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Specification and qualification of welding procedures for metallic materials — General rules

*Descriptif et qualification d'un mode opératoire de soudage pour les
matériaux métalliques — Règles générales*

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Foreword

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ISO 15607 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*, 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...”.

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Foreword

This document (EN ISO 15607:2003) 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 EN ISO 15607:2003 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2004, and conflicting national standards shall be withdrawn at the latest by April 2004.

This document supersedes EN 288-1:1992.

Annexes A, B and C are informative.

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Welding procedure specifications are needed in order to provide a well defined basis for planning of the welding operations and for quality control during welding. Welding is considered a special process in the terminology of standards for quality systems. Standards for quality systems usually require that special processes be carried out in accordance with written procedure specifications.

Preparation of a welding procedure specification provides the necessary basis for, but does not in itself ensure that the welds fulfil the requirements. Some deviations, notably imperfections and distortions, can be evaluated by non-destructive methods on the finished product.

Metallurgical deviations constitute a special problem, however, because non-destructive evaluation of the mechanical properties is impossible at the present level of non-destructive technology, this has resulted in the establishment of a set of rules for qualification of the welding procedure prior to the release of the specification to actual production. This European Standard defines these rules.

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1 Scope

This European Standard is part of a series of standards. Annex A gives details of this series of standard, annex B gives a flowchart for the use of these standards and Annex C gives a flow diagram for the development and qualification of a WPS.

This standard defines general rules for the specification and qualification of welding procedures for metallic materials. This standard also refers to several other standards as regards detailed rules for specific applications.

This standard is applicable to manual, mechanized and automatic welding.

Welding procedures are qualified by conforming to one or more welding procedure qualification records (WPQR). The use of a particular method of qualification is often a requirement of an application standard.

Qualification of pWPS by more than one method is not recommended. It is assumed that welding procedure specifications are used in production by competent welders, qualified in accordance with the relevant part of EN 287 or EN ISO 9606 or by competent operators qualified in accordance with EN 1418.

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 ISO 4063, *Welding and allied processes – Nomenclature of processes and reference numbers*. (ISO 4063:1998)

EN ISO 14555, *Welding — Arc stud welding of metallic materials*. (ISO 14555:1998).

prEN ISO 15609-1, *Specification and approval of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding* (ISO/DIS 15609-1:2000).

EN ISO 15609-2, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 2: Gas welding* (ISO 15609-2:2001).

prEN ISO 15609-3, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 3: Electron beam welding* (ISO/DIS 15609-3:2000).

prEN ISO 15609-4, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 4: Laser beam welding* (ISO/DIS 15609-4:2000).

prEN ISO 15609-5, *Specification and approval of welding procedures for metallic materials - Welding procedure specification - Part 5: Resistance welding* (ISO/DIS 15609-5:2000).

EN ISO 15610, *Specification and qualification of welding procedures for metallic materials - Qualification based on tested welding consumables* (ISO 15610:2003).

EN ISO 15611, *Specification and qualification of welding procedures for metallic materials - Qualification based on previous welding experience* (ISO 15611:2003).

prEN ISO 15612, *Specification and qualification of welding procedures for metallic materials - Approval by a standard welding procedure* (ISO/DIS 15612:2000).

EN ISO 15613, *Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production test* (ISO 15613:2000).

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2003).*

prEN ISO 15614-2, *Specification and approval of welding procedures for metallic materials - Welding procedure tests - Part 2: Arc welding of aluminium and its alloys (ISO/DIS 15614-2:2000).*

prEN ISO 15614-3, *Specification and qualification of welding procedures for metallic materials - Welding procedure tests - Part 3: Welding procedure tests for the arc welding of cast iron (was submitted to CEN Enquiry as prEN 288-12).*

prEN ISO 15614-4, *Specification and qualification of welding procedures for metallic materials - Welding procedure tests - Part 4: Finishing welding of aluminium castings (was submitted to CEN Enquiry as prEN 288-13).*

prEN ISO 15614-5, *Specification and approval of welding procedures for metallic materials - Welding procedure tests - Part 5: Arc welding of titanium, zirconium and their alloys (ISO/DIS 15614-5:2000).*

prEN ISO 15614-6, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 6: Copper and copper alloys.*

