UDC 621.643.2-462.3-034.14.018.44 : 620.1

May 1979

Seamless Tubes of Heat-resistant Steels

Technical Conditions of Delivery

DIN 17 175

Nahtlose Rohre aus warmfesten Stählen; Technische Lieferbedingungen

For connection with the International Standard ISO 2604/II issued by the International Organization for Standardization (ISO), see Explanations.

Sections marked with a dot (•) contain details on agreements which shall, or may be, reached at the time of ordering.

1 Scope

This standard applies to seamless tubes [1] including tubes for headers of heat-resistant steels according to Table 1 which are used in the construction of boilers, pipe-lines, pressure vessels and equipment for service up to 600 °C and at simultaneous high pressures, where the tototal stress and the relevant scaling conditions can raise or lower the temperature limit.

2 Other relevant standards and documents

DIN 2391 Part 1	Seamless steel precision tubes, cold drawn or cold rolled; dimensions
DIN 2413	Steel pipes; calculation of wall thickness subjected to internal pressure
DIN 2448	Seamless steel tubes, dimensions and weights
DIN 2915	Seamless and welded steel tubes for water-tube boilers; survey
DIN 2917	(at present circulating as draft) Seamless steel tubes for superheated steam mains and headers; dimensions
DIN 17 007 Part 2	Material numbers; system of the principal group 1: steel
DIN 50 049	Certificates on material testings
DIN 50 115	Testing of metallic materials; notched bar impact bending test
DIN 50 125	Testing of metallic materials; tensile test specimens, directions for their preparation
DIN 50 136	Testing of metallic materials; flattening test on tubes
DIN 50 137	Testing of steel; ring expanding test on tubes
DIN 50 138	Testing of steel; ring tensile test on tubes
DIN 50 140	Testing of metals; tensile test for tubes and strips from tubes without extensometer
DIN 50 145	Testing of metallic materials; tensile test
DIN-Normenheft 3	Code numbers and material numbers of ferrous materials in DIN Standards and Stahl-Eisen Werkstoffblättern (Beuth Verlag GmbH, Berlin and Köln; Verlag Stahleisen mbH, Düsseldorf).
Stahl-Eisen-Prüfblatt 1805	Sampling and sample preparation for the sample analysis of steels (Verlag Stahleisen mbH, Düsseldorf)
Stahl-Eisen-Prüfblatt 1915	Ultrasonic testing of tubes of heat-resistant steels for longitudinal defects (Verlag Stahleisen mbH, Düsseldorf)
Stahl-Eisen-Prüfblatt 1918	Ultrasonic testing of tubes of heat-resistant steels for transverse defects (Verlag Stahleisen mbH, Düsseldorf)
Stahl-Eisen-Prüfblatt 1919	Ultrasonic testing of tubes of heat-resistant steels for laminations (Verlag Stahleisen mbH, Düsseldorf)
Stahl-Eisen-Prüfblatt 1925	Eddy current testing of tubes for leak-tightness (Verlag Stahleisen mbH, Düsseldorf)
Handbuch für das Eisenhüttenlaboratorium Band 2:	Analysis of metallic materials, Düsseldorf 1966 (Verlag Stahleisen mbH, Düsseldorf)
Handbuch für das Eisenhüttenlaboratorium, Band 5 (Ergänzugsband)	A 4.1 – Compilation of recommended arbitration analyses, B – Sampling methods C – Analytical methods, always the latest edition (Verlag Stahleisen mbH, Düsseldorf)

[1] In the case of tubes for boiler parts which have to satisfy the "Technische Regeln für Dampfkessel" – TRD (Technical rules for steam boilers) published by the "Deutscher Dampfkesselausschuss" – DDA (German Steam Boiler Committee – DDA), these specifications will have to be additionally observed. If required, the "Technische Regeln für Druckbehälter" – AD-Merkblätter (Technical rules for pressure vessels) should also be taken into consideration.

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Explanations on pages 21 to 23

3 Definition

Steels possessing good mechanical properties even under long-time stressing at high temperatures, up to 600 °C, shall be regarded as being heat-resistant at high temperatures, for the purpose of this standard.

4 Classification

The standard covers tubes made from steel grades listed in Table 1.

• The choice of the particular steel grade is at the discretion of the customer (see Section 6.2).

5 Designation and ordering

5.1 The code numbers for the grades of steel were formed in accordance with Sections 2.1.1.1 and 2.1.2.2 of the Explanations to DIN Normenheft 3, and the material numbers according to DIN 17 007 Part 2.

5.2 The code number or the material number for the steel grade shall be appended to the symbol for the product according to the following examples:

Example 1:

Designation of a seamless steel tube of 38 mm outside diameter and 2.6 mm wall thickness according to DIN 2448 of steel St 35.8, material number 1.0305:

Tube DIN 2448 – St 35.8 – 38 x 2.6

or **Tube DIN 2448 – 1.0305 – 38 x 2.6**

Example 2:

Designation of a seamless steel tube of 240 mm inside diameter and 25 mm wall thickness according to DIN 2917 (at present circulating as draft) of steel St 45.8, material number 1.0405:

Tube DIN 2917 – St 45.8 – 240 x 25

or **Tube DIN 2917 – 1.0405 – 240 x 25**

5.3 • The order shall not only specify the designation according to Section 5.2 but also in every case the desired total length and the desired acceptance inspection certificate and for unalloyed steel tubes also the steel grade. In addition, further details in compliance with the other Sections marked with a dot (•) can be agreed at the time of ordering.

6 Requirements

6.1 Manufacturing process

6.1.1 Tubes to this standard shall be manufactured by hot or cold rolling, hot pressing, hot or cold drawing (see Section 6.3.1).

• **Note:** Within the framework of the provisions in Section 6.1.1 the tubemaking process is left entirely to the discretion of the supplier unless otherwise agreed at the time of ordering (see e.g. Section 6.10.2.1.2.)

6.1.2 The steels used for tubes shall be made by the oxygen blowing process, the open hearth furnace or the electric furnace.

All steels shall be killed.

• **Note:** Within the framework of the Provisions in Section 6.1.2 the melting process is left entirely to the discretion of the supplier; on request it must be made known.

6.2 Quality grades

6.2.1 The tubes can be supplied in two quality grades I and III, which among others are characterized by different extent of testing (cf. Table 3). For tubes of unalloyed steels both quality grades from Table 3 may apply, though for alloy steel tubes, only quality III applies.

The higher requirements made on quality grade 3 tubes generally call for special measures during melting or processing (e.g. flame scarfing or peeling) or for a particularly careful selection of casts.

6.2.2 • The choice of quality grade is left to the customer. It depends on the operating loads. This choice must conform with existing specifications or technical regulations such as the technical regulations for boiler and superheater tubes, stay tubes for ships boilers (TRD 102) issued by the German Steam Boiler Committee. The limits of applicability are specified in Table 4 of this Standard.

6.3 Delivery conditions

6.3.1 The tubes shall be supplied suitably heat treated over their entire length. The following heat treatment shall be used, depending on the type of steel:

- normalizing
- subcritical annealing
- hardening and tempering with continous cooling from the hardening temperature and subsequent tempering,
- hardening and tempering with isothermal transformation.

The condition for an efficient heat treatment is regarded as satisfied in the cases of the steels St 35.8, St 45.8, 17 Mn 4, 19 Mn 5 and 15 Mo 3, if hot working guarantees a good and reasonably uniform structure. Under identical conditions tempering instead of hardening plus tempering may be adequate for steels 13 CrMo 44 and 10 CrMo 9 10. Steels 14 MoV 63 and X 20 CrMoV 12 1 must always be supplied in the hardened and tempered condition.

6.3.2 • If the tube surface is intended to be coated with a corrosion inhibitor providing protection for a limited period, or if another special surface condition is desired for tubes intended for headers, this shall be agreed at the time of ordering.

6.4 Chemical composition

The chemical composition of steels based on ladle analysis [2] must correspond to Table 1. Minor deviations from these values are permissible, provided they do not impair the mechanical and technological properties, according to the requirements in Tables 5 to 7.

In the case of verification on the finished tube, deviations according to Table 2 are permissible compared to the data in Table 1.

[2] On delivery of sequentially cast material, such as is the normal practice in continuous casting, the term "cast" shall be replaced by the term "casting unit". The concomitant alterations required in the relevant particulars of this Standard still have to be worked out.

