
INTERNATIONAL STANDARD



2604 / V

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**Steel products for pressure purposes — Quality requirements —
Part V : Longitudinally welded austenitic stainless steel tubes**

Produits en acier pour appareils à pression — Spécifications de qualité — Partie V : Tubes en acier inoxydable austénitique soudés longitudinalement

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

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It has been approved by the member bodies of the following countries :

Australia	India	South Africa, Rep. of
Austria	Iran	Spain
Belgium	Ireland	Sweden
Bulgaria	Italy	Switzerland
Canada	Korea, Rep. of	Turkey
Czechoslovakia	Mexico	United Kingdom
Denmark	Netherlands	U.S.S.R.
Finland	Philippines	Yugoslavia
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The member bodies of the following countries expressed disapproval of the document on technical grounds :

Japan
U.S.A.

Steel products for pressure purposes – Quality requirements – Part V : Longitudinally welded austenitic stainless steel tubes

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the quality requirements for plain end longitudinally welded austenitic stainless steel tubes manufactured from the steel types listed in table 3 which are applied for pressure purposes at room temperature, at low temperatures or at elevated temperatures in cases where the creep properties are not the ruling characteristics for design.

NOTES

1 The steels included in this International Standard may be used for low temperature service in view of their good resistance to brittle fracture at temperatures down to -195°C . However, the purchaser should ensure, for any particular application, the suitability of the steel selected.

Where the purchaser requires, verification of the impact properties, these shall be tested in accordance with clause 5 of ISO 2604/II and the values to be obtained shall be agreed.

2 The word "tube" is synonymous with "pipe".

This International Standard does not cover :

- casing, tubing, drill pipe and linepipe for use by the oil and natural gas industries;
- tubes for the transport of gas, water and sewage.

2 REFERENCES

- ISO/R 85, *Bend test for steel*.
- ISO/R 165, *Flanging test on steel tubes*.
- ISO/R 166, *Drift expanding test on steel tubes*.
- ISO/R 202, *Flattening test on steel tubes*.
- ISO 375, *Steel – Tensile testing of tubes*.
- ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel*.
- ISO 404, *Steel and steel products – General technical delivery requirements*.¹⁾

ISO 683/XIII, *Heat-treated steels, alloy steels and free-cutting steels – Part 13 : Wrought stainless steels*.

ISO/R 783, *Mechanical testing of steel at elevated temperatures – Determination of lower yield stress and proof stress and proving test*.

ISO 1127, *Stainless steel tubes – Dimensions, tolerances and conventional masses per unit length*.

ISO 2566/II, *Steel – Conversion of elongation values – Part II : Austenitic steels*.²⁾

ISO 2604/I, *Steel products for pressure purposes – Quality requirements – Part I : Forgings*.

ISO 2604/II, *Steel products for pressure purposes – Quality requirements – Part II : Wrought seamless tubes*.

ISO 2604/IV, *Steel products for pressure purposes – Quality requirements – Part IV : Plates*.

ISO 2605/II, *Steel products for pressure purposes – Derivation and verification of elevated temperature properties – Part II : Proof stress of austenitic steel products*.

3 GENERAL REQUIREMENTS

3.1 Information to be supplied by the purchaser

3.1.1 The purchaser shall state in this enquiry and order the requirements given below :

- the tube dimensions and tolerances (see 3.9);
- the steel type (see table 3 and 3.2);
- the test category (see 3.12);
- the inspection procedures and type of documents (see 3.10, 3.16 and 4.2.2.1);
- the hydraulic test pressure required (see 3.14.5);
- the method of manufacture of the tube (see 3.4.2);

1) At present at the stage of draft. (Revision of ISO/R 404-1964.)

2) In preparation.

3.1.2 Certain alternatives are permitted by this International Standard and the purchaser may also state in his enquiry and order his requirements as follows, but if no such statement is made, supply will be at the option of the manufacturer :

- g) if a product or filler wire (check) analysis is required (see 3.6.2);
- h) if agreement is necessary on the welding procedure (see 3.7.2);
- i) any special requirements for freedom from defects (see 3.8.5);
- j) any special straightness requirements (see 3.8.7);
- k) if cast separation is required (see 3.13.1.3);
- l) if the hydraulic test is to be omitted (see 3.13.3);
- m) the details of non-destructive tests, if required (see 3.14.6);
- n) if elevated temperature proof stress acceptance tests are required and if so, the testing temperature selected from table 5 (see 4.2.2.2).

