INTERNATIONAL STANDARD

ISO 17642-2

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

Part 2: Self-restraint tests

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

Partie 2: Essais sur éprouvette auto-bridée

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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 17642-2 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 17642-2:2005) 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of an identical text or by endorsement, at the latest by September 2005, and conflicting national standards shall be withdrawn at the latest by September 2005.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 standard specifies the sizes of the test pieces, the specimens and the procedures for carrying out self-restraint cold cracking tests by:

— CTS(Controlled Thermal Severity)-test

— Tekken (Y-groove) or Lehigh (U-groove) test

in order to obtain information about the cold cracking sensitivity during welding.

This standard applies primarily but not exclusively to C-Mn 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 1043-1:1995, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints*

EN 1321, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

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

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.

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4 Designation and symbols

The following designations and symbols given in Table 1 apply.

Table 1 — Designation and symbols

Symbol	Designation	Unit
	CTS-test	
t	material thickness	mm
L_V	leg length vertical	mm
L_H	leg length horizontal	mm
L	length of the test bead	mm
	Tekken or Lehigh test (Y and U-groove)	
t	material thickness	mm
g	root gap	mm
W	diameter of drilled hole and groove width	mm
C_f	crack ratio for surface cracks	%
C_r	crack ratio for root cracks	%
C_s	crack ratio for cracks in sections	%
l_f	length of surface crack	mm
l_r	length of root crack	mm
H_c	height root crack	mm
H	minimum thickness of test bead	mm
L	length of the test bead	mm

5 Principle

5.1 General

The self-restraint cold cracking tests are designed to assess the cold cracking sensitivity of the parent materials and the arc welding consumables. The test consists of depositing a weld bead on a test sample made of two plates with pre-defined conditions and to examine transverse cut faces of the weld with a view to detect possible cracks either in the weld metal or in the heat affected zone.

This test procedure essentially applies to metal arc welding with covered electrodes and semi-automatic gas metal arc welding using solid and tubular wires. In general this method is not used for high current processes such as submerged-arc welding.

5.2 Qualitative evaluation

When using well determined welding conditions for welding a given material, a single evaluation test is performed. In the case of the CTS-test, the two test welds are examined.

5.3 Quantitative evaluation

When aiming at determining the cracking limit, a series of tests shall be performed. The no crack test shall be repeated, on the contrary, other tests shall be performed.

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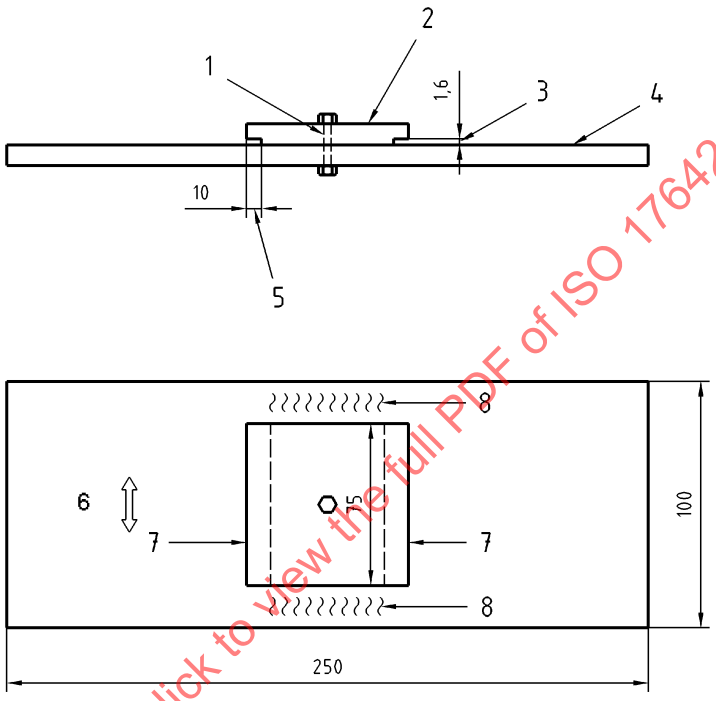
6 Test

6.1 CTS-test

6.1.1 Dimensions of the test pieces

The dimensions of the test piece shall be in accordance with Figure 1.

