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**Ductile iron fittings, accessories and  
their joints and valves — Epoxy coating**

*Raccords, accessoires et leurs assemblages et appareils de robinetterie  
en fonte ductile — Revêtement époxy*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 5, *Ferrous metal pipes and metallic fittings*, Subcommittee SC 2, *Cast iron pipes, fittings and their joints*.

# Ductile iron fittings, accessories and their joints and valves — Epoxy coating

## 1 Scope

This document specifies the requirements and test methods applicable to factory applied epoxy coatings (fusion bonded or 2-pack liquid epoxy) for ductile iron fittings and accessories supplied to ISO 2531 and ISO 7186, and ductile iron valves.

It covers internal and external coatings for use in the conveyance of raw water, potable water and waste waters for operating temperatures up to 60 °C.

This document contains specifications for performance tests and routine tests of the coating.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 2531, *Ductile iron pipes, fittings, accessories and their joints for water applications*

ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

ISO 7186, *Ductile iron products for sewerage applications*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8502-3, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2531 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 3.1

#### **adhesion**

#### **pull off test**

force per unit area, applied perpendicular to the surface, which is necessary to separate the coating from its substrate

### 3.2

#### **cross linkage**

chemical reaction between epoxy resin and hardener to form the final cured coating

**3.3  
impact resistance**

energy which a coating can withstand without damage under defined testing conditions

**3.4  
non-porosity**

absence of electrical puncture in a high voltage test (holiday test) under defined test conditions

**3.5  
epoxy coating**

factory applied coating with either

- fusion bonded epoxy powder applied by spraying or dipping in a fluidised bed on preheated parts, with or without post curing, or
- two-pack liquid epoxy consisting of a base and a catalyst component which are mixed together in the proportion specified by the manufacturer before application

**3.6  
chalking**

superficial reaction of *epoxy coating* (3.5) due to exposure to UV-radiation

Note 1 to entry: The process is confined to the surface only and results in a dulling of the surface.

**3.7  
performance test**

test which is done once and thereafter only when there is a change in the coating material or coating process

**3.8  
routine test**

test carried out to control the manufacturing process

Note 1 to entry: The frequency of the test is defined by this document or the manufacturer.

**3.9  
designated zone**

area of the casting designated by jointing/mating surfaces or process and test characteristics where a lower coating thickness standard is applied

EXAMPLE 1 An example of jointing/mating surfaces is joint areas.

EXAMPLE 2 Examples of process and test characteristics are bolt holes, marking, ribs, edges.

**3.10  
localised thickness**

measured thickness at any one point of one coated product

## 4 Routine test requirements

### 4.1 General

The following technical requirements shall be demonstrated by routine tests applied in production, on in-process and finished coated products with defined frequency. Routine tests shall be in accordance with the overview of requirements provided in [Table A.2](#).

[Annex D](#) outlines the handling, transportation and storage of coated products.

## 4.2 Surface preparation

Prior to coating application, all surfaces to be coated shall be blasted to be substantially clean and free from oil, grease and moisture. The surfaces to be coated shall meet the requirements of Class Sa 2.5 of ISO 8501-1 and  $\leq$  Rating 3 dust quantity of ISO 8502-3. Blasted fittings and accessories shall only be handled and stored, using tested methods to maintain Sa2.5 finish without any visible rusting and contamination, until coating application.

## 4.3 Coating appearance

The epoxy coating of the final product shall be of

- uniform colour, except for permitted marking;
- uniform appearance and smoothness, except for allowable repairs;
- free of visible defects (i.e. pinholes, bubbles, blisters, wrinkles, cracks or voids).

Slight superficial colour variations due to repairs or long exposure to sunlight (chalking) are permissible.

## 4.4 Coating thickness

When measured in accordance with the method defined in [6.1.3](#), except on the designated zones, the localized minimum thickness shall be greater than 200  $\mu\text{m}$  and the minimum average thickness shall be greater than or equal to 250  $\mu\text{m}$ . For the designated zones, a localized minimum thickness of 150  $\mu\text{m}$  is allowed.

