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Seamless and welded steel tubes for pressure purposes — Liquid penetrant testing

Tubes en acier sans soudure et soudés pour service sous pression — Contrôle par ressuage

Reference number
ISO 12095:1994(E)

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.

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.

International Standard ISO 12095 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 19, *Technical delivery conditions for steel tubes for pressure purposes*.

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Introduction

This International Standard covers liquid penetrant inspection of seamless and welded tubes for the detection of surface imperfections.

Four different test categories are considered (see tables 1 and 2). The choice between these categories is within the province of the ISO Technical Committee responsible for the development of the relevant product quality standards.

Other acceptance criteria may be specified in the relevant technical delivery document.

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Seamless and welded steel tubes for pressure purposes — Liquid penetrant testing

1 Scope

This International Standard refers to liquid penetrant testing of seamless and welded tubes for the detection of surface imperfections, according to four different test categories (see tables 1 and 2).

It may be applied to all or any part of the tube surface as required by the relevant product quality standards.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3059:1974, *Non-destructive testing — Method for indirect assessment of black light sources.*

ISO 3452:1984, *Non-destructive testing — Penetrant inspection — General principles.*

ISO 3453:1984, *Non-destructive testing — Liquid penetrant inspection — Means of verification.*

ISO 11484:1994, *Steel tubes for pressure purposes — Qualification and certification of non-destructive testing (NDT) personnel.*

3 General requirements

3.1 The liquid penetrant testing covered by this International Standard is usually carried out on tubes after completion of all the primary production process operations.

These inspections shall be carried out by personnel qualified in accordance with ISO 11484, as nominated by the manufacturer. In the case of third-party inspection, this shall be agreed between the purchaser and manufacturer.

3.2 The surface of the tube to be tested shall be sufficiently clean and free from oil, grease, sand or scale or any other foreign matter which could interfere with the correct interpretation of the indications obtained from liquid penetrant testing.

3.3 The type of indications, as well as the minimum dimension of the surface imperfections to be detected, depend on the specific tube manufacturing process and the surface finish.

4 Method of test

4.1 The liquid penetrant method is an effective means for detecting imperfections which are open to the surface (called surface imperfections in this International Standard). Typical surface imperfections detectable by this method are cracks, seams, laps, cold shuts, laminations and porosity.

The liquid penetrant method does not make it possible to determine the nature, shape and, more generally, the dimensions of the surface imperfections revealed. The dimensions of the penetrant indication do not directly represent the actual dimensions of the surface imperfection causing this indication. That is

why the classification of liquid penetrant indications shall be as follows:

a) linear indications, in which the length is equal to or more than three times the width;

b) rounded indications, which are circular or elliptical and in which the length is less than three times the width;

c) accumulated indications, which are linear or non-linear and aligned or clustered, arranged with a distance between them of not more than their own size, and consisting of three indications;

d) non-relevant indications, which are similar indications that may occur from localized surface irregularities due to machining marks, scratches or other surface conditions.

4.2 In principle, a liquid penetrant is applied to the surface to be examined and allowed to enter the surface imperfections. All excess penetrant is then removed, the surface of the part is dried, and a developer is applied. The developer functions both as a blotter to absorb penetrant that has been trapped in imperfections, and as a contrasting background to enhance the visibility of penetrant indications. The dyestuffs in penetrants are either colour-contrast (visible under white light) or fluorescent (visible under ultraviolet light). For both penetrant techniques, the following three types of penetrant systems can be used:

— water washable;

— postemulsifying;

— solvent removable.

Where the term "penetrant materials" is used in this International Standard, it is intended to include all penetrants, solvents or cleaning agents, developers, etc. used in the testing process.

4.3 For each tube or each part of the tube to be tested, either a colour-contrast penetrant technique or a fluorescent penetrant technique, both with one of the three types of penetrant systems, shall be used.

The general principles and the methods of verification of liquid penetrant testing as described in ISO 3452, ISO 3453 and ISO 3059, are to be applied (see also 4.4).

4.4 The liquid penetrant testing shall be in accordance with the following operational conditions.

a) For the choice of the penetrant system, the tube surface condition as well as the test category shall be taken into account.

b) The penetrant materials to be applied shall be free from halogen (chlorine/fluorine) and sulfur (in particular, for austenitic stainless steel tubes the chlorine content might be dangerous, and for nickel-based alloy tubes used at elevated temperatures the sulfur content might be dangerous).

c) The temperature of application shall be between 10 °C and 50 °C. When it is not practical to conduct the liquid penetrant testing within the given temperature range, the testing procedure shall be qualified at the proposed temperature using the liquid penetrant comparator block (e.g. a quench-cracked aluminium block).

d) The penetrant should be applied by brushing or spraying. For tubes or parts of the tubes, dipping or flooding is less effective but not prohibited.

e) The dwell time shall not be less than that recommended by the manufacturer of the penetrant system, usually it is between 3 min and 30 min.

f) The removal of excess water-washable or post-emulsified penetrant shall be performed with rinsing by water, under black light conditions where appropriate, at a pressure around 200 kPa (2 bar) with a maximum of 350 kPa (3,5 bar). The temperature of the water used for rinsing shall be less than 40 °C.

The excess solvent-removable penetrant shall be removed insofar as possible by using wipes of white, lint-free material that is clean and dry, until most traces of penetrant have been removed. Then the surface shall be lightly wiped with a lint-free material that has been slightly moistened with solvent, until all remaining traces of excess penetrant have been removed.

