNiMoNb 16 16	**1.4981**	Solution heat treated	215	255	530 to 690	35	22	65	45
X 8 CrNiMoVNb 16 13	**1.4988**	Solution heat treated and aged	255	295	540 to 740	30	20	50	35
X 5 NiCrAlTi 31 20 RK	**1.4958 RK**	Annealed for recrystallization	210	240	500 to 750	35	30	120	80
X 5 NiCrAlTi 31 20	**1.4958**	Solution heat treated	170	200	500 to 750	35	30	120	80
X 8 NiCrAlTi 32 21	**1.4959**	Solution heat treated	170	200	500 to 750	35	30	120	80

[1] Represents the mean from three test pieces. One single value may be lower, by not more than 30 %.

[2] In the case of strip, the values also apply to transverse test pieces. In the case of products 80 mm or more in length, the values are 5 % lower than those specified.

Table 4. **Minimum values of elevated temperature 0,2 % and 1 % proof stress**

Material		Heat treatment condition	0,2 % proof stress, in N/mm², at the following temperatures, in °C							1 % proof stress, in N/mm², at the following temperatures, in °C						
designation	number		100	200	300	400	500	550	600	100	200	300	400	500	550	600
X 6 CrNi 1811	1.4948	Solution heat treated	157	127	108	98	88	83	78	191	157	137	127	118	113	108
X 3 CrNiN 1811	1.4949	Solution heat treated	185	150	130	120	110	105	100	220	175	150	140	130	125	120
X 8 CrNiTi 1810	1.4941	Solution heat treated	162	142	132	123	113	108	103	201	181	172	162	152	147	142
X 6 CrNiMo 1713	1.4919	Solution heat treated	177	147	127	118	108	103	98	211	177	157	147	137	132	128
X 3 CrNiMoN 1713	1.4910	Solution heat treated	205	170	148	134	127	124	121	240	200	178	164	157	154	151
X 8 CrNiNb 1613	1.4961	Solution heat treated	175	157	137	128	118	118	113	205	186	167	157	147	147	142
X 8 CrNiMoNb 1616	1.4981	Solution heat treated	195	177	157	147	137	137	132	225	206	186	177	167	167	162
X 8 CrNiMoVNb 1613	1.4988	Solution heat treated and aged	215	196	177	167	157	152	147	245	226	206	196	186	181	177
X 5 NiCrAlTi 3120 RK	1.4958 RK	Annealed for recrystallization	180	160	145	130	120	115	110	205	180	165	155	145	140	135
X 5 NiCrAlTi 3120	1.4958	Solution heat treated	140	115	95	85	80	75	75	160	135	115	105	100	95	95
X 8 NiCrAlTi 3221	1.4959	Solution heat treated	140	115	95	85	80	75	75	160	135	115	105	100	95	95

Table 5. **Heat treatment condition and surface quality**

Symbol [1]	Heat treatment condition	Surface quality	Product form				Remarks
			Flats	Bar	Forging	Semi-finished	
a1	Hot formed, not heat treated, not descaled	Covered with rolling skin (locally dressed)	×	×	–	–	Only suitable for products that will be subsequently hot formed.
a2	Hot formed, not heat treated, ground on all sides	Clean (as obtained by grinding)	–	–	–	×	
b or Ic	Hot formed, heat treated [2], not descaled	Covered with rolling skin	×	×	×	–	Only suitable for components descaled or machined on all sides after production.
c1 or IIa	Hot formed, heat treated [2], mechanically descaled [3]	Clean	×	×	×	–	•• The descaling method used (e.g. grinding, blasting, peeling) depends on the product form and, unless otherwise specified, shall be up to the manufacturer.
c2 or IIa	Hot formed, heat treated [2], pickled		×	×	×	–	–
e	Hot formed, heat treated [2], machined	Bright	–	×	×	–	–
h or IIIb	Mechanically or chemically descaled, cold formed, heat treated [2], pickled	Smoother than strip in the hot rolled and pickled condition [4]	×	×	–	–	–
m or IIId	Mechanically or chemically descaled, cold formed, bright annealed [5], or bright annealed [5] and skin passed or drawn	Shiny, and smoother than condition h	×	×	–	–	Particularly suitable for grinding and polishing.
n or IIIc	Mechanically or chemically descaled, cold formed, heat treated [2], pickled, bright drawn or skin passed	Dull, and smoother than condition h	×	×	–	–	Particularly suitable for grinding, brushing or polishing.
o or IV	Ground	•• Type and extent of finish to be agreed.	×	×	–	–	The initial condition is usually b, c1, f, m or n.
p or V	Polished		×	×	–	–	
q	Brushed	Matt	×	–	–	–	The ideal initial condition is n.

[1] The symbols have been taken from DIN 17440.
[2] The term 'heat treated' refers to the heat treatment conditions specified in tables 3 and 4.
[3] •• Flats are particular suitable for brief pickling when supplied with this surface finish, subject to agreement at the time of ordering.
[4] Cf. DIN 17440.
[5] The term 'bright annealed' refers to the heat treatment conditions specified in tables 3 and 4 (cf. footnote 2), with the exception of the fact that this condition is achieved in a protective atmosphere.

