INTERNATIONAL STANDARD

ISO 15618-2

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Qualification testing of welders for underwater welding —

Part 2:
Diver-welders and welding operators for hyperbaric dry welding

Épreuve de qualification des soudeurs pour le soudage sous l'eau —

Partie 2: Scaphandriers soudeurs et opérateurs soudeurs pour le soudage hyperbare en caisson

Reference number
ISO 15618-2:2001(E)

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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 3.

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 part of ISO 15618 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15618-2 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 11, *Approval requirements for welding and allied processes personnel*, 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 15618 consists of the following parts, under the general title *Qualification testing of welders for underwater welding*:

— *Part 1: Diver-welders for hyperbaric wet welding*

— *Part 2: Diver-welders and welding operators for hyperbaric dry welding*

Annexes A and B of this part of ISO 15618 are for information only.

Contents

Foreword

The text of EN ISO 15618-2:2001 has been prepared by Technical Committee CEN/TC 121 "Welding", the secretariat of which is held by DS, 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 June 2002, and conflicting national standards shall be withdrawn at the latest by June 2002.

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

Introduction

This standard covers the principles to be observed in the approval testing of diver-welder or welding operator performance for the fusion welding of steels in a hyperbaric, dry environment.

The ability of the diver-welder or welding operator to follow verbal or written instructions and testing of his skill are therefore important factors in ensuring the quality of the welded product.

Testing of skill to this standard depends on welding methods in which uniform rules and test conditions are complied with, and standard test pieces are used.

This standard is intended to provide the basis for the mutual recognition by examining bodies for approval relating to diver-welder's or welding operator's competence in the various fields of application. Tests should be carried out in accordance with this standard unless more severe tests are specified by the relevant application standard when these should be applied.

The test weld may be used to approve a welding procedure and a diver-welder or welding operator, provided that all the relevant requirements, e.g. test piece dimensions, are satisfied.

The diver-welder's or welding operator's skill and job knowledge continue to be approved only if the diver-welder or welding operator are working with reasonable continuity on welding work within the extent of approval.

1 Scope

This standard applies to welding processes where the skill of the diver-welder or welding operator has a significant influence on weld quality.

This standard specifies essential requirements, ranges of approval, test conditions, acceptance requirements and certification for the approval testing of diver-welder or welding operator performance for the welding of steels underwater in a hyperbaric dry environment. The recommended format for the certificate of approval testing is given in Annex A.

During the approval test the diver-welder or welding operator should be required to show adequate practical experience and job knowledge (test non mandatory) of the welding processes, materials and safety requirements for which he is to be approved, information on these aspects is given in Annex B.

This standard is applicable when the diver-welder's or welding operator's approval testing is required by the purchaser, by inspection authorities or by other organisations.

The welding processes referred to in this standard include fusion welding processes which are designated as manual or partly mechanized welding for diver-welders and fully mechanized or automatic welding for operators (see 5.2).

All new approvals are in accordance with this standard from the date of this issue.

However, this standard does not invalidate previous diver-welder or welding operator approvals made to former national standards or specifications, providing the intent of the technical requirements is satisfied and the previous approvals are relevant to the application and production work on which they are to be employed.

Also, where additional tests should be carried out to make the approval technically equivalent it is only necessary to do the additional tests on a test piece which should be made in accordance with this standard. Consideration of previous approvals to former national standards or specifications should be at the time of the enquiry/contract stage and agreed between the contracting parties.

The certificate of approval testing is issued under the sole responsibility of the examiner or examining body.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 288-1
Specification and approval of welding procedures for metallic materials – Part 1: General rules for fusion welding

EN 288-2
Specification and approval of welding procedures for metallic materials – Part 2: Welding procedure specification for arc welding

EN 499
Welding consumables – Covered electrodes for manual metal arc welding of non alloy and fine grain steels – Classification

EN 571-1
Non-destructive testing – Penetrant testing – Part 1: General principles

EN 910
Destructive tests on welds in metallic materials – Bend tests

EN 970
Non-destructive examination of fusion welds – Visual examination

EN 1290,
Non-destructive examination of welds – Magnetic particle examination of welds

EN 1320
Destructive tests on welds in metallic materials – Fracture test

EN 1321
Destructive tests on welds in metallic materials – Macroscopic and microscopic examination of welds

EN 1418
Welding personnel – Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials

EN 1435
Non-destructive examination of welds – Radiographic examination of welded joints

EN 1600
Welding consumables – Covered electrodes for manual metal arc welding of stainless and heat resisting steels – Classification

EN 1714
Non destructive examination of welds – Ultrasonic examination of welded joints

EN ISO 4063
Welding and allied processes – Nomenclature of processes and reference numbers (ISO 4063:1998)

prEN ISO 5817
Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections (ISO/DIS 5817:2000)

EN ISO 6520-1
Welding and allied processes – Classification of geometric imperfections in metallic materials – Part 1: Fusion welding (ISO 6520-1:1998)

EN ISO 6947
Welds – Working positions – Definitions of angles of slope and rotation (ISO 6947:1993)

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

ISO 857-1
Welding and allied processes – Vocabulary – Part 1: Metal welding processes

ISO 3581
Covered electrodes for manual arc welding of stainless and other similar high alloy steels – Code of symbols for identification

3 Terms and definitions

For the purposes of this standard, the terms and definitions listed below and in EN 288-1 apply.