3.2 Designation

The tubes shall be designated by reference to this International Standard and by a reference indicating the steel type and, where appropriate (see 3.1.1 f), the method of the manufacture of the tube.

Example : Tubes manufactured in accordance with this International Standard of steel type TW 57 (see table 3) by longitudinally welding, cold finishing and heat treating according to table 3 (see 3.4.2) shall be designated as

Tube to ISO 2604/V, TW 57 – LWCF

NOTE – All data on designations in this International Standard are to be regarded as preliminary and will be revised as soon as a general system for the designation of steels and steel products has been established.

3.3 Steelmaking process

The steel shall be produced by an electric or by an oxygen process. Other processes may be used by agreement between the parties concerned.¹⁾ If requested, the purchaser shall be informed of the manufacturing process of the steel used.

3.4 Manufacture of the product

3.4.1 The tubes shall be manufactured from flat rolled plate, sheet or strip, longitudinally welded across the abutting edges by a continuous automatic electric welding process with or without the addition of filler metal.

If filler wire is used it shall comply with the appropriate requirements of table 6.

3.4.2 The methods of manufacture given in table 1 are covered by this International Standard and these are coded for designation purposes as shown.

TABLE 1 – Methods of manufacture

Method of manufacture	Designation
Longitudinally welded	LW
Longitudinally welded and heat treated	LWHT
Longitudinally welded and cold formed	LWCF

The purchaser shall state, in the enquiry and order, which method of manufacture and heat treatment is required by utilizing one of the above designations.

3.4.3 Welds joining lengths of strip shall be cut out of the finished tube.

3.4.4 As-welded or welded and heat treated tubes may be cold sized after the welding operation.

3.4.5 Cold-finished tubes, subsequent to welding and prior to heat treatment, shall be cold worked to ensure that optimum corrosion resistance in the weld area and parent metal will be developed during heat treatment.

3.5 Heat treatment

For tubes which are heat treated, the heat treatment shall be a solution treatment and shall consist of heating the tubes uniformly to a temperature within the range given in table 3 and then cooling rapidly in air or water.

3.6 Chemical composition

3.6.1 Ladle analysis

The steel shall show on ladle analysis the composition given in table 3 appropriate to the steel type specified.

3.6.2 Product analysis

3.6.2.1 If a check analysis on the product or the filler wire is required, the number of samples to be taken shall be agreed between the parties concerned.

In the case of the product, the samples shall be taken either from the test piece used for the verification of the mechanical properties, or from the whole thickness of the tube at the same location, as for the mechanical test samples.

3.6.2.2 If a check analysis on the product is required, the permissible deviations given in table 4 apply to the ladle analysis specified in table 3 for samples taken from the standard position (see 3.6.2.1). If a check analysis for acceptance purposes is required, this shall be stated in the enquiry and order.

¹⁾ Such as the user, purchaser and manufacturer of the equipment, the producer of the supplied construction material and the inspection and/or certifying authority.

3.6.3 Cases of dispute

In cases of dispute, the methods for chemical analysis shall be in accordance with the relevant International Standard. If no International Standard is available, the method to be used shall be agreed between the parties concerned.

3.7 Mechanical and technological properties

3.7.1 Mechanical properties

The mechanical properties at room temperature to be obtained on test pieces selected, prepared and tested in accordance with 3.13.1 and 3.14 are given in table 3.

NOTE – The mechanical properties can be affected by heating or reheating during fabrication. Purchasers who intend to heat or reheat any of the steels are advised to discuss the application and proposed heating or reheating treatment with the supplier.

3.7.2 Weldability

The finished tubes covered by this International Standard are generally regarded as being weldable. However, the general weldability of any of the steels cannot be guaranteed as the behaviour of the steel during and after welding is dependent not only on the steel, but also on the welding conditions and the final use for which the steel is employed. Therefore, where appropriate, the welding procedure should be agreed between the parties concerned at the time of enquiry and order.