6.5 Mechanical properties

6.5.1 The tensile strength, yield strength, elongation at fracture and impact strength of the tubes at room temperature must satisfy the requirements set down in Table 5, and the 0.2% proof stress at elevated temperatures must satisfy the requirements set down in Table 6. These are valid for the delivery condition and for the relevant testing conditions according to Section 8 of this Standard.

6.5.2 The 1 % creep limits and creep strengths of the steels are given in Appendix A to this Standard. The figures represent the mean values of the scatter band determined so far. These values will be checked periodically and possibly revised after further test results have been made available.

Note: The publication of the 1 % creep limits and the creep strengths up to the high temperatures quoted in Appendix A does not mean that the steels are allowed to be used up to these temperatures. This depends primarily on the overall working conditions, in particular on the scaling conditions.

6.6 Technological Properties

The tubes shall conform to the requirements for the ring test according to Section 8.6.5. Provisional data on the expansion (change in diameter) in the ring expanding test is given in Table 7.

No inadmissible defects (e.g. cracks, scale, laps and laminations) must be visible in the tests.

6.7 Surface condition

The tubes must have a smooth external and internal surface in keeping with the manufacturing process. A distinction is to be made between hot worked and cold worked finishes. The tubes shall be free from permissible cracks, scales and overlaps. Minute protuberances, depressions or shallow longitudinal grooves caused by the manufacturing process are permissible, provided that the wall thickness remains within the dimensional tolerances and the serviceability of the tubes is not adversely affected. The removal of surface defects of small depth by mechanical machining (e.g. grinding) is permissible provided that the minimum wall thickness is not exceeded.

6.8 Non-destructive testing

The requirements corresponding to the relevant Stahl Eisen-Prüfblätter (Testing Sheets) have to be satisfied in the non-destructive tests according to Section 8.4.7 and Section 8.6.6.

6.9 Physical properties

A special Stahl-Eisen-Werkstoffblatt (Material Data Sheet) (Publisher: Verein Deutscher Eisenhüttenleute, Postfach 8209, 4000 Düsseldorf) with data on the physical properties, is in preparation.

6.10 Dimensions and permissible deviations on dimension and form

6.10.1 • Orders where the dimensions are based on the outside diameter generally comply with DIN 2448 and DIN 2915; in special cases they can also be based on DIN 2391, Part 1.

Note: In cases where dimensions are ordered according to DIN 2391 Part 1 it does not follow that the permissible dimensional deviations in DIN 2391, Part 1 will be directly applicable (see Section 6.10.2.1.2 and Section 6.10.2.3).

Orders can also be based on the inside diameter. In this case the dimensions shall conform to DIN 2917 (at present circulating as draft).

6.10.2 The following conditions apply to the permissible deviations on dimension and form of the tubes.

6.10.2.1 • For orders based on the outside diameter, the permissible deviations on the outside diameter are subject to the following provisions:

6.10.2.1.1 The following permissible deviations on the outside diameter apply, except für permissible deviations on the outside diameter according to Section 6.10.2.1.2:

- for outside diameters $\leqq 100$ mm
- for non-profiled tubes ± 0.75 % (minimum ± 0.5 mm),
- for internally and/or externally profiled tubes ± 1.0 % (minimum ± 0.5 mm),
- for outside diameters > 100 mm $\leqq 320$ mm ± 0.90 %,
- for outside diameters > 320 mm ± 1.0 %

• If narrower diameter deviations have been negotiated for the tube ends, the following values can be maintained for the permissible deviations on the outside diameter over a length of approximately 100 mm by means of subsequent calibrating of the ends:

- for outside diameters $\geqq 45$ mm $\leqq 100$ mm ± 0.4 mm,
- for outside diameters > 100 mm $\leqq 200$ mm ± 0.5 %,
- for outside diameters > 200 mm ± 0.6 %.

6.10.2.1.2 • The following permissible deviations on the outside diameter apply to orders for cold worked tubes:

- for outside diameters $\leqq 120$ mm ± 0.6 % (minimum ± 0.25 mm),
- for outside diameters > 120 mm ± 0.75 %.

In special cases narrower permissible deviations on the outside diameter can be negotiated.

6.10.2.1.3 At points where the tube surface has been repaired by mechanical machining (e.g. grinding), e.g. as a result of indications received during non-destructive testing, it is permissible to exceed the minus deviation by a small amount over a length of not more than 1 m, on condition that the permissible minimum wall thickness is retained.

6.10.2.2 • For orders based of the inside diameter, the permissible deviation on the inside diameter is ± 1 %.

Note: For tube ends intended for rolling-in, tighter deviations on the inside diameter can be negotiated between customer and manufacturer.

6.10.2.3 The permissble deviations on the wall thickness of tubes listed in Table 8 apply for orders based on the outside diameter, and those in Table 9 for orders based on the inside diameter.

• Subject to agreement at the time of ordering, cold worked tubes can be supplied with permissible wall thickness deviations according to DIN 2391, Part 1.

6.10.2.4 • The permissible length deviations are listed in Table 10.

6.10.2.5 The following applies for the permissible deviations on form.

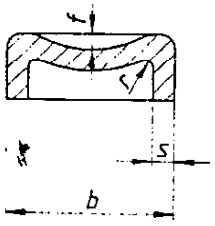
6.10.2.5.1 The ovality of the tubes shall be within the permissible deviations on the nominal diameter; tubes of rectangular cross section shall have 90° angles. The tubes shall be straight to the eye.

• Special requirements on straightness are subject to separate agreement.

6.10.2.5.2 The ends shall be cut if possible perpendicular at the axis with a machining tool; they shall be free from burrs.

6.10.2.5.3 The inner corner radius of tubes for headers with rectangular cross-section shall be $r > \frac{s}{3} \geq 8$ mm (s = wall thickness).

6.10.2.5.4 The deflection f of the lateral faces of tubes for headers with rectangular cross-section over the external lateral length b shall not exceed the values in Table 11.



6.11 Weights and permissible weight deviations

6.11.1 The weights per metre of tubing shall, wherever possible, be taken from the relevant dimensional standard, with the exception of X 20 CrMoV 12 1 steel tubes.

6.11.2 If the tubes are of non-standard size on the weights are not given in the dimensional standard, weights shall be calculated from the nominal dimensions with a density of 7.85 kg/dm^3, with the exception of steel X 20 CrMoV 12 1.

6.11.3 The weight of C 20 CrMoV 12 1 steel shall be calculated from the nominal dimensions with a density of 7.76 kg/dm^3.

6.11.4 The permissible weight deviations are as follows:

- for the individual tube $^{+\ 10}_{-\ 8}$ %,
- for a wagon load of at least 10 tonnes ± 7.5 %.

7 Heat treatment and subsequent processing

7.1 The reference data on the heat treatment temperatures are listed in Table 12.

7.2 The steels can be not formed in the temperature range between approximately 1100 °C to 850 °C, where the temperature may drop to 750 °C during the processing operation. The regulations for hot forming apply equally to fitting and straightening operations on site during which a close watch must be kept on temperature.

It would be expedient to perform forging and upsetting operations in the upper region of this temperature range i.e. between 1100 °C to 900 °C. Hot-bending and similar tube forming processes shall be carried out in the lower-ragion of this temperature range i.e. between 1000 °C to 850 °C, where the temperature may drop to 750 °C during the processing operation.

If the workpiece was heated above the normalizing temperature but not above 1000 °C before the last hot forming step or hot forming in a single step, and if the hot forming operation is completed above 750 °C, or, if the deformation in the last step did not exceed 5 %, above 700 °C, no subsequent normalizing will be required for the steels St 35.8, St 45.8, 17 Mn 4, 19 Mn 5, and 15 Mo 3; the steels 13 CrMo 4 4 and 10 CrMo 9 10 have only to be tempered.

In the case of repeated and/or prolonged hot forming operations at temperatures between approximately 1000 °C to 1100 °C the workpiece shall be cooled to temperatures below 350 °C before the last hot forming step is performed. The temperature of the named steels must not exceed 1000 °C in the subsequent hot forming operation, if normalizing or hardening and tempering is to be dispensed with.

If the temperature of the final forming process lies above 1000 °C the steels St 35.8, St 45.8, 17 Mn 4, 19 Mn 5 and 15 Mo 3 shall subsequently be normalized, and the steels 13 CrMo 4 4 and 10 CrMo 9 10 hardened and tempered.

The steels 14 MoV 6 3 and X 20 CrMoV 12 1 shall be hardened and tempered again after hot forming.

7.3 Tubes from steels according to this Standard can be cold worked e.g. bent, expanded, reduced and rolled-in, though some allowance will have to be made for the high yield point and tensile strength of the steels X 20 CrMoV 12 1 and 14 MoV 6 3.