3.1
diver-welder
a person who performs the welding under hyperbaric conditions

3.2
hyperbaric welding operator
a person who performs fully mechanized or automatic welding in dry hyperbaric conditions (see also EN 1418)

3.3
hyperbaric dry welding
the process of welding in a dry underwater environment wherein the gaseous atmosphere acting on the welding arc and weld is at an elevated pressure the level of which is determined by the depth of water

3.4
habitat
the sealed enclosure surrounding the work area from which the water has been displaced by a gaseous medium to provide a dry environment for performance of the welding operation

4 Symbols and abbreviations

4.1 General

Where the full wording is not used, the following symbols and abbreviations shall be used when completing the test certificate (see Annex A).

4.2 Test piece

a	nominal throat thickness
BW	butt weld
D	outside diameter of pipe
FW	fillet weld
P	plate
t	plate or pipe wall thickness
T	pipe
z	leg length of fillet weld

4.3 Consumable

nm	no filler metal
wm	with filler metal (solid wire)
B	basic covering
S	other coating types
fc	flux cored
mc	metal cored

4.4 Miscellaneous

bs	welding from both sides
gb	welding with gas backing
gg	back gouging or back grinding of welds
mb	welding with backing material
nb	welding without backing
ng	no back gouging or no back grinding
ss	single-side welding
wd	water depth

5 Essential variables for approval testing

5.1 General

The criteria specified in this clause shall be examined in order to identify the ability of the diver-welder or welding operator in these areas. Each criterion is considered to be a significant factor in the approval testing.

The diver-welder or welding operator shall be tested separately. The approval test shall be carried out on test pieces and is independent of the type of construction.

Approval of a diver welder according to this standard does not approve a welding operator and vice versa.

5.2 Welding processes

Welding processes are defined in ISO 857-1 and reference numbers of welding processes for symbolic representation are listed in EN ISO 4063.

This standard covers the following welding processes applicable in hyperbaric dry environment.

111 manual metal arc welding (metal arc welding with covered electrode);
114 self-shielded tubular-cored arc welding;
131 metal inert gas welding, MIG welding;
135 metal active gas welding, MAG welding;
136 tubular cored metal arc welding with active gas shield;
137 tubular cored metal arc welding with inert gas shield;
141 tungsten inert gas welding, TIG welding;
15 plasma arc welding.

Other fusion welding processes by agreement.

5.3 Joint types (butt and fillet welds)

Test pieces shall be produced for butt weld (BW) and fillet weld (FW) in plates (P) or pipes[1]) (T) for approval tests in accordance with 7.3.

5.4 Material groups

The designation of steel groups of material as defined in CR ISO 15608 shall apply.

This standard applies to the following material groups according to CR ISO 15608: 1, 2, 3, 7, 8 and 10.

In general, diver-welder's or welding operator's approval test shall involve depositing weld metal having a chemical composition and mechanical strength compatible with any of the steels in the parent metal group(s).

When welding parent metals from two different groups which do not give approval to each other, an approval for the combination as a separate group is required.

When the filler metal is dissimilar to the parent metal group, an approval for that combination of parent metal group and filler metal is needed.

5.5 Consumables

5.5.1 General

Only consumables for the intended hyperbaric application shall be used, e. g. by the welding procedure test.

[1]) The word "pipe", alone or in combination, is used to mean "pipe", "tube" or "hollow section".

5.5.2 Metal-arc welding with covered electrodes

Covered electrode groups are classified with respect to the most important characteristics according to EN 499 as given in 4.3. In the case of hyperbaric dry welding only two of these classifications are applicable. These are

– B basic covering;
– S other covering.

NOTE: For further details on covered electrodes reference should be made to EN 499, EN 1600 or ISO 3581 according to the steel in question.

5.6 Dimensions

The diver-welder or welding operator approval test shall be based on the thickness of the material (i.e. plate thickness or wall thickness of pipe) and pipe diameters which the diver-welder or welding operator will use in production. A range of approval is listed for each of the ranges of plate thickness and pipe wall thickness or pipe diameter as specified in Tables 1 and 2.

It is not intended that thicknesses or diameters should be measured precisely but rather the general philosophy behind the values given in Tables 1 and 2 should be applied.

Table 1 - Test piece (plate or pipe) and range of approval

Test piece thickness t mm	Range of approval
$t \leq 6$	$\geq t$ (max. 6 mm)
$t > 6$	0,5 t to 2 t (min. 6 mm)

Table 2 - Test piece diameter and range of approval

Test piece diameter D [a] mm	Range of approval
$D \leq 100$	0,7 D to 2 D
$100 < D \leq 300$ [b]	0,5 D to 2 D (min. 75 mm)
$D > 300$	$\geq 0,5\ D$
[a] For structural hollow sections, "D" is the dimension of the smallest side. [b] See also 6.3 a).	

5.7 Welding positions

The welding positions shall be taken from EN ISO 6947.

Angles of slope and rotation for straight welds in the welding positions shall be in accordance with EN ISO 6947.

5.8 Hyperbaric environment

The diver-welder or welding operator approval test shall be carried out under actual or simulated hyperbaric conditions at the appropriate water depth.

6 Range of approval

6.1 General

As a general rule, the test piece approves the diver-welder or welding operator not only for the conditions used in the test, but also for all joints which are considered easier to weld. The range of approval for each type of test is given in the relevant subclauses and tables. In these tables the range of approval is indicated in the same horizontal line.