EN ISO 15614-8, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 8: Welding of tubes to tube-plate joints (ISO 15614-8:2002).*

prEN ISO 15614-9, *Specification and qualification of welding procedures for metallic materials - Welding procedure tests - Part 9: Underwater hyperbaric wet welding (ISO/DIS 15614-9:2000).*

prEN ISO 15614-10, *Specification and approval of welding procedures for metallic materials - Welding procedure test - Part 10: Hyperbaric dry welding (ISO/DIS 15614-10:2000).*

EN ISO 15614-11, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 11: Electron and laser beam welding (ISO 15614-11:2002).*

prEN ISO 15614-12, *Specification and approval of welding procedures for metallic materials - Welding procedure tests - Part 12: Spot, seam and projection welding (ISO/DIS 15614-12:2000).*

prEN ISO 15614-13, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 13: Resistance butt and flash welding (ISO/DIS 15614-13:2002).*

EN ISO 15620, *Welding - Friction welding of metallic materials (ISO 15620:2000).*

ISO 857-1, *Welding and allied processes — Vocabulary — Part 1: Metal welding processes.*

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

3.1

welding procedure

specified course of action to be followed in making a weld, including the welding process(es), reference to materials, welding consumables, preparation, preheating (if necessary), method and control of welding and post-weld heat treatment (if relevant), and necessary equipment to be used

3.2

welding process

for the welding processes, the nomenclature and definitions given in ISO 857-1 are followed in this standard. The numbering system for welding processes in EN ISO 4063 is also followed

3.3**preliminary welding procedure specification (pWPS)**

a document containing the required variables of the welding procedure which has to be qualified has to be qualified using one of the methods described in accordance with clause 6

3.4**welding procedure specification (WPS)**

a document that has been qualified by one of the methods described in clause 6 and provides the required variables of the welding procedure to ensure repeatability during production welding.

3.5**work instruction**

simplified specification of the welding procedure, suitable for direct application in the workshop

3.6**welding procedure qualification record (WPQR)**

record comprising all necessary data needed for qualification of a preliminary welding procedure specification

3.7**welding procedure test**

making and testing of a standardized test piece, as indicated in the pWPS, in order to qualify a welding procedure

3.8**pre-production welding test**

welding test having the same function as a welding procedure test, but based on a non-standard test piece representative of the production conditions

3.9**standard welding procedure specification**

welding procedure specification which has been qualified by a welding procedure test not related to the manufacturer and qualified by an examiner or examining body

NOTE

A standard welding procedure may then be made available to any manufacturer.

3.10**previous welding experience**

when it can be shown by authenticated test data that the manufacturer's established production welding procedures have been capable of consistently producing welds of acceptable quality over a period of time

3.11**tested welding consumable**

welding consumable or consumable combination tested according to appropriate standards for testing of welding consumables

3.12**welding consumable**

materials consumed in the making of a weld, including filler metals and auxiliary materials

3.13**essential variable**

welding condition that requires qualification

3.14**non essential variable**

welding condition addressed in the WPS but not requiring qualification

3.15**range of qualification**

extent of qualification for an essential welding variable

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3.16

parent material

material(s) to be joined by welding

3.17

test piece

welded assembly which is used for testing purposes

3.18

test specimen

part or portion cut from the test piece in order to perform a specified destructive test

3.19

homogeneous joint

welded joint in which the weld metal and parent material have no significant differences in mechanical properties and/or chemical composition

NOTE A welded joint made of similar parent materials without filler metal is considered homogeneous.

3.20

heterogeneous joint

welded joint in which the weld metal and parent material have significant differences in mechanical properties and/or chemical composition

3.21

dissimilar material joint

welded joint in which the parent materials have significant differences in mechanical properties and/or chemical composition

3.22

imperfection

discontinuity in the weld or a deviation from the intended geometry. Imperfections are, e.g. cracks, lack of penetration, porosity, slag inclusions

NOTE EN ISO 6520-1 and EN ISO 6520-2 contain comprehensive lists of imperfections.