3.8 Appearance and soundness

3.8.1 The tubes shall have a workmanlike finish and shall be clean and free from such defects as can be established by the test category (see 3.12).

3.8.2 Tubes welded without the addition of the filler metal shall, unless otherwise agreed between the parties concerned, be dressed flush externally at the weld so that the tube is smooth and circular to the eye.

The internal projection of the weld bead shall be within 10 % of the specified thickness with a minimum of 0,15 mm and a maximum of 3 mm.

The misalignment of the abutting edges shall not exceed :

- for thicknesses $a \leq 12,7$ mm : 1,6 mm;
- for thicknesses $a > 12,7$ mm : 0,125 a or 3 mm, whichever is the smaller.

where a is the wall thickness, in millimetres.

3.8.3 For tubes welded with the addition of filler metal and supplied in the as-welded or welded and heat-treated condition, the outside and inside weld reinforcement shall not exceed the following maximum height :

- for the external weld bead : 0,5 a or 3 mm, whichever is the smaller;
- for the internal weld bead : 0,25 a or 3 mm, whichever is the smaller;

where a is the wall thickness, in millimetres.

3.8.4 Weld defects in tubes welded by a process using filter metal may be repaired at the option of the manufacturer, but tubes shall be repaired only before heat treatment or cold finishing respectively, except that defects found after initial heat treatment may be repaired provided that such tubes are re-heat treated. The repaired regions shall be non-destructively tested in accordance with annex A (ultrasonic) or annex B (eddy current).

3.8.5 Any special requirements for freedom from defects shall be agreed between the parties concerned at the time of the enquiry and order.

3.8.6 The requirements for surface defects, rectification and internal defects given in 8.1, 8.2 and 8.3 of ISO 404 apply.

3.8.7 The tubes shall be reasonably straight. Complete straightness cannot be guaranteed. Special requirements regarding straightness should be the subject of agreement.

3.8.8 The ends shall be cut nominally square with the axis of the tube. Special tolerances on end squareness may be agreed between the parties concerned.

3.9 Dimensions and tolerances

3.9.1 The dimensions shall be in accordance with the appropriate International Standards.

3.9.2 The tolerance on the outside diameter and thickness of the tubes depend upon the method of manufacture, the steel type and the heat treatment and should be selected from ISO 1127.

3.9.3 The requirements of 8.4 of ISO 404 apply.

3.10 Inspection procedures

The purchaser shall indicate in his enquiry and order which of the five inspection procedures listed in clause 4 of ISO 404 shall be followed.

NOTE – The inspection procedure selected shall, if appropriate, be compatible with the requirements of the International Standard covering the use of the product.

3.11 General rules for carrying out acceptance tests

The requirements of clause 5 of ISO 404 covering the following apply :

- a) place of acceptance;
- b) submission for inspection;
- c) rights of the inspector;
- d) acceptance.

3.12 Test categories

The tubes shall be subjected to the tests given in table 2 for the appropriate test category.

TABLE 2 – Test categories

Tests	Test categories			
	I	II	III	IV
Visual inspection	X	X	X	X
Tensile	X	X	X	X
Flattening or bend	X	X	X	X
Drift expanding or flanging		X		X
Weld inspection	X	X	X	X
Hydraulic	X	X	X*	X*
Acceptance non-destructive testing			X	X

* By agreement between the parties concerned, the hydraulic test can be replaced by a non-destructive test (see 3.13.3).

3.13 Number, selection and preparation of samples and test pieces

3.13.1 Mechanical tests at room temperature

3.13.1.1 The requirements of 2.3 and 2.4 of ISO/R 377, covering the identification and preparation of samples and test pieces, apply.

3.13.1.2 For test categories I and II the number of tubes on which mechanical tests at room temperature are to be performed shall be as follows :

- a) up to and including 323,9 mm outside diameter : one tube in each 200 tubes as made;
- b) over 323,9 mm outside diameter : one tube in each 100 tubes as made.

The samples shall be taken at random from batches as presented for inspection containing not more than 200 tubes. If the number of samples specified in this clause, when applied to a particular order, necessitates a number of tubes which includes a fraction, the fraction shall be treated as unity.

A batch is a convenient quantity of tubes of the same type of steel, diameter and thickness, such that a suitable number of sample tubes taken at random from a batch for purposes of test will adequately represent the whole batch.

