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September 1992

Seamless circular high-temperature austenitic steel tubes
Technical delivery conditions

DIN 17459

Nahtlose kreisförmige Rohre aus hochwarmfesten austenitischen Stählen; technische Lieferbedingungen

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 2604-2 : 1975; published by the International Organization for Standardization.

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

This standard specifies technical delivery conditions for seamless circular tubes made from high-temperature austenitic steel as specified in table 1. Such tubes are intended primarily to be used in high-pressure applications where elevated temperatures and high mechanical stresses are involved (e.g. in the construction of pressure boilers, pressure vessels, pipelines, and in the chemical industry).

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.

3 Steel grades

3.1 This standard deals with tubes made from the steel grades specified in table 1.

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

4 Designation and ordering

4.1 Standard designation

The standard designation shall give, in the following order:

a) name of product (tube);

b) number of the relevant dimensional standard (DIN 2462 Part 1);

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c) characteristic dimensions (outside diameter × wall thickness, *s*);
d) DIN number (DIN 17459);
e) material designation or number (cf. table 1);
f) symbol indicating heat treatment condition (cf. table 5).

Designation of a seamless circular tube in compliance with this standard and with DIN 2462 Part 1, with an outside diameter of 38 mm and a wall thickness of 2,6 mm, made of X 6 CrNi 18 11 steel (material number 1.4948), supplied in the cold formed, heat treated and pickled condition (h or III b):

Tube DIN 2462 – 38 × 2,6 – DIN 17459 – X 6 CrNi 18 11 h

or

Tube DIN 2462 – 38 × 2,6 – DIN 17459 – X 6 CrNi 18 11 III b

or

Tube DIN 2462 – 38 × 2,6 – DIN 17459 – 1.4948 h

or

Tube DIN 2462 – 38 × 2,6 – DIN 17459 – 1.4948 III b

4.2 • Essential order details

The following order details are essential.

4.2.1 Quantity (e.g. total length, number of items or mass).

4.2.2 Name of product (tube).

4.2.3 Number of relevant dimensional standard (DIN 2462 Part 1).

4.2.4 Characteristic dimensions (outside diameter × wall thickness) (cf. DIN 2462 Part 1).

4.2.5 DIN number (DIN 17459).

4.2.6 Material designation or number (cf. table 1).

4.2.7 Symbol denoting heat treatment condition (cf. table 5).

4.2.8 Type of length (cf. DIN 2462 Part 1).

4.2.9 Tolerance class for outside diameter and wall thickness (cf. DIN 2462 Part 1).

4.2.10 Type of DIN 50 049 inspection document (cf. subclause 6.1) and, in the case of third party inspection, the testing agency and any specifications to be complied with.

Example of an order:

100 m of seamless circular tube complying with DIN 2462 Part 1 and with this standard, with an outside diameter of 38 mm and a wall thickness of 2,6 mm, made of X 6 CrNi 18 11 steel (material number 1.4948), condition on supply h, in specified lengths of 6 m, belonging to tolerance class D2, T3, to be supplied with a DIN 50 049 – 3.1.B inspection document, shall be ordered as:

100 m tube DIN 2462 – 38 × 2,6
DIN 17459 – X 6 CrNi 18 11 – h
in specified lengths of 6 m, tolerance class D2, T3, with DIN 50 049 – 3.1.B inspection document

4.3 •• Optional order details

The essential order details may, if so agreed, be supplemented by one or more of the following items and tests.

4.3.1 The steelmaking process used (cf. subclause 5.1.1).

4.3.2 The manufacturing process used (cf. subclause 5.1.2.1).

4.3.3 Non-destructive testing for determining longitudinal and transverse imperfections (cf. subclause 5.10.2).

4.3.4 Ultrasonic testing of tubes made from 1.4959 steel (cf. subclause 5.10.3).

4.3.5 Non-destructive testing of tubes with an outside diameter not exceeding 20 mm and a wall thickness not exceeding 2 mm (cf. subclause 5.10.4).