6.2 Welding process

Each test approves one welding process. A change of welding process requires a new approval test. However, it is possible for a diver-welder or welding operator to be approved for more than one welding process by a single test or by several approval tests to be used to cover a multi-process joint. For example in a case where approval is required for a single-side butt joint with the root to be welded by TIG (141) without backing and to be filled by metal-arc welding with covered electrode (111), the diver-welder or welding operator may be approved by either of the following routes:

a) successful completion of an approval test simulating the multi-process joint, i.e. the root run welded by TIG (141) without backing, subsequent runs or layers welded by metal-arc welding with covered electrode (111) within the limits of the range of approval for each welding process;

b) successful completion of separate relevant approval tests one for TIG (141) without backing for the root run and a separate test for the fill by metal-arc welding with covered electrode (111) with backing or welded from both sides with or without gouging.

6.3 Joint types

Depending on the test piece, the range of welds for which the diver-welder or welding operator is approved is shown in Table 3; the following additional criteria are applicable:

a) approval for butt welds in pipes with diameter > 300 mm includes butt welds in plates;

b) approval for butt welds in plates in all relevant positions covers butt welds on pipes having an outside diameter ≥ 600 mm;

c) welding from one side without backing approves welds from one side with backing and welds from both sides with and without gouging;

d) welding in plates or pipes with backing approves welds made from both sides, but not for welds without backing;

e) butt welds approve fillet welds for similar welding conditions;

f) in cases where the production work is predominantly fillet welding, it is recommended that the diver-welder or welding operator should be approved also by an appropriate fillet welding test, i.e. on plate, pipe or branch connection (see EN 288-3).

g) welding from both sides without gouging approves welds from one side with backing and welds from both sides with gouging;

h) approval for butt welds in pipes without backing includes approval for branch connections within the same range of approval as in Tables 3 and 4. For a branch weld the range of approval is based on the diameter of the branch;

i) in cases where the production work is either branch welding or involves a complex branch connection a special training and testing is necessary.

Table 3 - Range of approval for tests on butt joints (details of weld type)

Details of weld type				Range of approval					
				Butt welds in plate				Butt welds in pipe	
				welded from one side (ss)		welded from both sides (bs)		welded from one side (ss)	
				with backing (mb)	no backing (nb)	with gouging (gg)	no gouging (ng)	with backing (mb)	no backing (nb)
Butt weld in plate	welded from one side (ss)	with backing	(mb)	x	–	x	–	[a]	–
		no backing	(nb)	x	x	x	x	[a]	[a]
	welded from both sides (bs)	with gouging	(gg)	x	–	x	–	[a]	–
		no gouging	(ng)	x	–	x	x	[a]	–
Butt weld in pipe	welded from one side (ss)	with backing	(mb)	x	–	x	–	x	–
		no backing	(nb)	x	x	x	x	x	x

[a] See 6.3 c) and 6.3 d).

Key
x indicates those welds for which the diver-welder or welding operator is approved
– indicates those welds for which the diver-welder or welding operator is not approved

6.4 Material groups

The range of approval for the material groups is only limited to those groups for which the consumable (see 5.5) is applicable.

6.5 Consumables

The approval range for covered electrodes and flux cored consumables includes all similar covered electrodes and flux cored consumables as well as gas combinations used in the diver-welder or welding operator approval test.

6.6 Dimensions

The range of approval according to plate thickness or wall thickness of pipe and/or pipe diameter is shown in Tables 1 and 2.

6.7 Welding positions

The range of approval for each welding position is given in Table 4. The welding positions and codes are given in EN ISO 6947.

Table 4 - Range of approval according to welding positions

Welding position of approval test piece				Range of approval																			
				Plates										Pipes									
				Butt welds					Fillet welds					Butt welds						Fillet welds			
														Pipe-axis and -angle									
														fixed					[a]	fixed			
														0°		90°	45°			0°		90°	
				PA	PC	PG	PF	PE	PA	PB	PG	PF	PD	PG	PF	PC	H-L045	J-L045	PB	PG	PF	PD[b]	
Plates	Butt welds		PA	x	–	–	–	–	x	x	–	–	–	–	–	–	–	–	x	–	–	–	
			PC	x	x	–	–	–	x	x	–	–	–	–	–	x	–	–	x	–	–	–	
			PG	–	–	x	–	–	–	–	x	–	–	–	–	–	–	–	–	–	–	–	
			PF	x	–	–	x	–	x	x	–	x	–	–	–	–	–	–	x	–	x	–	
			PE	x	x	–	x	x	x	x	–	x	x	–	–	–	–	–	x	–	x	x	
	Fillet welds		PA	–	–	–	–	–	x	–	–	–	–	–	–	–	–	–	–	–	–	–	
			PB	–	–	–	–	–	x	x	–	–	–	–	–	–	–	–	x	–	–	–	
			PG	–	–	–	–	–	–	–	x	–	–	–	–	–	–	–	–	–	–	–	
			PF	–	–	–	–	–	x	x	–	x	–	–	–	–	–	–	x	–	–	–	
			PD	–	–	–	–	–	x	x	–	x	x	–	–	–	–	–	x	–	–	x	
Pipes	Butt welds	fixed	0° PG	–	–	x	–	–	–	–	x	–	–	x	–	–	–	–	–	x	–	–	
			0° PF	x	–	–	x	x	x	x	–	x	x	–	x	–	–	–	x	–	x	x	
			90° PC	x	x	–	–	–	x	x	–	–	–	–	–	x	–	–	x	–	–	–	
			45° H-L045	x	x	–	x	x	x	x	–	x	x	–	x	x	x	–	x	–	x	x	
			45° J-L045	–	–	x	–	–	–	–	x	–	–	x	–	–	–	x	–	x	–	–	
		[a]		PB	–	–	–	–	–	x	x	–	–	–	–	–	–	–	–	x	–	–	–
	Fillet welds	fixed	0° PG	–	–	–	–	–	–	–	x	–	–	–	–	–	–	–	–	x	–	–	
			0° PF	–	–	–	–	–	x	x	–	x	–	–	–	–	–	–	x	–	x	–	
			90° PD[2]	–	–	–	–	–	x	x	–	–	x	–	–	–	–	–	x	–	–	x	

[a] PB for pipes may be welded only in the pipe: fixed; axis: vertical; weld: horizontal vertical

[b] This is an approved position and which is covered by the other related tests.