Dimensions in millimetres



Key

1 Clearance hole 13 mm diameter
2 Top plate
3 Root notch gap
4 Bottom plate
5 Root notch depth
6 Preferred principal rolling direction
7 Test welds
8 Anchor welds

Figure 1 — CTS test

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6.1.2 Preparation of the test pieces

All test pieces shall be prepared from those parent materials which are actually to be welded with the welding consumables to be tested (see Figure 2).

Machine the test material for the pieces by sawing, milling or grinding. Ensure that surfaces to be welded are milled or ground finish. Take care to minimize heating and deformation in the material during machining.

Use the general arrangement of the test piece shown in Figure 1 and the tolerances and surface finish requirements given in Table 2.

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Table 2 — CTS test piece dimensions/conditions and tolerances

Dimension/conditions	Values
Material thickness, *t* Top block	6 mm min. (75 ± 1) mm x (75 ± 1) mm x t
Bottom block	(250 ± 3) mm x (100 ± 3) mm x t
Root notch depth gap	 (10 ± 0,5) mm (1,6 ± 0,10) mm
Torque on bolt	(100 ± 5) N·m
Surface finish on mating faces	3,2 µm R_a max.
Surface finish on area to be welded	6,3 µm R_a max.
Mating face gap	0,05 mm max.

Top and bottom blocks shall both have the same thickness. Top blocks shall be machined and bottom blocks may be machined or flame cut. Both blocks shall be of the same material.

In those exceptional circumstances where it is impossible to machine both blocks from the test material, the top block shall be from the material under test and the bottom block from a material of equivalent yield strength. It is important that the susceptibility of the bottom block to HAZ hydrogen cracking is less than that of the test material.

Where the principal rolling direction of the plate can be determined, arrange the rolling directions of the top and bottom plates to be the same (see Figure 1).

Ensure that the surfaces to be welded are ground smooth and free from scale, rust, oil, grease and other contaminants.

Use a bolt with a 12 mm diameter for assembling the blocks. Degrease the bolt, a suitable plain nut and any washers to be used prior to use. Do not use nuts and bolts treated by plating processes. Insert the bolt through the top and bottom blocks, add the nut and washers and tighten to the required torque (see Table 2). Check the torque value prior to all welding operations and adjust as necessary.

6.1.3 Anchor welds

Make the anchor welds (shown in Figure 1) with a welding consumable with a yield strength equal to or greater than the yield strength of the material under test, up to parent material yield strength of 895 N/mm².

NOTE Where the yield strength of the parent material exceeds 895 N/mm², the consumable selected can have a yield strength less than that of the parent material (but greater than 895 N/mm²) and /or austenitic stainless steel weld deposit can be used.

Start and finish the anchor fillet welds 10 mm (± 3 mm) from the corners of the top plate and make them the following throat sizes:

up to 15 mm plate thickness: (6 ± 1) mm;

plate thickness 15 mm and over: (13 ± 1) mm.

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Deposit the welds with a procedure to avoid hydrogen cracking, using preheat, interpass and post-heating control as necessary.

Dry all consumables used for anchor welds in accordance with the manufacturers' recommendations to give the lowest possible hydrogen levels.

Check the torque on the bolt and tighten the bolt where necessary. Leave the assembly for 12 h before test welding.

6.1.4 Test welds

6.1.4.1 Preheating

When the test piece is to be preheated, place the assembly in an oven and leave it for sufficient time to ensure even and thorough heating. Set the oven at a higher temperature than required for the test in order to allow for cooling of the assembly during transfer and set-up.

Prior to any welding, check the temperature of the test blocks using a calibrated surface pyrometer or thermocouple. Where the tests demand a specific preheat temperature, welding should not be commenced until the required temperature is achieved. Temperatures of the top and bottom blocks in the test area shall not differ by more than 5 °C.

6.1.4.2 Deposition

A jig should be used to position the assembly. The position of the electrode/wire with respect to the test block (see Figure 2) shall be such that the deposited test welds are symmetrically in the flat positions across the full width of the block in a single direction and in a single pass. Ensure that the test weld does not extend beyond the ends of the block.