No subsequent heat treatment is required after cold bending, cold expansion and cold reduction with a normal amount of cold forming [3].

Generally a minimum of 15 minutes annealing at the temperatures specified in Table 13 suffices at higher amounts of cold forming.

7.4 The steels referred to in this Standard are weldable (see DIN 8528 Part 1). Table 13 contains references to welding processes and data on the heat treatment of tubes after welding.

8 Testing

8.1 Testing of initial material

For tubes of quality grade III (Table 3), provided they have been made from pre-rolled round or square steel, an etch test is to be carried out on a disc in order to determine whether the crop end has been cut off far enough. This disc is sliced from the crop end of every round or square bar originating for one ingot. At the choice of the manufacturer an ultrasonic test for piping can be employed instead.

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3) Consult the VGB-Instructions issued by the Association of operators of Large Power Stations (Technische Vereinigung der Grosskraftwerksbetreiber – VBG) on the manufacturing and supervision of heavy-duty steam boilers (available from the VGB-Dampftechnik GmbH, Essen)

8.2 • Acceptance testings

Tubes to this Standard are only supplied with acceptance testings [1]. The type of acceptance testing certificates according to DIN 50049 shall be agreed at the time of ordering. The acceptance testing [1] is subject to the requirements in Sections 8.3 to 8.8. In addition the requirements of Sections 8.5 and 8.6 apply also for subsequent testings in response to complaints.

8.3 General test conditions

8.3.1 All testings including acceptance shall be carried out in the manufacturers works such that the production flow is not unnecessarily impeded.

8.3.2 The manufacturing works shall take steps to prevent rejected tubes and those the repair of which is not permissible from being despatched to customer.

8.4 Extent of testing (see also Table 3)

8.4.1 The tubes shall be tested in batches. They shall be divided into batches of 100 tubes according to the grades of steel, quality grades and dimensions and in the case of alloy steels, if possible, according to cast. For tubes up to an outside diameters ≦ 51 mm the tubes must come from the same heat-treated batch. Surplus amounts of up to 50 tubes shall be distributed evenly between the individual batches. Number of pieces and surplus amounts between 51 and 100 tubes shall be considered as a complete batch.

8.4.2 • In the event of subsequent testing of the chemical composition of the finished tube having been agreed to at the time of ordering, this will normally consist of one testing per cast and delivery.

8.4.3 For the tensile test two tubes shall be tested from each of the first two batches, in accordance with Section 8.4.1, and one tube from each subsequent batch chosen by the inspector.

If a delivery consists of a batch containing a maximum of 10 tubes, only one tube shall be taken.

8.4.4 The absorbed energy shall be tested on the tubes selected according to Section 8.4.3 provided their nominal wall thickness has the following values:
for steel 14 MoV 6 3 and X 20 CrMoV 12 1 > 10 mm,
for the steel 15 Mo 3 > 20 mm,
for all other steels > 30 mm.

8.4.5 • If the 0.2 %-yield limit at elevated temperature is to be tested, this must be stated in the order together with the required test temperature; this extent of testing shall be carried out on one specimen per cast and dimension, unless otherwise agreed.

8.4.6 The tubes shall be ring-tested (see Table 14).

8.4.6.1 Quality grade I tubes selected according to Section 8.4.3 shall be ring-tested (allowing for the dimensions quoted in Table 14) using specimens taken from one end.

8.4.6.2 Quality grade III tubes shall be ring-tested on the rolled lengths allowing for the dimensions quoted in Table 14, with an extent of testing applicable all steel grades except for the steels 14 MoV 6 3 and X 20 CrMoV 12 1:

for tubes with an outside diameter ≦ 51 mm in Section 8.4.6.2.1

and

for tubes with an outside diameter > 51 mm in Section 8.4.6.2.2.

The extent of testing according to Section 8.4.6.2.3 applies for tubes of all dimensions of the steel grades 14 MoV 6 3 and X 20 CrMoV 12 1.

At a subsequent subdivision of the rolled lengths into partlengths no further test specimens need to be taken, provided suitable markings show that the part-lenghts belong to the tested rolled length. If this cannot be guaranteed, the testings on the rolled lengths shall be dropped and in their stead the part-lengths shall be tested as rolled lengths.

8.4.6.2.1 20 % of the rolled lengths of Grade III tubes ≦ 51 mm outside diameter – except tubes of steels 14 MoV 6 3 and X 20 CrMoV 12 1 – shall be tested at one end, i.e. random-wise such that the 20 % of the tubes requiring testing are chosen arbitrarily from the total batch. It ring-testing is performed on part lengths, which are not related to rolled lengths, 20 % of the part lengths shall be tested random-wise (see above) at one end. As far as heat-treated tubes are concerned steps must be taken to ensure that the part lengths come from batches which had been subjected to the same heat treatment. As far as tubes with hot-formed ends are concerned (see Section 6.3.1, paragraph 2) steps must be taken to ensure that the part lengths belong to batches from the same production run, i.e. an identical heating practice.

8.4.6.2.2 Quality grade III tubes > 51 mm outside diameter shall be ring-tested at both ends of each rolled length. Each part length which is not related to the rolled length, shall be tested at both ends.

Each part length from tubes > 51 mm outside diameter can also be ring-tested at one end only provided it has been verified once for the relevant manufacturing process and manufacturing works that the ring test performed on one end of a part length furnishes the same information as the information gained in a test with ring specimens taken from both ends of the original rolled length.

8.4.6.2.3 Each rolled length from quality grade III tubes manufactured from the steels 14 MoV 6 3 and X 20 CrMoV 12 1 shall be ring-tested at both ends, independet of the tube diameter. The same applies to the testing of part lengths.

8.4.7 The manufacturer shall non-destructively test all quality grade III tubes for longitudinal defects.

• A supplementary non-destructive testing for transverse defects and/or laminations can also be agreed on when ordering.

8.4.8 The internal and external condition of each tube must be checked.

8.4.9 The wall thickness, and depending on the order, either the outside diameter or the inside diameter shall be checked.

8.4.10 All tubes shall be tested for leak tightness; that is at the discretion of the manufacturer either by an hydraulic test or by a suitable non-destructive testing (e.g. Eddy current according to Stahl-Eisen Testing Sheet 1925).

8.4.11 The manufacturer shall submit all alloy steel tubes to an appropriate material identification testing.

8.5 Sampling

8.5.1 • If an agreement has been reached in the order to check the chemical analysis of finished tubes, for wet analysis the required turnings must be taken over the entire wall thickness of the tube; an appropriate procedure shall be adopted for spectro-analysis [4].

8.5.2 Flat testpieces in accordance with Section 8.4.3 normally extending over the entire wall thickness and cut longitudinally from the tubes shall be used for tensile testing. The testpieces must not be heat-treated nor straightened over the gauge length. The removal of local inequalities from the flat testpieces is permissible, but the rolling skin must be allowed to remain as far as it is possible on the thinnest sections of the test-piece.

Small diameter tubes can be tested as a whole.

The tensile test on tubes of ≧ 200 mm outside diameter can be done on transverse test specimen, provided this is compatible with the tube dimensions without requiring straightening. In this case a tube ring shall be cut off and halved.

8.5.3 A set of three DVM-specimens is taken in a transverse direction from the tubes selected according to Section 8.4.3 for the notch impact/bending test. The notch impact/bending specimens shall be taken in longitudinal direction from tubes of < 200 mm outside diameter.

8.5.4 • Section 8.5.2 applies logically in cases where agreement has been reached in the order on the determination of the 0.2 %-yield limit at elevated temperatures; since, where possible, hot tensile tests are normally performend on round test specimens sampling requires, if the occasion arises, prior agreement.

8.5.5 The specimens for the ring tests shall be taken according to DIN 50 136 (ring flattening test), DIN 50 137 (ring expanding test) and/or DIN 50 138 (ring tensile test) (see Table 3).

8.5.6 All specimens for the tests according to Sections 8.5.2 to 8.5.5 shall be adequately identifiable in order to show which tubes and specimens go together.

8.6 Applicable test methods

8.6.1 The chemical composition shall be tested according to the methods [5] prescribed by the "Chemiker-ausschuss des Vereins Deutscher Eisenhüttenleute" (Chemists Committee of the Association of German Ferrous Metallurgy Engineers).

8.6.2 The tensile test shall be carried out according to DIN 50 145 using the short proportional test bar according to DIN 50 125 or with specimens according to DIN 50 140.

