INTERNATIONAL STANDARD

**ISO 17642-3**

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# Destructive tests on welds in metallic materials — Cold cracking tests for weldments — Arc welding processes —

## Part 3: Externally loaded tests

*Essais destructifs des soudures sur matériaux métalliques — Essais de fissuration à froid des assemblages soudés — Procédés de soudage à l'arc —*

*Partie 3: Essais sur éprouvette soumise à une charge extérieure*

Reference number
ISO 17642-3:2005(E)

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# Foreword

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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 17642-3 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

ISO 17642 consists of the following parts, under the general title *Destructive tests on welds in metallic materials — Cold cracking tests for weldments — Arc welding processes*:

— *Part 1: General*

— *Part 2: Self-restraint tests*

— *Part 3: Externally loaded tests*

Annex ZA provides a list of corresponding International and European Standards for which equivalents are not given in the text.

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# Foreword

This document (EN ISO 17642-3:2005) has been prepared by Technical Committee CEN/TC 121 “Welding”, the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 44 “Welding and allied processes”.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2005, and conflicting national standards shall be withdrawn at the latest by September 2005.

EN ISO 17642 consists of the following parts, under the general title *Destructive tests on welds in metallic materials - Cold cracking tests for weldments - Arc welding processes*:

- Part 1: General
- Part 2: Self-restraint tests
- Part 3: Externally loaded tests

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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## 1 Scope

This European Standard specifies the sizes of the backing plates, specimens and procedures for carrying out externally loaded cold cracking tests by implant-test in order to obtain information about the cold cracking sensitivity during welding.

This standard applies primarily but not exclusively to carbon, manganese and low alloy steels.

## 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.

EN 1043-1, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints*

EN ISO 3690*, Welding and allied processes - Determination of hydrogen content in ferritic arc weld metal (ISO 3690:2000)*

CR ISO 15608, *Welding - Guidelines for a metallic material grouping system (ISO/TR 15608:2000)*

EN ISO 17642-1:2004, *Destructive tests on welds in metallic materials - Cold cracking tests for weldments – Arc welding processes - Part 1: General (ISO 17642-1:2004)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 17642-1:2004 apply.

## 4 Designation and symbols

The following designations and symbols given in Table 1 apply.

**Table 1 — Designation and symbols**

| Symbol | Designation | Unit |
|---|---|---|
| | Implant-test | |
| *L* | Length of the test bead | mm |
| *d* | Implant-diameter | mm |
| *D* | Diameter of drilled holes | mm |

## 5 Principle

The externally loaded cold cracking tests serve the purpose of determining the cold cracking sensitivity. According to EN ISO 17642-1:2004, Table 2, one testing procedure is available. By using the test procedure the cracks are generated after welding of the test pieces.

The specimens provide quantitative - preheat temperature, heat input, diffusible hydrogen content and applied stress - and qualitative information.

# 6 Description of the tests

## 6.1 General

### 6.1.1

The externally loaded cold cracking test is designed to assess the cold cracking sensitivity of parent materials used for arc welding.

This test procedure applies to metal arc welding with covered electrodes and semi-automatic gas shielded metal arc welding using solid and cored wires and submerged-arc welding.

The test provides a qualitative assessment (cracks or no cracks, single test) and determination of minimum preheat temperature, minimum heat input, maximum diffusible hydrogen content or maximum applied stress for freedom of cracks (crack/no crack boundary determination).

### 6.1.2 Single test

Where a fixed set of welding conditions is being used on a specific material, only one test weld shall be evaluated.

### 6.1.3 Crack/no crack boundary determinations

Where a series of tests is to be used to obtain a crack/no crack boundary criterion the no-crack test apparently defining the boundary shall be repeated. If this test also gives a no-crack result no further testing shall be required. If cracking is observed in the duplicate test further shall be performed to define the boundary.

NOTE 1 Where heat input is the variable it is preferable that the boundary is defined within the range ± 0,5 kJ/mm and that the duplicate tests are carried out within ± 0,1 kJ/mm.

NOTE 2 Where preheat is the variable it is preferable that the boundary is defined within the range of ± 12,5 °C.