Key
x indicates those welding positions for which the diver-welder or welding operator is approved
– indicates those welding positions for which the diver-welder or welding operator is not approved

6.8 Hyperbaric environment

6.8.1 Water depth (wd)

The range of approval for water depth is given in Table 5.

Table 5 - Range of approval according to water depth

Depth of welding for test piece	Range of approval wd
wd ≤ 100 m	wd ± 20 m
100 m < wd ≤ 200 m	wd ± 30 m
> 200 m	wd ± 40 m

6.8.2 Gas atmosphere

For water depth ≤ 20 m, a change from an argon (only applied in automatic welding in a constricted area) or heliox atmosphere to an air or nitrox atmosphere requires a new approval test. The converse shall not require a new approval test.

For water depth > 20 m the use of air or nitrox atmosphere is not permitted.

7 Examination and testing

7.1 General

Only approved commercial diver can participate in the examinations and tests.

7.2 Supervision

The welding and testing of test pieces shall be witnessed by an examiner or examining body.

The test pieces shall be marked with the identification of the examiner and the diver-welder or welding operator before welding starts.

The examiner or examining body may stop the test if the welding conditions are not correct or if it appears that the diver-welder or welding operator does not have the technical competence to achieve the required standard, e.g. where there are excessive and/or systematic repairs.

7.3 Shapes and dimensions of test pieces

The shape and dimension of test pieces (see 5.6) required are shown in Figures 1 to 4.

Dimensions in millimetres

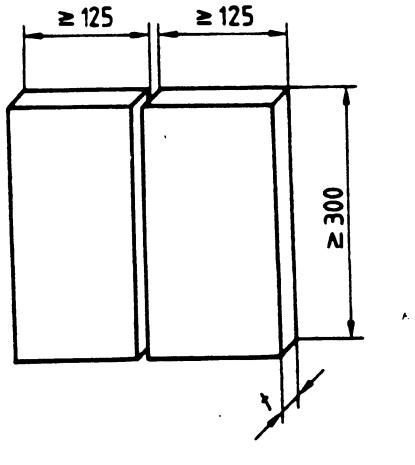
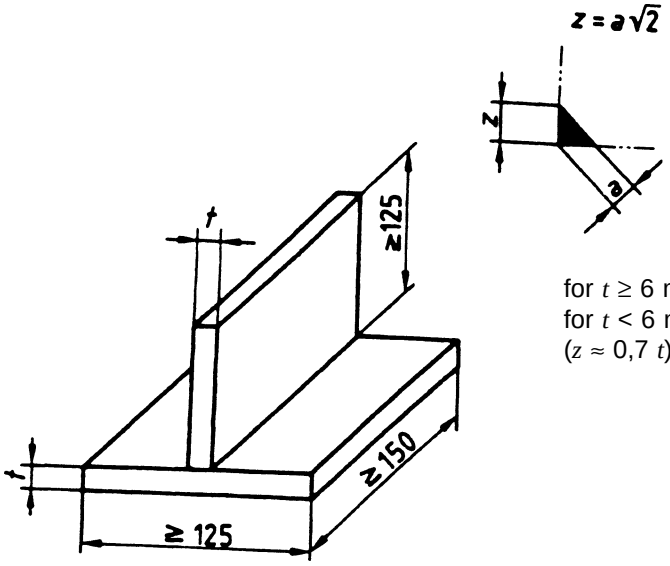


Figure 1 - Dimensions of test piece for a butt weld in plate

Dimensions in millimetres



for $t \geq 6$ mm, $a \leq 0{,}5\ t$
for $t < 6$ mm, $0{,}5\ t \leq a \leq t$
($z \approx 0{,}7\ t$)

Figure 2 - Dimensions of test piece for fillet weld(s) on plate

Dimensions in millimetres

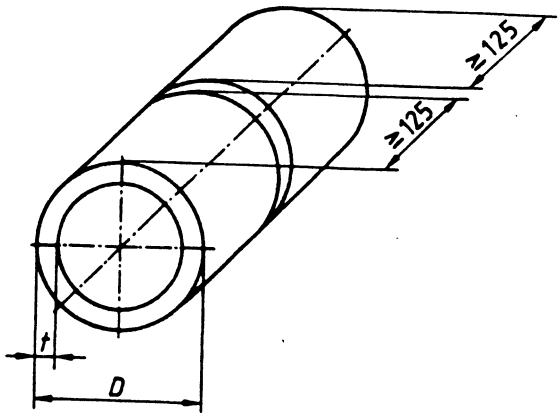
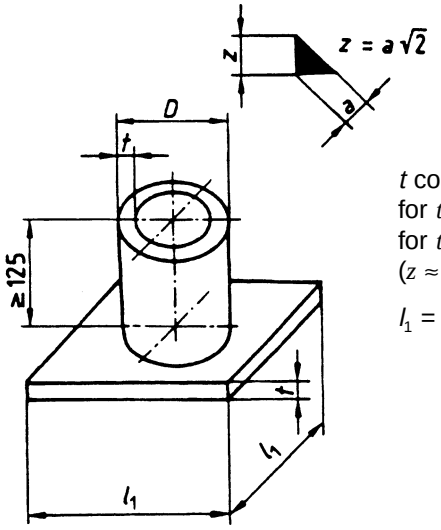


Figure 3 - Dimensions of test piece for a butt weld in pipe



t corresponds to the thinner part
for $t \geq 6$ mm, $a \leq 0{,}5\ t$
for $t < 6$ mm, $0{,}5\ t \leq a \leq t$
($z \approx 0{,}7\ t$)

$l_1 = D + 150$ mm min.

