
INTERNATIONAL STANDARD



2604/VI

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Steel products for pressure purposes — Quality requirements — Part VI : Submerged arc longitudinally or spirally welded steel tubes

Produits en acier pour appareils à pression — Spécifications de qualité — Partie VI : Tubes en acier soudés à l'arc longitudinalement ou en hélice sous flux en poudre

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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.

International Standard ISO 2604/VI was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in June 1976.

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

| | | |
|---------------------|----------------|-----------------------|
| Australia | Hungary | ISO 2604-6:1978 |
| Austria | India | South Africa, Rep. of |
| Belgium | Iran | Spain |
| Bulgaria | Ireland | Sweden |
| Canada | Italy | Switzerland |
| Czechoslovakia | Korea, Rep. of | Turkey |
| Denmark | Mexico | United Kingdom |
| Egypt, Arab Rep. of | Philippines | U.S.S.R. |
| Finland | Poland | Yugoslavia |
| France | Romania | |

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 VI : Submerged arc longitudinally or spirally welded steel tubes

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the quality requirements for plain end submerged arc welded 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 under conditions where the creep properties are not the ruling characteristics for design.

It covers longitudinally and spirally welded tubes.

NOTE – The word “tube” is synonymous with “pipe”.

This International Standard does not cover:

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

2 REFERENCES

ISO/R 85, *Bend test for steel*.

ISO 148, *Steel – Charpy impact test (V-notch)*.¹⁾

ISO 336, *Plain end steel tubes, welded or seamless – General table of dimensions and masses per unit length*.

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*.²⁾

ISO/R 643, *Micrographic determination of the austenitic grain size of steels*.

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

ISO/R 1106, *Recommended practice for radiographic inspection of fusion welded butt joints for steel plates up to 50 mm (2 in) thick*.

ISO 2566/1, *Steel – Conversion of elongation values – Part 1 : Carbon and low alloy steels*.

ISO 2605/1, *Steel products for pressure purposes – Derivation and verification of elevated temperature properties – Part 1 : Yield or proof stress of carbon and low alloy steel products*.

ISO 2694, *Pressure vessels*.³⁾

3 GENERAL REQUIREMENTS

3.1 Information to be supplied by the purchaser

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

- a) the tube dimensions and tolerances (see 3.9);
- b) the steel type (see table 3 and 3.2);
- c) the test category (see 3.12);
- d) the inspection procedures and type of documents (see 3.10, 3.16, 4.2 and 5.2).

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:

- e) type of finish or heat treatment (see 3.4.2);
- f) type of seam, longitudinal or spiral (see 3.4.2);
- g) if welding procedure qualification certificate or welding procedure qualification tests are required (see 3.4.2);
- h) if a product (check) analysis is required (see 3.6.2);
- i) if additional mechanical tests are required (see 3.7.1.2);
- j) if agreement is necessary on the welding procedure (see 3.7.2);
- k) any special straightness requirements (see 3.8.4);

1) At present at the stage of draft. (Revision of ISO/R 148-1960.)

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

3) At present at the stage of draft.

- l) any special requirements for freedom from defects (see 3.8.6);
- m) if special protection is required (see 3.8.8);
- n) if special tolerances for the outside diameter at the end of the tube are required (see 3.9.2);
- o) if room temperature impact tests are required and, if so, the number of test pieces (see 3.13.1.7);
- p) if the hydraulic test is to be omitted (see 3.13.3);
- q) the details of non-destructive tests, if required (see 3.14.5);
- r) if elevated temperature proof stress tests are required, and if so, the testing temperature selected from table 6 (see 4.2.2.2);
- s) if low temperature V-notch impact tests are required and, if so, the testing temperature selected from table 7 (see 5.2.2).

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 3.1.2 e) and f)), the method of the manufacture of the tube.

Example : Tubes manufactured in accordance with this International Standard of steel type TSAW 32 (see table 3) by spirally welding and heat treating according to table 3 (see 3.4.2) shall be designated as

Tube to ISO 2604/VI, TSAW 32-SWHT

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

3.3.1 Unless otherwise stated on the enquiry and order, the steelmaking process and the deoxidation practice within the provisions of 3.3.2, 3.3.3 and table 3 will be at the option of the steel manufacturer.