## 4.5 Adhesion (pull off test/cross cut knife test)

Adhesion (pull off test) shall be tested in accordance with the test method defined in [6.1.4](#) on production samples.

The epoxy coating adhesion shall achieve an average value of at least 8,0 MPa and a minimum single value of 6,0 MPa. The manufacturer shall determine the test locations on the products.

Alternatively, the adhesion test can also be done by cross cut knife test method. Where the cross knife test is chosen for adhesion, it shall be carried out according to [Annex B](#). The epoxy adhesion rating shall be no more than level 2.

## 4.6 Cross linkage (MIBK/ $\Delta T_g$ )

When tested in accordance with the test method defined in [6.1.5](#), after wiping with an MIBK solution, the cloth and the coating surface shall be visually examined. Any discolouration, matting and/or smearing observed shall not exceed the limits specified by the coating manufacturer.

Alternatively, the cross linkage of coating can be determined by its change in glass transition temperature ( $\Delta T_g$ ) and  $\Delta T_g$  shall be no more than 5 °C.

## 4.7 Non-porosity

When tested in accordance with the test method described in [6.1.6](#), with a voltage of 1 500 V, the coated body of the product shall be free from porosity. This means that no electrical puncture should occur. This requirement does not apply to designated zone.

## 4.8 Repairs

Repairs shall be carried out when there is a fault. The fault can be

- localized damage,
- holding point,
- earthing surface for the non-porosity test, or
- other coating fault.

The coating manufacturer should establish the repair procedure. The material to be used shall satisfy two conditions:

- be suitable for protecting fittings and accessories under the required service conditions;
- be compatible in all aspects with the previously applied epoxy coating.

The repairs shall comply with the requirements specified in [4.4](#), [4.6](#), and [4.7](#).

## 5 Performance requirements

### 5.1 General

The following technical requirements shall be demonstrated by performance tests, in order to verify the coating material and process prior to production coating. Performance tests shall be in accordance with the overview of requirements provided in [Table A.1](#). [Annex C](#) provides the requirements of the coating material. [A.2](#) defines the DN grouping of performance tests.

Where there is a change of coating material or process, the performance tests shall be undertaken on the new coating material or process.

### 5.2 Materials in contact with water intended for human consumption

When used under the conditions for which they are designed, in permanent or in temporary contact with water intended for human consumption, the coating shall not have any detrimental effects on the properties of that water for its intended use.

When used for conveying water intended for human consumption, the coating materials in contact with the water shall meet the relevant requirements of the national standards or regulations in the country of use with respect to effect on water quality.

### 5.3 Materials in contact with sewage waters

The coatings shall comply with requirements of chemical resistance and abrasion resistance, defined in ISO 7186. If needed, the chemical resistance test can be performed at pH 1 by agreement between manufacturer and purchaser.

### 5.4 Impact resistance

When tested in accordance with the test method described in [6.2.1](#), no holidays shall be permitted.

### 5.5 Resistance to hot water

When tested in accordance with test method specified in [6.2.2](#), the coating adhesion shall meet a minimum requirement of 6,0 MPa. In addition, on visual examination there shall be no cracks, wrinkles, disbondment or blisters.

## 6 Test methods

### 6.1 Routine tests

#### 6.1.1 Surface preparation

The blasted surface of the product shall be visually checked for its compliance, and shall at least meet the requirements of Class Sa 2.5, as specified in ISO 8501-1, and  $\leq$  Rating 3 and  $\leq$  Class 2 as specified in ISO 8502-3.

#### 6.1.2 Coating appearance

The appearance of the finished coating shall be checked visually.

#### 6.1.3 Coating thickness

The thickness of the coating shall be measured with a non-destructive instrument (e.g. magnetic or electro-magnetic type) with measuring accuracy of at least  $\pm 1\%$ .

#### 6.1.4 Adhesion (pull off/cross cut knife test)

Adhesion (pull off/cross cut knife) shall be defined on surfaces of a coated product, or coated test plates (if more convenient). The test plates should be manufactured of identical material and coated by the identical process. In order to properly test the adhesion of the coating to the surface, the test areas shall be selected in such a way that the coating thickness is no less than 250  $\mu\text{m}$ .