Figure 4 - Dimensions of test piece for a fillet weld on pipe

7.4Welding conditions

The approval test for the diver-welder or welding operator shall correspond to the conditions used in production and follow a WPS or pWPS prepared in accordance with EN 288-2.

The following conditions shall apply:

a) the welding equipment for manual and partly mechanized welding shall be equivalent to that used in production and the welding equipment for fully mechanized or automatic welding shall be identical to that used in production;

b) the welding time for the test piece shall correspond to the working time under usual production conditions;

c) the test piece shall have at least one stop and one re-start in the root run and in the top capping run and be identified in the inspection length to be examined;

d) any pre-heat or controlled heat input required in the WPS or pWPS is mandatory for the diver-welder's or welding operator's test piece;

e) any post-weld heat treatment required in the WPS or pWPS may be omitted unless bend tests are required;

f) identification of the test piece;

g) the diver-welder or welding operator shall be allowed to remove minor imperfections, except on the surface layer, by grinding, gouging or any other method used in production. The approval of the examiner or examining body shall be obtained;

h) the test shall be carried out under actual or simulated hyperbaric conditions in the range of water depth specified in 6.8.1.

7.5 Test methods

Each completed weld shall be examined visually according to EN 970 in the as-welded condition. When required (see Table 6), visual inspection can be supplemented by magnetic particle (EN 1290), penetrant (EN 571-1) or

other test methods, and macroscopic examination (EN 1321) on butt welds. If accepted by visual inspection, additional testing shall be performed as specified in Table 6. The macroscopic specimen shall be prepared and etched on one side to clearly reveal the weld.

When radiography is used, bend tests shall always be applied to butt welds made by welding processes 114, 131, 135, 136 and 137.

Prior to mechanical testing, backing strips, where used, shall be removed. The test piece can be sectioned by thermal cutting or by mechanical means discarding the first and last 25 mm of the test piece at the end of the plates (Figures 5 and 6).

Table 6 - Test methods

Test method	Butt weld plate	Butt weld pipe	Fillet weld
Visual examination	mandatory	mandatory	mandatory
Radiographic examination	mandatory [a;e]	mandatory [a;e]	not mandatory
Bend test	mandatory [b]	mandatory [b]	not mandatory
Fracture test	mandatory [a]	mandatory [a]	mandatory [c;d]
Macroscopic examination	not mandatory	not mandatory	not mandatory [d]
Magnetic particle/penetrant examination	not mandatory	not mandatory	not mandatory

[a] Radiographic or fracture test shall be used, but not both.

[b] When radiographic examination is used, then additional bend tests are mandatory for the processes 114, 131, 135, 136, 137.

[c] The fracture test should be supported by magnetic particle/penetrant testing when required by the examiner or examining body.

[d] The fracture test may be replaced by a macroscopic examination of at least four sections.

[e] The radiographic examination may be replaced by an ultrasonic examination for thickness ≥ 8 mm or ferritic steels only in accordance with EN 1714.

7.6 Test pieces and test specimens

7.6.1 General

In 7.6.2 to 7.6.5 details of the type, dimensions and preparation of test pieces and test specimens are given. In addition, the requirements for mechanical tests are indicated.

7.6.2 Butt weld in plate

When radiographic testing is used, the inspection length of the weld (see Figure 5a)) in the test piece shall be radiographed in the as-welded condition in accordance with EN 1435 using class B technique.

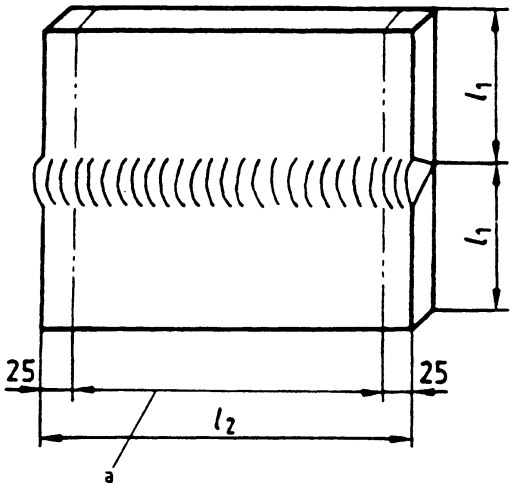
When fracture testing is used, it shall be carried out in accordance with EN 1320. One root fracture test specimen and one face fracture test specimen shall be tested. The inspection length of the test specimen shall be ≈ 50 mm. The specimen preparation, types of notch profiles and methods of fracture shall be in accordance with EN 1320.

When transverse bend testing is used, one root bend test specimen and one face bend test specimen shall be tested in accordance with EN 910. The diameter of the former or the inner roller shall be 4 t, and the bending angle at least 120 °, unless the low ductility of the parent metal or filler metal imposes other limitations.

