



BSI Standards Publication

Qualification test of welders - Fusion welding

Part 6: Cast irons

National foreword

This British Standard is the UK implementation of EN 287-6:2018. It supersedes BS EN 287-6:2010, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/36, Qualification of welding personnel and welding procedures.

A list of organizations represented on this committee can be obtained on request to its secretary.

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European foreword

This document (EN 287-6:2018) has been prepared by Technical Committee CEN/TC 190 “Foundry Technology”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by October 2018, and conflicting national standards shall be withdrawn at the latest by October 2018.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 287-6:2010.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 13 “Welding of cast iron” to revise the following standard:

EN 287-6: 2010, *Qualification test of welders — Fusion welding — Part 6: Cast iron*

The following modifications were made:

- Normative references revised;
- Subclause 4.2: Process designations brought in accordance with EN ISO 4063 and welding processes "138" and "143" added;
- Subclause 5.5: Last paragraph revised;
- Subclause 6.5: Table 2 revised;
- Subclause 6.6: Revised and Tables 4 and 5 inserted;
- Subclause 7.4 Table 6: NOTE added;
- Subclause 7.5.2: Tolerances added in Figures 1, 2a), 3, 4a) and 5; "F" and Key added in Figures 2b), 2d) and 4b);
- Annex A: Title changed in “Material groups of cast irons (relating to CEN ISO/TR 15608:2017);
- Annex A: Table A.1 revised;
- Annex C, C.2.2.4: Welding processes "138" and "143" added;
- Bibliography revised.

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

Introduction

The ability of a welder to follow written instructions and verification of a person's skills are important factors in ensuring the quality of a welded product.

The testing of a welder's skill in accordance with this standard depends on welding techniques and conditions used in which uniform rules are complied with, and standard test pieces are used.

The principle of this European Standard is that a qualification test qualifies the welder not only for the conditions used in the test, but also for all joints which are considered easier to weld on the presumption that the welder has received a specific training and/or has industrial practice within the range of qualification.

The qualification test can be used to qualify a welding procedure and a welder provided that all the relevant requirements, e.g. test piece dimensions, are satisfied.

1 Scope

This document specifies main requirements, limits, inspection conditions and acceptance requirements as well as related inspection documents of welders for welded cast iron test pieces and workpieces.

It provides a set of technical rules for a systematic qualification test of a welder's skills, and enables such qualifications to be uniformly accepted independently of the type of product, location and examiner or examining body.

This document specifies the testing of a welder's skill unless a higher level skill test is required.

The acceptance of a welder's skill in accordance with this document implies a practical experience and knowledge regarding the welding process, materials and safety requirements (see Annex C).

This document is to be used when requirements on part of a customer, testing or monitoring body or other organization are postulated.

This document defines the qualification test of welders for the fusion welding of cast irons. The welding processes referred to in this standard include those fusion welding processes which are designated as manual or partly mechanized welding. It does not cover fully mechanized and automated welding processes (see EN ISO 14732). Cast iron materials which are covered by this document are mentioned in 5.4.

The inspection document and certification are made out under the responsibility of the testing body.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CEN ISO/TR 15608:2017, *Welding — Guidelines for a metallic materials grouping system (ISO/TR 15608:2017)*

EN 1011-8, *Welding — Recommendations for welding of metallic materials — Part 8: Welding of cast irons*

EN ISO 1071, *Welding consumables — Covered electrodes, wires, rods and tubular cored electrodes for fusion welding of cast iron — Classification (ISO 1071)*

EN ISO 3452-1, *Non-destructive testing — Penetrant testing — Part 1: General principles (ISO 3452-1)*

EN ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063)*

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

EN ISO 6947, *Welding and allied processes — Welding positions (ISO 6947)*

EN ISO 9017, *Destructive tests on welds in metallic materials — Fracture test (ISO 9017)*

EN ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels (ISO 9606-1)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding (ISO 15609-1)*

EN ISO 15609-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 2: Gas welding (ISO 15609-2)*

EN ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints (ISO 17637)*

EN ISO 17638, *Non-destructive testing of welds — Magnetic particle testing (ISO 17638)*

EN ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds (ISO 17639)*

ISO/TR 25901-3, *Welding and allied processes — Vocabulary - Part 3: Welding processes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 9606-1 apply.

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

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

4 Symbols and abbreviations

4.1 General

Where the full wording is not used, the following abbreviations and reference numbers shall be used when completing the welder's qualification test certificate (see Annex B).