8.6.3 The notch impact/bending test shall be carried out at room temperature in accordance with DIN 50 115 using DVM-specimens. The notch shall be cut vertically to the longitudinal axis and the surface of the tube.

8.6.4 The 0.2 %-yield limit at elevated temperature is determined in accordance with DIN 50 145.

8.6.5 The ring tests shall be carried out in accordance with the standards covering the annular flattening tests, ring expanding tests and ring tensile tests listed in Section 8.5.5.

8.6.5.1 The ring expanding test shall be carried out according to DIN 50 137 where the change in the diameter of the specimen expanded to fracture shall also be measured. The evaluation of the deformability of ring expanding specimens is based on the appearance of the fracture and the fracture surfaces.

8.6.5.2 In the annular flattening test according to DIN 50 136 the specimens or tube ends shall be squeezed until the definite distance H is reached between the pressure plates. For this distance H in mm applies.

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

Where s = wall thickness in mm, d_a = outside diameter in mm and c is a constant. For the steel St 35.8 the c-constant is 0.09, for the steels St 45.8, 17 Mn 4, 19 Mn 5, 15 Mo 3, 13 CrMo 4 4 and 10 CrMo 9 10 it is 0.07 and for the steels 14 MoV 6 3 and X 20 CrMoV 12 1 it is 0.05.

• If the ratio s/d_a is greater than 0.15 the distance between the plates shall be negotiated.

If an annular flattening test is performed according to Section 8.4.6 the test can be continued to fracture or until a crack appears, so as to make it possible to assess the appearance of the fractured surface. The decisive factor is that the prescribed distance between the plates is reached without cracking

8.6.6 • The non-destructive test shall always be carried out before the ring specimens are cut off.

Non-profiled tubes shall normally be ultrasonically tested i.e.

a) according to Stahl-Eisen Test Sheet 1915 when testing tubes of ≧ 10 mm outside diameter, for longitudinal defects.

b) according to Stahl-Eisen Test Sheet 1918, after agreement has been reached, on testing tubes having an outside diameter > 133 mm, for transverse defects.

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[4] The sampling practice conforms, as a rule, to Stahl-Eisen-Prüfblatt 1805 – Probenahme und Probenvorbereitung für die Stückanalyse bei Stählen – (Sampling and sample preparation for the sample analysis of steels) – (Publisher: Verlag Stahleisen mbH, Düsseldorf).

[5] Handbuch für das Eisenhüttenlaboratorium (Handbook for the Ferrous Metallurgy laboratory), Vol. 2: Die Untersuchung der metallischen Stoffe (The testing of metallic materials), Düsseldorf; Verlag Stahleisen mbH, 1966; Vol. 5 (supplement): A 4.1 – Aufstellung empfohlener Schiedsverfahren (Compilation of recommended arbitration analyses), B – Probenahmeverfahren (Sampling methods), C – Analysenverfahren (Analysis methods), always the latest edition (Verlag Stahleisen mbH, Düsseldorf).

c) according to Stahl-Eisen Test Sheet 1919, after agreement has been reached on testing tubes having an outside diameter > 133 mm and a wall thickness > 8 mm, for laminations.

In cases in which the aforementioned testing methods are not applicable (such as when testing profiled tubes or tubes having outside diameters < 10 mm for longitudinal defects), agreement on the relevant testing method will have to be reached at the time of ordering.

8.6.7 Visual inspection [6] with the naked eye requires that:

a) the whole external tube surface shall be examined in suitable lighting for surface defects,

b) the entire inner tube surface shall be examined in suitable lighting from both tube ends for surface defects.

The surface finish of the tubes should permit detection of significant defects. For quality grade III tubes this generally denotes descaled surfaces, unless the chosen method of production or heat treatment ensures a suitable surface finish for visual inspection and ultrasonic testing.

8.6.8 The dimensions shall be checked with suitable instruments.

8.6.9 • When checking leak tightness, internal hydraulic testing with water (refer to Section 8.4.10) shall generally be carried out at a uniform pressure of 80 bar. Higher test pressures require prior agreement. The test pressure shall be limited so that the yield point at 20 °C will not be reached or exceeded (cf. DIN 2413 June 1972 edition Section 4.6). In the case of thin-walled large diameter tubes this will already have to be considered at pressures of 80 bar.

8.7 Re-testings

8.7.1 If one of the selected tubes fails to pass the tests according to Sections 8.6.2 (tensile test) and 8.6.3 (notch impact/bending test) and in the case of quality grade I tubes according to Section 8.6.5 (ring test) it shall be rejected, and two further tubes shall be taken from the batch and the tests repeated. In these new tests each tube must satisfy the requirements, otherwise the whole batch must be rejected.

8.7.2 If one specimen, taken at random, from a rolled lenght or part length of quality grade III tubes of ≤ 51 mm outside diameter according to Section 8.4.6.2.1 fails in the ring check test, the test shall be repeated on the same end of the relevant rolled length or part length. If this replacement specimen proves unsatisfactory, the relevant rolled length or part length shall be rejected and the test repeated at one end of a further 20 % of the rolled lengths or part lengths of the batch. It another specimen fails again, the test will have to be extended to all rolled lengths or part lengths of the batch. Rolled lengths or part lengths which fail in the ring test shall be rejected.

If one ring test specimen from a rolled length or part length fails in single tests on quality grade III tubes according to Sections 8.4.6.2.2 and 8.4.6.2.3 the test shall be repeated on the same rolled length or part length. If this specimen also fails, the relevant rolled length or part length shall be rejected. On rejection of one rolled length it is left to the discretion of the manufacturer to ring test the corresponding part lengths.

8.7.3 If the unsatisfactory test results were due to unfavourable heat-treatment, it is at the discretion of the manufacturer's works to submit the rejected batch to further heat-treatment and re-submit it for acceptance. The manufacturer's works are entitled to remove the defects detected in the tests according to Sections 8.4.6 (ring test) 8.4.7 (non-destructive test) and 8.4.8 (visual inspection) by suitable means and to re-submit the tubes for acceptance.

8.8 Test certificates

8.8.1 • The acceptance test [1] shall be certified by an Acceptance Inspection Certificate A, B, or C, according to DIN 50049, Section 3 (July 1972 edition).

Note: The certificates shall give the full wording of the identification marks, according to Section 9.1.

8.8.2 • If certificates require to be issued only for part of the requirements guaranteed by Acceptance Inspection Certificates A or C according to DIN 50049, the manufacturer shall additionally confirm in an Inspection Certificate according to DIN 50049 and for quality grade III tubes in an Acceptance Inspection Certificate B according to DIN 50049, that the tube material corresponds in steel grade and steel quality to DIN 17175, that all tubes have passed the leak tightness test and have an unobstructed bore, that they have been correctly annealed, or hardened and tempered over their entire lengths in a manner consistent with the tube material, and that quality grade III tubes have been manufactured from roughed-down squares or rounds, that an etch test or ultrasonic test was carried out, that the chemical composition was determined according to the ladle analysis and, if agreed at the time of ordering, also the steelmaking process be quoted. With tubes of quality grade III the carrying-out of an ultrasonic test has to be editionally stated in the Acceptance Inspection Certificate B according to DIN 50049.

9 Identification of the tubes

9.1 The finished tubes shall be marked approximately 300 mm from the end.

The identification consists normally of a stamp mark. Another identification practice may be adopted for thin-walled tubes. The following identification marks shall be applied

on both ends:

material designation (Code No of grade of steel), for unalloyed steels the quality grade (unless quality grade I),

the trade mark stamp and

the inspectors stamp;

on one end:

the cast number or an identifying mark for the cast, applicable only for steels 15 Mo 3, 13 CrMo 4 4, 10 CrMo 9 10, 14 MoV 6 3 and X 20 CrMoV 12 1 for

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[1] See page 1

[6] A proven, suitable non-destructive testing process can also be used instead of the visual inspection method.

tubes of ≧ 159 mm outside diameter [7]; in addition, the tube number for quality grade III tubes.

9.2 The stamp mark can be made more conspicuous according to Section 9.1 e.g. by a coloured line; the lines of the colour identification may be used for this.

10 Complaints

10.1 External and internal defects justify complaints, if they seriously affect the workability and serviceability of the type of steel and shape of the product.

10.2 The customer shall give the supplier an opportunity to prove [8] that the complaints were justified, preferably by submission of samples from the unsatisfactory material delivered.

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[7] This limit applies also for tubes orders based on the inside diameter, provided the nominal outside diameter ≧ 159 mm.