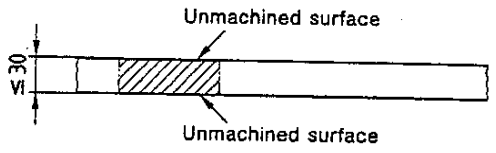
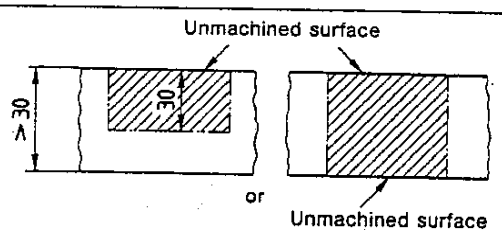
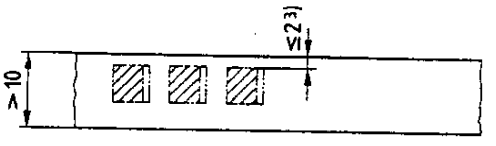
Table 6. **Test units and scope of testing for tensile testing and notched bar impact testing at ambient temperature**

Product form	Relevant size, in mm [1]	Test unit	Scope of testing
Plate	Thickness: ≤ 20	Not more than 4 rolled plates per cast, size and heat treatment batch	1 set of test pieces [3]
	Thickness: >20	Rolled plate	1 set of test pieces [3]
Cold or hot rolled strip, and plate cut therefrom	Thickness: ≤ 12	Uncut strip	1 set of test pieces [3] taken from both ends of each strip
Bars and forgings	≤ 160	Not more than 500 kg of products from the same cast, relevant size [2], and heat treatment batch	1 set of test pieces [3] (Where a consignment consists of more than four equivalent test units, only four test units shall be tested.)

[1] The relevant size of plate is its thickness, of round bars, their diameter, and of rectangular bars, the smaller of the edge lengths. In the case of forgings of simple shape, refer to figure 3.

[2] Products of differing relevant sizes may be combined in one test unit, provided the difference between the smallest and largest size is not more than 20 %.

[3] A set of test pieces for tensile testing and, where agreed, notched bar impact testing (cf. subclause 7.2.3), shall consist of three test pieces.

Tested to be performed	Product thickness, in mm	Orientation of axis, for an as rolled width of		Distance of test piece (illustrated as hatched portion) from the unmachined surface, in mm
		< 300 mm	≥ 300 mm	
Tensile test [1]	≤ 30	Longitudinal	Transverse	
	> 30			
Notched bar impact test [2]	> 10	Transverse	Transverse	

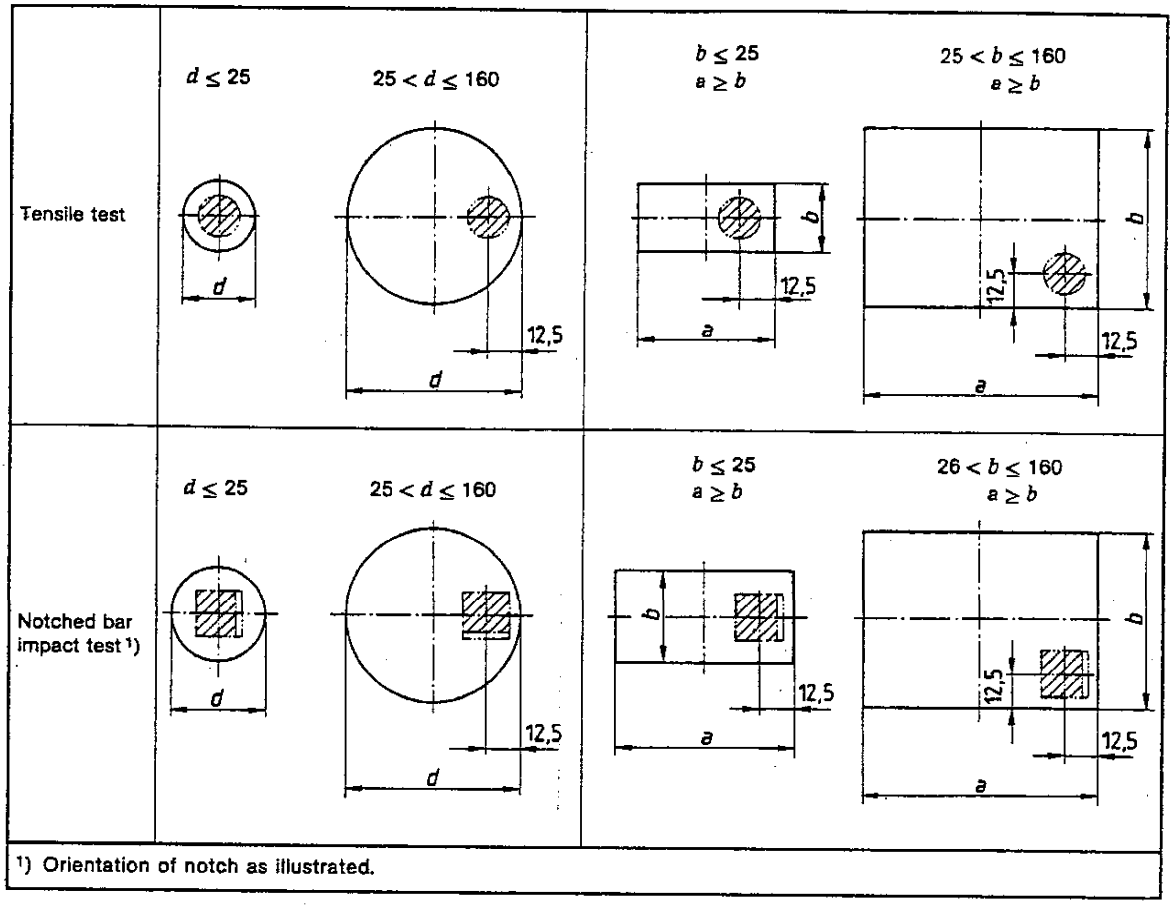
[1] Sampling shall be in accordance with DIN EN 10 002 Part 1 (cf. subclauses 7.4.2.1 and 7.4.2.2). In cases of dispute, products that are 3 mm thick or more shall have an original gauge length, L_0, equal to $5{,}65\sqrt{S_0}$. Round bars may be used as test pieces where products are over 10 mm thick. In the case of products over 30 mm thick, round bars shall be taken so that their axis is at a distance equal to one-fourth of the product thickness from the unmachined surface.