3.3.2 The steel shall be produced by the open hearth, electric or one of the basic oxygen processes. Other processes may be used by agreement between the parties concerned.¹⁾

If he so requests, the purchaser shall be informed of the steelmaking process used.

3.3.3 Deoxidation practice shall be as defined in table 3 for the steel type specified.

NOTE – ISO documents covering the use of tubes for pressure purposes place additional limitations on deoxidation practice for certain applications. For such applications the purchaser shall ensure that these limitations are 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.

3.4 Manufacture of the product

3.4.1 The tubes shall be manufactured from steel plate, sheet or strip welded continuously across the abutting edges by an automatic submerged arc welding process using at least one run on the inside and at least one run on the outside of the tube. The wire/flux combination used shall be compatible with the parent metal.

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 |
|---|-------------|
| <i>Longitudinally welded</i> | |
| As welded | LW |
| Welded and heat treated according to table 3 | LWHT |
| Welded, cold finished and heat treated according to table 3 | LWCF |
| <i>Spirally welded</i> | |
| As welded | SW |
| Welded and heat treated | SWHT |

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

Unless otherwise specified, the type of seam (longitudinal or spiral) is at the option of the manufacturer and as appropriate to the outside diameter and thickness. Longitudinally welded tubes may be hot or cold finished.

3.4.3 The manufacturer shall on request supply details of his welding procedure and, if necessary, a welding procedure approval certificate acceptable to the parties concerned.

If the purchaser requires welding procedure approval for his particular order, this shall be agreed at the time of enquiry and order.

3.4.4 Repair welds shall be carried out in accordance with the following instructions and are to be submitted for the approval of the purchaser's representative.

The defect shall be completely removed and the cavity cleaned.

The repair shall be carried out by qualified welders accepted by the parties concerned, following a procedure suitable for the tube and further heat treatments. This procedure shall be accepted by the parties concerned.

The repaired surface shall be blended smoothly into the surrounding parent metal.

The tube shall be heat treated after repair in accordance with the requirements of the weld procedure specification.

Each length of repaired tube shall be tested hydraulically in accordance with 3.13.3, and non-destructively tested in accordance with annex A or B.

3.5 Heat treatment

3.5.1 If the tubes are ordered in the heat-treated condition, the heat treatment shall be as given in table 3 for the particular steel type ordered. Tubes which are cold finished shall be heat treated.

3.5.2 By agreement between the parties concerned, tubes may be delivered in a condition other than the final heat-treated condition as given in table 3. In such cases they shall be suitable for subsequent manipulation and the purchaser shall be informed of the heat treatment necessary to give the required properties (see also 3.7.1).

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 is required, the number of samples to be taken shall be agreed between the parties concerned.

The samples shall be taken either from the test pieces 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 tables 4 and 5 apply to the 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.

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

3.7.1.1 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.

3.7.1.2 If heat treatments different from or additional to the normal reference heat treatment are to be carried out after the delivery of the tubes (which may have an adverse effect on the mechanical properties), the purchaser may require, at the time of enquiry and order, additional mechanical tests on additional samples which have been given heat treatments different from or additional to those in table 3. In this case, the heat treatment of the samples and the mechanical properties to be obtained on them shall be agreed between the parties concerned at the time of enquiry and order.

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, but especially of the steels with relatively high alloy content, 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 The misalignment of 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 3,2 mm, whichever is the smaller.

3.8.3 Misalignment of the weld seam is acceptable provided that complete penetration and complete fusion have been achieved.

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

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

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

3.8.7 The ends shall be cut square with the axis of the tube within 1,6 mm measured not less than three times per 8 h working shift.

3.8.8 The tubes may be supplied uncoated or with the manufacturer's standard mill protective coating unless otherwise specified.

3.9 Dimensions and tolerances

3.9.1 The dimensions shall be in accordance with ISO 336.

3.9.2 The thickness of each tube (apart from weld reinforcement) shall be subject to the following tolerances : $\pm \frac{15}{8} \%$.

3.9.3 The outside diameter of the body of the tube as calculated by measuring the circumference shall not deviate from the specified diameter by more than $\pm 0,75 \%$ or ± 6 mm, whichever is the less.