4.3.6 Sizes of tubes if other than specified here (cf. subclause 5.11.2).

4.3.7 Cross section of tubes if other than circular (cf. subclause 5.11.3).

4.3.8 Determination of elevated temperature 0,2 % or 1 % proof stress (cf. subclause 6.3.1.4).

4.3.9 Chemical composition as determined by product analysis (cf. subclause 5.3.2).

4.3.10 Internal hydrostatic pressure testing at a higher pressure than specified here (cf. subclause 6.5.9).

4.3.11 Method of tightness testing to be used (cf. subclause 6.5.9).

4.3.12 Continuous marking (cf. subclause 7.3).

Example of an order with optional details:

100 m of seamless circular tube complying with DIN 2462 Part 1 and this standard, with an outside diameter of 38 mm and a wall thickness of 2,6 mm, made from X 6 CrNi 18 11 steel (material number 1.4948), as delivered condition m, in specified lengths of 6 m, belonging to tolerance class D2, T3, where the tube has been tested non-destructively, with verification of elevated temperature proof stress, to be supplied with a DIN 50 049 – 3.1.C inspection document, shall be ordered as:

100 m tube DIN 2462 – 38 × 2,6
DIN 17459 – X 6 CrNi 18 11 – m
in specified lengths of 6 m, tolerance class D2, T3, with DIN 50 049 – 3.1.C inspection document, tested non-destructively – 300 °C proof stress

5 Requirements

5.1 Manufacturing process

5.1.1 Unless otherwise specified, the steelmaking process shall be at the manufacturer's discretion.

•• If so agreed, the purchaser shall be informed of the steelmaking process used.

5.1.2 Tubes are normally produced by hot or cold rolling, hot pressing or cold drawing, or a combination of these processes. The manufacturing process shall be at the manufacturer's discretion.

5.1.2.1 •• If so agreed, the purchaser shall be informed of the manufacturing process used.

5.2 As delivered condition

Tubes shall be supplied in one of the conditions specified in tables 3 and 5. The solution heat treatment temperature of hot pressed tubes shall be as specified in table A.3, with quenching in water (with the exception of grade X 8 CrNiMoVNb 16 13).

5.3 Chemical composition

5.3.1 Ladle analysis

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

5.3.2 Product analysis

5.3.2.1 •• A product analysis may be agreed at the time of ordering. Where such an analysis is carried out, the results may deviate from the values given in table 1 by the amounts listed in table 2.

5.3.3 Deviations

With the consent of the purchaser, minor deviations of the chemical composition from the limiting values specified are permitted, provided they do not adversely affect the mechanical properties and weldability of the tube.

5.4 Mechanical properties

5.4.1 The values of 0,2 % and 1 % proof stress, tensile strength, elongation at fracture and impact energy at ambient temperature shall comply with the values given in table 3.

5.4.2 The elevated temperature 0,2 % and 1 % proof stress shall be as specified in table 4.

5.4.3 The values specified in tables 3 and 4 apply for the conditions specified in subclause 5.2, under the conditions of test specified in clause 6.

5.4.4 Guideline values for rupture stress are given in appendix A, table A.1.

5.5 Technological properties

5.5.1 Tubes shall pass the tests referred to in subclauses 6.5.4 and 6.5.7. Note that tubes as specified here are suitable for both hot and cold forming.

5.6 Weldability

5.6.1 Tubes as covered here are suitable for arc welding.

5.6.2 The steels specified here may not be suitable for all welding operations, as the behaviour of steel during and after welding changes as a function of the material, form and size of the component, and of the manufacturing and service conditions (cf. DIN 8528 Part 1).

5.6.3 Any filler metal required shall be selected, on the basis of DIN 8556 Part 1, 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.

5.7 Heat treatment and hot forming

Guideline temperatures for heat treatment and hot forming are given in table A.3.

5.8 Heat treatment condition and surface quality

5.8.1 • Tubes shall be supplied in one of the conditions specified in table 5, this being at the purchaser's discretion.

5.8.2 Tubes shall have a smooth inner and outer surface, consistent with the manufacturing process used.

5.8.3 Slight irregularities in the surface resulting from the manufacturing process (e.g. excess weld metal, raised spots, pit marks, scores) are permitted, provided the thickness tolerance is not exceeded (cf. subclause 5.11.1) and the performance of the tubes is not adversely affected.

5.8.4 Dressing of imperfections (e.g. by grinding) is permitted, provided the thickness after dressing continues to meet the requirements specified in subclause 5.11.1. Repair of surface defects by hammering is not permitted.