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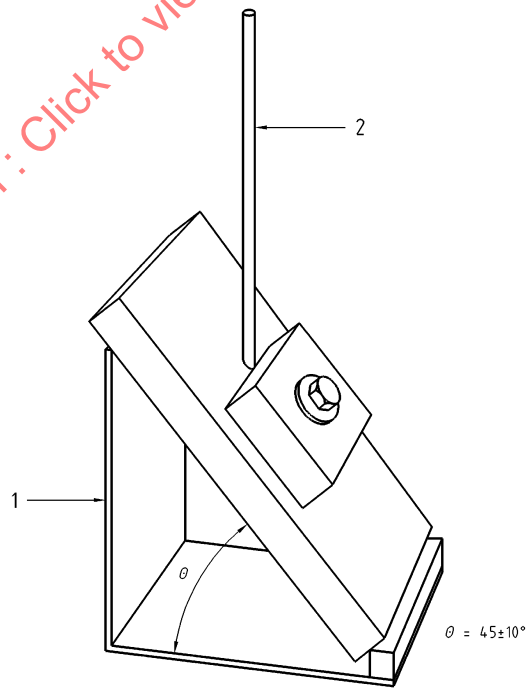

Key

1 Test jig
2 Welding consumable

Figure 2 — Jig used to position test assembly

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Determine the weld length by measuring from the start of the weld to the centre of the weld crater as shown in Figure 3. Calculate the value of heat input (in kJ/mm).

NOTE Manual welding is difficult to control and monitor adequately. It is therefore recommended that mechanized deposition equipment is used.

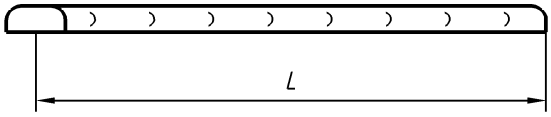


Figure 3 — Measurement of weld length, *L*

6.1.4.3 Post-heating

Where post-heating is to be carried out, transfer the assembly to an oven immediately following the completion of the first test welding. Monitor post-heating by using calibrated surface pyrometer or thermocouples.

6.1.4.4 Cooling

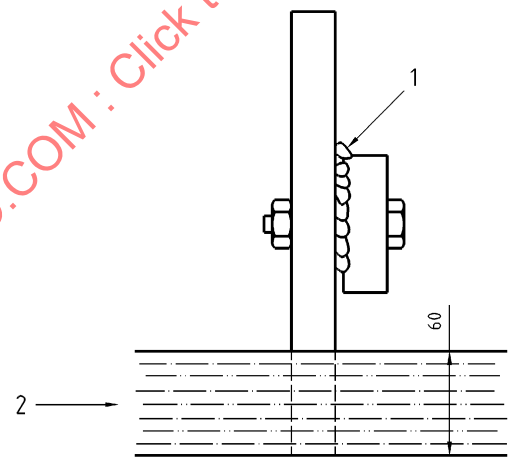
Following deposition of the first test weld bead and after any post-heating treatment, transfer the test assembly to a cooling bath whereby the end of the assembly opposite the welded end is immersed in cold flowing water to a depth of (60 ± 5) mm (see Figure 4).

Complete transfer to the bath within 60 s of the completion of welding (post-heating, where applied).

Ensure that the water temperature at the exit of the cooling bath does not exceed 30 °C during the test.

Keep the assembly in the bath until the temperature has fallen to ambient and then remove it.

Dimensions in millimetres



Key

1 Test weld
2 Water

Figure 4 — Cooling bath arrangement

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6.1.4.5 Deposition of the second weld

Allow 48 h (minimum) from removal from the cooling bath before depositing the second test weld in accordance with 6.2.5.2.

Cooling of the second test weld shall be the same as for the first test weld.

Following cooling to ambient temperature of the second test weld, leave the assembly for 48 h (minimum) before proceeding with further work.

6.1.4.6 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.

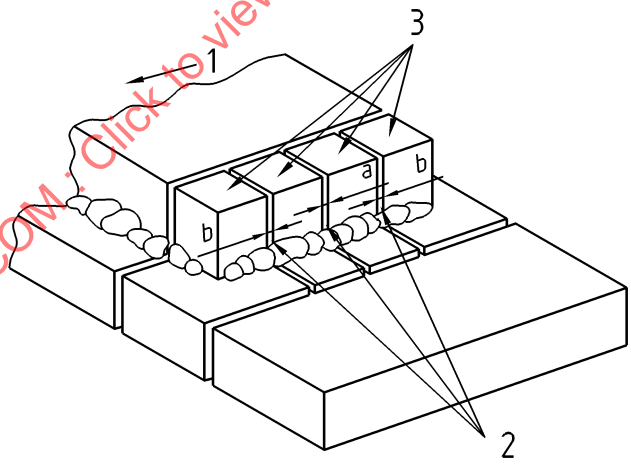
6.1.5 Test results

6.1.5.1 Metallographic examination

6.1.5.1.1 Sectioning

The test pieces shall be sectioned for equal size samples for metallurgical examination according to EN 1321, see Figure 5.