[2] The notch axis shall be at right angles to the unmachined surface.

[3] Where products are over 30 mm thick, notched bar impact test pieces shall be taken so that their axis is at a distance equal to one-fourth of the product thickness from the unmachined surface.

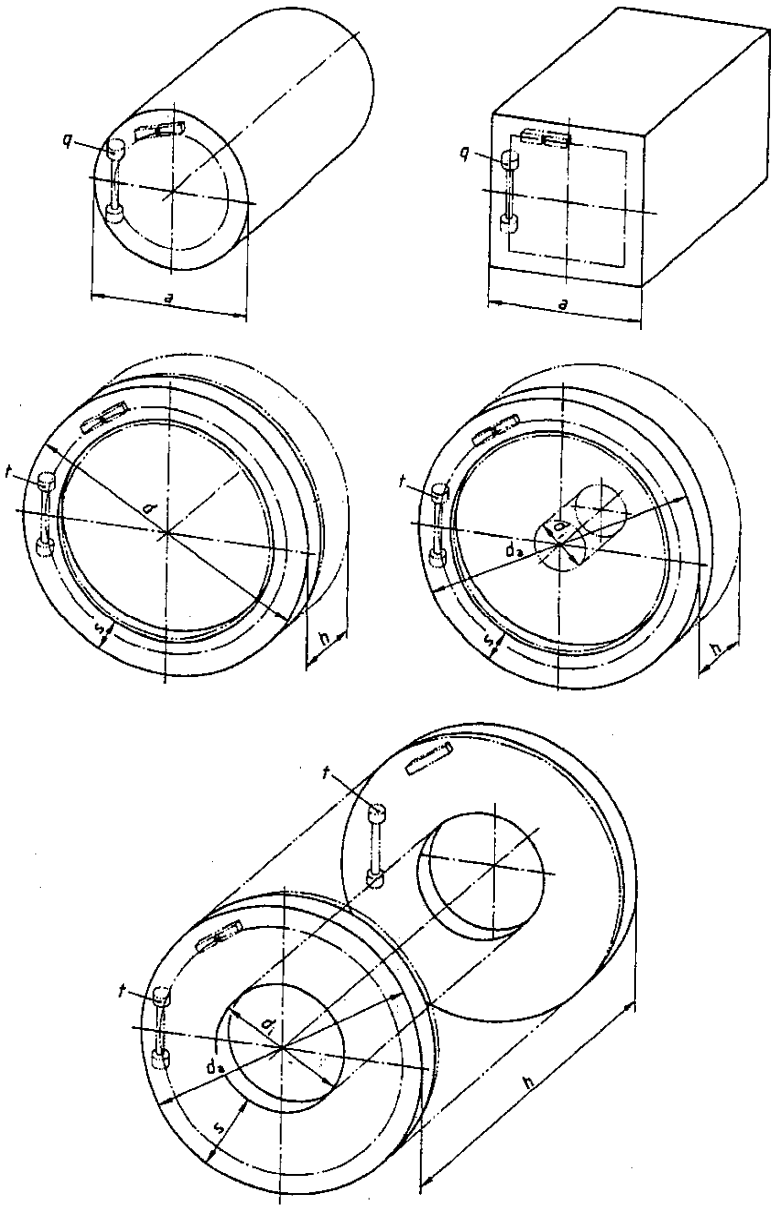
Figure 1. Orientation of test pieces taken from plate and strip

Dimensions in mm



1) Orientation of notch as illustrated.