3.13.1.3 For test categories III and IV the number of tubes on which mechanical tests at room temperature are to be performed shall be as follows :

- not heat treated : 2 % of the tubes from each batch;
- heat treated : 2 % of the tubes from each heat treatment batch.

For tubes not heat treated, a batch shall consist only of tubes of the same diameter and thickness and of the same

steel type. For tubes which are heat treated, a batch shall consist only of tubes of the same diameter and thickness and of the same steel type subjected to the same finishing treatment in a continuous furnace or heat treated in the same furnace charge in a batch-type furnace.

Cast separation may be carried out when agreed between the parties concerned and specified in the enquiry and order (see 4.2.2.2).

3.13.1.4 The test sample shall be cut from the tube after final heat treatment. If the tubes are to be delivered in a condition different from the specified final heat treatment condition, the test samples shall be in the reference heat treatment condition required by table 3.

3.13.1.5 From each tube selected for testing, one test piece shall be prepared for each of the mechanical tests required by 3.12.

For the tensile test on the material, the test piece may be taken at the manufacturer's option from

- a) lengths of tube of full section;
- b) strips cut longitudinally from the tube; or
- c) rings of the required width parted and flattened.

The strip or ring test piece shall not include the weld.

For tubes over 219,1 mm outside diameter, a tensile test on the weld shall be carried out. A strip or ring test piece shall be prepared with the weld at the centre of the parallel portion and at 90° to the axis of the test piece.

For the bend test, the test piece shall consist of a circumferential strip not less than 12,5 mm wide and of the full thickness of the tube. The centre of the weld when visible shall be at the centre of the test piece. The edges may be rounded to a radius of 1,6 mm.

3.13.2 Visual inspection

Every tube shall be inspected.

3.13.3 Hydraulic test

A hydraulic test shall be carried out on each tube, except that by agreement between the parties concerned the hydraulic test may be omitted for tubes of test categories III and IV which for acceptance purposes have been ultrasonically tested in accordance with annex A or eddy current tested in accordance with annex B.

3.13.4 Weld inspection

3.13.4.1 NON-DESTRUCTIVE TESTING

Non-destructive testing shall be used for the continuous examination of the weld area. This examination is made for the purpose of quality control during the process of manufacture by a method and at a place chosen by the manufacturer. For acceptance non-destructive testing, see 3.13.5.

3.13.4.2 MACROSCOPIC TEST

A macroscopic test shall be carried out on a sample cut from the end of each selected tube for the flattening or bend test and examined before testing.

3.13.5 Acceptance non-destructive testing

All tubes to test categories III and IV shall be non-destructively tested for acceptance purposes (see 3.14.6).

3.14 Test methods and test results

3.14.1 Tensile test at room temperature

3.14.1.1 The tensile test shall be carried out in accordance with ISO 375.

3.14.1.2 For the test on the base material, the tensile strength R_m , the yield strength and elongation A shall be determined. The results shall meet the requirements given in table 3.

For the yield strength either the 0,2 % proof stress (non-proportional elongation) $R_{p0,2}$ or the 1,0 % proof stress (non-proportional elongation) $R_{p1,0}$ may be determined as specified. Alternatively the 0,2 % or 1,0 % proof stress values (total elongation) $R_{t0,2}$ or $R_{t1,0}$ may be determined.

The percentage elongation shall be reported with reference to a $5,65\sqrt{S_0}$ gauge length. If other gauge lengths are used, the corresponding elongation on $5,65\sqrt{S_0}$ shall be obtained by reference to ISO 2566/II. In cases of dispute, a gauge length of $5,65\sqrt{S_0}$ shall be used. For the test on the weld, only the tensile strength shall be determined and it shall comply with the requirements of table 3.

3.14.2 Flattening or bend test

3.14.2.1 At the option of the manufacturer, and as determined by the dimensions of the tube, either a flattening test (see 3.14.2.2) or a bend test (see 3.14.2.3) shall be carried out.