5.9 Tightness

Tubes shall be subjected to tightness testing under the conditions specified in subclause 6.5.9.

5.10 Imperfections

Cf. subclauses 6.5.11 to 6.5.14.

5.11 Dimensions, tolerances and mass per unit length

5.11.1 The dimensions, tolerances and mass per unit length of tubes shall be as specified in DIN 2462 Part 1.

5.11.2 •• If so agreed, tube sizes other than specified in DIN 2462 Part 1 may be supplied.

5.11.3 •• If so agreed, non-circular (e.g. oval) tubes may be supplied.

6 Testing

6.1 Inspection documents

Tubes complying with this standard shall be supplied with one of the following DIN 50 049 (EN 10 204) inspection documents:

a) EN 10 204 inspection certificate A;
b) EN 10 204 inspection certificate B;
c) EN 10 204 inspection certificate C;
d) EN 10 204 inspection report.

6.1.1 The certificate or report shall include the following particulars:

a) the results of testing as described in subclause 6.5;
b) the titles of any technical specifications on which testing for compliance with requirements is based;
c) the results of ladle analysis for all elements specified in table 1 for the relevant steel grade (this may also be given in an EN 10 204-2.2 inspection document).
d) marking (cf. clause 7).

6.1.2 Where any of the optional tests listed in subclause 4.3 have been agreed, the test results shall be given in an EN 10 204-3.1.B inspection document.

6.2 Test site

Tubes shall be tested at the manufacturer's works. Where an inspector (of a testing agency) is responsible for testing, production shall not be unduly disturbed. A summary of scope of testing and inspection documents is given in table 6.

6.3 Scope of testing

6.3.1 Tubes shall be tested by batches.

6.3.1.1 Tubes shall be separated into batches according to material, cast, size (wall thickness) and, if necessary, heat treatment condition, each batch consisting of 100 tubes. Tubes may also be separated according to as manufactured length.

Remainders of up to 50 units may be distributed uniformly among the other batches, remainders of over 50 units and consignments of less than 50 units being considered a whole batch.

6.3.1.2 One tube shall be taken as a sample from each batch, from which test pieces are then taken. The following tests shall be carried out on the sample:

a) one tensile test at ambient temperature; where tubes with an outside diameter of 200 mm or more and a wall thickness of 12 mm or more are used as pressure vessel shells, 10 % of the tubes per batch shall be tested;
b) one set of test pieces shall be taken for impact testing from samples with a wall thickness of 20 mm or more; where tubes are used as pressure vessel shells, 10 % of the tubes per batch shall be tested.

6.3.1.3 •• If so agreed, one product analysis per cast shall be performed.

6.3.1.4 •• Where determination of the 0,2 % and 1 % proof stress has been agreed, the test temperature and scope of testing shall also be the subject of agreement.

6.3.1.5 Where *s* does not exceed 40 mm, each tube or as manufactured length shall undergo a flattening, expanding ring, or ring tensile test as a function of the outside diameter (cf. table 7). If required by the manufacturer, a drift expanding test may be performed instead of an expanding ring test.

6.3.1.6 Where *s* exceeds 40 mm, both ends of the tube over a length of 25 mm shall undergo non-destructive testing as described in subclause 6.5.10.

6.3.1.7 Only 10 % of the tubes in one batch need undergo ultrasonic testing as described in *Stahl-Eisen-Prüfblatt* (Iron and steel test sheets) 1915 and 1918.

6.3.1.8 Tubes with an outside diameter exceeding 20 mm or a wall thickness exceeding 2 mm (with the exception of grade X 8 NiCrAlTi 32 21) shall undergo non-destructive testing as described in subclause 6.5.11.

6.3.1.9 One sample from each batch shall undergo the following:

a) tightness test;
b) materials identity test;
c) visual check for surface appearance;
d) check for dimensional accuracy.

6.4 Sampling and sample preparation

See figure 1 for location and orientation of test pieces.