Figure 2. Orientation of test pieces taken from bars of any cross-sectional shape



Product form	Location and orientation of test piece	Relevant size
Disc [1], with $0{,}1 \cdot d \leq h \leq d$ Pierced disc, with $0{,}1 \cdot d_a \leq h \leq d_a$ and $d_i \leq 0{,}4 \cdot d_a$	At $h/6$ and $d_a/6$, but max. 50 mm; test pieces taken from a ring cut from the bar (t stands for tangential test piece).	h
Ring, with $h \leq d_a$ and $d_i > 0{,}4 \cdot d_a$	At $h/6$ and $s/6$, but max. 50 mm; test pieces taken from a ring or a pierced disc cut from the bar end (t stands for tangential test piece).	h or s, whichever is smaller.
Bush, with $h > d_a$ and $d_i > 0{,}4 \cdot d_a$		s
[1] Discs cut from bars shall be treated as bars with regard to their relevant size.		

Figure 3. Relevant sizes and orientation of test pieces taken from forgings of simple shape

Appendix A

Dimensional standards for products covered here

DIN 174	Bright steel flats; dimensions, tolerances and mass
DIN 175	Polished steel rounds; dimensions and tolerances in accordance with ISO tolerance class h9
DIN 176	Bright steel hexagons; dimensions, tolerances and mass
DIN 178	Bright steel squares; dimensions, tolerances and mass
DIN 668	Bright steel rounds; dimensions and tolerances in accordance with ISO tolerance class h11
DIN 669	Bright steel shafts; dimensions and tolerances in accordance with ISO tolerance class h9
DIN 670	Bright steel rounds; dimensions and tolerances in accordance with ISO tolerance class h8
DIN 671	Bright steel rounds; dimensions and tolerances in accordance with ISO tolerance class h9
DIN 1013 Part 1	Hot rolled round steel for general applications; dimensions and tolerances
DIN 1013 Part 2	Hot rolled round steel for special applications; dimensions and tolerances
DIN 1014 Part 1	Hot rolled square steel for general applications; dimensions and tolerances
DIN 1014 Part 2	Hot rolled square steel for special applications; dimensions and tolerances
DIN 1015	Hot rolled steel hexagons for general applications; dimensions and tolerances
DIN 1017 Part 1	Hot rolled steel flats for general applications; dimensions, tolerances and mass
DIN 1017 Part 2	Hot rolled steel flats for special applications; dimensions, tolerances and mass
DIN 7526	Steel forgings; tolerances and permissible deviations for drop forgings
DIN 7527 Part 1	Steel forgings; machining allowances and permissible deviations for hammer forged discs
DIN 7527 Part 2	Steel forgings; machining allowances and permissible deviations for hammer forged pierced discs
DIN 7527 Part 3	Steel forgings; machining allowances and permissible deviations for seamless hammer forged rings
DIN 7527 Part 4	Steel forgings; machining allowances and permissible deviations for seamless hammer forged bushes
DIN 7527 Part 5	Steel forgings; machining allowances and permissible deviations for hammer forged, rolled and welded rings
DIN 7527 Part 6	Steel forgings; machining allowances and permissible deviations for hammer forged bars
DIN 59381	Cold rolled stainless and high-temperature steel strip; dimensions, tolerances and mass
DIN 59382	Cold rolled stainless steel wide strip and plate; dimensions, tolerances and mass
DIN EN 10029	Hot rolled steel plate 3 mm thick or above; tolerances on dimensions, shape and mass
DIN EN 10051	Continuously hot rolled uncoated unalloyed and alloy steel plate, sheet and strip; dimensional and geometrical tolerances

Appendix B
Additional information

B.1 Rupture stress

Table B.1 specifies guideline values for rupture stress, as a function of heat treatment condition. The values represent mean values from scatterbands established to date and may be revised at a later date, as investigations continue. According to current data, it may be assumed that the lower limit of the scatterband is approximately 20 % lower than the mean value specified.

The scatterband is greater for X 5 NiCrAlTi 31 20 RK steel at temperatures over 550 °C and for X 8 NiCrAlTi 32 21 steel at temperatures over 700 °C. In the case of the former steel, the lower limit of the scatterband is lower than the mean values specified by the following amounts:

approx. 20 % at 550 °C;
approx. 25 % at 600 °C;
approx. 30 % at 700 °C.

In the case of the latter steel, it is lower by the following amounts:

approx. 20 % at 700 °C;
approx. 25 % at 800 °C;
approx. 30 % at 900 °C;
approx. 35 % at 1000 °C.

B.2 Guideline values for physical properties

Selected guideline values for physical properties are given in table B.2 and have been taken from *Stahl-Eisen-Werkstoffblatt* (Iron and steel materials sheet) 310 (at present at the stage of draft), issued by the *Verein Deutscher Eisenhüttenleute*, Postfach 82 09, D-4000 Düsseldorf 1.

B.3 Guideline temperatures for heat treatment and hot forming

B.3.1 Since the strength of the steels covered here may be influenced by cold forming and welding, consultation between purchaser and manufacturer regarding subsequent treatment is recommended.

B.3.2 Table B.3 gives guideline temperatures for heat treatment and hot forming.