Pull off test shall be conducted as specified in ISO 4624.

If fracture is only associated with the adhesive and the result is less than 8,0 MPa, the test may be deemed as a no-test, and another test should be performed with a suitable adhesive for the epoxy coating.

Cross cut knife test shall be carried out according to [Annex B](#).

#### 6.1.5 Cross linkage (MIBK/ $\Delta T_g$ )

The test shall be conducted using methyl isobutyl ketone (MIBK).

On a dust-free coated product, a clean white cloth dipped in MIBK shall be rubbed repeatedly on the surface over an area of at least 16  $\text{cm}^2$  for a period of  $30 \pm 5$  s. The colour and the nature of both the cloth and the coated surface shall be noted.

The limits of discolouration, matting and/or smearing can be compared by testing the reference coated fresh sample supplied by the coating manufacturer.

The change in glass transition temperature  $\Delta T_g$  of the coating reference sample should be determined by differential scanning calorimetry (DSC), as defined in ISO 11357-2.

#### 6.1.6 Non-porosity

A holiday detector set at a voltage of 1 500 V and conductive rubber test electrodes are required as test instruments. A pulsed holiday detector shall be used unless there is an earthing electrode connected directly to the metal surface. The use of the detector shall follow the manufacturer's instructions. The holiday detector's suitability shall also be checked by demonstrating that it can detect a 1 mm diameter holiday drilled through the coating (in a coated surface) when set at the required 1 500 V.

During the measurement, the test electrode shall traverse all the coated surface with intimate contact, because any significant air gap results in a lower voltage being applied to the coating. The test electrode

should be moved slowly with a maximum movement rate of 0.2 m/s. Holidays shall be indicated by an acoustic and/or optical signal from the test device.

## 6.2 Performance test

### 6.2.1 Impact resistance strength

The impact resistance strength shall be tested by dropping a weight on the coating with a given energy and checking for the absence of coating holidays. The sample to be tested shall be supported by a rigid construction so that the impact energy caused by the impact of the falling weight is absorbed by the sample. The test specimen shall have a wall thickness no less than 6 mm. The coating thickness at the position of impact, shall be no greater than 350  $\mu\text{m}$ . The front surface of the falling weight shall be a section of a sphere of hardened steel with a diameter of 25 mm.

The test shall be carried out at a temperature of 18 °C to 25 °C. The impact energy shall not be less than  $(2,5 \text{ J} \pm 5\%)$ . Care shall be taken to ensure that as little as possible friction occurs when the falling weight is dropped.

Ten impacts, separated by at least 30 mm, shall be carried out. The occurrence (or not) of holidays shall be tested at each impact using the non-porosity test specified in [6.1.6](#). There should be no holiday resulting from any of the 10 impacts.

### 6.2.2 Resistance to hot water

The test shall be carried out on six epoxy-coated ductile iron test samples coated parallel with the production. The test samples shall be immersed for 7 days in deionized water at  $(70 \pm 2) \text{ }^\circ\text{C}$ , or 14 days at  $(60 \pm 2) \text{ }^\circ\text{C}$ .

After this test period, the samples shall be taken from the water bath, cooled and dried. The samples shall be immediately prepared for testing and shall be tested in accordance with [6.1.4](#) within 24 h after removal from the hot water.

## Annex A (normative)

### Quality assurance

#### A.1 General

The manufacturer should demonstrate the conformity of the product with this document by carrying out performance tests in accordance with [Table A.1](#) and routine tests in accordance with [Table A.2](#).