6.4.1 Tensile test

6.4.1.1 Tensile test pieces shall be taken parallel to the tube axis in the form of tube sections, flattened strips or round bar test pieces as specified in DIN EN 10 002 Part 1. It shall be permitted to repair local imperfections. The test piece shall not be heat treated nor straightened along its length. Where *s* exceeds 30 mm, the axis of round bar test pieces shall be located at a point which corresponds to a distance from the outer surface equal to one-fourth of the wall thickness, or as near as possible to this point.

6.4.1.2 In the case of tubes with an outside diameter of 200 mm or more, and where straightening is not required, it shall be permitted to take test pieces transverse to the tube axis and machine them on all sides to produce flat or round bar test pieces.

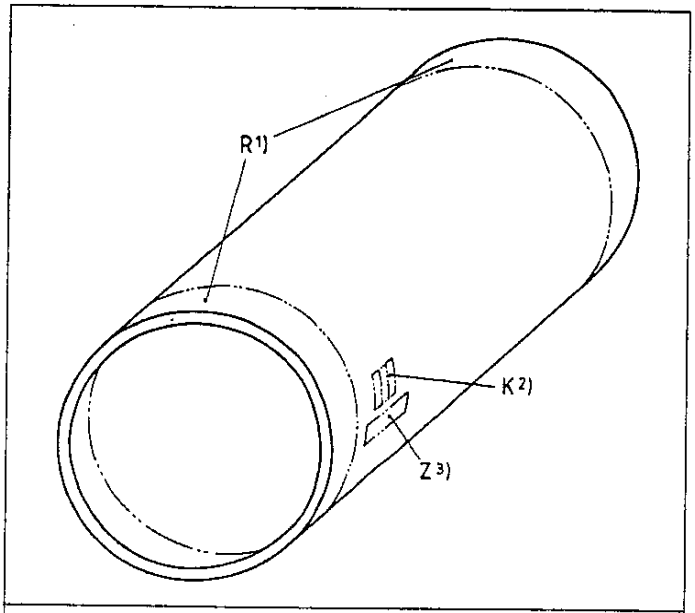
6.4.2 Impact test

Where straightening is not required, a set of three ISO-V notch test pieces shall be taken transverse to the tube axis. Otherwise, they shall be taken parallel to the tube axis. Where *s* exceeds 30 mm, the axis of the test pieces shall be located at a point which corresponds to a distance from the outer surface equal to one-fourth of the wall thickness, or as near as possible to this point.

The test pieces shall be taken and prepared so that the notch axis runs at right angles to the tube surface.

6.4.3 Ring tests

Test pieces for the flattening, expanding ring, drift expanding and ring tensile tests shall be taken from both ends of the sample or the as manufactured length (cf. table 7).



1) Cf. subclause 6.4.3.
2) Transverse or parallel to tube axis, where *s* is at least 20 mm (cf. subclause 6.4.2).
3) Cf. subclause 6.4.1.

In the above figure,
K = set of three ISO-V notch test pieces as specified in DIN EN 10 045 Part 1;
R = test pieces for ring tests;
Z = tensile test piece.

Figure 1. Test piece location and orientation

Where as manufactured lengths of tube are to be cut to smaller lengths after testing, no further tests need be carried out, provided that the smaller lengths are suitably identified as having been taken from the as manufactured length thus tested.

6.4.4 Chemical composition

For determination of the chemical composition based on a product analysis of the manufactured tube, sample chips shall be taken at points uniformly distributed over the wall thickness, this also applying where spectral analyses are to be carried out. Unless otherwise specified, sampling shall be in accordance with *Stahl-Eisen-Prüfblatt* 1805.

6.5 Test procedure

6.5.1 The tensile test shall be carried out at ambient temperature as described in DIN EN 10 002 Part 1.

6.5.2 •• Where it has been agreed to determine the 0,2 % and 1 % proof stress, testing shall be carried out as described in DIN EN 10 002 Part 5.

6.5.3 Impact testing shall be carried out as described in DIN EN 10 045 Part 1.

6.5.4 The flattening test shall be carried out as described in DIN 50 136, the test pieces or tube ends being flattened until a distance between platens, H, in mm, as defined below, is reached:

$$H = \frac{(1 + c)\,s}{c + s/d_a}$$

where

s it the wall thickness, in mm;

d_a is the outside diameter, in mm;

c is a constant which is equal to 0,10. Where the ratio s/d_a is greater than 0,25, c shall be reduced by 0,01.