[8] See also: Explanations to the "Complaints Clause" in Quality Standards for Iron and Steel. DIN-Mitt. 40 (1961), No 2, p. 111/112.

Further standards

DIN 2401 Part 1 Components under internal or external pressure; pressure and temperature data; definitions, nominal pressure ratings

DIN 8528 Part 1 Weldability; metallic materials, definitions

Table 1. **Summary of heat-resisting steels for seamless tubes, their chemical composition (cast analysis) and colour designation of tubes**

Steel grade		Chemical composition in weight %									Colour designation 1)
Code number	Material numbers	C	Si	Mn	P max.	S max.	Cr	Mo	Ni	V	
St 35.8	1.0305	≦ 0.17	0.10 to 0.35 2)	0.40 to 0.80	0.040	0.040					white
St 45.8	1.0405	≦ 0.21	0.10 to 0.35 2)	0.40 to 1.20	0.040	0.040					yellow
17 Mn 4 3)	1.0481 3)	0.14 to 0.20	0.20 to 0.40	0.90 to 1.20	0.040	0.040	≦ 0.30				red and black
19 Mn 5 3)	1.0482 3)	0.17 to 0.22 4)	0.30 to 0.60	1.00 to 1.30	0.040	0.040	≦ 0.30				yellow and brown
15 Mo 3	1.5415	0.12 to 0.20 4)	0.10 to 0.35	0.40 to 0.80	0.035	0.035		0.25 to 0.35			yellow and carmine red
13 CrMo 4 4	1.7335	0.10 to 0.18 4)	0.10 to 0.35	0.40 to 0.70	0.035	0.035	0.70 to 1.10	0.45 to 0.65			yellow and shades of silver
10 CrMo 9 10	1.7380	0.08 to 0.15	≦ 0.50	0.40 to 0.70	0.035	0.035	2.00 to 2.50	0.90 to 1.20			red and green
14 MoV 6 3	1.7715	0.10 to 0.18	0.10 to 0.35	0.40 to 0.70	0.035	0.035	0.30 to 0.60	0.50 to 0.70		0.22 to 0.32	red and shades of silver
X 20 CrMoV 12 1	1.4922	0.17 to 0.23	≦ 0.50	≦ 1.00	0.030	0.030	10.00 to 12.50	0.80 to 1.20	0.30 to 0.80	0.25 to 0.35	blue

1) • In normal practice both ends are painted with rings in the colour required. If requested it can be agreed at the time of ordering that the paint marking in the relevant colours should extend over the entire length of the tube.
2) The minimum silicon content is allowed to fall below 0.10 %, when the steel is aluminium-killed, or vacuum-deoxidized.
3) These steels can only be considered for headers.
4) When the wall thicknesses ≧ 30 mm the carbon content is permitted to be 0.02 % higher.

Table 2. **Permissible deviations in the chemical composition of the sample analysis from the limits quoted in the cast analysis** (see Table 1)

Element	Limits quoted in cast analysis according to Table 1 Weight %	Permissible deviation [1] of sample analysis from the limits quoted in the cast analysis according to Table 1 Weight %
C	≤ 0,24	± 0,02
Si	≤ 0,35 > 0,35 ≤ 0,60	± 0,03 ± 0,04
Mn	≤ 1,00 > 1,00 ≤ 1,30	± 0,04 ± 0,05
P S	≤ 0,040	+ 0,010
Cr	≤ 2,00 > 2,00 ≤ 2,50 ≥ 10,00 ≤ 12,50	± 0,05 ± 0,07 ± 0,15
Mo	≤ 0,30 > 0,30 ≤ 1,20	± 0,03 ± 0,04
Ni	0,30 ≤ 0,80	± 0,03
V	0,22 ≤ 0,35	± 0,03

[1] In a cast the deviation of an element in a sample analysis is permitted to be below the minimum value or only above the maximum value of the range stipulated for the cast analysis, though not both at the same time.

Table 3. **Scope of tests for seamless tubes in both quality grades and authority for the execution of the testings**

No	Tests	Acc. to Section	Quality grade I	Quality grade III	Authority for the execution of the testings [1]
1	Tensile test [2]	8.4.3	on two tubes per batch from the first two batches, on one tube from each subsequent batch	on two tubes per batch from the first two batches, on one tube from each subsequent batch	S. A.
2	Notch impact/bending test [3]	8.4.4	on tubes according to No 1	on tubes according to No 1	S. A.
3	Ring test [3]	8.4.6	on one end of the tubes according to No 1	depending on the diameter (see Section 8.4.6) on 20 % of the rolled or part lengths at one end, or on 100 % of the rolled or part lengths at both ends, if necessary though also at one end see Section 8.4.6.2.2.	S. A.
4	Non-destructive test	8.4.7		all tubes	M. W.
5	Visual inspection of tube surface	8.4.8	all tubes	all tubes	S. A.
6	Gauging	8.4.9	all tubes	all tubes	S. A.
7	Leakage test	8.4.10	all tubes	all tubes	M. W.
8	Grade identification test	8.4.11		all alloy tubes	M. W.
	Special tests [4] No 9, No 10				
9	Control analysis	8.4.2	subject to agreement	subject to agreement	M. W.
10	Hot tensile test	8.4.5	unless otherwise agreed 1 specimen per cast and size or 1 specimen per cast and annealing batch (heat-treatment batch)	unless otherwise agreed 1 specimen per cast and size or 1 specimen per cast and annealing batch (heat-treatment batch)	S. A.

1) S. A. = Subject to agreement; M. W. = Manufacturing Works.

2) 1 specimen or 1 set of specimens suffices for batch sizes of up to 10 tubes.

3) The particulars on the size ranges governing the application of these testings in Table 14 shall be complied with.

4) • Special tests shall only be carried out, after an agreement has been reached between the manufacturer and customer.

Table 4. **Limits governing the application of quality grades I and III**

Quality grade [1]	Outside diameter ≦ 63.5 mm		Outside diameter > 63.5 mm	
	Temperature [2] °C	Permissible working pressure [3] bar	Temperature [2] °C	Permissible working pressure [3] bar
I	≦ 450	≦ 80	≦ 450	≦ 32
III	> 450	> 80	> 450	> 32

1) If pressure and temperature data do not belong to the same group, the higher group applies.
2) Temperature of conveyed fluid.
3) See DIN 2401 Part 1.

Table 5. **Mechanical properties of seamless tubes of heat-resisting steels at room temperature**

Steel grade		Tensile strength	Yield point [1], [2] for wall thickness in mm			Elongation at fracture ($L_o = 5 \cdot d_o$)		Impact strength (DVM specimens [3])
Code number	Material number	N/mm²	≦16	> 16 ≦40	> 40 ≦60	long.	transv.	transverse
			N/mm² minimum			% minimum		J minimum
St 35.8	1.0305	360 to 480	235	225	215	25	23	34
St 45.8	1.0405	410 to 530	255	245	235	21	19	27
17 Mn 4	1.0481	460 to 580	270	270	260	23	21	34
19 Mn 5	1.0482	510 to 610	310	310	300	19	17	34
15 Mo 3	1.5415	450 to 600	270 [4]	270	260	22	20	34
13 CrMo 4 4	1.7335	440 to 590	290 [4]	290	280	22	20	34
10 CrMo 9 10	1.7380	450 to 600	280	280	270	20	18	34
14 MoV 6 3	1.7715	460 to 610	320	320	310	20	18	41
X 20 CrMoV 12 1	1.4922	690 to 840	490	490	490	17	14	34 [5]

1) For tubes of ≦ 30 mm outside diameter and ≦ 3 mm wall thickness the minimum values are by 10 N/mm² lower.
2) For > 60 mm wall thickness, the values of tubes from the steels St 35.8, St 45.8, 17 Mn 4, 19 Mn 5, 15 Mo 3 and 14 MoV 6 3 are subject to agreement; for wall thicknesses > 60 to ≦ 80 mm a minimum value of 270 N/mm² or 260 N/mm² applies for tubes from the steels 13 CrMo 4 4 and 10 CrMo 9 10 and a minimum value of 490 N/mm² for tubes from the steel X 20 CrMoV 12 1.
3) When testing longitudinal specimens (see Section 8.5.3) the minimum impact strength is 14 J higher.
4) A 15 N/mm² higher minimum value applies for ≦ 10 mm wall thicknesses.
5) For hot-extruded tubes the minimum value falls to 27 J.