4.2 Reference numbers of welding processes

This European Standard covers the following manual or partly mechanized welding processes (reference numbers of the symbolic designation of welding processes are listed in EN ISO 4063):

- 111 Manual metal arc welding;
- 114 Self-shielded tubular cored arc welding;
- 131 MIG welding with solid wire electrode;
- 135 MAG welding with solid wire electrode;
- 136 MAG welding with flux cored electrode;
- 138 MAG welding with metal cored electrode;
- 141 TIG welding with solid filler material (wire/rod);
- 143 TIG welding with tubular cored filler material (wire/rod);
- 15 Plasma arc welding;
- 311 Oxyacetylene welding.

4.3 Abbreviations

4.3.1 Test pieces

<i>a</i>	designed fillet weld thickness;
BW	butt weld;
FW	fillet weld;
CPC	simulated crack (<u>c</u> ast iron <u>p</u> late <u>c</u> rack);
CPH	tapped blind hole (<u>c</u> ast iron <u>p</u> late <u>h</u> ole);
<i>t</i>	material thickness of test piece (plate or wall thickness);
<i>z</i>	leg length of fillet weld.

4.3.2 Consumables

FeC-1	similar welding consumable;
FeC-2	similar welding consumable;
FeC-GF	similar welding consumable;
FeC-GP	similar welding consumable;
Fe1	iron based consumable;
Fe2	iron based consumable;
Ni	nickel based consumable;
NiFe-1	nickel based consumable;
NiFe-2	nickel based consumable;
NiCu	nickel based consumable;
Z	any concerted consumable.

NOTE See EN ISO 1071.

4.3.3 Other weld details

hw	homogeneous weld metal;
sw	semi-homogeneous weld metal;
nw	non-homogeneous weld metal;
bs	welding from both sides;
ss	single-side welding;
gg	gouging or grinding of root run;
ng	without gouging or grinding;
mb	welding with backing;
nb	welding without backing.

5 Essential variables

5.1 General

The qualification of welders is based on essential variables. For each essential variable, a range of qualification is defined. All test pieces shall be welded using the essential variables independently. The test piece for the qualification test is unattached from the type of component.

5.2 Welding processes

The welding processes are defined in ISO/TR 25901-3 (see also 4.2).

5.3 Type of weld and joint preparation

For those butt and fillet weld test pieces made of cast iron plates with tapped blind holes and for those test pieces made of cast iron with simulated cracks the qualification test shall be made in accordance with 7.2.

5.4 Material groups

5.4.1 General

In order to reduce the number of qualification tests, materials with similar welding characteristics are grouped in accordance with CEN ISO/TR 15608 (see also 5.4.2).

5.4.2 Cast iron groups

According to the operational requirements the following cast iron materials are relevant.

Cast iron groups in accordance with CEN ISO/TR 15608:

- 71 grey (lamellar graphite) cast irons;
- 72 spheroidal graphite cast irons;
- 73 malleable cast irons;
- 74 austempered ductile cast irons;
- 75 austenitic cast irons;
- 76 other cast iron materials.

5.5 Weld metals

It is differentiated between homogeneous weld metal (hw), semi-homogeneous weld metal (sw) and non-homogeneous weld metal (nw).

For the qualification test, suitable consumables shall be selected in view of the parent metal and the welding process.

The welding process shall conform to the relevant pWPS or WPS (see EN ISO 15609-1 and EN ISO 15609-2).

If a qualification test is made by using one kind of welding consumables, shielding gases or fluxes the test will also be accepted for the same cast iron material group for welding consumables, shielding gases or welding fluxes with the same designation in accordance with the appropriate European Standard for the consumable, shielding and flux concerned.

5.6 Welding positions

The welding position shall be chosen in accordance with Figure C.1. The welding positions and symbols refer to EN ISO 6947. The test pieces shall be welded in accordance with the nominal angles of the welding positions in accordance with EN ISO 6947.

6 Range of qualification

6.1 General

As a basic principle the qualification test of a welder not only covers the referring test piece and the skill for these special variables, it also covers joints and appropriate variables which are easier to create.

6.2 Welding process

Each qualification test refers to one welding process. A change of the welding process requires a new qualification test.

6.3 Welding position

The welding position PB includes the position PA.

The welding position PC includes the positions PA and PB.

The welding position PF includes the positions PB and PA.

NOTE The positions of weld are illustrated in Figure C.1.