6.5.5 The drift expanding test shall be carried out as described in DIN 50 135, using a tapered mandrel with a 60° taper angle, until the material has expanded, as a function of the ratio inside diameter (d_i) to outside diameter (d_a), by the following amounts (as a percentage of the outside diameter):

20 % where d_i/d_a is greater than 0,6;

15 % where d_i/d_a is less than or equal to 0,6.

6.5.6 The expanding ring test shall be carried out as described in DIN 50 137. Test pieces shall be subjected to load until fracture, or until the inside diameter has expanded to 40 %, then assessed.

6.5.7 The ring tensile test shall be carried out as described in DIN 50 138.

6.5.8 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).

6.5.9 Tightness testing shall be carried out by applying an internal hydrostatic pressure as described in DIN 50 104. Unless otherwise agreed, the test pressure shall be 80 bar and maintained for at least five seconds.

The load level shall not be below a value corresponding to 1,1 times the factor of safety with respect to the 0,2 % proof stress (cf. subclause 4.6 of the June 1972 edition of DIN 2413, where this factor is equal to 0,9). This shall also be considered when testing thin-walled tubes with large outside diameters at 80 bar.

Where tightness testing is carried out with air and with a foaming medium, the test pressure shall be 0,3 bar and maintained for at least five seconds.

•• Unless otherwise specified, the manufacturer shall select one of the above methods for tightness testing.

Instead of internal hydrostatic pressure testing, non-destructive testing (e.g. eddy current testing as described in *Stahl-Eisen-Prüfblatt* 1925) or tightness testing using helium may be carried out.

6.5.10 Non-destructive testing of the tube ends shall be carried out as described in *Stahl-Eisen-Prüfblatt* 1919, where s exceeds 40 mm. This may also be carried out, instead of the ring tensile test, where s is not more than 40 mm and an outside diameter exceeding 508 mm.

6.5.11 When tubes with an outside diameter exceeding 20 mm and a wall thickness exceeding 2 mm are checked for longitudinal imperfections by ultrasonic testing, the requirements given in *Stahl-Eisen-Prüfblatt* (Iron and steel test sheet) 1915 shall be met.

6.5.12 •• If so agreed, tubes may be subjected to ultrasonic testing for longitudinal imperfections as described in *Stahl-Eisen-Prüfblatt* 1915 or for transverse imperfections as described in *Stahl-Eisen-Prüfblatt* 1918, with the exception of tubes made from material number 1.4959.

6.5.13 •• If so agreed, tubes made from material number 1.4959 may be subjected to ultrasonic testing.

6.5.14 •• If so agreed, tubes with an outside diameter not exceeding 20 mm and a wall thickness not exceeding 2 mm shall be subjected to ultrasonic testing as described in *Stahl-Eisen-Prüfblatt* 1915.

6.5.15 A visual check of the outside and, as far as possible, the inside of tubes, shall be made by a person with normal vision under sufficient light.

Note. Instead of the visual check, the manufacturer and purchaser may agree on a suitable alternative method.

6.5.16 Tube dimensions shall be measured using suitable instruments.

6.5.17 Determination of straightness shall be carried out by suitable means.

6.5.18 Determination of materials identity shall be carried out by suitable means (e.g. spectroscopy).

6.6 Retests

6.6.1 Tubes which do not pass the tests specified in subclauses 6.5.4 to 6.5.17 (except for subclause 6.5.8) shall be sorted out. The manufacturer shall be entitled to correct any defects or deficiencies determined upon testing and to submit the tubes for renewed inspection.

6.6.2 If one test tube fails the tensile test or the impact test, the manufacturer shall be permitted to retest twice the number of test pieces taken from the same tube, in which case all test pieces shall satisfy the requirements. If this is not the case, the tube shall be sorted out.

Instead of retesting the failed tube as described above, two other tubes may be taken from the same batch and subjected to renewed tensile and impact testing. Should these tubes also fail, the batch shall be deemed not to be in conformance with the standard. However, the manufacturer and purchaser may agree that all units belonging to the same batch be tested individually.

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

Material		Percentage by mass									
designation	number	C	Si	Mn	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 within one cast that an element shows 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 for one cast.