NOTE 1 Flushing the surface with solvent following the application of the penetrant and prior to developing is prohibited.

g) Drying of the surface subsequent to washing with water can be assisted by using wipes of white, lint-free material that is clean and dry or by using a hot-air blast at a pressure below 200 kPa (2 bar) and a temperature below 70 °C. Drying after the solvent-removing process is generally by normal

evaporation, therefore no other drying techniques are necessary.

NOTE 2 The temperature of the tube shall not exceed 50 °C, unless otherwise agreed between the purchaser and manufacturer.

h) The wet developer shall be applied by spraying, in such a manner as to assure complete coverage of the area to be tested with a thin, even film of developer. The dry-powder developer shall be applied either by dipping the tube, or the parts of the tube to be tested, into a fluid bed of dry developer or by dusting it with the dry-powder developer through a manual powder bulb or a spray powder gun (conventional or electrostatic) provided that the powder is dusted evenly over the entire surface to be tested.

i) The development time begins as soon as the wet-developer coating is dry or immediately after the application of the dry-powder developer. Generally, the development time is equal to the penetration time and varies from 5 min to 30 min, and if the bleedout does not alter the inspection results, development periods of more than 30 min are permitted.

j) The inspection of the areas to be tested shall be performed after the applicable development time as specified in 4.4 i), to assure proper bleedout of penetrant from the imperfections onto the developer coating. It is good practice to observe the surface while applying the developer as an aid to evaluating indications. For fluorescent penetrant indications, the inspection shall be carried out in a darkened area using a UV-A radiation source with a background of light level not exceeding 20 lx and a black light intensity of at least 8 W/m^2 on the surface of the area to be inspected. For visible penetrant indications, the illumination of the surface of the area to be inspected shall not be less than 350 lx (see note 3).

NOTE 3 As a guide, this level of illumination would be achieved by using either a fluorescent tube of 80 W at a distance of about 0,7 m or a tungsten filament lamp of 100 W at a distance of about 0,6 m.

5 Test categories

5.1 Four test categories, corresponding to four severity levels, have been established in accordance with tables 1 and 2 . These tables specify the number and/or the maximum permissible dimension of diameter or length, in millimetres.

5.2 The inspection shall be carried out with the naked eye without any magnification. Table 3 shows the minimum dimension below which the penetrant indications are not to be taken into consideration in the corresponding test categories.

6 Evaluation and acceptance

6.1 Only relevant indications with major dimensions above those given in table 3 shall be taken into consideration for the acceptable limits. Relevant indications are those which result from unacceptable imperfections. Similar indications produced by machining marks or other non-relevant surface conditions are not to be considered. Any indication in excess of the dimensions of the acceptance standards according to 6.2, which is believed to be non-relevant, shall be re-examined to verify whether or not actual defects are present. Surface conditioning may precede the re-examination.

6.2 Depending upon the requirements of the product quality standard, the indications obtained by the liquid penetrant testing shall be evaluated and classified according to the following.

a) For testing the total surface of the tube, an imaginary frame aperture of 100 mm × 150 mm shall be placed over the area showing the greatest number of indications. The classification based on the kind, number and dimension of the indications shall be taken according to table 1.

b) For testing the weld seam, an imaginary frame aperture of 50 mm × 150 mm shall be placed over the area showing the greatest number of indications, with the 50 mm dimension centred over the weld seam. The classification based on the kind, number and dimension of the indications shall be taken according to table 2.

c) For testing the bevel face at the tube ends, linear indications with a length less than 8 mm are acceptable.

d) For calculating the cumulative length of accumulated indications, the following regulations shall be taken into account:

— in both cases, the length of the major axis of linear or rounded indications;

— if the gap between two indications is less than the length or the diameter of the two indications, the total overall length of the indications shall be used.

6.3 For tubes or parts of tubes showing indications greater than that permitted by the corresponding test category, one of the following actions shall be taken subject to the requirements of the product standard.

a) The suspect area shall be explored by dressing using an acceptable method. After checking that the remaining thickness is within tolerance, the tube shall be retested as previously specified. If no indications in excess of the acceptance level are obtained, the tube shall be deemed to have passed this test.

b) Crop off the suspect area. The manufacturer shall ensure, to the satisfaction of the purchaser, that all the defective area has been removed.

c) The tube shall be deemed not to have passed this test.

d) The defective area may be repaired by welding in accordance with the requirement of the product standard.

7 Test report

When specified, the manufacturer shall submit to the purchaser a test report that includes, at least, the following information:

a) a reference to this International Standard;

b) date of test;

c) acceptance level;

d) statement of conformity;

e) material designation by grade and size;

f) type and details of inspection technique;

g) description of the reference standard, when used;

h) equipment calibration method used.

Table 1 — Tube surface: Maximum permissible number and dimension (diameter, length) within a frame aperture of 100 mm × 150 mm

Dimensions in millimetres

Test category	Wall-thickness	Type of indications					
		Rounded		Linear		Accumulated	
		Number	Dimension	Number	Dimension	Number	Dimension
P 1	⩽ 16	5	3,0	3	1,5	1	4,0
	> 16 ⩽ 50	5	3,0	3	3,0	1	6,0
	> 50	5	3,0	3	5,0	1	10,0
P 2	⩽ 16	8	4,0	4	3,0	1	6,0
	> 16 ⩽ 50	8	4,0	4	6,0	1	12,0
	> 50	8	4,0	4	10,0	1	20,0
P 3	⩽ 16	10	6,0	5	6,0	1	10,0
	> 16 ⩽ 50	10	6,0	5	9,0	1	18,0
	> 50	10	6,0	5	15,0	1	30,0
P 4	⩽ 16	12	10,0	6	10,0	1	18,0
	> 16 ⩽ 50	12	10,0	6	18,0	1	27,0
	> 50	12	10,0	6	30,0	1	45,0