NOTE Excessive forces or vibrations or methods that create heat should not be applied.



Key

1 Welding direction
2 Indicates faces polished and examined for cracking
3 Test pieces
a,b Faces polished and examined for cracking

Figure 5 — Sectioning of CTS test piece

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6.1.5.1.2 Preparation and examination

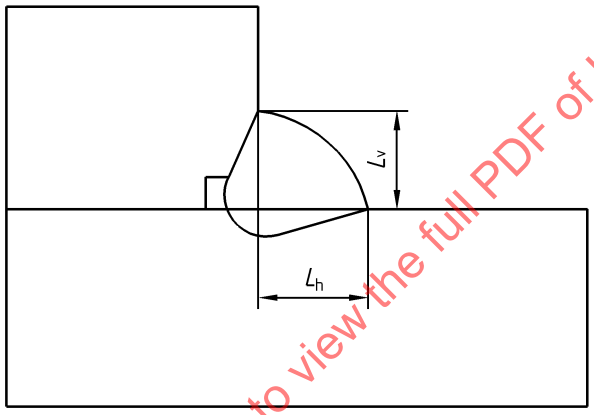
Prepare the six cut faces for micro-examination. Examine the prepared faces of the weld metal and HAZ for cracking at a minimum magnification of x 50. Examine either face 2b or 3a first (see Figure 5) in accordance with EN 1321. Confirm the result for uncracked specimens at a suitable magnification (x 200 is a suitable range).

6.1.5.1.3 Measurements

If the weld metal is found to display root cracking of total length greater than 5 % of the throat thickness, the test piece is invalid and testing of the test pieces involved is terminated.

If there are HAZ cracks longer than 5 % of the leg length, report the test weld as "Cracked" and terminate the metallographic examination. Examine all six faces if no cracking is found.

When the bottom plate material is different to that used for the top plate and HAZ cracking is only present in the bottom plate, the test is declared invalid.



Leg length = $\frac{L_v + L_h}{2}$

Figure 6 — Measurement of leg length

6.1.5.2 Hardness testing

One of the central faces from each test weld (face 3a or 2b in Figure 5) shall be subject to Vickers hardness tests according to EN 1043-1:1995, Figure 4, HV10, HV5.

Select the indentation load of 2,5 kg, 5 kg or 10 kg so that the hardness impressions are contained within the grain coarsened zone of the HAZ and such that 10 impressions can be accommodated. Discount results from HAZ hardness impressions entering the weld zone, the grain refined zone or the unaffected parent material and make a further impression.

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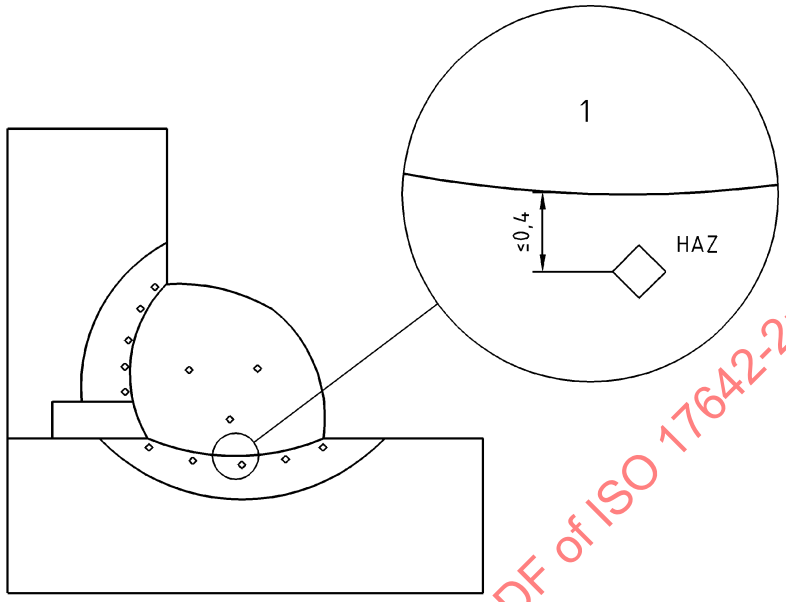
Dimensions in millimetres



Key
1 Weld

NOTE The distance of any indentation should be not less than that permitted by EN 1043-1 for the previous indentation.