Table 6. **Minimum 0.2 % yield limit of seamless tubes at elevated temperatures**

Steel grade		Wall thickness s	0.2 %-yield limit at							
Code number	Material number	mm	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C	500 °C	550 °C
			N/mm² minimum							
St 35.8	1.0305	≤ 16	185	165	140	120	110	105	–	–
		$16 < s \leq 40$	180	160	135	120	110	105	–	–
		$40 < s \leq 60$ [1]	175	155	130	115	110	105	–	–
St 45.8	1.0405	≤ 16	205	185	160	140	130	125	–	–
		$16 < s \leq 40$	195	175	155	135	130	125	–	–
		$40 < s \leq 60$ [1]	190	170	150	135	130	125	–	–
17 Mn 4	1.0481	≤ 40	235	215	175	155	145	135	–	–
		$40 < s \leq 60$ [1]	225	205	165	150	140	130	–	–
19 Mn 5	1.0482	≤ 40	255	235	205	180	160	150	–	–
		$40 < s \leq 60$ [1]	245	225	195	170	155	145	–	–
15 Mo 3	1.5415	≤ 40 [2]	225	205	180	170	160	155	150	–
		$40 < s \leq 60$ [1]	210	195	170	160	150	145	140	–
13 CrMo 4 4	1.7335	≤ 40 [2]	240	230	215	200	190	180	175	–
		$40 < s \leq 60$	230	220	205	190	180	170	165	–
		$60 < s \leq 80$	220	210	195	180	170	160	155	–
10 CrMo 9 10	1.7380	≤ 40	245	240	230	215	205	195	185	–
		$40 < s \leq 60$	235	230	220	205	195	185	175	–
		$60 < s \leq 80$	225	220	210	195	185	175	165	–
14 MoV 6 3	1.7715	≤ 40	270	255	230	215	200	185	170	–
		$40 < s \leq 60$ [1]	260	245	220	205	190	175	160	–
X 20 CrMoV 12 1	1.4922	≤ 80	430	415	390	380	360	330	290	250

1) For wall thicknesses greater than 60 mm the values are subject to agreement.

2) For wall thicknesses ≤ 10 mm, 15 N/mm² higher minimum 0.2 % yield limits apply at all temperatures.

Table 7. **Provisional data [1] (change in diameter) in the ring expanding test.**

Steel grade	Expansion [2] in ring expanding test (provisional data) For diameter ratios d_i/d_a					
	≧0.9	≧0.8 <0.9	≧0.7 <0.8	≧0.6 <0.7	≧0.5 <0.6	<0.5
	% minimum					
unalloyed steels	8	10	12	20	25	30
alloyed steels	6	8	10	15	20	30

1) These values shall be regarded as initial recommendations which are based on a series of tests and will have to be re-assessed in the light of future experience.

2) The deformability of ring expanding test specimens will additionally be assessed in terms of the appearance of the fracture and fracture surfaces.

Table 8. **Permissible wall thickness deviations for orders based on the outside diameter**

Permissible wall thickness deviations for outside diameters d_a and wall thicknesses s								
$d_a \leqq 130$ mm			130 mm $< d_a \leqq 320$ mm			320 mm $< d_a \leqq 660$ mm		
$\leqq 2 \cdot s_n$	$2 \cdot s_n < s \leqq 4 \cdot s_n$	$> 4 \cdot s_n$	$\leqq 0{,}05\, d_a$	$0{,}05\, d_a < s \leqq 0{,}11\, d_a$	$> 0{,}11\, d_a$	$\leqq 0{,}05\, d_a$	$0{,}05\, d_a < s \leqq 0{,}09\, d_a$	$> 0{,}09\, d_a$
+ 15 % - 10 %	+ 12,5 % - 10 %	± 9 %	+ 17,5 % - 12,5 %	± 12,5 %	± 10 %	+ 22,5 % - 12,5 %	+ 15 % - 12,5 %	+ 12,5 % - 10 %

Note: s_n = Nominal wall thickness according to DIN 2448

Table 9. **Permissible wall thickness deviations for orders based on the bore**

Permissible wall thickness deviations for inside diameter d_i ≧200 mm to ≦720 mm and wall thicknesses s		
$\leqq 0{,}05\, d_i$	$0{,}05\, d_i < s \leqq 0{,}10\, d_i$	$> 0{,}10\, d_i$
+ 22,5 % - 12,5 %	+ 15 % - 12,5 %	+ 12,5 % - 10 %

Table 10. **Permissible deviations on length**

For orders specifying	Permissible deviations on length in mm
Production lengths	1)
Random lengths	± 500
Exact lengths	
from ≦ 6 m (nominal size)	$^{+10}_{0}$
from > 6 m ≦ 12 m (nominal size)	$^{+15}_{0}$
from > 12 m	subject to agreement

1) The products are supplied in production lengths which differ according to diameter, wall thickness and production plant.

Table 11. **Permissible deflection *f***

b in mm	≦100	>100 ≦200	>200 ≦300	>300
f in mm	≦0,75	≦1	≦1,5	≦2

Table 12. **Reference data for hot forming, normalising and hardening and tempering of high-temperature seamless tube steels** [1]

Steel grade		Hot forming	Normalising	Hardening and tempering	
Code number	Material number	°C	°C	Hardening temperature [2] °C	Tempering temperature °C
St 35.8	**1.0305**	between 1100 and 850 [3]	900 to 930	–	–
St 45.8	**1.0405**		870 to 900	–	–
17 Mn 4	**1.0481**		880 to 910	–	–
19 Mn 5	**1.0482**		880 to 910	–	–
15 Mo 3	**1.5415**		910 to 940	–	–
13 CrMo 4 4	**1.7335**		–	910 to 940	660 to 730
10 CrMo 9 10 [4]	**1.7380** [4]		–	900 to 960	700 to 750
14 MoV 6 3	**1.7715**		–	950 to 980	690 to 730
X 20 CrMoV 12 1	**1.4922**		–	1020 to 1070	730 to 780

1) The work pieces must attain the specified temperature over the entire cross-section. Provided this has definitely been done further holding at these temperatures is unnecessary when normalising and hardening. The temperatures laid down for tempering shall be held for approximately 30 minutes minimum for the steels 13 CrMo 4 4 and 10 CrMo 9 10 and for 1 hour minimum for the steels 14 MoV 6 3 and X 20 CrMoV 12 1, with the annealing time being counted from the moment when the lower limit of the given temperature range is reached.

2) Cooling in air or controlled atmosphere. Accelerated cooling e.g. in liquid, can become necessary at greater wall thicknesses.

3) The temperature can drop to 750 °C during processing.

4) In addition to given quenching and tempering treatment the following sequence of treatment can be considered for the steel:
900 °C to 960 °C/furnace to 700 °C ≧ 1 hour 700 °C/air.

Table 13. **Welding methods and data for the heat-treatment after welding**

Steel grade		Welding methods	Annealing temperatures [1] and holding time [2] [3] at the required heat-treatment after welding °C
Code number	Material number		
St 35.8	**1.0305**	All fusion welding methods and flash butt-welding	520 to 600
St 45.8	**1.0405**		520 to 600
17 Mn 4	**1.0481**		520 to 580
19 Mn 5	**1.0482**		520 to 580
15 Mo 3	**1.5415**		530 to 620
13 CrMo 4 4	**1.7335**		600 to 700
10 CrMo 9 10	**1.7380**		650 to 750
14 MoV 6 3 [4]	**1.7715**	All fusion welding methods, except gas fusion welding	690 to 730
X 20 CrMoV 12 1 [5]	**1.4922**		720 to 780

1) If required (see Section 7.3) these temperatures apply also to annealing treatments after cold forming.

2) The holding time for the specified temperatures depends on the thickness of the workpieces. A minimum holding time of 15 minutes is recommended for a thickness $\leqq$ 15 mm, a minimum holding time of 30 minutes, for thicknesses $>$ 15 to $\leqq$ 30 mm and a minimum holding time of 60 minutes for thicknesses $>$ 30 mm.

At thicknesses $>$ 30 mm a minimum holding time of 90 minutes is required for 10 CrMo 9 10. Furnace anneals should be performed in the mid-range of the specified temperatures. For local anneals the external surface shall be at the maximum temperature.

3) The annealing treatment shall also comply with the instructions of the manufacturer of the filler metals.

4) Judging from the experience gained up to now, repeated annealing treatments shall not exceed a total holding time of 10 hours, with the subsequent annealing treatments being performed in the lower temperature range when the material is in the air-hardened condition.

5) Welding shall be followed by cooling below 150 °C (though for thick-walled tubes not below 100 °C).