## 6.2 Implant-test

### 6.2.1 Test materials

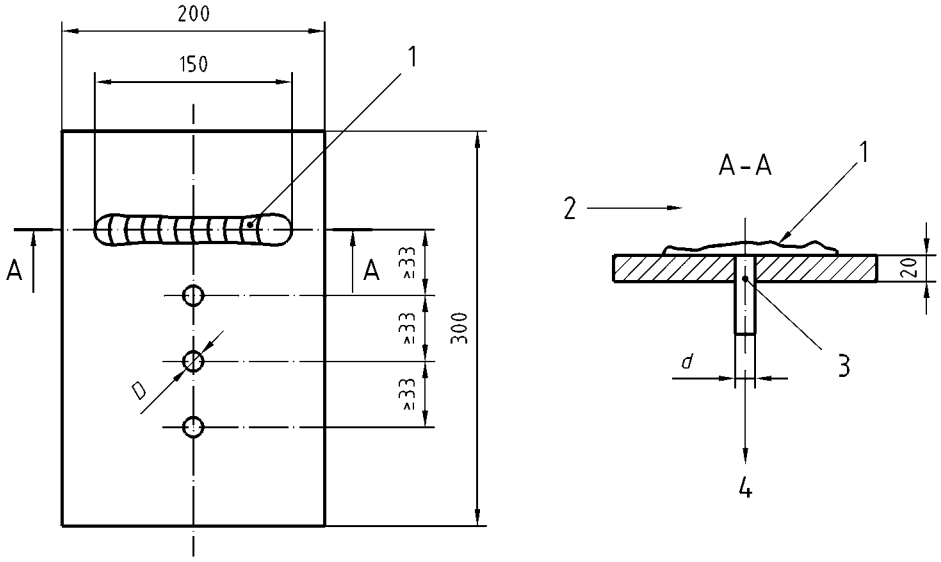
The implant specimen and the backing plate shall be from the same group according to CR ISO 15608.

### 6.2.2 Dimensions of the test pieces

The dimensions of the backing plate of the implant specimen shall be in accordance with Figures 1, 2 and 3, and Table 2.

If the welding thermal conditions do not allow to use the recommended dimensions, other dimensions may be used provided that they are mentioned in the test report.

Dimensions in millimetres

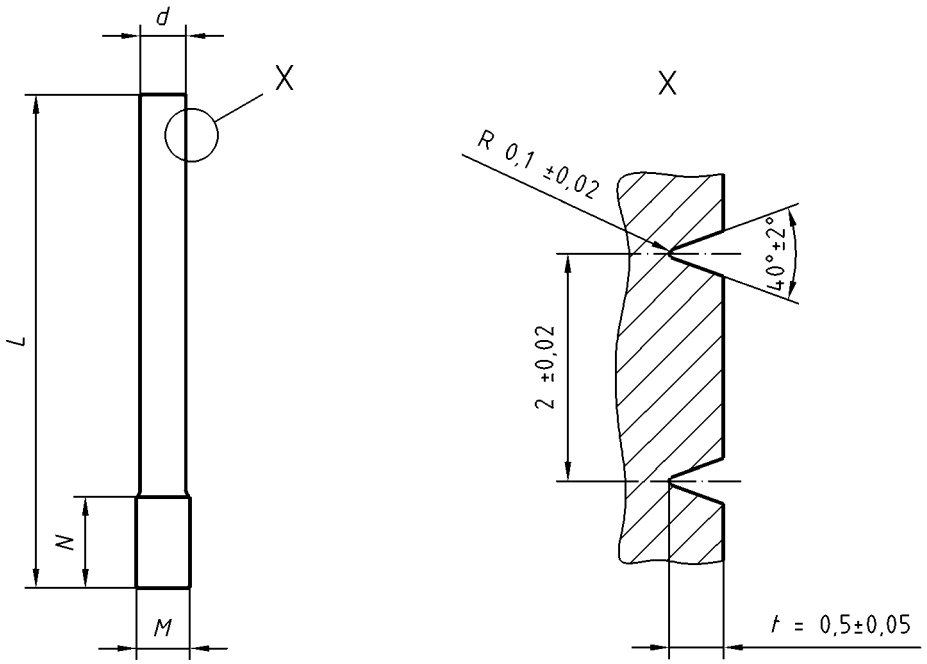



**Key**
1 Temperature measurement
2 Welding direction
3 Implant specimen
4 Test load *F*

NOTE 1 The length of the test bead should be "150 mm min.".
NOTE 2 The minimum distance between the first test bead and the plate edge should be 100 mm.

**Figure 1 — Implant test**

Dimensions in millimetres




NOTE 1 Dimension M is depending on the testing equipment.

NOTE 2 Dimension N is depending on the testing equipment.