Where required by the purchaser, the tolerance on the outside diameter within 100 mm of the ends of the tube as measured by taping the circumference shall not exceed $\begin{matrix} + 2,4 \\ - 0,8 \end{matrix}$ mm.

3.9.4 The height of outside and inside weld reinforcement shall not exceed the following values :

- for thickness $\leq 12,7$ mm : 3 mm;
- for thickness $> 12,7$ mm : 4,5 mm.

3.9.5 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 procedures 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.

NOTE - If required, an impact test at room temperature may be carried out for any of the test categories (see 3.13.1.7).

TABLE 2 - Test categories

| Tests | Test categories | | |
|-------------------------|-----------------|---------------------------------|--------------------------------|
| | VI | VII | VIII |
| Visual inspection | X | X | X |
| Hydraulic | X | X | X (see 3.13.3) |
| Tensile (base material) | X | X | X |
| Tensile (weld) | X | X | X |
| Bend (weld) | X | X | X |
| Non-destructive testing | | X (random) (see 3.13.4.2) | X (100 %) (see 3.13.4.3) |

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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 The number of tubes on which mechanical tests at room temperature are to be performed shall be as follows :

- a) test category VI : 1 % of the tubes from each batch;
- b) test category VII : 2 % of the tubes from each batch;
- c) test category VIII : 2 % of the tubes from each batch;

For test categories VI, VII and VIII the samples shall be taken at random from batches as presented for inspection containing not more than 100 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.

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).

3.13.1.3 The test sample shall be cut from the tube in the final condition of supply. 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.

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

3.13.1.5 For the tensile test, the test piece may be taken longitudinally or transversely at the option of the manufacturer. The dimensions of the test piece shall comply with the appropriate International Standard.

For the tensile test on the material, the test piece shall be cut clear of the weld.

For the tensile test on the weld, the weld shall be at the centre of the test piece and at right angles to the longitudinal axis of the test piece. The weld may be dressed.

3.13.1.6 For the weld bend test one face and one root bend test piece with dimensions in accordance with ISO/R 85 shall be cut from one end of each selected sample with the weld at the centre of the test piece. Alternatively for thicknesses greater than 20 mm two side bend test pieces for a side bend test in both directions shall be cut.

The weld should be dressed flush with the surface of the tube and the edges of the test piece may be rounded to a radius of 1,6 mm.

3.13.1.7 Where the dimensions of the tube permit the taking of a full size (10 mm × 10 mm) test piece, and if agreed between the parties concerned, one, or if agreed at the time of enquiry and order, three V-notch impact test pieces shall be taken from one of the tubes selected.

NOTE — If the application code as, for example, in ISO 2694, requires impact tests then the purchaser should ensure that corresponding requirements are stated on his enquiry and order.

The form and dimensions of the test pieces shall be in accordance with ISO 148.

The test pieces shall be cut so that their longitudinal axes are transverse to the longitudinal axis of the tube. The notch shall be perpendicular to the original surface of the tube.

If an impact test on the weld is required, the position of the test pieces and the test requirements shall be agreed between the parties concerned.

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 category VIII which have been non-destructively tested for acceptance purposes.

3.13.4 Non-destructive testing

3.13.4.1 The tube welds shall be subjected to non-destructive testing in accordance with 3.13.4.2 or 3.13.4.3.

3.13.4.2 For tubes of test category VII, random non-destructive examination of the tube weld, to an extent agreed between the parties concerned, shall be effected.

3.13.4.3 For tubes of test category VIII, a 100 % non-destructive examination of the tube weld shall be effected.

3.14 Test methods and test results

3.14.1 Tensile test at room temperature

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

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

At the option of the manufacturer, the transverse yield stress may be determined by the ring expansion method.

For the yield strength, either the upper yield stress R_{eH} or the 0,5 % proof stress (total elongation) $R_{t0,5}$ 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 2566/1. In cases of dispute, a gauge length of $5,65\sqrt{S_0}$ shall be used.

The test across the weld shall show a tensile strength not less than the minimum tensile strength of the plate material. The yield stress and the percentage elongation do not require to be measured.

3.14.2 Bend test (weld)

The weld bend test shall be carried out in accordance with ISO/R 85.