The following holding times are recommended:

$\leqq$ 8 mm	thickness	30 minutes minimum
$>$ 8 $\leqq$ 30 mm	thickness	60 minutes minimum
$>$ 30 $\leqq$ 60 mm	thickness	120 minutes minimum
$>$ 60 mm	thickness	180 minutes minimum

Table 14. **Size ranges for the application of mechanical and technological methods for testing tubes in both qualities**

Tube diameter mm		Nominal wall thickness of the tubes				
external	internal	< 2 mm	≧2 mm ≦16 mm	> 16 mm ≦30 mm	>30 mm ≦40 mm	> 40 mm
≦21.3	≦15	Tensile test Ring flattening test	Tensile test Ring flattening test	–	–	–
>21.3 ≦146	> 15	Tensile test Ring flattening test	Tensile test Notch impact/bending test [1] Ring expanding test	Tensile test Notch impact/bending test [1] Ring flattening test	Tensile test Notch impact/bending test Ring flattening test	Tensile test Notch impact/bending test
> 146 [3]			Tensile test Notch impact/bending test [1] Ring tensile test	Tensile test Notch impact/bending test [1] Ring tensile test [2]	Tensile test Notch impact/bending test Ring tensile test [2]	Tensile test Notch impact/bending test

[1] Only for tubes manufactured from steels 14 MoV 6 3 and X 20 CrMoV 12 1 in nominal thicknesses > 10 mm and for tubes manufactured from the steel 15 Mo 3 in nominal thicknesses > 20 mm.

[2] Tubes ≦ 100 mm inside diameter shall be ring flattening-tested instead of ring tensile-tested.

[3] This limit applies also for tubes, orders for which are based on the inside diameter, provided the nominal outside diameter > 146 mm.

Appendix A

The following Table gives tentative figures for the long time high temperature strength of the steels used for seamless tubes. The figures listed are m e a n v a l u e s for the scatter range representing results so far available. These mean values will be examined from time to time and amended where necessary as further results become available. From the data so far available from long time creep tests it can be assumed that the b o t t o m l i m i t of this scatter range at the stated temperatures for the steel grades listed is about 20 % lower than the mean value quoted.

Table A. 1.

Steel grade	Temperature	1 %-time yield limit [1], [2] for		Creep strength [2], [3] for		
		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Code number	°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
St 35.8 St 45.8	380	164	118	229	165	145
	390	150	106	211	148	129
	400	136	95	191	132	115
	410	124	84	174	118	101
	420	113	73	158	103	89
	430	101	65	142	91	78
	440	91	57	127	79	67
	450	80	49	113	69	57
	460	72	42	100	59	48
	470	62	35	86	50	40
	480	53	30	75	42	33
17 Mn 4 19 Mn 5	380	195	153	291	227	206
	390	182	137	266	203	181
	400	167	118	243	179	157
	410	150	105	221	157	135
	420	135	92	200	136	115
	430	120	80	180	117	97
	440	107	69	161	100	82
	450	93	59	143	85	70
	460	83	51	126	73	60
	470	71	44	110	63	52
	480	63	38	96	55	44
	490	55	33	84	47	37
	500	49	29	74	41	30
15 Mo 3	450	216	167	298	245	228
	460	199	146	273	209	189
	470	182	126	247	174	153
	480	166	107	222	143	121
	490	149	89	196	117	96
	500	132	73	171	93	75
	510	115	59	147	74	57
	520	99	46	125	59	45
	530	84	36	102	47	36
	540	(70)	(28)	(82)	(38)	(28)
	550	(59)	(24)	(64)	(31)	(25)

[1] This being the stress referred to in the original cross-section which leads to a permanent elongation of 1 % after 10 000 or 100 000 hours (h).

[2] A bracket denotes that the steel should preferably no longer be used for continuous service at the relevant temperature.

[3] This being the stress referred to in the original cross-section which results in rupture after 10 000, 100 000 or 200 000 hours (h).

Table A. 1. (continued)

Steel grade	Temperature	1 %-time yield limit [1], [2] for		Creep strength [2], [3] for		
		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Code number	°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
13 CrMo 4 4	450	245	191	370	285	260
	460	228	172	348	251	226
	470	210	152	328	220	195
	480	193	133	304	190	167
	490	173	116	273	163	139
	500	157	98	239	137	115
	510	139	83	209	116	96
	520	122	70	179	94	76
	530	106	57	154	78	62
	540	90	46	129	61	50
	550	76	36	109	49	39
	560	64	30	91	40	32
	570	53	24	76	33	26
10 CrMo 9 10	450	240	166	306	221	201
	460	219	155	286	205	186
	470	200	145	264	188	169
	480	180	130	241	170	152
	490	163	116	219	152	136
	500	147	103	196	135	120
	510	132	90	176	118	105
	520	119	78	156	103	91
	530	107	68	138	90	79
	540	94	58	122	78	68
	550	83	49	108	68	58
	560	73	41	96	58	50
	570	65	35	85	51	43
	580	57	30	75	44	37
	590	50	26	68	38	32
	600	44	22	61	34	28
14 MoV 6 3	480	243	177	299	218	182
	490	219	155	268	191	163
	500	195	138	241	170	145
	510	178	122	219	150	127
	520	161	107	198	131	109
	530	146	94	179	116	91
	540	133	81	164	100	76
	550	120	69	148	85	61
	560	109	59	134	72	48
	570	(98)	(48)	(121)	(59)	(37)
	580	(88)	(37)	(108)	(46)	(28)

For footnotes [1], [2] and [3] see page 18

Table A. 1. (continued)

Steel grade	Temperature	1 %-time yield limit [1], [2] for		Creep strength [2], [3] for		
		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Code number	°C	N/mm²	N/mm²	N/mm²	N/mm²	N/mm²
X 20 CrMoV 12 1	470	324	260	368	309	285
	480	299	236	345	284	262
	490	269	213	319	260	237
	500	247	190	294	235	215
	510	227	169	274	211	191
	520	207	147	253	186	167
	530	187	130	232	167	147
	540	170	114	213	147	128
	550	151	98	192	128	111
	560	135	85	173	112	96
	570	118	72	154	96	81
	580	103	61	136	82	68
	590	90	52	119	70	58
	600	75	43	101	59	48
	610	64	36	87	50	40
	620	53	30	73	42	33
	630	44	25	60	34	27
	640	36	20	49	28	22
	650	29	17	40	23	18

For footnotes [1], [2] and [3] see page 18

Explanations

This Standard replaces Standards DIN 17 175 Part 1 (January 1959 edition) — Seamless tubes of heat-resisting steels; technical delivery conditions —, DIN 17 175 Part 2 (January 1959x edition) — Seamless tubes of heat-resisting steels; quality specifications for relevant steels — and DIN 17 175 Part 2 Supplement (June 1969 edition) — Seamless tubes of heat-resisting steels; long-term hot strength values —. The publication of this revised version (necessitating 2 drafts) had been delayed, because on the one hand the answer to the question whether or not the lower minimum yield points or minimum proof stresses at elevated temperatures quoted in international standard

ISO 2604/II

E: Steel products for pressure purposes — Quality requirements — Part 2: Wrought seamless tubes

D: Stahlerzeugnisse für Druckbehälter; Gütevorschriften, Teil 2: Nahtlose Rohre

compared with DIN 17 175 Part 2 (January 1959x edition) should be used, proved more complicated than expected and at the same time it had been intended to wait for the forthcoming international negotiations, and also the determination of the long-term hot strength values, the dimensional deviations and the scope of ring testing took up a great deal of time and had to be studied in special committees.

This Standard differs from ISO 2604/II, DIN 17 175 Part 1 and Part 2 (January 1959 edition) and DIN 17 175 Part 2 Supplement (June 1969 edition) in the following major points:

a) Tubes for headers are included in the scope.

b) The range of steels was extended to grades 17 Mn 4 (1.0481), 19 Mn 5 (1.0482), 14 MoV 6 3 (1.7715) and X 20 CrMoV 12 1 (1.4922). This Standard therefore includes ferritic and martensitic types of steel envisaged in ISO 2604/II for service at elevated temperature, up to grades TS 2, TS 37 and TS 38; see tabular comparison at end of "Explanations".

c) The chemical composition of the steels was in part narrowed down, especially for the elements phosphorus and sulphur, compared with the January 1959 edition of this Standard and ISO 2604/II. The change in the molybdenum content of steel 13 CrMo 4 4 (1.7335) from 0.40 % to 0.50 % into 0.45 % to 0.65 % as in ISO 2604/II is of particular interest.

d) As in ISO 2604/II a table on the permissible deviations allowed for sample analyses was included in this new edition as opposed to the limits for the ladle analysis.

e) A change occurred in the quality grades, inasmuch as only quality grades I and III were retained. These quality grades cannot be compared directly with the testing categories II to V of ISO 2604/II. Quality grades I and III resemble testing categories II and V most closely, though an allowance has to be made for the difference in testing scopes.

f) The requirements of the scope for the ring tests (which are far more severe than in ISO 2604/II) were checked and modified in a Working Committee expressly formed for this purpose. In view of the 100 % non-destructive testing for longitudinal defects, the scope for the ring tests was restricted for quality grade III tubes.