**Figure 2 — Implant specimen (Helical)**

Dimensions in millimetres

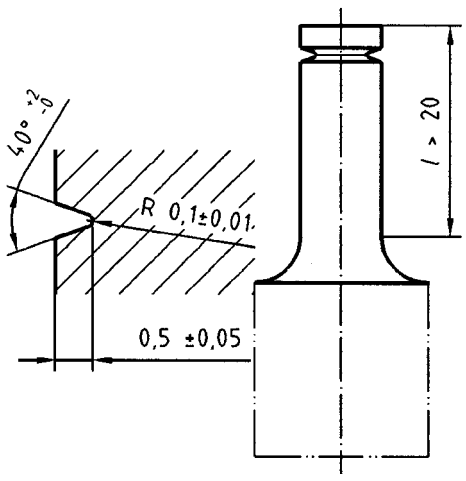



**Figure 3 — Implant specimen (circular)**

### 6.2.3 Preparation of the test pieces

The implant specimen shall be prepared by turning and the backing plate shall be prepared by drilling.

Care shall be taken to minimize heating and deformation in the material during machining.

The dimension of the backing plates shall be as given in Table 2.

Use the general arrangement of the backing plate and specimens as given in Figures 1 and 2 and the tolerances as given in Table 2.

The implant specimen shall be adequately covered by the test bead. Normally, a 8 mm diameter implant specimen is used. However, for small weld beads a 6 mm implant may be used.

**Table 2 — Implant backing plate/test specimens dimensions/conditions and tolerances**

| Backing plate | |
|---|---|
| plate thickness | 20 mm |
| width<br>length | 200 mm<br>300 mm |
| diameter of hole *D* | *D*-*d* = (0,05-0,15) mm |
| material | C-Mn steel or similar to steel of implant |
| distance *a* | ≥ 33 mm |
| no. of holes | ≥ 4 (see Figure 1) |
| Implant specimen | |
| length | dependent on equipment |
| diameter *d* | 6 + 0<br>- 0,05<br>+ 0<br>8 - 0,05 |
| type of notch | helical, circular, V-notch |
| notch angle $\alpha$ | (40 ± 2)° |
| notch depth *t* | (0,5 ± 0,05) mm |
| notch radius *R* | (0,1 ± 0,01) mm |
| pitch | (1 ± 0,02) mm |

The hole and the implant shall be machined in such a way that the implant clearance in the support plate shall range from 0,05 mm to 0,15 mm (sliding fit).

### 6.2.4 Welding of the test welds

#### 6.2.4.1 Preheat

When the test requires a preheat, both backing plate and the implant specimen shall be preheated by any suitable method.

Prior to any welding, check the temperature of the backing plate and implant using a calibrated thermocouple. Where the test demands a specific temperature of preheat, welding should not be commenced until the required temperature is achieved. The temperatures of the backing plate and the implant in the test area shall not differ by more than 5 °C.

