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Non-destructive testing of steel tubes —

Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections

Essais non destructifs des tubes en acier —

Partie 5: Contrôle par magnétoscopie des tubes en acier ferromagnétique sans soudure et soudés pour la détection des imperfections de surface

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10893-5 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 19, *Technical delivery conditions for steel tubes for pressure purposes*.

This first edition cancels and replaces ISO 13664:1997 and ISO 13665:1997, which have been technically revised.

ISO 10893 consists of the following parts, under the general title *Non-destructive testing of steel tubes*:

— *Part 1: Automated electromagnetic testing of seamless and welded (except submerged arc-welded) steel tubes for the verification of hydraulic leaktightness*

— *Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections*

— *Part 3: Automated full peripheral flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections*

— *Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

— *Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

— *Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

— *Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections*

— *Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes*

— *Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections*

— *Part 12: Automated full peripheral ultrasonic thickness testing of seamless and welded (except submerged arc-welded) steel tubes*

Non-destructive testing of steel tubes —

Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections

1 Scope

This part of ISO 10893 specifies requirements for magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections on the tube body and the end/bevel face at the ends.

For the tube body, it specifies requirements for the detection of surface imperfections on all or part of the outside surface of tubes. However, by agreement between the purchaser and manufacturer, it can be applicable to the inside surface over a limited length from the ends of tubes, dependent on the tube diameter.

In addition, this part of ISO 10893 can be used, as appropriate, to locate the position of external surface imperfections detected by another non-destructive testing method (e.g. ultrasonic) prior to dressing of the tube surface, and to ensure complete removal of the imperfection after dressing is complete.

For the end/bevel face at the ends of plain-end and beveled-end tubes, this part of ISO 10893 specifies requirements for the detection of laminar imperfections which can interfere with subsequent fabrication and inspection operations (e.g. welding and ultrasonic inspection of the welds).

This part of ISO 10893 is applicable to the detection of imperfections, other than laminar imperfections, on the end/bevel face. In this case, magnetization is applied in the direction essentially perpendicular to the orientation of the particular imperfections being detected.

It can also be applicable to the testing of hollow sections.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9712, *Non-destructive testing — Qualification and certification of personnel*

ISO 9934-1, *Non-destructive testing — Magnetic particle testing — Part 1: General principles*

ISO 9934-2, *Non-destructive testing — Magnetic particle testing — Part 2: Detection media*

ISO 9934-3, *Non-destructive testing — Magnetic particle testing — Part 3: Equipment*

ISO 10893-8, *Non-destructive testing of steel tubes — Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections*

ISO 11484, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9934-1 and ISO 11484 and the following apply.

3.1
tube
hollow long product open at both ends, of any cross-sectional shape

3.2
seamless tube
tube made by piercing a solid product to obtain a tube hollow, which is further processed, either hot or cold, into its final dimensions

3.3
welded tube
tube, made by forming a hollow profile from a flat product and welding adjacent edges together, and which after welding can be further processed, either hot or cold, into its final dimensions

3.4
manufacturer
organization that manufactures products in accordance with the relevant standard(s) and declares the compliance of the delivered products with all applicable provisions of the relevant standard(s)

3.5
agreement
contractual arrangement between the manufacturer and purchaser at the time of enquiry and order

4 General requirements

4.1 Unless otherwise specified by the product standard or agreed on by the purchaser and manufacturer, a magnetic particle inspection shall be carried out on tubes after completion of all the primary production process operations (rolling, heat treating, cold and hot working, sizing, primary straightening, etc.).

4.2 The surface of the tube and of the end/bevel face at both tube ends being tested shall be sufficiently clean and free of oil, grease, sand or scale or any other foreign matter which can interfere with the correct interpretation of the indications obtained from the magnetic particle inspection. The type of indications, as well as the minimum dimension of the surface imperfections being detected, depends on the specific tube manufacturing process and the surface finish.

4.3 This inspection shall be carried out by trained operators qualified in accordance with ISO 9712, ISO 11484 or equivalent, and supervised by competent personnel nominated by the manufacturer. In the case of third-party inspection, this shall be agreed on between the purchaser and manufacturer.