3.14.2.2 The flattening test shall be carried out in accordance with ISO/R 202. The test piece shall show no crack or flaw when the distance between the platens is not greater than the value given by the formula :

$$H = \frac{(1 + C) a}{C + a/D_0}$$

where

- H is the distance, in millimetres, between platens;
- a is the specified thickness of tube, in millimetres;
- D_0 is the specified outside diameter, in millimetres;
- C is a constant depending on the steel type (see table 3).

3.14.2.3 The bend test shall be carried out in accordance with ISO/R 85. The test piece shall be doubled over cold

with the root of the weld in tension, round a bar of diameter equal to three times the thickness of the test piece, with a minimum of 6 mm, without showing crack or flaw, but slight premature failure at the edges shall not be considered cause for rejection.

3.14.3 Drift expanding or flanging test

Unless otherwise agreed at the time of enquiry and order, it is at the option of the tube manufacturer whether a drift expanding or flanging test is carried out.

3.14.3.1 The drift expanding test shall be carried out in accordance with ISO/R 166. The test piece shall, without cracking, be expanded by a mandrel, having an included angle of 30°, 45° or 60° at the option of the manufacturer, to increase the outside diameter by the amount specified in table 3 as being appropriate to the steel type specified.

3.14.3.2 The flanging test shall be carried out in accordance with ISO/R 165. The outside diameter of the flange shall exceed the outside diameter of the tube by the amount shown in table 3 as being appropriate to the steel type specified. After flanging, the tube shall show no crack or flaw.

3.14.4 Macroscopic test

For the macroscopic test, the cross-section of the sample shall be ground to at least a 600 grit finish for a distance of at least 25 mm each side of the weld or the complete section and etched in a suitable reagent to reveal the structure.

When examined at a magnification of 10 X the weld shall be free from defects such as cracks, porosity and undercutting and shall exhibit complete fusion with the parent metal through the full thickness of the tube.

3.14.5 Hydraulic test

Every tube, except as provided in 3.13.3, shall be hydraulically tested at the manufacturer's works.

The hydraulic pressure for all test categories shall be 1,5 times the design pressure but not greater than the pressure calculated from the formula :

$$p = \frac{20 \sigma a}{D_0}$$

where

- p is the test pressure, in bars;
- D_0 is the specified outside diameter, in millimetres;
- a is the specified thickness, in millimetres;
- σ is the stress, in newtons per square millimetre, which shall be taken as 70 % of the specified 1 % proof stress at room temperature as specified in the order.

NOTE — Until agreement is reached on the use of 1 % proof stress for design, σ may be taken as 80 % of the 0,2 % proof stress.

Where the application of the test pressure obtained by the formula could lead to technical difficulties, its application shall be by agreement between the parties concerned.

The test pressure shall be maintained sufficiently long for proof and inspection. Any tube failing to withstand the hydraulic pressure test shall be deemed not to comply with this International Standard.

3.14.6 Acceptance non-destructive testing

All finished tubes of test categories III and IV shall be subjected to non-destructive testing for acceptance purposes in accordance with annex A (ultrasonic method) or annex B (eddy current method). The choice between these two methods is left to the manufacturer, depending on the manufacturing route used and the dimensions of the tube.

3.15 Retests

The requirements of 6.5 and 7.6 of ISO 404 apply.

3.16 Documents

The purchaser shall state at the time of the enquiry and order which of the documents specified by clause 4 of ISO 404 are to be provided (see also 3.10).

3.17 Marking

3.17.1 The tubes shall be legibly marked to show :

- a) the identification symbols for the type of steel as given in table 3;
- b) the brand of the manufacturer of the tubes;
- c) a designation of the method of manufacture;
- d) symbols, letters or numbers which relate the test certificates, test pieces and product to each other.

3.17.2 The materials used for marking shall be free of lead, copper, zinc and tin.

3.17.3 On small diameter tubes which are bundled or boxed, the information in 3.17.1 may be marked on a tag securely attached to the bundle or box in which they are shipped.

4 ADDITIONAL REQUIREMENTS APPLICABLE TO STEEL TYPES HAVING SPECIFIED ELEVATED TEMPERATURE PROPERTIES

4.1 Mechanical properties

For the steel types which have specified elevated temperature properties, the minimum elevated temperature proof stress values derived in accordance with ISO 2605/II are given in table 5.