**Table A.1 — Performance tests**

No.	Test	Requirement	Clause	Test method
1	Materials in contact with potable water	National standards	<a href="#">5.2</a>	National standard
2	Material in contact with sewage water	ISO 7186	<a href="#">5.3</a>	ISO 7186
3	Impact resistance	No holidays after impact	<a href="#">5.4</a>	<a href="#">6.2.1</a>
4	Resistance to hot water	The minimum $\geq 6,0$ MPa, after immersion in hot water	<a href="#">5.5</a>	<a href="#">6.2.2</a>

**Table A.2 — Routine tests**

No.	Test	Requirement	Clause	Test method, minimum frequency	Clause
1	Surface preparation	$\geq$ Sa 2.5	<a href="#">4.2</a>	Visual, 100 % of surface	<a href="#">6.1.1</a>
2	Coating appearance	Uniform, free of visual defects	<a href="#">4.3</a>	Visual, 100 % of surface	<a href="#">6.1.2</a>
3	Coating thickness	Thickness $\geq 250$ $\mu\text{m}$ (body)	<a href="#">4.4</a>	Non-destructive method, once per shift	<a href="#">6.1.3</a>
4	Adhesion (pull off test or cross cut knife test)	Average adhesion $\geq 8,0$ MPa, with the minimum $\geq 6,0$ MPa/ No more than rating 2	<a href="#">4.5</a>	Pull off method, once per week/ Cross cut knife test, once per day	<a href="#">6.1.4</a>
5	Cross linkage (MIBK) or DSC	No deviation against reference test sample/ $\Delta T_g \leq 5$ °C	<a href="#">4.6</a>	MIBK test, once per shift/DSC test once per week	<a href="#">6.1.5</a> <a href="#">Annex B</a>
6	Non-porosity	No electrical puncture	<a href="#">4.7</a>	High voltage test, once/shift	<a href="#">6.1.6</a>

#### A.2 Performance tests, fitting, valve and accessory size grouping

In order to ensure the fitness of the coating material, process and the products to be coated, the performance tests shall be carried out for products with similar thickness, diameter and geometry. The DN grouping for testing shall be as shown as in [Table A.3](#).

**Table A.3 — DN grouping**

<b>DN grouping</b>	40 to 500	600 to 2000	2200 to 2600
<b>Preferred DN</b>	150	1000	2400
NOTE ISO 2531, one DN outside the range, no test.			

### A.3 Quality assurance system

The manufacturer controls the quality of the products during their manufacture by a system of process control in order to comply with the technical requirements of this document.

The manufacturer can implement a quality management system such as ISO 9001 or other equivalent.

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## Annex B (normative)

### Cross cut knife test method

#### B.1 General

This annex sets out the method for evaluating the adhesion of the coating by applying a knife to a cross cut coating.

#### B.2 Apparatus

The following apparatus is required:

- strong pointed knife;
- safety glasses.

#### B.3 Procedure

The procedure shall be as follows.

- Inscribe a V-cut with two 25 mm lines intersecting at their centre at an angle of approximately 30° to each other.
- Insert the blade of the knife at the point of the V-cut, 45° to the surface. Then with an upward flicking action attempt to dislodge the coating within the V. If little or no coating is removed, repeat this action within the V at least four times to confirm the integrity of the coating.
- Examine the appearance of the disbonded surface and compare with the descriptive rating set out in [Table B.1](#).

**Table B.1 — Descriptive coating rating**

Rating	Description
1	Coating is not removed cleanly at any point in the V-cut. The entire profile contains some adherent coating.
2	Coating is removed in small chips with some difficulty. Substantial coating remains adherent to the surface profile.
3	Coating is removed in chips, which are slightly larger in area to the knife-point inserted under the coating. Some of the coating remains adherent to the surface of the iron within the V-cut.
4	Coating is removed with no chipping of the coating, and with minimal resistance.
5	No coating remains adherent to the steel within the V-cut.

#### B.4 Report

Report the test rating as 1 to 5 according to the result obtained.

## Annex C (informative)

### Coating material

#### C.1 General

The coating material supplier should provide a product data sheet and a safety data sheet of each type of material.

The coating manufacturer should put in place measures to implement the instructions in [C.2](#) and [C.3](#).

#### C.2 Product data sheet

The product data sheet may include the following:

- material properties, physical and chemical properties;
- application data; safety data sheet
- drinking water approval (if applicable) ;
- other information necessary.

#### C.3 Safety data sheet

The safety data sheet may include the following:

- company and product general information;
- hazard identification of preparation;
- first aid measures;
- fire-fighting measures;
- accident release measures;
- handling and storage;
- exposure controls and personal protection;
- toxicological information;
- disposal recommendation;
- other information necessary.