Table 3. **Mechanical properties of tubes with wall thicknesses up to 50 mm [1], at ambient temperature**

Material designation	Material number	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, A_5 ($L_0 = 5{,}65\sqrt{S_0}$), as a percentage		Min. impact energy [2] (ISO-V), in J	
						Longitudinal	Transverse	Longitudinal	Transverse
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 [3]	1.4941	Solution heat treated	195	235	490 to 640	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 [4]	1.4981	Solution heat treated	215	255	530 to 690	35	22	65	45
X 8 CrNiMoVNb 16 13 [4]	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] Where the wall thickness exceeds 50 mm, values of mechanical properties shall be the subject of agreement.
[2] Represents the mean from three test pieces. One single value may be lower, by not more than 30 %.
[3] Values apply to cold formed tubes; in the case of hot formed tubes, the values shall be the subject of agreement.
[4] Values apply to tubes with an outside diameter up to 20 mm.

6.6.3 The manufacturer shall be permitted to correct defects or deficiencies by means of heat treatment or in another suitable manner, and resubmission of a failed batch shall be at his discretion. If the batch fails testing after resubmission, it shall be deemed not to be in conformance with this standard.

6.6.4 Test results that may be deemed to have been falsified by incorrect sampling, sample preparation or testing shall not be counted.

7 Marking

7.1 One end of each tube in compliance with this standard shall be clearly and durably marked with the following information:

a) manufacturer's mark;
b) material designation or number;
c) symbol denoting heat treatment condition (cf. table 5);
d) the letter 'X', where tubes made from grade X 8 CrNiTi 18 10 have been hot formed;
e) article number and, where the outside diameter is 114,3 mm or more, the symbol denoting cast number, or the number itself;
f) the inspector's mark;
g) symbol indicating that non-destructive testing in accordance with subclause 6.5.12 has been carried out.

7.2 Tubes shall be marked by means of stamping, engraving or imprinting. Thin-walled tubes or those with a small outside diameter may be marked by other suitable means (e.g. by labelling the bundle).

7.3 •• Continuous marking of a length of tube may be agreed at the time of ordering.

8 Complaints

8.1 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 degree. This shall apply unless otherwise agreed at the time of ordering.

8.2 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 products objected to or samples of the products supplied.

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 18 11	1.4948	Solution heat treated	157	127	108	98	88	83	78	191	157	137	127	118	113	108
X 3 CrNiN 18 11	1.4949	Solution heat treated	185	150	130	120	110	105	100	220	175	150	140	130	125	120
X 8 CrNiTi 18 10 [1]	1.4941	Solution heat treated	162	142	132	123	113	108	103	201	181	172	162	152	147	142
X 6 CrNiMo 17 13	1.4919	Solution heat treated	177	147	127	118	108	103	98	211	177	157	147	137	132	128
X 3 CrNiMoN 17 13	1.4910	Solution heat treated	205	170	148	134	127	124	121	240	200	178	164	157	154	151
X 8 CrNiNb 16 13	1.4961	Solution heat treated	175	157	137	128	118	118	113	205	186	167	157	147	147	142
X 8 CrNiMoNb 16 16	1.4981	Solution heat treated	195	177	157	147	137	137	132	225	206	186	177	167	167	162
X 8 CrNiMoVNb 16 13	1.4988	Solution heat treated and aged	215	196	177	167	157	152	147	245	226	206	196	186	181	177
X 5 NiCrAlTi 31 20 RK	1.4958 RK	Annealed for recrystallization	180	160	145	130	120	115	110	205	180	165	155	145	140	135
X 5 NiCrAlTi 31 20	1.4958	Solution heat treated	140	115	95	85	80	75	75	160	135	115	105	100	95	95
X 8 NiCrAlTi 32 21	1.4959	Solution heat treated	140	115	95	85	80	75	75	160	135	115	105	100	95	95

[1]) Values apply to cold formed tubes; in the case of hot formed tubes, the values shall be the subject of agreement.

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

Symbol	Heat treatment condition	Surface quality
c1 or **II a**	Hot formed, heat treated [1], descaled	Clean
c2 or **II a**	Hot formed, heat treated [1], pickled	
h or **III b**	Cold formed, heat treated, pickled	Pickled bright, smoother than condition c2 (II a)
m or **III d**	Cold formed and heat treated (scale-free)	Bright annealed, smoother than condition h (III b)
For [1], see subclause 5.2.		