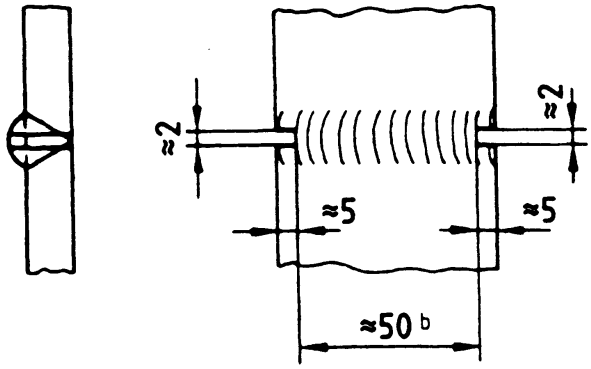
During testing, the test specimens shall not reveal any one single failure > 3 mm in any direction. Failures appearing at the edges and corners of a test specimen during testing shall be ignored in the evaluation.

For plate thickness ≥ 12 mm, the transverse bend tests can be substituted by two side bend tests in accordance with EN 910.

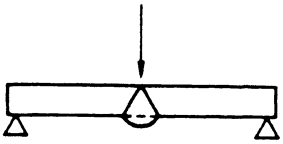
Dimensions in millimetres



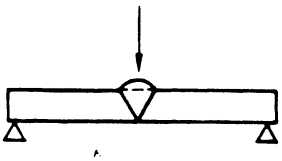
5a) Sectioning into an even-numbered quanitity of test specimens



5b) Preparation



5c) Fracture testing, face side



5d) Fracture testing, root side

NOTE Figure 5 b) shows the notch profile q, according to EN 1320.

[a] Inspection length of the test piece
[b] Inspection length of the test specimen

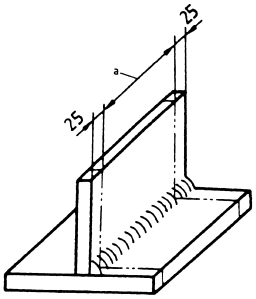
Figure 5 - Preparation and fracture testing of test specimens for a butt weld in plate

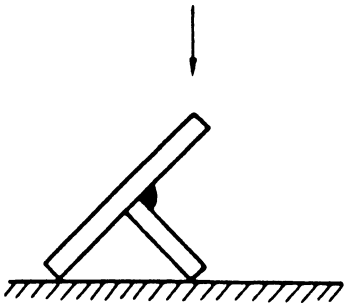
7.6.3 Fillet weld on plate

For fracture tests according to EN 1320 the test piece can be cut, if necessary, into several test specimens (see Figure 6a)). Each test specimen shall be positioned for breaking as shown in Figure 6b), and examined after fracture.

When macroscopic examination is used, at least four test specimens shall be taken equally spaced in the inspection length. Macroscopic tests shall be carried out in accordance with EN 1321.

Dimensions in millimetres





6a) Inspection length of the fillet welds **6b) Fracture testing**

NOTE In Figure 6 b), the fillet weld may be notched, if necessary

[a] Inspection length of the test piece

Figure 6 - Preparation and fracture testing of test specimens for a fillet weld on plate

7.6.4 Butt weld in pipe

A minimum weld length of 150 mm is required for testing of pipes. If the circumference is less than 150 mm, additional weld test pieces will be required.

When radiographic testing is used, the inspection length of the weld (see Figure 7 a) and 7 b)) in the test piece shall be radiographed in the as-welded condition in accordance with EN 1435 using class B technique.

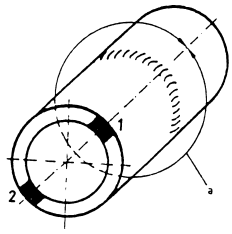
When fracture testing is used, it shall be carried out in accordance with EN 1320. The inspection length of the fracture test specimen shall be ≈ 40 mm. Test specimen preparation, types of notch profiles and methods of fracture shall be in accordance with EN 1320.

When transverse bend testing is used, it shall be carried out in accordance with EN 910. The diameter of the former or the inner roller shall be 4 t, and the bending angle shall be at least 120° unless the low ductily of the parent metal or filler metal imposes other limitations.

The number of fracture or transverse bend test specimens depends on the welding position. For welding position PA or PC, one root and one face bend test specimen shall be tested (see Figure 7 a)). For all other welding positions, two root and two face bend test specimens shall be tested (see Figure 7 b)).

During testing, the test specimens shall not reveal any one single failure > 3 mm in any direction. Failures appearing at the corners of a test specimen during testing shall be ignored in the evaluation.

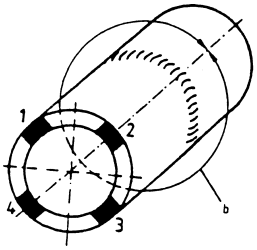
For wall thickness ≥ 12 mm, the transverse bend tests can be substituted by side bend tests in accordance with EN 910.



Position 1:
For one root fracture or one root transverse bend or one side bend test specimen

Position 2:
For one face fracture or one root face transverse bend or one side bend test specimen

7a) Sectionning into at least two test specimens

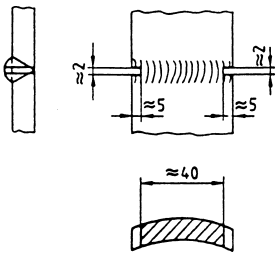


Position 1 + 3:
Each position one root fracture or one root transverse bend or one side bend test specimen

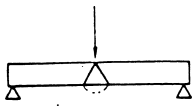
Position 2 + 4:
Each position one face fracture or one face transverse bend or one side bend test specimen

7b) Sectioning into at least four test specimens

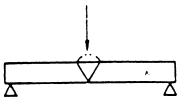
Dimensions in millimetres



7c) Preparation of the test specimen



7d) Fracture testing, root side



7e) Fracture testing, root side

NOTE Figure 7 c) shows the notch profile *q*

[a] Inspection length of the test piece
[b] Inspection length of the test piece

Figure 7 - Preparation and fracture testing of test specimens for a butt weld in pipe

7.6.5 Fillet weld on pipe

For fracture tests in accordance with EN 1320, the test piece shall be cut into four or more test specimens and fractured (see Figure 8).