The operating authorization issued by the employer shall be according to a written procedure. NDT operations shall be authorized by a level 3 NDT individual approved by the employer.

NOTE The definition of levels 1, 2 and 3 can be found in appropriate International Standards, e.g. ISO 9712 and ISO 11484.

5 Test method

5.1 General

5.1.1 Inspection area (the tube body or end/bevel face) and inspection direction (longitudinal or transverse) shall be as specified in the product standards or purchaser order.

5.1.2 The entire outside surface of each tube or part of it, as required, shall be inspected using the magnetic particle method, for the detection of longitudinal and/or transverse surface imperfections, using a.c. or d.c. magnetization, as appropriate to the magnetic particle technique adopted. In the case of end/bevel testing, the use of dry magnetic powder is only permitted by prior agreement between the purchaser and manufacturer. Otherwise, the requirements given in ISO 9934-1, ISO 9934-2 and ISO 9934-3 shall apply.

5.1.3 The detecting media shall be applied simultaneously with magnetization to reveal the presence of surface imperfections, using an illumination of not less than 500 lux.

The use of residual magnetism, i.e. application of magnetic particles after initial tube magnetization, is only permitted after prior agreement between the purchaser and manufacturer, but generally not permitted in the case of end/bevel face testing.

In cases where there is insufficient sensitivity due, for instance, either to poor contrast between the detecting media and the part of the tube surface under inspection or as a result of the magnetization technique adopted, the tube area being tested shall, prior to inspection, be coated with a white background paint to aid contrast. Alternatively, fluorescent particles shall be used and the inspection carried out in a darkened area using a UV-A radiation source, with a background white light level not exceeding 20 lux and a black light intensity of at least 10 W/m^2.

5.1.4 It is outside the scope of this part of ISO 10893 to specify the levels of magnetization required, and current levels required to achieve such levels of magnetization, to reveal the presence of unacceptable surface imperfections. However, in all cases, the magnetization requirements together with the use of detecting media (with the exception in 5.1.2) given in ISO 9934-1, ISO 9934-2 and ISO 9934-3 shall apply.

5.1.5 During the production testing of tubes, the level of magnetization achieved using the adopted technique and equipment shall be checked at regular intervals, not exceeding 4 h, for example using a magnetic field strength meter, as appropriate. In the case of end/bevel testing, alternatively, a reference tube containing either an artificial simulation of, or a naturally occurring laminar imperfection on, the end/bevel face may be used, where the manufacturer shall demonstrate the presence of a consistent indication of the imperfection.

5.2 Testing the tube body

5.2.1 General

During the production testing of tubes, magnetization shall be applied in the circumferential direction for the detection of longitudinal surface imperfections or in the direction parallel to the major axis of the tube for the detection of transverse surface imperfections.

5.2.2 Magnetization methods

For testing the tube body one of the following magnetization methods shall be applied.

a) Method A — Current flow method

The current derived from a d.c., a.c., full or half-wave rectified a.c. external power source is passed between two contact areas on the surface of the tube. This method is intended for the detection of imperfections which lie generally parallel to the major axis of the tube.

b) Method B — Threaded bar/cable method

The current (as in method A) is passed through a rigid bar or flexible cable placed within the tube bore and approximately concentric with it. This method is intended (as in method A) for the detection of imperfections which lie generally parallel to the major axis of the tube.

c) Method C — Encircling coil method

A rigid or semi-rigid current-carrying coil is placed around the tube and the surface of the tube within the influence of the coil is magnetized in the direction parallel to the major axis of the tube, favouring the detection of generally transverse imperfections.

d) Method D — Magnetic flow method

The tube, or part of it, forms part of the magnetic circuit of an electromagnet which carries current from an external power source (as in method A). This method favours the detection of imperfections lying at right angles to an imaginary line connecting the poles pieces of the electromagnet.

Other magnetization techniques or combinations of the techniques given in 5.2.2 a) to 5.2.2 d) may be used provided the requirements for field strength and direction are met.