Table 6. **Summary of scope of testing and DIN 50049 (EN 10204) inspection documents**
(See figure 1 for location and orientation of test pieces and subclause 6.3.1 for batch sizes.)

Test to be carried out			Scope of testing	DIN 50049 inspection document
No.		Subclause		
1	Ladle analysis	5.3.1	1 analysis per cast or casting unit (all elements given in table 1 for the relevant grade)	EN 10204 inspection report
2	Tensile test at ambient temperature	6.3.1.2 6.4.1 6.5.1	1 test piece from one sample per batch [1]	EN 10204 inspection report or certificate A, B or C
3	Impact test	6.3.1.2 6.4.2 6.5.3	1 set of 3 test pieces from 1 sample per batch, where s is at least 20 mm [2]	EN 10204 inspection report or certificate A, B or C
4	Ring test (cf. table 7)	6.3.1.5 6.4.3 6.5.4 6.5.5 6.5.6 6.5.7	1 test piece from one end of each tube or as manufactured length, where s does not exceed 40 mm [3]	EN 10204 inspection report or certificate A, B or C
5	Non-destructive testing of tube ends	6.3.1.6 6.5.10	All tubes, where s exceeds 40 mm.	EN 10204 inspection certifcate B
6	Tightness test	6.3.1.9 6.5.9	All tubes	EN 10204 inspection certificate B
7	Visual check	6.3.1.9 6.5.15	All tubes	EN 10204 inspection report or certificate A, B or C
8	Materials identity test	6.3.1.9 6.5.18	All tubes	EN 10204 inspection certificate B
9	Check for dimensional accuracy	6.3.1.9 6.5.16 6.5.17	All tubes	EN 10204 inspection report or certificate A, B or C
10	Non-destructive testing of tube [4]	6.3.1.6 6.5.11	All tubes	EN 10204 inspection certificate B
11	•• Tensile test at elevated temperature	6.3.1.2 6.5.2	Subject to agreement.	EN 10204 inspection report or certificate A, B or C
12	•• Product analysis	6.4.4 6.5.8	1 analysis per cast.	EN 10204 inspection certificate B

[1] Where tubes with an outside diameter of 200 mm or more and a wall thickness of 12 mm or more are to be used as pressure vessel shells, test pieces shall be taken from 10 % of the tubes per batch.
[2] Where tubes are to be used as pressure vessel shells, test pieces shall be taken from 10 % of the tubes per batch.
[3] Where tubes are to undergo ultrasonic testing as described in *Stahl-Eisen-Prüfblatt* 1915 and 1918, test pieces shall be taken from 10 % of the tubes per batch.
[4] •• Subject to agreement in the case of tubes with an outside diameter not exceeding 20 mm and a wall thickness not exceeding 2 mm and of tubes made from grade X 8 NiCrAlTi 32 21 (cf. subclause 6.5.12).

Table 7. **Ring tests to be carried out (as a function of tube size)**

Tube diameter, in mm		Wall thickness, in mm		
Outside	Inside	Up to 2	Over 2 up to 16	Over 16 up to 40
≤ 21,3	≤ 15	Flattening test	Flattening test	–
≤ 21,3	> 15	Flattening test	Expanding ring test [1]	–
> 21,3 ≤ 146	≤ 15	–	Expanding ring test [1]	Flattening test
> 21,3 ≤ 146	> 15	Flattening test	–	Flattening test
> 146	≤ 100	–	Ring tensile test [2]	Ring tensile test
> 146	> 100	–	–	Ring tensile test

[1] A drift expanding test may be performed instead of the expanding ring test.

[2] Instead of the ring tensile test, the manufacturer shall be permitted to perform non-destructive testing as described in subclause 6.5.10 in the case of tubes with an outside diameter exceeding 508 mm.

Appendix A
Additional information

A.1 Rupture stress

Table A.1 specifies guideline values for the rupture stress of seamless tubes as covered here. 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.

A.2 Guideline values for physical properties

Selected guideline values for physical properties are given in table A.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.