6.4 Cast iron material groups

See CEN ISO/TR 15608 (see also Table A.1).

The range of qualification is given in Table 1.

Table 1 — Range of qualification for test pieces

Material groups of test pieces	Range of qualification for material group								
	71	72.1	72.2	72.3	72.4	73.1	73.2	73.3	74
71	X	X	X	X	X	X	X	X	
72.1		X	X			X	X	X	
72.2		X	X			X	X	X	
72.3		X	X	X		X	X	X	
72.4		X	X	X	X	X	X	X	
73.1						X			
73.2		X	X	X	X	X	X		
73.3		X	X	X	X	X	X	X	
74									X

6.5 Test piece

The qualification test at a test piece CPH authorizes the welder for welds up to $0,25 \times$ wall thickness (t) and a total area of 25 cm^2 at the surface in accordance with Table 2.

The correlation of permitted welding operations is given in Table 2.

Table 2 — Correlation of permitted welding operations

	Type of weld/test pieces		
	CPH	BW, FW	CPC
Competence for permitted welding operation	Rework of imperfections close to the surface and surface imperfections.	Joint welding	Rework of persistent cracks and other imperfections by welding.
Depth of re-workable irregularities/imperfections	$0,25 \times t$	Unlimited	Unlimited
Total local area	25 cm^2	Unlimited	Unlimited

The range of validity for the different welding operations and test pieces is given in Table 3.

Table 3 — Range of validity of the welded test piece

Type of weld	Range of validity for permitted welding operations			
	CPH	FW	BW	CPC
CPH	X			
FW	X	X		
BW	X	X	X	
CPC	X			X

6.6 Type of welding consumables

For homogeneous, semi-homogeneous and non-homogeneous weld metal separate qualification tests shall be carried out. The types of weld deposits and welding consumables are given in Table 4.

Table 4 — Types of weld deposits and welding consumables

Type of weld deposit see 4.3.3	Type of welding consumable see 4.3.2
Homogeneous (hw)	FeC-1; FeC-2; FeC-GF; FeC-GP
Semi-homogeneous (sw)	Fe1; Fe2
Non-homogeneous (nw)	Ni; NiFe-1; NiFe-2, NiCu

The range of approval for the "Type of weld deposit - mode of operation" is given in Table 5.

Table 5 — Type of weld deposit - mode of operation

"Type of weld deposit - mode of operation", test pieces (4.3.3)	Range of qualification		
	hw	sw	nw
hw	x	—	—
sw	—	x	—
nw	—	—	x
X indicates those weld deposits types for which the welder is qualified. — indicates those weld deposits types for which the welder is not qualified.			

7 Procedure of the qualification test and examination

7.1 Supervision

The welding of test pieces shall be witnessed by the examiner or examining body. The testing shall be verified by the examiner or examining body.

The test pieces shall be marked with the identification of the examiner and the welder 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 welder does not have the skill to fulfil the requirements of this European Standard.

7.2 Shapes and dimensions of test pieces

The shapes and dimensions of test pieces required are shown in Figures 1, 3, 5 and 6.

7.3 Welding conditions

Preparation and welding shall be in accordance with a pWPS or WPS in accordance with EN ISO 15609-1 and EN ISO 15609-2. Before generating pWPS or WPS the following conditions shall be fulfilled:

- a) welding process(es) of the qualification test(s) shall be similar to the process(es) in practice;
- b) assortment of welding consumables shall be aligned to welding position and welding process, e.g. welding with non-homogeneous filler metal NiFe1 in accordance with EN ISO 1071;
- c) joint preparation and dimensions of cast iron test piece(s) shall be in accordance with Figures 1, 3, 5 and 6;
- d) welding position(s) shall be similar to the position(s) in practice (Figure C.1);
- e) assessment of weld shall be in accordance with Clause 8;
- f) welding time for the test piece shall correspond to the working time under usual production conditions.

BW and CPC test pieces shall be in accordance with this European Standard single-side welds.

7.4 Range of testing

Finished welds are to be visually tested (see EN ISO 17637) before any further treatments. If necessary, the visual testing can be supplemented by magnetic particle testing (see EN ISO 17638) or penetrant testing (see EN ISO 3452-1) or macroscopic examination (macro-section) (see EN ISO 17639). The range of testing is given in Table 6.