4.2 Verification and testing

4.2.1 Test categories

All the test categories shown in 3.12 are applicable to tubes covered by clause 4.

4.2.2 Elevated temperature proof stress

4.2.2.1 The elevated temperature proof stress values shall be verified either by elevated temperature acceptance testing or by the procedure given in ISO 2605/II.

4.2.2.2 If the elevated temperature proof stress values are to be verified by acceptance tests, one test shall be made on each cast using a test sample prepared in accordance with 3.13.1 and with the test piece taken at a position adjacent to one of the test pieces used for the tensile test at room temperature. If tubes of more than one thickness are to be supplied from one cast, then the test shall be made on the thickest tube.

The proof stress tests at elevated temperature shall be carried out in accordance with ISO/R 783 at a temperature selected from table 5 and agreed between the parties concerned at the time of enquiry and order.

For retests, the requirements of 6.5 of ISO 404 apply.

4.2.2.3 If the elevated temperature proof stress values are to be verified by the procedure given in ISO 2605/II the 95 % lower confidence limits of the elevated temperature proof stress values, which are necessary for the application of that procedure, are given in figures 1 to 9 for the various steel types.

TABLE 3 — Chemical composition, mechanical properties at room temperature and heat treatment

Steel No. 7)	Chemical composition, % (1, 2)										Mechanical properties at room temperature ^{3, 5)}					Heat treatment					
	C	Si	Mn	P _{max.}	S _{max.}	N _{max.}	Nb	Ti	N/mm ²	R _m	A _{min.}	Flattening test constant C	Bend test D ₅ max.	Drift expanding and flanging test (% increase in D ₁)		Reference heat treatment ³⁾	Temperature	Cooling condition			
														D ₁ /D ₀ ratio	> 0.6				< 0.8		
TW 46	≤ 0,03	≤ 1,00	≤ 2,00	0,045	0,030	17,00 – 19,00	—	0,00 – 12,00	—	175	205	490 – 690	30	0,09	3a	9	15	17	Q	950 – 1 100	
TW 47	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,030	17,00 – 19,00	—	8,00 – 11,00	—	195	235	490 – 690	30	0,09	3a	9	15	17	Q	950 – 1 100	
TW 50	≤ 0,08	≤ 1,00	≤ 2,00	0,045	0,030	17,00 – 19,00	—	9,00 – 12,00	Nb ≥ 10 × C ≤ 1,00	205	245	510 – 710	30	0,09	3a	9	15	17	Q	950 – 1 100	
TW 53	≤ 0,08	≤ 1,00	≤ 2,00	0,045	0,030	17,00 – 19,00	—	9,00 – 12,00	Ti ≥ 5 × C ≤ 0,80	195	235	510 – 710	30	0,09	3a	9	15	17	Q	950 – 1 100	
TW 57	≤ 0,03	≤ 1,00	≤ 2,00	0,045	0,030	16,00 – 18,50	2,00 – 2,50	11,00 – 14,00	—	185	215	490 – 690	30	0,09	3a	9	15	17	Q	950 – 1 100	air, or water
TW 58	≤ 0,03	≤ 1,00	≤ 2,00	0,045	0,030	16,00 – 18,50	2,50 – 3,00	11,50 – 14,50	—	185	215	490 – 690	30	0,09	3a	9	15	17	Q	950 – 1 100	
TW 60	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,030	16,00 – 18,50	2,00 – 2,50	10,50 – 14,00	—	205	245	510 – 710	30	0,09	3a	9	15	17	Q	950 – 1 100	
TW 61	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,030	16,00 – 18,50	2,50 – 3,00	11,00 – 14,50	—	205	245	510 – 710	30	0,09	3a	9	15	17	Q	950 – 1 100	
TW 69	≤ 0,10	≤ 1,00	≤ 1,50	0,045	0,030	19,00 – 23,00	—	30,00 35,00	Ti 0,15 – 0,60 and Al 0,15 – 0,60	195	235	490 690	25	0,09	3a	9	15	17	Q	900 1 040	

1) Elements not quoted in table 3 shall not be intentionally added without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall be taken to prevent the addition of such elements from scrap or other materials used in the manufacture, but residual elements may be present provided the mechanical properties and applicability are not adversely affected. If the level of residual elements is important in relation to the properties or weldability of the steel, the cast (ladle) analysis for such elements shall be reported.