A.3 Guideline temperatures for heat treatment and hot forming

A.3.1 Table A.3 gives guideline temperatures for heat treatment and hot forming.

A.3.2 Although the steels covered here are usually suitable for cold forming, it should be noted that this will alter their mechanical and physical properties.

A.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 A.4, which is based on tensile tests at elevated temperature, a rate of strain of 0,5 % per minute having been applied.

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

Material designation	Material number	Heat treatment condition	Temperature, in °C	1 % creep limit [1], in N/mm², after 10 000 h	1 % creep limit [1], 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 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 A.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 12.

Table A.1 (continued).

Material designation	Material number	Heat treatment condition	Temperature, in °C	1 % creep limit [1], in N/mm², after 10 000 h	1 % creep limit [1], 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 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	128	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 12.

Table A.1 (concluded).

Material designation	Material number	Heat treatment condition	Temperature, in °C	1 % creep limit [1], in N/mm², after 10 000 h	1 % creep limit [1], 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 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 12.

Table A.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 8 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 8 NiCrAlTi 32 21	1.4959																									

[1]) Cf. [1].

Table A.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 8 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	1.4958	920 to 1000	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 A.4. **0,2 % proof stress 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 31 20	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 2413	Design of wall thickness of steel tubes for resistance to internal pressure
DIN 2462 Part 1	Seamless stainless steel tubes; dimensions and mass per unit length
DIN 8528 Part 1	Weldability of metallic materials; concepts
DIN 8556 Part 1	Filler metals for welding stainless and heat resisting steel; designation and technical delivery conditions
DIN 17014 Part 1	Heat treatment of ferrous materials; terminology
DIN 50049	Inspection documents for the delivery of metallic materials
DIN 50104	Internal hydrostatic pressure testing of hollow bodies; general specifications
DIN 50135	Drift expanding test on metal tubes
DIN 50136	Flattening test on metal tubes
DIN 50137	Expanding ring test on metal tubes
DIN 50138	Ring tensile test on metal tubes
DIN EN 10002 Part 1	Tensile testing of metallic materials; method of test at ambient temperature
DIN EN 10002 Part 5	Tensile testing of metallic materials; method of test at elevated temperatures
DIN EN 10045 Part 1	Metallic materials; Charpy notched bar impact test; method of test

EURONORM 103 Microscopic determination of the ferritic and austenitic grain size of steel

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

Stahl-Eisen-Prüfblatt 1915 *Ultraschallprüfung auf Längsfehler von Rohren aus warmfesten Stählen* (Ultrasonic testing for longitudinal imperfections in steel tubes with elevated temperature properties) *)

Stahl-Eisen-Prüfblatt 1918 *Ultraschallprüfung auf Querfehler von Rohren aus warmfesten Stählen* (Ultrasonic testing for transverse imperfections in steel tubes with elevated temperature properties) *)

Stahl-Eisen-Prüfblatt 1919 *Ultraschallprüfung auf Dopplungen von Rohren aus warmfesten Stählen* (Ultrasonic testing for laminations in steel tubes with elevated temperature properties) *)

Stahl-Eisen-Prüfblatt 1925 *Elektromagnetische Prüfung von Rohren zum Nachweis der Dichtheit* (Electromagnetic testing of tubes for verification of leak tightness) *)

Handbuch für das Eisenhüttenlaboratorium *)

Literature

[1] F. Richter, *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 and in ISO 2604-2 : 1975

DIN 17459		ISO 2604-2	[1])
Material designation	Material number		
X 6 CrNi 18 11	1.4948	TS 48	○
X 3 CrNiN 18 11	1.4949	–	
X 8 CrNiTi 18 10	1.4941	TS 54	○
X 6 CrNiMo 17 13	1.4919	TS 63	●
X 3 CrNiMoN 17 13	1.4910	–	
X 8 CrNiNb 16 13	1.4961	TS 56	○
X 8 CrNiMoNb 16 16	1.4981	TS 67	●
X 8 CrNiMoVNb 16 13	1.4988	–	
X 5 NiCrAlTi 31 20	1.4958	–	
X 8 NiCrAlTi 32 21	1.4959	TS 69	○

[1]) The symbols indicate the degree of conformance of the chemical composition of the materials covered here, as compared with ISO 2604-2 : 1975, 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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