Table 6 — Range of testing

Test method	Test pieces			
	BW	FW	CPC	CPH
Visual test	X	X	X	X
Fracture test	X	X ^a	—	—
Macro-section (without polishing)	+	+	X	X
Magnetic particle/ Penetrant testing	X	X	X	X
X mandatory + optional				
NOTE Other test methods e.g. radiographic testing and ultrasonic testing can give additional information.				
^a The fracture test can be replaced by 4 macroscopic examinations.				

7.5 Test pieces and test specimen

7.5.1 General

In 7.5.2 to 7.5.5 details of the type, dimensions and preparation of the test piece(s) and test specimen are given. In addition, the requirements for destructive tests are indicated.

7.5.2 Butt weld of cast iron plate (BW)

When fracture tests in accordance with EN ISO 9017 shall be made, the examination range shall include the total testing area. For this reason, the test piece shall be divided into two parts (Figure 2 a)). The length of the fracture test specimen is approximately 65 mm. If necessary, the weld reinforcement can be removed, and starting and ending point of the weld can be notched (approximately 5 mm, Figure 2 b)). For single-side welds (ss) without backing (nb) half of the examination length should be within the face and the other half within the root layer (Figures 2 c) and 2 d)).

Dimensions in millimetres

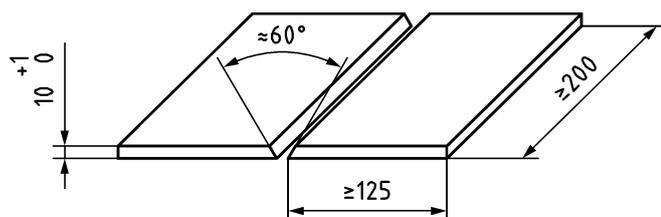
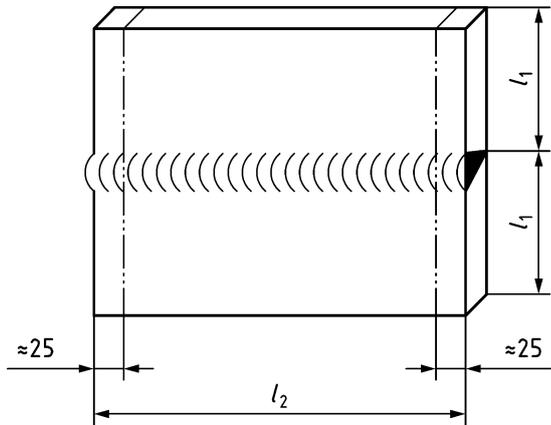
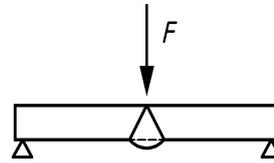


Figure 1 — Butt weld

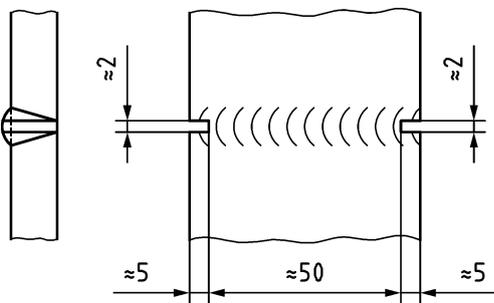
Dimensions in millimetres



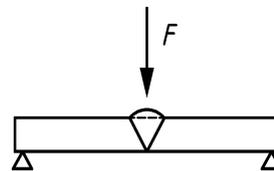
a) segmenting in two test specimen



b) top side fracture test



c) preparation



d) root fracture test

Key

F force direction

Figure 2 — Preparation of butt welded cast iron plate test pieces for fracture test

7.5.3 Fillet weld of cast iron plate (FW)

According to EN ISO 9017 the test piece for the fracture test can be divided into several test areas (Figure 4 a)). Each test area shall be prepared and examined after the fracture test in accordance with Figure 4 b)).