B.3.3 Although the steels covered here are usually suitable for cold forming (e.g. drawing, spinning, bending), it shall be noted that this will alter their mechanical and physical properties.

B.3.4 Steels covered here are suitable for arc welding. Note that weldability is not a function of the steel grade, but rather depends on the conditions present during welding, on the product design and on the conditions in service (cf. DIN 8528 Part 1). Any filler metal required shall be selected as a function of the intended application, the expected stresses, the welding process and conditions in service, due consideration being given to other relevant technical specifications. It is recommended that the purchaser consult the manufacturer as to the best welding process and filler metal for the steel grade in question.

Welding without the use of filler metals (e.g. flash welding) shall be permitted.

B.3.5 Flame cutting shall be carried out under suitable conditions, i.e. the powder, protective gas or plasma shall be carefully selected. Any edge zones which may have been adversely affected by flame cutting shall be dressed.

B.4 Additional information on heat resistance

In addition to the specifications given in table 4, information on the heat resistance of X 5 NiCrAlTi 31 20 and X 8 NiCrAlTi 32 21 steels is provided in table B.4, which is based on tensile tests at elevated temperature, a rate of strain of 0,5 % per minute having been applied.

Table B.1. **Guideline values for rupture stress**

Material designation	Material number	Heat treatment condition	Temperature, in °C	1 % creep limit [1], in N/mm², after		Rupture stress [1], in N/mm², after		
				10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
X 6 CrNi 18 11	**1.4948**	Solution heat treated	500	147	114	250	192	176
			510	142	111	239	182	166
			520	137	108	227	172	156
			530	132	104	215	162	146
			540	127	100	203	151	136
			550	121	96	191	140	125
			560	116	92	177	128	114
			570	111	88	165	117	104
			580	106	84	154	107	95
			590	100	79	143	98	86
			600	94	74	132	89	78
			610	88	69	122	81	70
			620	82	63	113	73	62
			630	75	56	104	65	55
			640	68	49	95	58	49
			650	61	43	87	52	43
			660	55	37	80	47	38
			670	49	32	73	42	34
			680	44	28	67	37	30
			690	39	25	61	32	26
			700	35	22	55	28	22
			710	(31)	(15)	(45)	(22)	
			720	(28)	(14)	(41)	(20)	
			730	(26)	(13)	(38)	(18)	
			740	(25)	(12)	(36)	(16)	
			750	(24)	(11)	(34)	(15)	
X 3 CrNiN 18 11	**1.4949**	Solution heat treated	550			230	178	
			560			216	163	
			570			202	150	
			580			188	137	
			590			174	125	
			600			160	114	
			610			146	103	
			620			133	92	
			630			121	82	
			640			110	73	
			650			100	64	
			660			91	56	
			670			82	49	
			680			74	42	
			690			67	36	
			700			60	30	
X 8 CrNiTi 18 10	**1.4941**	Solution heat treated	550			230	170	150
			560			220	150	130
			570			210	140	120
			580			190	120	110
			590			170	110	100
			600			160	100	90
			610			140	92	82
			620			130	84	74
			630			120	76	66
			640			110	68	60

[1] Values given in parentheses have been extrapolated.

Table B.1 (continued).

Material designation	Material number	Heat treatment condition	Temperature, in °C	1 % creep limit, in N/mm², after 10 000 h	1 % creep limit, in N/mm², after 100 000 h	Rupture stress [1], in N/mm², after 10 000 h	Rupture stress [1], in N/mm², after 100 000 h	Rupture stress [1], in N/mm², after 200 000 h
X 8 CrNiTi 18 10 (concluded)	1.4941	Solution heat treated	650			100	62	54
			660			90	56	48
			670			82	50	43
			680			74	44	40
			690			66	39	38
			700			60	35	29
X 6 CrNiMo 17 13	1.4919	Solution heat treated	550	180	125	250	175	
			560	169	117	235	164	
			570	158	109	220	153	
			580	147	101	205	142	
			590	136	93	190	131	
			600	125	85	175	120	
			610	115	77	160	109	
			620	105	70	147	98	
			630	96	63	135	88	
			640	87	56	123	78	
			650	79	49	111	69	
			660	71	43	100	60	
			670	64	38	91	52	
			680	57	33	82	46	
			690	51	29	73	40	
			700	46	25	65	34	
X 3 CrNiMoN 17 13	1.4910	Solution heat treated	550			290	220	(200)
			560			272	202	(184)
			570			254	186	(166)
			580			237	170	(151)
			590			220	155	(137)
			600			205	141	(122)
			610			190	127	(113)
			620			174	114	(100)
			630			162	102	(91)
			640			148	92	(81)
			650			135	83	(73)
			660			122	75	(65)
			670			112	68	(58)
			680			102	61	(52)
			690			93	56	(46)
			700			84	52	(42)
			710			78	48	(39)
			720			71	45	(36)
			730			65	41	(34)
			740			58	37	(31)
			750			52	34	(28)
			760			48	31	(26)
			770			44	28	(24)
			780			41	25	(21)
			790			37	22	(19)
			800			33	20	(17)
X 8 CrNiNb 16 13	1.4961	Solution heat treated	580	127	91	182	129	115
			590	120	84	170	119	105
			600	113	78	157	108	94
			610	106	73	145	98	85
			620	99	67	134	89	77
			630	92	61	124	80	69
			640	85	55	113	72	61

For [1], see page 14.