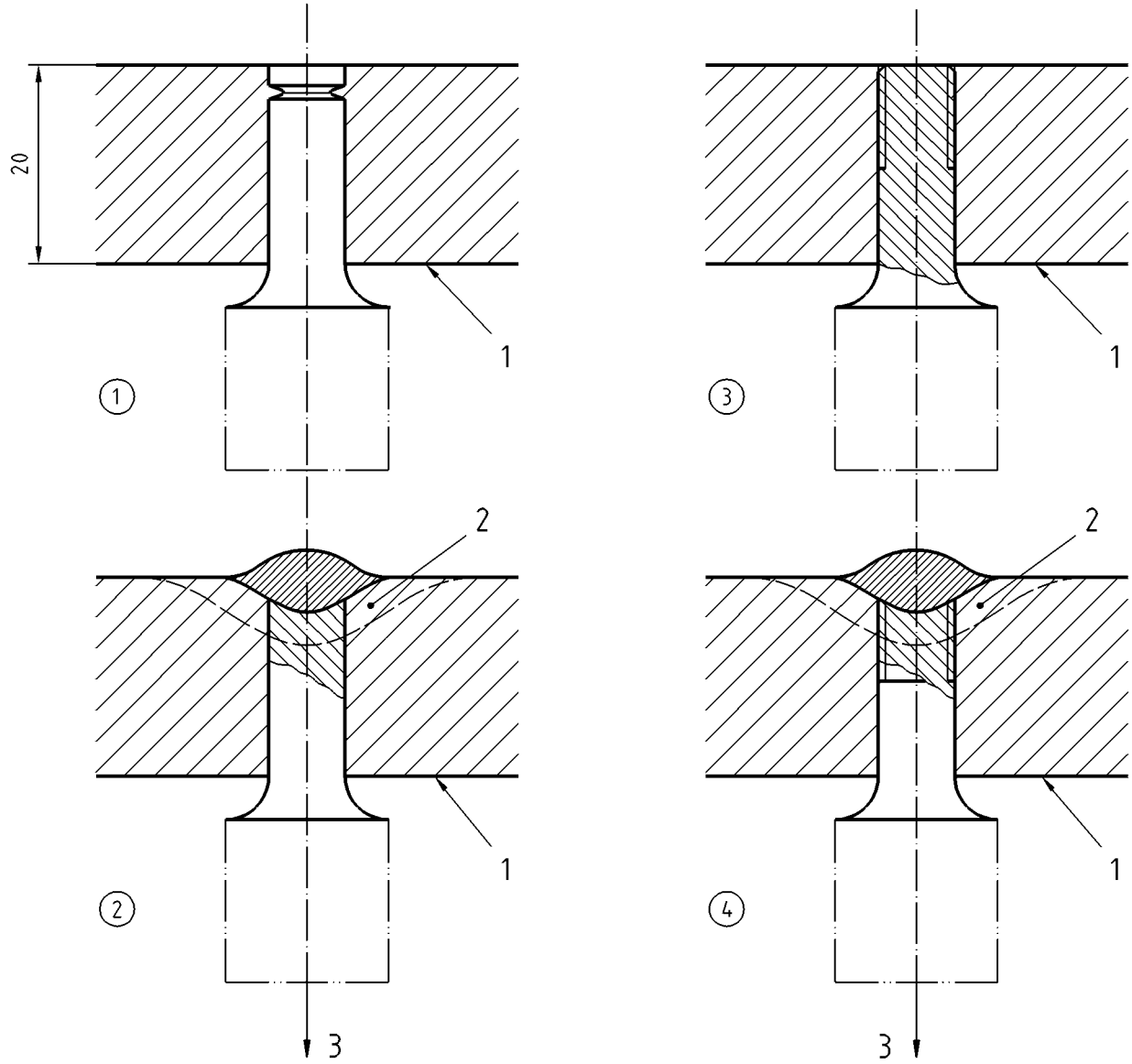
#### 6.2.4.2 Deposition

Each weld bead shall be deposited in the flat position in one direction and in a single pass. The welding process shall be automated or mechanized. Manual welding which is difficult to control and monitor adequately is not permitted.

Fusion penetration shall be such as to locate the notch in the coarse grain heat affected zone of the implant specimen. See Figure 4.

Calculate the value of heat input (in kJ/mm).

NOTE If coated manual metal-arc welding electrodes are used for producing the implant test welds, they should be treated in accordance with manufacturers' recommendations for specific hydrogen levels unless different hydrogen levels should be arbitrarily tested.




**Key**

1 Backing plate
2 Heat affected zone
3 Load

**Figure 4 – Deposition (circular and helical implant)**

#### 6.2.4.3 Implant loading

The implant shall be subject to a tensile static load. The load, *F*, shall be applied as follows : after the end of welding at temperature $T_L$ depending on the preheating temperature $T_V$.

| | |
|---|---|
| $T_V \leq 100$ °C | 100 °C < $T_L$ < 150 °C |
| $T_V > 100$ °C | $T_L = T_V + 50$ °C |

The specimen shall be slowly loaded, and the specified load shall be reached within a time of 20 s to 60 s, and before the temperature reaches 100 °C or as soon as the holding temperature is reached.

The specimen may be released after a load holding time of at least 16 h.

The load *F* shall be related to the orthogonal section of the notch root cylinder.

$$\sigma_J = \frac{4F}{\pi(d-2t)^2} \quad (\mathrm{N/mm^2})$$

where

$\sigma_J$ is related to the cross section at the notch

*F* is the load

*d* is the diameter of the specimen

In many cases, $\sigma_J$, is chosen equal to $R_{p0,2}$ of the implant material.

The loading apparatus should comply with the following conditions: the selected load is to be set with an accuracy of ± 1 % and to be maintained constant over the whole test period. The specimen shall be largely free of bending, torsion, or shock loading.

#### 6.2.4.4 Cooling time t8/5 / t3/1

If no post heating is applied to the implant test, the thermal cycle shall be characterized by measuring and recording the cooling time between 800 °C and 500 °C ($t_{8/5}$) and the cooling time between 300 °C and 100 °C ($t_{3/1}$).

If post weld heating above 100 °C is applied, then $t_{8/5}$ should be measured but $t_{3/1}$ is not applicable.

Cooling times shall be obtained from one of the following:

- a thermocouple placed in the implant specimen HAZ provided that the maximum temperature recorded is not less than 1100 °C,

- a thermocouple placed in the weld metal during deposition.

Correlation between measurement in the implant specimen HAZ and the measurement in the weld metal shall be established. Such a correlation shall be periodically checked.