Dimensions in millimetres

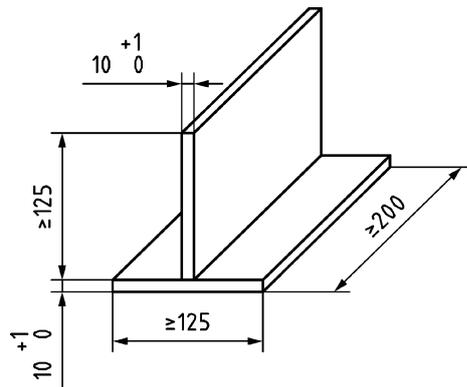
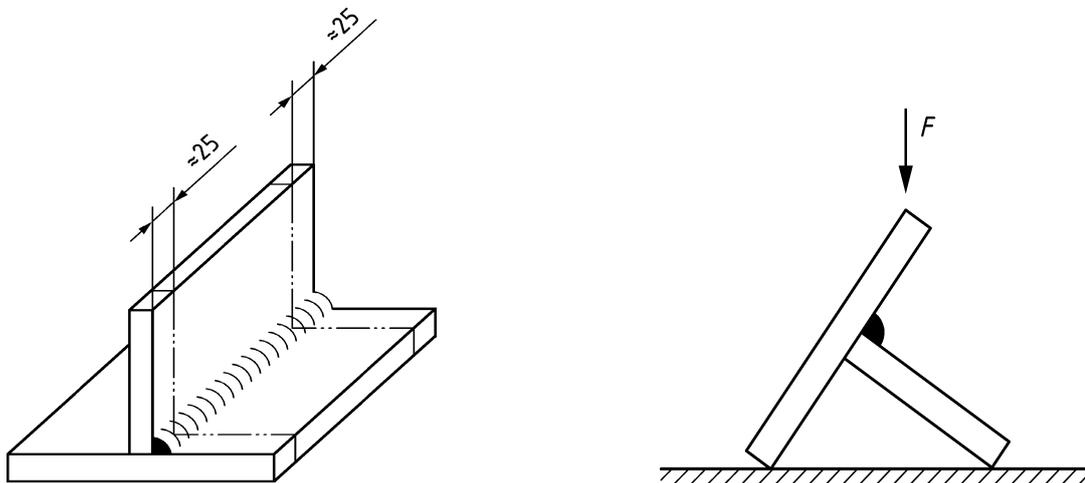


Figure 3 — Fillet weld

Dimensions in millimetres



a) even-numbered preparation

b) fracture test notching of root possible

Key

F force direction

Figure 4 — Preparation and fracture test at fillet welds of cast iron plates

7.5.4 Cast iron plate with tapped blind hole (CPH)

In accordance with Figure 5.

Macro-section through the centre of the welded hole.

Dimensions in millimetres

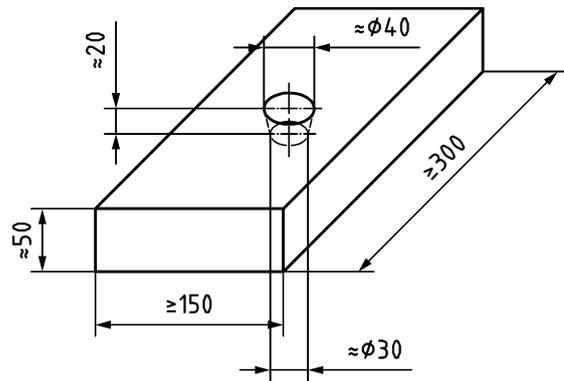


Figure 5 — Cast iron plate (CPH)

7.5.5 Cast iron plate with crack (CPC)

In accordance with Figure 6.

Macro-section transverse to the welded simulated crack.

Dimensions in millimetres

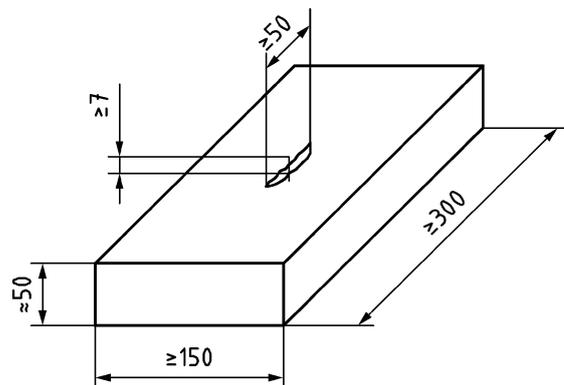


Figure 6 — Cast iron plate (CPC)

8 Acceptance requirements for test pieces

Test pieces shall be evaluated to the acceptance requirements specified for relevant types of imperfections.

A complete explanation of imperfections can be found in EN ISO 6520-1.

The acceptance requirements for imperfections found by test methods in accordance with this standard shall, unless otherwise specified, be assessed in accordance with EN 1011-8. A welder is qualified if the imperfections are within quality level B in EN 1011-8.

If the imperfections in the welder's test piece exceed the permitted maximum specified, then the welder fails the test.