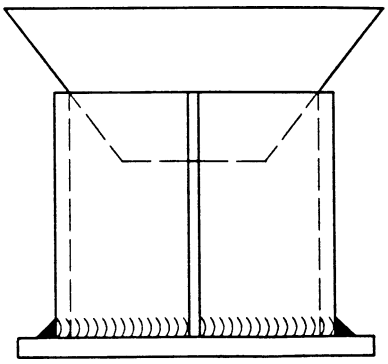


Figure 8 - Preparation and fracture testing of test specimens for a fillet weld on pipe

8 Acceptance requirements for test pieces

Test pieces shall be assessed according to the acceptance requirements specified for relevant types of imperfections. A full explanation of these imperfections is given in EN ISO 6520-1. The acceptance requirements for imperfections found by test methods according to this standard shall, unless otherwise specified, be assessed in accordance with prEN ISO 5817. A diver-welder or welding operator is approved if the imperfections in the test piece are within the specified limits of level B in prEN ISO 5817, except for imperfection types as follows - excess weld metal, excessive convexity, excessive throat thickness and excess penetration, for which level C shall apply.

If the imperfections in the diver-welder or welding operator's test piece exceed the permitted maximum specified, then the diver-welder or welding operator shall not be approved.

Reference should also be made to the corresponding acceptance criteria for non-destructive examination. Specified procedures shall be used for all destructive and non-destructive examinations.

9 Re-tests

If any test piece fails to comply with the requirements of this standard, the diver-welder or welding operator shall produce a new test piece.

If it is established that failure is attributed to the diver-welder's or welding operator's lack of skill, the diver-welder or welding operator shall be regarded as incapable of complying with the requirements of this standard without further training before re-testing.

If it is established that failure is due to metallurgical or other extraneous causes and cannot be directly attributed to the diver-welder's or welding operator's lack of skill, an additional test or additional specimens are required in order to assess the quality and integrity of the new test material and/or new test conditions.

10 Period of validity

10.1 Initial approval

The validity of the diver-welder's or welding operator's approval begins from the date when all the required tests are satisfactorily completed. This date may be different to the date of issue marked on the certificate.

A diver-welder's or welding operator's approval shall remain valid for a period of two years providing that the relevant certificate is signed at six month intervals by the employer/co-ordinator and that all the following conditions are fulfilled:

a) The diver-welder or welding operator shall be engaged with reasonable continuity on welding work within the current range of approval. An interruption for a period no longer than three months is permitted.

b) There shall be no specific reason to question the diver-welder's or welding operator's skill and knowledge.

If any of these conditions are not fulfilled, the approval shall be cancelled.

10.2 Prolongation

The validity of the approval on the certificate may be prolonged for a further period of two years, within the original range of approval, provided each of the following conditions as well as the conditions according to 10.1 are fulfilled:

a) the production welds made by the diver-welder or welding operator are of the required quality;

b) records of all tests according to Table 6, half yearly documented, shall be maintained on file with the diver welder's or welding operator's approval certificate.

The examiner or examining body shall verify compliance with the above conditions and sign the prolongation of the diver-welder's or welding operator's approval test certificate.

11 Certificate

It shall be verified that the diver-welder or welding operator has successfully passed the performance approval test. All relevant test conditions shall be recorded on the certificate. If the diver-welder or welding operator fails any of the prescribed tests, no certificate shall be issued.

The certificate shall be issued under the sole responsibility of the examiner or examining body and shall contain all the information detailed in Annex A. The format of Annex A is recommended to be used as the diver-welder's or welding operator's approval test certificate.

If any other form of diver-welder's or welding operator's approval test certificate is used, it shall contain the information required in Annex A. The manufacturer's pWPS or WPS as shown in EN 288-2 shall give information about materials, welding positions, processes and range of approval etc. in accordance with this standard.

The diver-welder's or welding operator's approval test certificate shall be issued at least in one of the official CEN languages (English, French, German).

The practical test and the examination of job knowledge (see Annex B) shall be designated by "Accepted" or "Not tested".

Each change of the essential variables for the approval testing beyond the permitted ranges requires a new test and a new approval certificate.

12 Designation

The designation of a diver-welder or welding operator approval shall comprise the following items in the order given (the system is arranged so that it can be used for computerisation):

a) the number of this standard;
b) the essential variables;
   1) welding processes, refer to 5.2 and EN ISO 4063;
   2) semi-finished product: plate (P), pipe (T), refer to 5.3;
   3) joint type: butt weld (BW), fillet weld (FW), refer to 5.3;
   4) material group: refer to 5.4;
   5) consumables: refer to 5.5;
   6) dimension of test piece: thickness (t) and pipe diameter (D), refer to 5.6;
   7) welding positions: refer to 5.7 and EN ISO 6947;
   8) details of the weld type: refer to 6.3 and Table 3, for abbreviations to 4.4;
   9) water depth (wd) refer to Table 5 and 6.8, for abbreviation to 4.4.