Figure 7 — Typical positions of hardness test impressions

6.2 TEKKEN-test (Y-groove) and Lehigh test (U-groove)

6.2.1 General

Type Y relates to more stringent test conditions and is recommended for parent material testing. Type U is valid for less stringent test conditions and recommended for weld metal testing.

6.2.2 Dimensions of the test pieces

The dimensions of the test pieces shall be in accordance with Figure 8.

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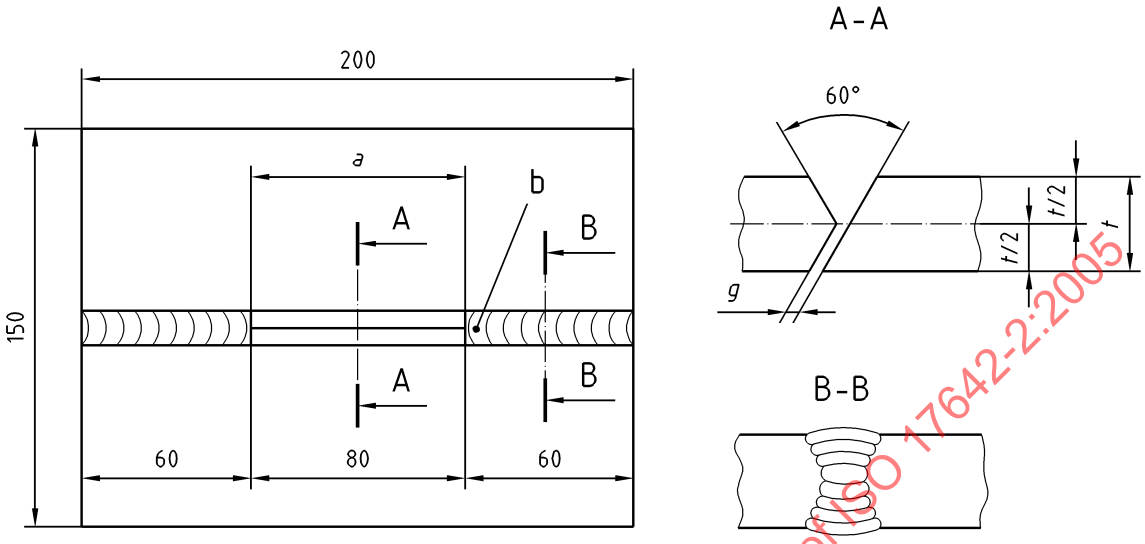
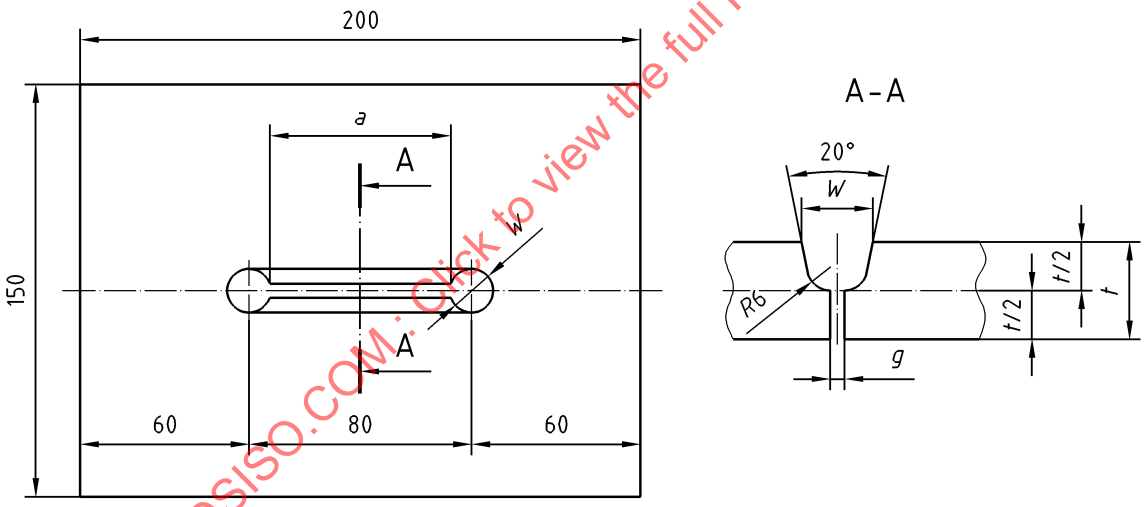
Dimensions in millimetres