9 Re-test

If any test fails to comply with the requirements of this European Standard, the welder shall be given the opportunity to repeat the qualification test. If it is established that failure is due to metallurgical or other extraneous causes that cannot be directly attributed to the welder's lack of skill, an additional test is 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 qualification

The validity of the welders qualification begins from the date of welding of the test piece(s).

This is providing that the required testing has been carried out and the test result obtained were acceptable.

10.2 Confirmation of the validity

The welder's qualification test certificate issued is valid for a period of two years. This is providing that the welding co-ordinator or the responsible personnel of the employer can confirm that the welder has been working within the initial range of qualification. This shall be confirmed every six months.

10.3 Prolongation of qualification

Welder's qualification test certificates in accordance with this standard can be prolonged every two years by an examiner/examination body.

Before prolongation of the certification takes place, 10.2 needs to be satisfied and also the following conditions need to be confirmed:

- a) all records and evidence used to support prolongation are traceable to the welder and identifies the WPS'(s) that have been used in production;
- b) evidence used to support prolongation shall be of a volumetric nature (radiographic testing or ultrasonic testing) or for destructive testing (fracture or bends) made on two welds during the previous six months. Evidence relating to prolongation needs to be retained for a minimum of two years;
- c) the welds shall satisfy the acceptance levels for imperfections as specified in Clause 8;
- d) the test results mentioned in 10.3 b) shall demonstrate that the welder has reproduced the original test conditions.

11 Certificate

It shall be verified that the welder has successfully passed the qualification test. All essential variables shall be recorded on the certificate. If the test piece(s) fail(s) any of the required tests, no certificate shall be issued.

The certificate shall be issued under the sole of responsibility of the examiner or examination body and shall contain all information detailed in Annex B. The format of this Annex B is recommended to be used as the welder's qualification test certificate. If any other form of welder's qualification is used, it shall contain the information required in Annex B.

In general, for each test piece a separate welder's qualification test certificate shall be issued.

Other essential variables are not allowed to be changed.

It shall be ensured that the welder's qualification test certificate cannot lead to ambiguity. Therefore, it is recommended to issue the welder's qualification test certificate in at least one of the languages English, French or German in combination with any other language, if necessary.

The practical test and the examination of job knowledge (Annex C) shall be designated by "accepted" or "not tested".

Each change of the essential variables for the qualification test beyond the permitted ranges requires a new test and a new welder's qualification test certificate.

12 Designation

The designation of a welder qualification shall comprise the following items in order given (the system is arranged so that it can be used for computerization):

- a) the number of this standard;
- b) the essential variables:
 - 1) welding process; refer to 5.2 and EN ISO 4063;
 - 2) type of weld: butt weld (BW), fillet weld (FW), tapped blind hole (CPH), simulated crack (CPC) refer to 5.3;
 - 3) material group: refer to 5.4;
 - 4) welding consumables: refer to 4.3.2;
 - 5) welding position: refer to 5.6 and EN ISO 6947;
 - 6) execution of weld: refer to 4.3.3 and 6.3.

EXAMPLE Designation:

Welder qualification EN 287-6 111 BW 71 nw PA ss nb

Explanation:

Welding process:	manual metal arc welding	111
Butt weld:		BW
Material group:	grey cast iron	71
Welding consumables:	non-homogeneous weld metal	nw
Welding position:	flat position	PA
Execution of weld:	single side weld	ss
	without backing	nb

Abbreviations taken from Clause 4.

Annex A
(informative)

Material groups of cast irons (relating to CEN ISO/TR 15608:2017)

Table A.1 — Material group and number

Group	Sub-group	Type of cast iron
71	—	Grey cast irons with specified tensile strength or Brinell hardness
72	—	Spheroidal-graphite cast irons with specified mechanical properties
	72.1	Spheroidal-graphite cast irons, ferrite type, with specified tensile strength, 0,2 % proof stress, elongation and specified impact resistance values
	72.2	Spheroidal-graphite cast irons, ferrite type, with specified tensile strength, 0,2 % proof stress and elongation or specified Brinell hardness
	72.3	Spheroidal-graphite cast irons EN-GJS-500-7 and EN-GJS-450-10 (if > 20 % perlite) or specified Brinell hardness
	72.4	Spheroidal-graphite cast irons, perlite type, with specified tensile strength, 0,2 % proof stress and elongation or specified Brinell hardness
73	—	Malleable cast irons
	73.1	Weldable whiteheart malleable cast irons, in wall thicknesses up to 8 mm decarburized to C-contents $\leq 0,3$ %
	73.2	Whiteheart malleable cast irons
	73.3	Blackheart malleable cast irons
74	—	Austempered ductile cast irons
75	—	Austenitic cast irons
76	—	Other cast irons excepting groups 71 to 75

Annex B
(informative)

Welder's qualification test certificate

Designation(s):

.....