In response to objections by customers that for them ring tests were less valuable as a means for assessing the deformability of the tubes than for detecting surface defects since neither the rupture elongations nor the yield point/tensile-ratios furnished adequate information on tube performance during cold bending, Table 7 containing provisional data on the minimum expansion of the tube in the ring expanding test was additionally included in the standard at the suggestion of steelmakers. Since the values in Table 7 are in principle of a tentative nature, all participants are invited to comment from personal experience on the validity of these values.

g) The leaktightness test in the form of an internal pressure test with water can now be replaced at the discretion of the manufacturer by a suitable non-destructive testing method (e.g. Eddy current testing according to Stahl-Eisen-Prüfblatt (Testing Sheet)-1925)

h) Non-destructive testing for longitudinal defects has now been extended to all quality grade III tubes of 10 mm outside diameter and over. Testing for transverse defects and laminations can additionally be negotiated for quality grade III tubes having outside diameters greater than 133 mm, and outside diameters greater than 133 mm having wall thicknesses greater than 8 mm. Testing is generally done ultrasonically.

i) Visual inspection of the tubes can be replaced by a proven, suitable non-destructive testing method.

j) As distinct from ISO 2604/II this Standard also contains data on form and dimensional deviations. Differing from the requirements in DIN 17 175 Part 1 (January 1959 edition), the tolerances currently quoted for orders based on the outside diameter are now set out either according to the ratio of the nominal wall thickness to the outside diameter or as a multiple of the nominal wall thickness. The additional, local 5 % allowance on the lower tolerance limit of the nominal wall thickness is no longer valid. Subject to agreement on ordering, cold finished tubes can now be supplied with closer tolerances. In compliance with the request of consumers it is now possible to order tubes of 200 mm bore and larger based on the inside diameter. Corresponding deviations on the inside diameter and wall thicknesses were fixed for this particular requirement.

k) The data on the physical properties have been deleted. The Verein Deutscher Eisenhüttenleute (Association of German Ferrous Metallurgy Engineers) is currently preparing an appropriate Stahl-Eisen-Werkstoffblatt (Material Data Sheet) containing also data on steels outwith DIN 17 175.

l) As previously, the values for the impact energy apply to DVM-specimens. Steelmakers have pointed out that the notch impact/bending test quoted for DIN 17 175 steels served solely as a guide to the satisfactory nature of the heat treatment and for the presence of adequate ductility. At the request of the Technical Testing Authorities and consumers they were, however, willing to collect the test results from

ISO-V specimens as regards the applicability of brittle fracture criteria, in order to enable DIN 17 175 to change over to this type of specimen when revised next.

m) The minimum data for the room temperature yield point and the elevated temperature.0.2 % yield limit were determined from available sets of data by means of cumulative frequency curves. A classification according to wall thickness differing from ISO 2604/II proved unavoidable, so as to be able to at least retain or even increase the present values in the majority of cases. Compared with ISO 2604/II this classification of the wall thicknesses generally gives higher values at lower wall thicknesses and, in part, lower values at greater wall thicknesses.

In order to lower the values for the thickness range greater than 60 mm to 80 mm by 10 N/mm^2 compared with the values in the greater than 40 mm to 60 mm wall thickness range of steels 13 CrMo 4 4 (1.7335) and 10 CrMo 9 10 (1.7380) the steel manufacturers had insufficient data at present on the over 60 mm to 80 mm thickness range for a significant evaluation to be carried out; extrapolation beyond the reasonably well substantiated range would only be possible up to wall thickness of approximately 60 mm, where the wall thickness effect observed at present in the range of up to 50 mm is still confirmed. The steelmakers expressed their willingness to collate data for analysing the current requirements at a later date.

n) ISO 2604/II contains no requirements for values of the 1 % time yield limit. The requirements in the current revised standard for steels St. 35.8 (1.0305), St. 45.8 (1.0405), 15 Mo 3 (1.5415), 13 CrMo 4 4 (1.7335) and 10 CrMo 9 10 (1.7380) contained in the previous version of DIN 17 175, agree with those in DIN 17 175 Part 2, Supplement (June 1969 edition). The values for the newly included steels 17 Mn 4 (1.0481) and 19 Mn 5 (1.0482) obtained from Stahl-Eisen-Werkstoffblatt 610 – Seamless headers of high temperature steels – have been supplemented by extrapolated values for 380 °C and 390 °C. The values for the 1 % limit of the other freshly included steels 14 MoV 6 3 (1.7715) and X 20 CrMoV 12 1 (1.4922) were based on the most up to-date evaluations.

o) The values for creep strength merit the following comments:

The requirements for steels St 35.8 (1.0305), St 45.8 (1.0405), 15 Mo 3 (1.5415) and 13 CrMo 4 4 (1.7335) – though for the two last-named steels only the values for 10^5 and 2.10^5 h – were taken from DIN 17 175 Part 2, Supplement (June 1969 edition).

In contrast, the 10^4 h – creep strength values of steels 15 Mo 3 and 13 CrMo 4 4 as well as the 10^4 and 10^5 h – creep strength values of the steel 14 MoV 6 3 (1.7715) agree with those of the corresponding steels in ISO 2604/II; the requirements for the 2.10^5 h – creep strength values of steel 14 MoV 6 3 were based on the most recent evaluations in the 480 °C to 500 °C temperature range, thereby differing from ISO 2604/II.

The creep strength values of steel 10 CrMo 9 10 (1.7380) agree, in principle, with those of steel TS 34 according to ISO 2604/II, though minor deviations of up to 4 N/mm^2 maximum have crept in during the smoothing of the curve as a result of three-dimensional interpolation (time, temperature, stress) which seem none-the-less justified in view of the improved utilizability of the data in the computer.

The 10^4 h – creep strength values of steel X 20 CrMoV 12 1 (1.4922) agree in the 500 °C to 610 °C temperature range with those of steel TS 40 according to ISO 2604/II; in contrast the 10^5 and 2.10^5 h – creep strength values in the 470 °C to 600 °C temperature range agree with the requirements in Stahl-Eisen Delivery Condition 675-69 – "Seamless tubes of high-temperature steels" –; the remaining values were extrapolated on the basis of the latest evaluations.

The values, which are quoted in Documents ISO/TC 17/SC 10/ETP N 99 and N 148 and envisaged for the forthcoming revised edition of ISO 2604/II for steels TS 5 and TS 9 H, were used for steels 17 Mn 4 (1.0481) and 19 Mn 5 (1.0482).

p) Thin-walled tubes may be marked by methods other than stamp-marking.

Comparison of ferritic and martensitic steels according to ISO2604/II, envisaged for use at elevated temperatures, with equivalent German steels

	Steels based on			
	German documents		ISO 2604/II	
1)	Code number	Material number	2)	3)
–	–	–	TS 2	–
DIN	St 35.8	1.0305	TS 5	●
DIN	St 45.8	1.0405	TS 9H	●
DIN	17 Mn 4	1.0481	TS 14	○
DIN	19 Mn 5	1.0482	TS 18	○
DIN	15 Mo 3	1.5415	TS 26	●
DIN	13 CrMo 4 4	1.7335	TS 32	●
DIN	10 CrMo 9 10	1.7380	TS 34	●
DIN	14 MoV 6 3	1.7715	TS 33	●
SEL	12 CrMo 19 5	1.7362	TS 37	○
SEL	X 12 CrMo 9 1	1.7386	TS 38	●
DIN	X 20 CrMoV 12 1	1.4922	TS 40	X

1) DIN = contained in DIN 17 175; SEL = contained in Stahl-Eisen List, 6th edition 1977, Düsseldorf, Verlag Stahl-Eisen mbH.

2) Code No of steels in ISO 2604/II.

3) This column shows the degree of agreement in the chemical composition of the German steels on the one hand and the ISO 2604/II steels on the other hand. Notations: X = full agreement, ● = minor deviations, ○ = significant deviations.