8a) Y-groove test



8b) U-groove test

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Key

a Test welding (Y-groove or U-groove)
b Anchor weld (any)
t Thickness of the test plate
g Root gap 2,0 mm ± 0,2 mm
W Diameter of drilled hole (depending on thickness) and groove width

Figure 8 — Shape and dimensions of test plates

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6.2.3 Preparation of the test pieces

Machine the test material for the test pieces by sawing, milling or grinding. Ensure that surfaces to be welded are milled or ground finish. Take care to minimize heating and deformation in the material during machining. Use the general arrangement of the test piece shown in requirements given in Figure 8.

The un-welded edge of the test piece may be flame cut.

Where the principal rolling direction of the plate can be determined, arrange the rolling directions of the plates to be the same and parallel to the welding direction.

Ensure that the surfaces to be welded are ground smooth and free from scale, rust, oil, grease and other contaminants.

6.2.4 Anchor welds

Make the anchor welds (shown in Figure 8 for the y-groove test) with a welding consumable with a yield strength equal to or greater than the yield strength of the material under test.

Deposit the welds with a procedure to avoid hydrogen cracking, using preheat, interpass and post-heating control as necessary.

Dry all consumables used for anchor welds in accordance with manufacturers' recommendations to give the lowest possible hydrogen levels.

6.2.5 Test welds

6.2.5.1 Preheating

When the test piece is to be preheated, place the assembly in an oven and leave it for sufficient time to ensure even and thorough heating. Set the oven at a higher temperature than required for the test in order to allow for the cooling of the assembly during transfer and set-up.

Prior to any welding, check the temperature of the test piece using a calibrated surface pyrometer or thermocouples. Where the tests demand a specific preheat temperature, welding should not be commenced until the required temperature is achieved. Temperatures of the test piece in the test area shall not differ by more than 5 °C.

6.2.5.2 Deposition

The welding shall be carried out in the flat position in such conditions that the cooling rate shall not be affected. The welding shall be started when the temperature of the whole test plate has reached the specified pre-heat temperature.

The test bead shall be welded as shown in Figure 9 a). If welding is carried out automatically using a machine, adopt Figures 9 b) and 9 c). Calculate the value of heat input (in kJ/mm).

NOTE 1 When coated manual metal-arc welding electrodes are used for producing the CTS test welds, sometimes they are not treated in accordance with the manufacturer's recommendations. The treatments applied in these cases, if any, should be noted on the test report.

NOTE 2 Manual welding is difficult to control and monitor adequately. It is therefore recommended that mechanized deposition equipment is used.

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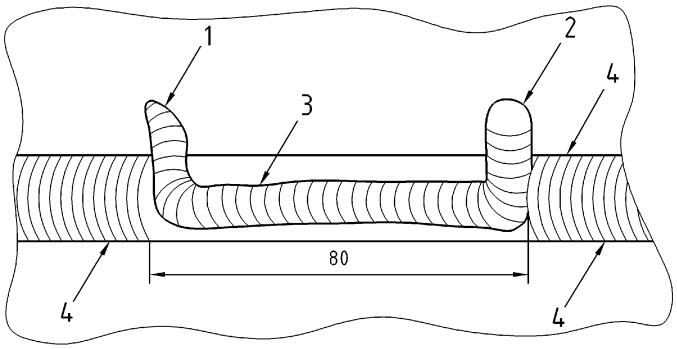
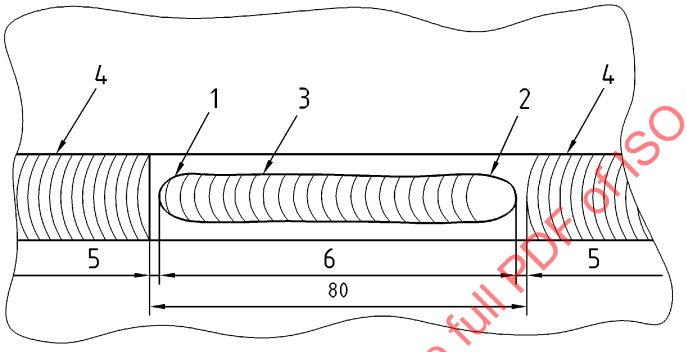
Dimensions in millimetres