The test pieces after having been bent cold through an angle of 180° round a mandrel of the diameter given in table 3 shall show no cracks or other defects exceeding 3,20 mm in any direction in the weld metal or between the weld and tube metal. Slight premature failure at the edges shall not be considered a cause for rejection.

3.14.3 Impact test at room temperature

3.14.3.1 The impact test shall be carried out in accordance with ISO 148.

3.14.3.2 If one test piece is used, the value obtained shall meet the requirements given in table 3.

3.14.3.3 If three test pieces are used, the average value obtained shall meet the requirements given in table 3. One individual value may be below the specified value provided that it is not less than 70 % of that value.

3.14.4 Hydraulic test

Every tube, except as provided in 3.13.3, shall be hydraulically tested at the manufacturer's works unless it is agreed by the parties concerned that the tests shall be carried out elsewhere.

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

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

where

p is the test pressure, in bars;

D 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 *X* % of the minimum yield strength for the steel type specified (*X* is 60 for test category VI and 80 for test categories VII and VIII)

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.

3.14.5 Non-destructive testing

Non-destructive testing shall be carried out on tubes tested to quality categories VII and VIII by the methods detailed below.

3.14.5.1 If test category VII has been ordered, random checks on the tube weld shall be carried out on the finished tube at the agreed intervals by radiographic or ultrasonic means at the manufacturer's option. The technique outlined in ISO/R 1106, or an agreed equivalent procedure, shall be used as a basis for radiographic testing. The method outlined in annex A shall be used as a basis for ultrasonic tests. Annex B shall be used as the basis for radiographic acceptance levels.

3.14.5.2 If test category VIII has been ordered, the full length of the weld of the finished tube shall be inspected either by radiography or, if agreed, by an ultrasonic method. If the ultrasonic method is used, the tubes shall also be radiographed for a distance of 200 mm from each end.

The technique outlined in ISO/R 1106, or an agreed equivalent procedure, shall be used as a basis for radiographic testing. The method outlined in annex A shall be used as a basis for ultrasonic testing. Annex B shall be used as the basis for radiographic acceptance levels.

3.15 Retests

The requirements of 6.5 and 7.6 of ISO 404 apply except in the case of impact tests where the average of the results on three test pieces is taken. In this latter case the following procedure shall be used.

If the average of three impact values is lower than the specified value, or if any one value is lower than 70 % of this specified value, three additional test pieces shall be taken from the same sample and tested. The average value of the six tests shall be not less than the specified value. Not more than two of the individual values may be lower than the specified value and not more than one may be lower than 70 % of this value.

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 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, see 3.4.2;
- d) symbols, letters or numbers which relate the test certificates, test pieces and products to each other.

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

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 2605/1 are given in table 6.

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 2605/1.

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 6 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 2605/1, the 95 % lower confidence limits of the elevated temperature proof stress values, which are necessary for the application of that procedure, are given in figure 1 to 8 for the various steel types.

5 ADDITIONAL REQUIREMENTS APPLICABLE TO STEEL TYPES HAVING SPECIFIED LOW TEMPERATURE PROPERTIES

5.1 Mechanical properties

For the steel types which have specified low temperature properties, the minimum longitudinal Charpy V-notch impact values are given in table 7 (see also 5.2.6).

5.2 Verification and testing

5.2.1 All the test categories shown in 3.12 are applicable to the tubes covered by clause 5.

5.2.2 Tests are only to be carried out if so stated in the enquiry and order and if the thickness of the tube is equal to or greater than 6 mm.

NOTE – International Standards covering the use of tubes for pressure purposes include mandatory low temperature test requirements (see for example ISO 2694).

5.2.3 If low temperature impact tests are required, the number of tubes on which impact tests shall be carried out shall be :

- for tubes not heat-treated : one tube per batch;
- for heat-treated tubes : one tube per heat treatment batch as defined in 3.13.1.

5.2.4 From the sample tube, three longitudinal ISO V-notch test pieces shall be prepared, the form and dimensions of which shall be in accordance with ISO 148.

The test pieces shall be cut so that the longitudinal axes are parallel to the longitudinal axis of the tube. The notch shall be perpendicular to the original surface of the tube.

5.2.5 The tests shall be carried out in accordance with ISO 148 at a temperature selected from table 7 and agreed between the parties concerned at the time of enquiry and order.