2) For permissible deviations on product (check) analysis, see table 4.

3) Q = Quenched

R_{p0,2} = 0,2 % proof stress (non-proportional elongation)

R_{p1,0} = 1,0 % proof stress (non-proportional elongation)

R_m = tensile strength

A = percentage elongation after fracture on gauge length L₀ = 5,65 √S₀

D = maximum diameter of mandrel

a = thickness of test piece

D_i = internal diameter

D_o = outside diameter

4) For acceptance purposes, total elongation proof stress may be used (see 3.14.1.2).

5) Mechanical properties at elevated temperature are given in table 5.

6) The mandrel diameter shall not, however, be smaller than 6 mm (see 3.14.2.3).

7) For comparable types of steel in other International Standards, see table 7.

TABLE 4 – Permitted deviations from the specified composition

Element	Maximum of specification range	Permissible deviation from the specified composition ^{1, 2)}
Carbon	≤ 0,03	± 0,005
	> 0,03 – 0,25	± 0,01
Manganese	≤ 0,40 – 0,70	± 0,03
	> 0,70 – 1,0	± 0,04
	> 1,0 – 2,0	± 0,05
Silicon	≤ 1,0	± 0,05
Sulphur and Phosphorus specified max.	≤ 0,030	+ 0,003
	> 0,030 – 0,040	+ 0,004
	> 0,040 – 0,050	+ 0,005
Nickel	> 5,0 – 10,0	± 0,10
	> 10,0 – 20,0	± 0,15
	> 20,0	± 0,20
Chromium	> 15,0 – 20,0	± 20,0
	> 20,0	± 0,25
Molybdenum	> 2,0 – 3,0	± 0,08
Titanium and Niobium	All ranges	± 0,05

1) The deviations, other than when maxima only are specified, apply either above or below the specified limits of the range but not both above and below for the same element from different sample products from the same cast. When maxima only are specified, the deviations are positive only. The values are valid only if the samples were selected according to 3.6.2.1.

2) These values shall be considered as provisional until more confident data are available.

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TABLE 5 — Minimum 0,2 % and 1 % proof stress ($R_p 0,2$) and $R_p 1,0$ values at elevated temperature

Steel No.	Reference heat treatment ^{1), 2)}	$R_{p0,2}$ min. 3), N/mm ²															$R_{p1,0}$ min. N/mm ²														
		100	150	200	250	300	350	400	450	500	550	600	650	700	Temperature, °C	100	150	200	250	300	350	400	450	500	550	600	650	700			
TW 46	Q	118	105	95	86	78	73	70	68	66	65	64	—	—	161	143	130	121	115	109	104	102	99	97	94	91	89				
TW 47	Q	132	120	109	100	93	87	84	80	79	77	76	—	—	182	163	151	142	135	129	123	120	118	115	111	107	101				
TW 50	Q	171	162	153	147	139	134	129	126	124	122	121	—	—	209	197	186	177	171	166	164	161	160	158	155	—	—				
TW 53	Q	148	144	138	134	129	124	119	114	111	107	104	101	99	192	180	172	164	158	152	148	144	140	138	135	130	124				
TW 57	Q	137	126	115	105	97	90	86	83	80	77	76	75	74	169	154	141	132	126	120	116	112	108	105	103	100	98				
TW 58	Q	137	126	115	105	97	90	86	83	80	77	76	75	74	169	154	141	132	126	120	116	112	108	105	103	100	98				
TW 60	Q	155	144	132	121	113	107	101	98	95	91	90	89	88	194	176	163	153	147	141	136	132	128	125	122	119	116				
TW 61	Q	155	144	132	121	113	107	101	98	95	91	90	89	88	194	176	163	153	147	141	136	132	128	125	122	119	116				
TW 69	Q	—	—	—	—	—	—	—	—	—	—	—	—	—	206	194	184	175	169	162	157	154	149	144	137	126	110				

- 1) Q = quenched.
 - 2) For temperatures and cooling conditions, see table 3.
 - 3) If necessary, missing values shall be agreed between the parties concerned at the time of enquiry and order.
- NOTE — All values are subject to revision when more data become available.