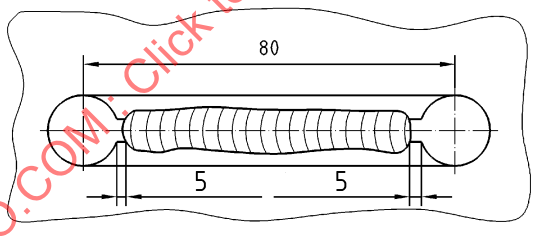


9a)



9b)

Y-groove test



9c)

U-groove test

Key

1 Start
2 Crater treatment
3 Test bead
4 Anchor weld
5 Approximately 2 mm
6 Approximately 76 mm

Figure 9 — Welding method of test bead

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6.2.5.3 Post-weld heat treatment

Where post-heating is required, transfer the assembly to an oven immediately following the completion of the first test welding.

Monitor post-heating by using calibrated surface pyrometer or thermocouples.

Following cooling to ambient temperature leave the test piece for 48 h (minimum) before proceeding with further work.

6.2.5.4 Hydrogen determination

The diffusible hydrogen content of the consumable (in ml per 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 CTS or Y groove testing.

6.2.6 Test results

6.2.6.1 General

Depending on the requirement examine the test weld for cracks on the surface, the root and at sections for their lengths and calculate the crack ratio and measure the hardness in the HAZ.

6.2.6.2 Visual examination

Examine the test weld for surface cracks visually and calculate the crack ratio from the following formula:

$$C_f = \frac{\Sigma_{l_f}}{L} \times 100$$

where:

C_f is the crack ratio for root (%);

L is the length of test bead (mm);

Σl_f is the aggregate length (mm) of root cracks.

6.2.6.3 Metallographic examination

6.2.6.3.1 Sectioning

The test pieces shall be sectioned for metallurgical examination according to EN 1321, see Figure 11.

NOTE Excessive forces or vibrations or methods that create heat should not be applied.

The positions of the 5 sectioning cuts if welding as per Figure 9 (a) shall be the position at both ends of the bead placed in parallel to the groove as shown in Figure 11 (a) and the positions quartering the distance between both ends.

The positions of the 5 sectioning cuts if welding as per Figure 9 (b) shall be the positions nearest to the starting point where the width of bead becomes constant and the centre of the bead crater, and the positions quartering the distance there of as shown in Figure 11 (b).

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6.2.6.3.2 Preparation and examination

Examine the prepared faces of the weld metal and HAZ for cracking at minimum magnification of x 50. Confirm the result for uncracked specimens at a suitable magnification (x 200 minimum).

6.2.6.3.3 Measurements

Calculate the section crack ratio from the following formula:

$$C_s = \frac{H_c}{H} \times 100$$

where:

C_s is the respective section crack ratio (%);

H is the minimum thickness (mm) of test bead shown in Figure 10;

H_c is the height (mm) of root crack shown in Figure 10.

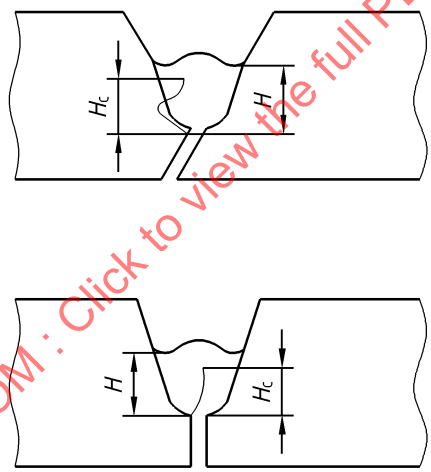

Figure 10 — Measuring procedure

NOTE Any weld imperfections shorter than 0,5 mm ($H_c \leq 0{,}5$ mm) in the height should not be regarded as a hydrogen induced cold crack.

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