5.2.6 The average value of the three tests shall meet the requirements given in table 7. One of the three individual values may be below the specified minimum average value of table 7 provided that it is not less than 70 % of that value.

5.2.7 For retests, the following procedure shall be used. If the average of three impact values is lower than the specified value, or if any one value is lower than 70 % of this specified value, three additional test pieces shall be taken from the same sample and tested. The average value of the six tests shall be not less than the specified value. Not more than two of the individual values may be lower than the specified value and not more than one may be lower than 70 % of this value.

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

| Steel No. | Chemical composition, % (1, 2, 3) | | | | | | | Mechanical properties at room temperature ⁹⁾ | | | | | Heat treatment | | | | | | | | |
|-----------|-----------------------------------|-------------|-------------|--------|--------|-------------|-------------|---|-----|------|-----------|----------------|----------------|--------|-------------|------------------|--|----------------------------|-------------------|--------------------------|----------------------------------|
| | C | Si | Mn | P max. | S max. | Cr | Mo | Others ⁶⁾ | low | high | Thickness | R _e | R _m | A min. | K(√11) min. | Bend test (weld) | Reference heat treatment ⁹⁾ | Austenizing temperature °C | Cooling condition | Tempering temperature °C | Cooling condition ¹¹⁾ |
| TSAW 3 | < 0,17 | < 0,35 | 0,40 — 1,00 | 0,060 | 0,060 | — | — | N < 0,0084 ¹⁾ | 6 | 6 | < 4,0 | 195 | 360 — 480 | 26 | — | 4a | N | 900 — 940 | air | — | — |
| TSAW 5 | < 0,17 | < 0,35 | 0,40 — 1,00 | 0,040 | 0,040 | — | — | Al _{met} ≤ 0,0155 (6, 7) | 7 | 6 | < 4,0 | 215 | 360 — 480 | 26 | — | 4a | N | 900 — 940 | air | — | — |
| TSAW 7 | < 0,20 | < 0,35 | 0,50 — 1,30 | 0,050 | 0,050 | — | — | N < 0,0084 ¹⁾ | 6 | 6 | < 4,0 | 225 | 410 — 530 | 24 | — | 4a | N | 890 — 930 | air | — | — |
| TSAW 9 | < 0,20 | < 0,35 | 0,50 — 1,30 | 0,040 | 0,040 | — | — | Al _{met} ≤ 0,0155 (6, 7) | 7 | 6 | < 4,0 | 245 | 410 — 530 | 24 | — | 4a | N | 890 — 930 | air | — | — |
| TSAW 15 | < 0,20 | < 0,40 | 0,60 — 1,50 | 0,040 | 0,040 | — | — | Al _{met} ≤ 0,0155 (6, 7) | 7 | 6 | < 4,0 | 285 | 460 — 560 | 22 | — | 6a | N | 880 — 920 | air | — | — |
| TSAW 18 | < 0,20 | 0,10 — 0,50 | 0,90 — 1,60 | 0,040 | 0,040 | — | — | Al _{met} ≤ 0,0155 (6, 7) | 7 | 6 | < 4,0 | 315 | 490 — 610 | 21 | — | 6a | N | 880 — 920 | air | — | — |
| TSAW 26 | 0,12 — 0,20 | 0,15 — 0,35 | 0,50 — 0,80 | 0,030 | 0,040 | < 0,30 | 0,25 — 0,35 | Al _{met} ≤ 0,0126 ¹⁾ | — | 6 | < 4,0 | 265 | 440 — 560 | 24 | — | 6a | N (+ T) | 900 — 940 | air | (600 — 650) | air |
| TSAW 28 | 0,12 — 0,20 | 0,15 — 0,35 | 0,50 — 0,80 | 0,035 | 0,035 | < 0,30 | 0,40 — 0,60 | Al _{met} ≤ 0,0126 ¹⁾ | — | 6 | < 4,0 | 275 | 450 — 590 | 23 | — | 6a | N (+ T) | 900 — 940 | air | (600 — 650) | air |
| TSAW 32 | 0,10 — 0,18 | 0,15 — 0,35 | 0,40 — 0,80 | 0,040 | 0,040 | 0,70 — 1,30 | 0,40 — 0,60 | Al _{met} ≤ 0,0206 ¹⁾ | — | 6 | < 4,0 | 305 | 470 — 620 | 20 | — | 6a | N + T | 900 — 950 | air | 630 — 700 | air |
| TSAW 33 | 0,08 — 0,18 | 0,15 — 0,35 | 0,40 — 0,70 | 0,040 | 0,040 | 0,30 — 0,60 | 0,50 — 0,70 | V = 0,22 — 0,35 | — | 6 | < 4,0 | 285 | 460 — 610 | 19 | — | 6a | N + T | 930 — 980 | air | 670 — 720 | air |
| TSAW 34 | 0,08 — 0,18 | 0,15 — 0,50 | 0,40 — 0,80 | 0,040 | 0,040 | 2,00 — 2,50 | 0,90 — 1,10 | Al _{met} ≤ 0,0206 ¹⁾ | — | 6 | < 4,0 | 265 | 480 — 630 | 18 | — | 6a | N + T | 900 — 950 | air | 650 — 750 | air |
| TSAW 37 | < 0,18 | < 0,50 | 0,30 — 0,60 | 0,030 | 0,030 | 4,00 — 6,00 | 0,45 — 0,65 | Al _{met} ≤ 0,0206 ¹⁾ | — | 6 | < 4,0 | 205 | 410 — 560 | 20 | — | 6a | A | 850 — 880 | furnace | — | — |