#### 6.2.4.5 Hydrogen determination

The diffusible hydrogen content of the consumable (in ml/100 g deposited metal) shall be determined according to EN ISO 3690 and the relevant consumable standard.

Ensure that atmospheric conditions for hydrogen determination are representative of those during testing.

### 6.2.5 Test results

#### 6.2.5.1 Fracture

The implant may fracture while the load is maintained. In this case, the load and the time to fracture shall be recorded.

#### 6.2.5.2 Metallographic examination for cracks

If no fracture occurs, cracks which may have formed at the notch under the applied load can be detected using the following method:

Metallographic examinations at magnifications ranging from 400 to 600 on 3 longitudinal sections located in the weld bead direction according to Figure 5.

Dimension in millimetres

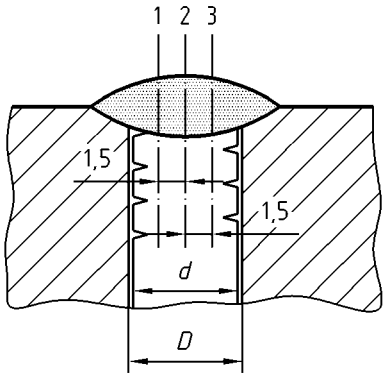



**Figure 5 — Location of the longitudinal sections 1, 2 and 3 for metallographic examination and hardness testing**

#### 6.2.5.3 Examination after crack oxidation

If no crack occurs, a crack which may have formed at the notch under the applied load can be detected using the oxidation method as follows:

Oxidation of the hydrogen induced crack (1 h at temperatures from 250 °C to 300 °C) followed by fatigue of the test assembly with a longitudinal load applied to the implant specimen, up to fracture, both operations being performed without separating the implant specimen from the support plate till it breaks by fatigue. Observation of the fracture surface appearance thus makes it possible to distinguish the cold oxidized crack from the subsequent fatigue propagation.

#### 6.2.5.4 Hardness measurement

The hardness of the HAZ of the implant shall be determined according to EN 1043-1 using a load of HV-10.

## 7 Test report

The test report shall include, if applicable, the following information:

a) reference to this standard;

b) identification of the backing plate/implant;

c) material of backing plate and implant (chemical analysis and mechanical properties);

d) dimensions of the implant (diameter);

e) type of notch (helical, circular);

f) conditions of welding and testing (process, consumable, diffusible hydrogen, welding parameters, preheating, stress level;

g) number and length of cracks and methods of detection;

h) time and load to fracture or holding time;

i) test criterion: cracking or fracture;

j) t8/5 / t3/1;

k) hardness values.

Example of a typical report is given in Annex A.

# Annex A
(informative)

# Test report for implant test

Manufacturer:

Purpose of examination:

| | | | | | | |
|---|---|---|---|---|---|---|
| Description of investigation | | | | | Date<br>Test no. | |
| Cast no.<br>Other details | | | Material thickness, mm:<br>Rolling direction indicated: | | Y/N | |
| Composition | C %<br>Cr %<br>Nb % | Si %<br>Mo %<br>Ca % | Mn %<br>Ni %<br>B % | P %<br>V %<br>Ti % | S %<br>Cu %<br>Al % | |
| Mechanical test<br>Yield UTS<br>Elongation | N % | | | | | |
| Welding details | | | Process | | | |
| Parameters | Test weld | | Welding consumable | | Test weld | |
| Electrode/Wire diameter | | | Specification | | | |
| Amperage | | | Classification | | | |
| Voltage | | | Shielding gas/flux | | | |
| Polarity | | | Baking treatment | | | |
| Travel speed | | | Preheat temperature<br>Interpass temperature (max.)<br>Post heat temperature<br><br>Measuring method | | | |
| Gas type | | | | | | |
| Gas flow rate l/min | | | | | | |
| Heat input | | | | | | |
| Hydrogen determination<br><br>Method | | | Date<br><br>Result | | | |
| Metallurgical examination/hardness testing | | | | | | |
| Section and face | Metallurgical examination<br><br>Result (C or NC) | | Hardness, HV | | | |
| | | | HAZ* | Weld metal | Parent metal | |
| | | | | | | |
| C = Cracked<br><br>F = Failed | | NC = Not cracked | *Hardness = | | Max.value:Min.value<br><br>Average value | |
| Conclusion: Cracked /Not cracked | | | Signature | | | |

# Annex ZA
(normative)
# List of corresponding European and International Standards for which equivalents are not given in the text

| European Standard | Corresponding International Standard |
|---|---|
| EN 1043-1 | ISO 9015-1, *Destructive tests on welds in metallic materials - Hardness testing - Part 1: Hardness test on arc welded joints* |

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