Table B.1 (continued).

Material designation	Material number	Heat treatment condition	Temperature, in °C	1 % creep limit [1], in N/mm², after		Rupture stress [1], in N/mm², after		
				10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
X 8 CrNiNb 16 13 (concluded)	**1.4961**	Solution heat treated	650	78	49	103	64	53
			660	72	44	93	57	47
			670	66	39	84	50	41
			680	59	34	76	44	36
			690	54	30	70	39	31
			700	49	26	64	34	27
			710	45	24	59	30	25
			720	42	21	55	27	22
			730	39	19	51	25	19
			740	36	17	47	22	17
			750	34	16	44	20	15
X 8 CrNiMoNb 16 16	**1.4981**	Solution heat treated	580	177	128	270	186	162
			590	167	118	246	169	147
			600	157	108	225	152	132
			610	147	98	205	136	118
			620	137	88	186	122	103
			630	126	79	169	107	91
			640	118	72	152	94	80
			650	108	64	137	83	71
			660	98	56	124	75	63
			670	89	49	111	66	55
			680	80	43	100	59	49
			690	72	38	91	51	42
			700	64	34	83	44	35
			710	58	29	77	37	29
			720	53	26	70	31	24
			730	47	22	64	26	20
			740	44	19	59	23	17
			750	42	17	54	20	15
X 8 CrNiMoVNb 16 13	**1.4988**	Solution heat treated and aged	580	202	152	299	209	180
			590	194	145	274	189	164
			600	186	137	250	172	147
			610	176	128	228	156	132
			620	165	117	207	139	117
			630	152	106	189	125	105
			640	139	95	173	111	93
			650	128	83	157	98	82
X 5 NiCrAlTi 31 20 RK	**1.4958 RK**	Annealed for recrystallization	500			315	258	(242)
			510			297	241	(225)
			520			280	224	(207)
			530			262	206	(190)
			540			243	189	(172)
			550	164	(132)	224	171	(155)
			560	154	(122)	204	153	(138)
			570	144	(111)	184	136	(122)
			580	133	(101)	165	119	(106)
			590	123	(92)	147	104	(92)
			600	113	(82)	131	90	(80)
			610	103	(74)	117	79	(70)
			620	93	(65)	106	70	(62)
			630	84	(58)	96	62	(55)
			640	75	(51)	87	56	(49)

For [1], see page 14.

Table B.1 (concluded).

Material designation	Material number	Heat treatment condition	Temperature, in °C	1 % creep limit [1], in N/mm², after		Rupture stress [1], in N/mm², after		
				10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
X 5 NiCrAlTi 31 20 RK (concluded)	**1.4958 RK**	Annealed for recrystallization	650	67	(46)	80	51	(44)
			660	60	(41)	73	46	(40)
			670	55	(37)	67	42	(36)
			680	50	(33)	61	38	(33)
			690	45	(30)	55	34	(29)
			700	41	(27)	50	30	(26)
X 5 NiCrAlTi 31 20	**1.4958**	Solution heat treated	500			290	215	(196)
			510			279	205	(186)
			520			267	195	(176)
			530			254	184	(166)
			540			240	172	(155)
			550			225	160	(143)
			560			208	147	(130)
			570			190	133	(117)
			580			172	119	(105)
			590			155	106	(93)
			600	115	(85)	140	95	(83)
			610	109	(79)	128	85	(74)
			620	102	(74)	118	78	(68)
			630	96	(69)	109	72	(63)
			640	90	(64)	103	67	(59)
			650	84	(59)	97	63	(55)
			660	78	(55)	91	59	(52)
			670	73	(51)	85	55	(48)
			680	68	(47)	80	52	(45)
			690	63	(43)	74	48	(41)
			700	58	(40)	69	44	(38)
X 8 NiCrAlTi 32 21	**1.4959**	Solution heat treated (at 1100 to 1200 °C)	700	59,0	42,0	74,0	50,0	(44,0)
			710	55,5	38,0	68,0	45,0	(39,4)
			720	52,0	34,4	62,0	40,9	(35,5)
			730	48,5	31,3	56,0	37,4	(32,2)
			740	45,0	28,4	51,5	34,3	(29,3)
			750	41,7	26,0	47,5	31,6	(26,8)
			760	38,4	23,5	43,7	29,1	(24,6)
			770	35,6	21,3	40,5	27,0	(22,4)
			780	32,9	19,3	37,5	24,9	(20,7)
			790	30,5	17,6	35,0	23,1	(19,0)
			800	28,2	16,0	32,6	21,4	(17,5)
			810	26,2	14,7	30,4	19,8	(16,2)
			820	24,2	13,4	28,4	18,4	(15,1)
			830	22,4	12,1	26,5	17,0	(14,0)
			840	20,8	11,1	24,7	15,7	(13,0)
			850	19,1	10,0	23,0	14,4	(12,1)
			860	17,6	9,1	21,4	13,3	(11,2)
			870	16,1	8,2	19,9	12,2	(10,3)
			880	14,7	7,3	18,4	11,2	(9,5)
			890	13,4	6,5	17,0	10,3	(8,7)
			900	12,1	5,7	15,6	9,4	(8,0)
			910	10,9	5,0	14,4	8,6	(7,3)
			920	9,8	4,4	13,2	7,8	(6,7)
			930	8,8	3,9	12,1	7,1	(6,2)
			940	7,8	3,4	11,1	6,4	(5,6)
			950	6,9	2,9	10,1	5,8	(5,0)
			960	6,1	2,5	9,2	5,3	(4,5)
			970	5,3	2,1	8,4	4,8	(4,1)
			980	4,6	1,8	7,7	4,4	(3,7)
			990	4,0	1,6	7,0	4,0	(1,3)
			1000	3,5	1,4	6,4	3,7	(1,0)