WPS – Reference:

Examiner or examining body – Reference No.:

Welder's Name:

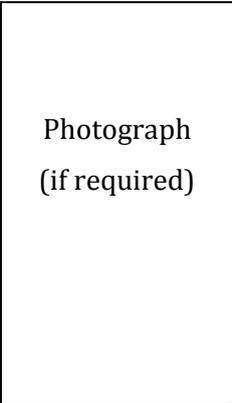
Identification:

Method of identification:

Date and place of birth:

Employer:

Code/Testing Standard:



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

	Test piece	Range of qualification
Welding process(es)		
Type of test piece		
Type of weld		
Material group(s)		
Welding consumable (Designation)		
Shielding gas		-----
Auxiliaries (e.g. backing gas)		-----
Welding position		
Weld details		

Type of qualification tests	Performed and accepted	and Not tested	Name of examiner or examining body:
Visual testing Radiographic testing Fracture test Bend test Macroscopic examination			Place, date and signature of examiner or examining body: Date of welding: Validity of qualification until:

Confirmation of the validity by employer/welding co-ordinator for the following 6 month (refer to 10.2)

Date	Signature	Position or title

Prolongation for qualification by examiner or examining body for the following 2 years (refer to 10.3)

Date	Signature	Position or title

Annex C (informative)

Job knowledge

C.1 General

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

However, some countries can require that the welder undergo a test of job knowledge. If the job knowledge test is carried out, it should be recorded on the welder's qualification test certificate.

This annex outlines the job knowledge that a welder 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 C.2, relevant to the qualification test of welders.

The actual tests of a welder's job knowledge can 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.

C.2 Requirements

C.2.1 Welding equipment

C.2.1.1 Oxyacetylene welding

- a) Identification of gas cylinders;
- b) identification and assembly of essential components;
- c) selection of correct nozzles and welding torches.

C.2.1.2 Arc welding

- a) Identification and assembly of essential components and equipment;
- b) type of welding current;
- c) correct connection of the welding return cable.

C.2.2 Welding process¹⁾

C.2.2.1 Oxyacetylene welding (311)

- a) Gas pressure;
- b) selection of nozzle type;
- c) type of gas flame;
- d) effect of overheating;
- e) maximum allowable quantity of gas.

C.2.2.2 Metal arc welding with covered electrode (111)

- a) Handling and drying of electrodes;
- b) differences of types of electrodes.

C.2.2.3 Self-shielded tubular cored arc welding (114)

- a) Types and size of electrodes;
- b) type, size and maintenance of nozzles/contact tip;
- c) selection and limitations of mode of metal transfer;
- d) protection of the welding arc from draughts.

C.2.2.4 Gas-shielded metal arc welding, tungsten inert gas welding, plasma arc welding (131, 135, 136, 138, 141, 143 and 15)

- a) Types and size of electrodes;
- b) identification of shielding gas and flow rate;
- 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.

C.2.3 Parent metals

- a) Basic principles of cast irons;
- b) classification of base metals of cast iron materials in accordance with CEN ISO/TR 15608;
- c) methods and control of preheating;
- d) control of interpass temperature;
- e) control of cooling rate.

1) The numbers refer to EN ISO 4063.

C.2.4 Welding consumables

- a) Classification of filler metals, e.g. in accordance with EN ISO 1071;
- b) storage, handling and conditions of welding consumables;
- c) selection of correct size;
- d) cleanliness of electrodes and filler wires;
- e) control of wire spooling;
- f) control and monitoring of gas flow rates and quality.

C.2.5 Safety precautions

C.2.5.1 General

- a) Safe assembly, setting up and turn off 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.

C.2.5.2 Oxyacetylene welding

- a) Safe storage, handling and use of compressed gases;
- b) leak detection on gas hoses and fittings;
- c) measure to be taken in the event of a flashback.

C.2.5.3 All arc welding processes

- a) Environment of increase hazard electric shock;
- b) radiation from the arc;
- c) irritated welding current.