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.

If the purchaser so requires for reasons of formability etc., a maximum Cu content of 0,25 % may be imposed.

2) For permissible deviations on product (check) analysis, see tables 4 and 5.

3) All steels shall be fully killed, except steels TSAW 3 and TSAW 7, which may be semi-killed.

4) For electric furnace steel nitrogen (N) ≤ 0,012 %.

5) Aluminium may be replaced by other elements having a similar effect.

6) Where a maximum Al_{met} of 0,012 % or 0,020 % is specified, determination of the total aluminium content, provided it does not exceed the specified value, shall be deemed to meet this requirement.

Where a minimum Al_{met} of 0,015 % is specified, determination of the total aluminium content shall be deemed to meet this requirement provided the total aluminium content value obtained is not less than 0,018 %.

In cases of dispute, the metallic aluminium content shall be determined.

7) Alternatively an austenitic grain size of 6 or finer, determined in accordance with ISO/R 643, can be agreed.

8) Other elements having the same effect may be used by agreement between the purchaser and the supplier.

9) N = normalized T = tempered A = annealed

R_e = yield strength

R_m = tensile strength

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

KV = Charpy V-notch impact strength

D = maximum diameter of mandrel

a = thickness of test piece.

10) For acceptance purposes, total elongation proof stress may be used (see 3.14.1).

11) As long as no values are specified here, they shall where required (see 3.13.1.7) be agreed at the time of enquiry and order.

TABLE 4 – Permitted deviation from the specified composition for carbon and carbon-manganese steels

| Element | Maximum of specification range | Permissible deviation from the specified composition ^{1, 2)} |
|---------------------------|--------------------------------|---|
| Carbon | ≤ 0,25 | ± 0,03 |
| Silicon | ≤ 0,50 | ± 0,05 |
| Manganese | ≤ 2,0 | ± 0,10 |
| Sulphur specified max. | ≤ 0,050 | + 0,005 |
| Phosphorus specified max. | ≤ 0,050 | + 0,005 |

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TABLE 5 – Permitted deviation from the specified composition for low and medium alloy steels

| Element | Maximum of specification range | Permissible deviation from the specified composition ^{1), 2)} |
|---------------------------------------|--------------------------------|--|
| Carbon | ≤ 0,25 | ± 0,03 |
| Silicon | ≤ 0,50 | ± 0,05 |
| Sulphur and phosphorus specified max. | ≤ 0,050 | + 0,005 |
| Chromium | ≤ 6,0 | ± 0,10 |
| Molybdenum | ≤ 0,35 > 0,35 – 1,5 | ± 0,04 ± 0,05 |
| Vanadium | ≤ 0,35 | ± 0,03 |

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 deviation are positive only. The values are valid only if the samples were selected according to 3.6.2.1.

2) These values apply only to fully killed steels and shall be considered as provisional until more confident data are available.