EXAMPLE 1

Diver welder approval EN ISO 15618-2 111 P BW 8 B t09 PF ss nb wd200

Explanation

Welding process: manual metal arc welding (metal arc welding with covered electrode)	111
Plate	P
Butt weld	BW
Material group: austenitic steel	8
Filler metal: basic covering	B
Dimension of test piece: thickness 9 mm	t09
Welding position: butt weld on plate, vertical upwards	PF
Details of the weld type:	
– single side	ss
– without backing	nb
Water depth: 200 m	wd200

EXAMPLE 2

Welding operator approval EN ISO 15618-2 136 T BW 1 fc t20 D219 PA ss nb wd200

Explanation

Welding process: tubular cored metal arc welding with active gas shield	136
Pipe	T
Butt weld	BW
Material group: low carbon non alloyed steel	1
Filler metal: flux cored wire	fc
Dimension of test piece: thickness 20 mm	t20
pipe diameter: 219 mm	D219
Welding position: butt weld on pipe, rotating pipe horizontal axis, flat	PA
Details of the weld type:	
– single side	ss
– without backing	nb
Water depth: 200 m	wd200

NOTE For explanation of abbreviations used in the designation examples, see clause 4.

Annex A
(informative)

Diver-welder or welding operator approval test certificate for hyperbaric dry welding

Designation: . . . . . Examiner or examining body:

Manufacturer's Welding Procedure Specification

Reference No. (if applicable): . . . . . Reference No.

Diver-welder's/welding operator's Name: . . . .

Identification: . . . . . Photograph (if required)

Method of Identification: . . . . . .

Date and place of birth: . . . . . .

Employer: . . . . . .

Code/Testing Standard: . . . . . .

Job knowledge: Acceptable/Not tested (delete as necessary)

	Weld test details	Range of approval
Water depth		
Gas atmosphere		
Welding process		
Plate or pipe		
Joint type		
Parent metal group(s)		
Filler metal type/designation		
Shielding gases		
Auxiliaries		
Test piece thickness (mm)		
Pipe outside diameter (mm)		
Welding position		
Gouging/backing		

Additional information is available on attached sheet and/or welding procedure specification No.:

Type of test	Performed and acceptable	Not required
Visual		
Radiography		
Magnetic particle		
Penetrant		
Macro		
Fracture		
Bend		
Ultrasonic		
Additional Tests[a])		
a) Append separate sheet if required		

Name, date and signature . . . . . .

Examiner or examining body . . . . . .

Date of issue . . . . . .

Location . . . . . .

Validity of approval until . . . . . .

Prolongation for approval by examiner or examining body
for the following two years (refer to 10.2)

Date	Signature	Position or title

Annex B
(informative)

Job knowledge

B.1 General

The test of job knowledge is recommended, but it is not mandatory.

However, some countries may require that the diver-welder or welding operator undergoes a test of job knowledge. If the job knowledge test is carried out, it should be recorded on the diver-welder or welding operator's certificate.

This Annex outlines the job knowledge that a diver-welder or welding operator should have to ensure that procedures are followed and common practices are complied with. The job knowledge indicated in this Annex is only pitched at the most basic level.

Owing to different training programmes in various countries, it is only proposed to standardize general objectives or categories of job knowledge. The actual questions used should be drawn up by the individual country, but should include questions on areas covered in B.2, relevant to the diver-welder or welding operator's approval test.

The actual tests of a diver-welder or welding operator's job knowledge may be given by any of the following methods or combinations of these methods:

a) written objective tests (multiple choice);

b) oral questioning following a set of written questions;

c) computer testing;

d) demonstration/observation testing following a written set of criteria.

The test of job knowledge is limited to the matters related to the welding process used in the test.

B.2 Requirements

B.2.1 Equipment for arc welding

a) Identification and assembly of essential components and equipment;

b) Type of welding current;

c) Correct connection of the welding return cable.

B.2.2 Welding process[2])

B.2.2.1 Metal-arc welding with covered electrode (111)

a) Handling and drying of electrodes;

b) Differences of types of electrodes.

B.2.2.2 Gas-shielded metal-arc welding (114, 131, 135, 136, 137, 141, 15)

a) Types and size of electrodes;

b) Identification of shielding gas and flow rate (without 114);

c) Type, size and maintenance of nozzles/contact tip;

d) Selection and limitations of mode of metal transfer;

e) Protection of the welding arc from draughts.

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[2]) The numbers refer to EN ISO 4063.

B.2.3 Parent metals

a) Identification of material;
b) Methods and control of pre-heating;
c) Control of interpass temperature.

B.2.4 Consumables

a) Identification of consumables;
b) Storage, handling and conditions of consumables;
c) Selection of correct size;
d) Cleanliness of electrodes and flux-cored electrodes;
e) Control of wire spooling;
f) Control and monitoring of gas flow rates and quality.

B.2.5 Safety and accident prevention

B.2.5.1 General

a) Safe assembly, setting up and closing down procedures;
b) Safe control of welding fumes and gases;
c) Personal protection;
d) Fire hazards;
e) Welding in confined spaces;
f) Awareness of welding environment.

B.2.5.2 All arc processes

a) Environment of increase hazard of electric shock;
b) Radiation from the arc;
c) Effects of stray arcing.

B.2.5.3 Gas-shielded metal-arc welding

a) Safe storage, handling and use of compressed gases;
b) Leak detection on gas hoses and fittings.

B.2.6 Welding sequences/procedures

Appreciation of welding procedure requirements and the influence of welding parameters.

B.2.7 Edge preparation and weld representation

a) Conformance of weld preparation to procedure specification (WPS);
b) Cleanliness of fusion faces;

B.2.8 Weld imperfections

a) Identification of imperfections;
b) Causes;
c) Prevention and remedial action.

B.2.9 Diver-welder or welding operator approval

The diver-welder or welding operator shall be aware of the range of the approval.

ICS 25.160.01

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