For [1], see page 14.

Table B.2. **Guideline values for physical properties** [1])

Material		Density, in 10^3 kg/m³	Modulus of elasticity, in 10^9 N/m², at a temperature, in °C, of											Coefficient of linear thermal expansion, in $10^{-6} \cdot K^{-1}$, at a temperature between 20 °C and										Thermal conductance, in W/(m · K), at 20 °C	Specific heat capacity, in J/(kg · K), at 20 °C	Resistivity, in Ω · m, at 20 °C
designation	number		20	100	200	300	400	500	600	700	800	900	1000	100	200	300	400	500	600	700	800	900	1000			
X 6 CrNi 18 11	1.4948	7,93	198	192	183	175	167	159	150	142				16,3	16,9	17,3	17,8	18,2	18,5	18,7				17	450	0,71
X 3 CrNiN 18 11	1.4949																									
X 6 CrNiTi 18 10	1.4941																									
X 6 CrNiMo 17 13	1.4919	7,98																						16		0,77
X 3 CrNiMoN 17 13	1.4910																									
X 6 CrNiNb 16 13	1.4961	7,98																								0,78
X 6 CrNiMoNb 16 16	1.4981	8,01																								0,77
X 6 CrNiMoVNb 16 13	1.4988	7,96																						15		0,79
X 5 NiCrAlTi 31 20 RK	1.4958 RK	7,94	197	191	184	177	170	162	155	148	141	134	127	15,4	16,0	16,5	16,8	17,2	17,5	17,9	18,3	18,6	19,0	12	460	0,99
X 5 NiCrAlTi 31 20	1.4958																									
X 6 NiCrAlTi 32 21	1.4959																									

[1]) Cf. [1] and *Stahl-Eisen-Werkstoffblatt* 310.

Table B.3. **Guideline temperatures for heat treatment and hot forming**

Material		Temperature, in °C, for		Hot forming	
designation	number	annealing for recrystallization [1]	solution heat treatment [1]	Temperature, in °C	Quenching medium
X 6 CrNi 18 11	1.4948	–	1000 to 1080	1150 to 750	Air
X 3 CrNiN 18 11	1.4949	–	1000 to 1080		
X 6 CrNiTi 18 10	1.4941	–	1070 to 1150		
X 6 CrNiMo 17 13	1.4919	–	1020 to 1100		
X 3 CrNiMoN 17 13	1.4910	–	1020 to 1100		
X 8 CrNiNb 16 13	1.4961	–	1050 to 1100		
X 8 CrNiMoNb 16 16	1.4981	–	1050 to 1100		
X 8 CrNiMoVNb 16 13	1.4988	–	1100 to 1150 [2]		
X 5 NiCrAlTi 31 20 RK	1.4958 RK	920 to 1000	–		
X 5 NiCrAlTi 31 20	1.4958	–	1100 to 1200		
X 8 NiCrAlTi 32 21	1.4959	–	1100 to 1200 [3]		

[1] Followed by rapid quenching in water or air.
[2] Followed by ageing at 750 to 800 °C for 1 to 5 h in air.
[3] After solution heat treatment, the grain size index shall be within the range of 1 to 5 as specified in EURONORM 103.

Table B.4. **0,2 % proof stress [1] at temperatures over 600 °C**

Material		Heat treatment condition	Minimum 0,2 proof stress [1], in N/mm², at a temperature, in °C, of			
designation	number		700	800	900	1000
X 5 NiCrAlTi 3120	1.4958	Solution heat treated	75	70	50	20
X 8 NiCrAlTi 32 21	1.4959	Solution heat treated				

[1] The values are based on tensile tests at elevated temperature, a rate of strain of 0,5 % per minute having been applied.