5.3 Testing the end/bevel face

5.3.1 During the production testing of the end/bevel face at both ends, magnetization shall, at the discretion of the manufacturer, be applied either parallel to the major axis of the tube or radially through the tube thickness; simultaneously, the detecting media shall be applied to the end/bevel face, to reveal the presence of laminar imperfections.

5.3.2 When using magnetization parallel to the major axis of the tube, this shall be achieved using a rigid concentric coil surrounding or inside the tube, positioned close to the tube end. The coil shall be energized using an alternating or a half- or full-wave rectified or direct current source. In this case, it shall be demonstrated by a measuring device that the induced currents in the tube wall produce a magnetic flux perpendicular to the surface.

Alternatively, the current flow method may be used by passing current around the tube circumference using clamps on the tube end that are 180° apart. After inspection, the test shall be repeated after rotating the clamps by 90° with respect to their initial position. In this case, but only by agreement between the purchaser and manufacturer, it is permissible to conduct the test using residual magnetization and fluorescent particles.

5.3.3 When using magnetization applied radially through the thickness of the tube at the ends, this shall be achieved using an a.c. or d.c. yoke, with the pole pieces applied radially between the inner and outer surface of the tube across the tube thickness at the ends. By agreement between the purchaser and manufacturer, the use of a permanent magnet of sufficient power is permitted. Other methods of applying radial magnetization may be adopted, provided the manufacturer can demonstrate their equivalence to the method described above.

6 Evaluation of indications

6.1 General

The inspection shall be carried out visually without image magnification.

A remote inspection technique, such as using television camera is permitted, provided the manufacturer can demonstrate that the acceptance criteria are not affected.

6.2 Special requirements for evaluation of indications in the pipe body

The magnetic particle inspection method does not make it possible to determine the nature, shape, orientation and, more particularly, the depth of surface imperfections revealed as indications. The dimensions and extent of magnetic particle "build-up" of indications do not directly represent the actual dimensions of the surface imperfection causing the indication. For these reasons, the classification/evaluation of magnetic particle indications shall be as follows:

a) linear indications: indications where the length of the indication is equal to or more than three times the width of the indication;

b) rounded indications: indications which are circular or elliptical in shape, where the length of the indication is less than three times the width of the indication;

c) accumulated indications: indications which are linear or rounded and are aligned or clustered with a separation of not more than the length of the smallest indication and consisting of at least three indications;

d) non-relevant indications: indications which may result from localized surface irregularities to a particular tube-making process, for example machining marks, scratches and sizing/straightening marks.

The minimum dimension of indications that shall be considered during the evaluation shall be as given in Table 1, in relation to the acceptance level specified.

Table 1 — Minimum dimension of indications that shall be considered during evaluation

Acceptance level	Diameter, D, or length, L, of the smallest indication that shall be considered mm
M1	1,5
M2	2,0
M3	3,0
M4	5,0

Only relevant indications with their major dimension equal to or greater than that given in Table 1 shall be taken into account when determining the incidence of such indications, according to the appropriate acceptance level. Non-relevant indications are not to be considered during evaluation.

Relevant indications obtained by magnetic particle inspection in accordance with this part of ISO 10893 shall be evaluated and classified as follows.

a) For general testing of tube surfaces, either of the entire surface or a localized area, an imaginary frame aperture of 100 mm × 150 mm shall be placed over the area with the highest incidence of relevant indications. The indications shall be classified with regard to the type, number and dimensions of the indications within the frame, according to the appropriate acceptance level given in Table 2.

b) For testing the weld seam of a welded tube, an imaginary frame aperture of 50 mm × 150 mm, with the weld centred on the 50 mm dimension of the frame aperture, shall be placed over the area with the highest incidence of relevant indications. The indications shall be classified with regard to the type, number and dimensions of the indications within the frame, according to the appropriate acceptance level given in Table 3.

c) For calculating the cumulative length of accumulated indications, the length along the major axis of linear and rounded indications shall be used, and in cases where the separation between two adjacent indications is less than the length or the diameter of the larger of the two indications, the indications shall be considered as one and the sum of the individual lengths or diameters plus the separation shall be used to calculate the overall length.