C.2.5.4 Shielded gas arc welding

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

C.2.6 Welding sequences/procedures

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

C.2.7 Joint preparation and weld representation

- a) Conformance of joint preparation to the welding procedure specification (WPS);
- b) cleanliness of fusion faces.

C.2.8 Weld imperfections

- a) Identification of imperfections;
- b) causes;
- c) prevention and remedial action.

C.2.9 Range of welder qualification

The welder should be aware of the range of his/her qualification.

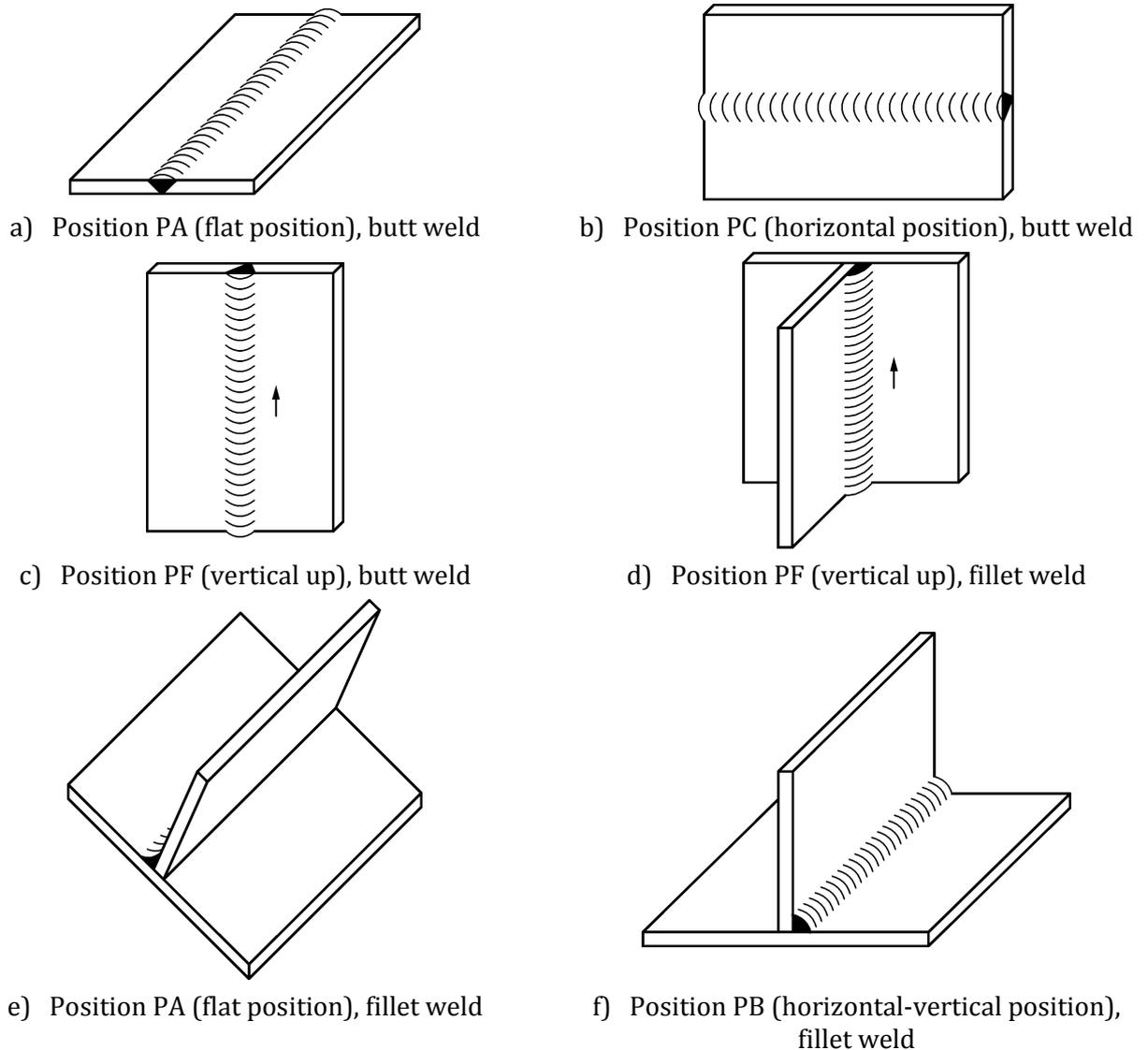


Figure C.1 — Weld positions

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