Standards and other documents referred to

DIN 8528 Part 1	Weldability of metallic materials; concepts
DIN 17 010	General technical delivery conditions for steel and steel products
DIN 17 014 Part 1	Heat treatment of ferrous materials; terminology
DIN 17 440	Stainless steel; technical delivery conditions for sheet, hot rolled strip, wire rod, drawn wire, steel bars, forgings and semi-finished products
DIN 50 049	Inspection documents for the delivery of metallic materials
DIN EN 10 002 Part 1	Tensile testing of metallic materials; method of test at ambient temperature
DIN EN 10 002 Part 5	Tensile testing of metallic materials; method of test at elevated temperature
DIN EN 10 045 Part 1	Metallic materials; Charpy notched bar impact test; method of test
DIN EN 10 079	Definition and classification of steel products by shape and dimensions
EURONORM 103	Microscopic determination of the ferritic and austenitic grain size of steel

Stahl-Eisen-Prüfblatt 1805 [1]) *Probenahme und Probenvorbereitung für die Stückanalyse von Stählen* (Sampling and sample preparation for the product analysis of steel)

Handbuch für das Eisenhüttenlaboratorium *)

Cf. appendix A for other relevant standards.

*) Obtainable from *Verlag Stahleisen mbH*, Postfach 82 29, D-4000 Düsseldorf 1.

For [1]), see page 20.

Literature

[1] Richter, F. *Physikalische Eigenschaften von Stählen und ihre Temperaturabhängigkeit* (Physical properties of steel as a function of temperature), published in *Stahl-Eisen-Sonderberichte* (Iron and steel special reports), 1983 : 10 *).

Explanatory notes

Some of the steel grades specified here have been taken from *Stahl-Eisen-Werkstoffblatt* (SEW) 670 and *Stahl-Eisen-Lieferbedingungen* (Iron and steel delivery conditions) (SEL) 675, which have been withdrawn.

Up to now, steel grades X 8 CrNiNb 16 13, X 8 CrNiMoNb 16 16 and X 8 CrNiMoVNb 16 13 were supplied on the basis of SEW 670, SEL 675 and of *VdTÜV-Werkstoffblatt* (VdTÜV Materials sheet) 104 [1]).

Steel grades X 6 CrNiMo 17 13 and X 6 CrNi 18 11, as specified in *VdTÜV-Werkstoffblätter* 312 and 313 respectively, have been available for a long time, but were not covered in SEW 670.

Steel grades X 3 CrNiN 18 11 and X 3 CrNiMoN 17 13, as specified in *VdTÜV-Werkstoffblätter* 383 and 484 respectively, are relatively new materials, information regarding the good performance of the latter grade having already been published.

Requirements regarding grade X 8 CrNiTi 18 10 are based on experience gathered with the high-temperature steel with material number 1.4878 as specified in SEW 470 and the influence of molybdenum on the strength of that steel. The chemical composition specified for steel grade X 8 CrNiTi 18 10 is largely in compliance with the information given in *VdTÜV-Werkstoffblatt* 464.

Grades X 5 NiCrAlTi 31 20 and X 8 NiCrAlTi 32 21 are variants of the high-temperature steel grade X 10 NiCrAlTi 32 20 (1.4876) as specified in SEW 470. Requirements regarding these grades are based on extensive research, together with regression analyses regarding the influence of the chemical composition on the service life.

Grade X 5 NiCrAlTi 32 20 is intended for service temperatures of 500 to 700 °C. When used at temperatures around 500 °C, and when supplied in the annealed for recrystallization condition, this steel grade offers certain advantages. Grade X 8 NiCrAlTi 32 21 is suitable for service temperatures of 700 to 1000 °C.

Comparison of similar materials as specified in this standard, ISO/CD *) 9327-5, and ISO 9328-5 : 1991.

DIN 17460		ISO/CD 9327-5	[1])	ISO 9328-5	[1])
Material designation	Material number				
X 6 CrNi 18 11	1.4948	X 7 CrNi 18 9	○	X 7 CrNi 18 9	○
X 3 CrNiN 18 11	1.4949	–		–	
X 8 CrNiTi 18 10	1.4941	X 7 CrNiTi 18 10	○	X 7 CrNiTi 18 10	○
X 6 CrNiMo 17 13	1.4919	X 7 CrNiMo 17 12	○	X 7 CrNiMo 17 12	○
X 3 CrNiMoN 17 13	1.4910	–		–	
X 8 CrNiNb 16 13	1.4961	X 7 CrNiNb 16 13	●	–	
X 8 CrNiMoNb 16 16	1.4981	–		–	
X 8 CrNiMoVNb 16 13	1.4988	–		–	
X 5 NiCrAlTi 31 20	1.4958	–		X 8 NiCrAlTi 32 21	○
X 8 NiCrAlTi 32 21	1.4959	–		X 7 NiCrAlTi 32 21	○

*) Committee Draft.

[1]) The symbols indicate the degree of conformance of the chemical composition of the materials covered here, as compared with ISO/CD 9327-5 and ISO 9328-5 : 1991, as follows: ● = slightly different; ○ = substantially different.

*) Obtainable from *Verlag Stahleisen mbH*, Postfach 82 29, D-4000 Düsseldorf 1.

[1]) Obtainable from *Maximilian-Verlag*, Postfach 23 52, D-4900 Herford.

International Patent Classification

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B 21 J 1/00
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C 22 C 38/04
C 22 C 38/40
G 01 N 33/20