3.23

manufacturer

person or organization responsible for the welding production

3.24

examiner

person who has been appointed to verify compliance with the applicable standard

NOTE In certain cases, an external independent examiner can be required

3.25

examining body

organisation that has been appointed to verify compliance with the applicable standard

NOTE In certain cases, an external independent examining body can be required

3.26

manufacturer of consumables

party who manufactures the consumables totally or performs the final part of production, which determines the quality of the consumables

3.27

welding co-ordination personnel

personnel who have responsibilities in the manufacturing operation for welding and welding related activities whose competence and knowledge has been demonstrated by e.g. training, education and/or relevant manufacturing experience

3.28**heat input**

energy introduced into the weld region during welding

3.29**parent material thickness**

nominal thickness of the materials to be welded

3.30**weld metal thickness**

thickness of the weld metal excluding any reinforcement

4 Abbreviations

For the purposes of qualification of welding procedures, the abbreviations listed in Table 1 apply.

Table 1 — Abbreviations

Abbreviation	Description
pWPS	Preliminary Welding Procedure Specification
WPQR	Welding procedure Qualification Record
WPS	Welding Procedure Specification

5 Welding procedure specification format

prEN ISO 15609-1, EN ISO 15609-2, prEN ISO 15609-3, prEN ISO 15609-4 and prEN ISO 15609-5 define a format for the welding procedure specifications for the following welding processes:

- arc welding;
- gas welding;
- electron beam welding;
- laser beam welding;
- resistance welding.

WPS for other welding processes and for special applications may be covered by specific standards, for example :

- for stud welding, see EN ISO 14555;
- for friction welding, see EN ISO 15620.

WPS shall be classified as pWPS until qualified using an appropriate method in accordance with clause 6.

6 Development and qualification of welding procedures**6.1 General**

Qualification of welding procedures shall be performed prior to actual welding in production.

The manufacturer shall prepare a pWPS and shall ensure that it is applicable for the actual production, using experience from previous productions and the general fund of knowledge of welding technology.

Each pWPS shall be used as a basis for establishment of WPQR qualified according to one of the methods listed in Table 2.

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Table 2 — Methods of qualification

Method based on	Application
Welding Procedure test (see 6.2)	Can always be applied, unless the procedure test does not adequately correspond to the joint geometry, restraint, accessibility of the actual welds.
Tested welding consumables (see 6.3)	Application is limited to welding procedures using consumables. The testing of the consumables shall cover the parent material used in production. Further limitations as regards material and other parameters are specified in EN ISO 15610.
Previous welding experience (see 6.4)	Application is limited to procedures used previously for a large number of welds in comparable items, joints and materials. Requirements are specified in EN ISO 15611.
Standard welding procedure (see 6.5)	Similar to welding procedure test and limitations are specified in prEN ISO 15612.
Pre-production welding test (see 6.6)	Can always be applied in principle but requires manufacture of a test piece under production conditions. Suitable for mass production. Requirements are specified in EN ISO 15613.
NOTE: For the choice of a particular method, see clause 1.	

If the qualification involves welding of test pieces, then the test pieces shall be welded in accordance with the pWPS.

The WPQR shall comprise all variables (essential and non essential) as well as the specified ranges of qualification given in the appropriate standard. On basis of the WPQR, the WPS for production welding is developed under the responsibility of the manufacturer unless otherwise required (see annex B).

6.2 Qualification based on welding procedure test

This method specifies how a welding procedure can be qualified by the welding and testing of a standardized test piece.

A welding procedure test may be required whenever the properties of the material in the weld metal and the heat affected zone are critical for the application.

The different parts of prEN ISO 15614 define the welding procedure tests for the following welding processes:

- arc welding;
- gas welding;
- electron beam welding;
- laser beam welding;
- resistance welding.

Welding procedure tests for other welding processes and for special applications may be covered by specific standards, for example:

- for stud welding, see EN ISO 14555;
- for friction welding, see EN ISO 15620.

6.3 Qualification based on tested welding consumables

This method specifies how a welding procedure can be qualified by using tested welding consumables.

Some materials do not deteriorate significantly in the heat affected zones. In this case, this method of qualification may be used.

EN ISO 15610 defines the method of qualification by using tested welding consumables for the following welding processes:

- arc welding;
- gas welding.

Qualification by this method for other welding processes and for special applications may be covered by specific standards.

6.4 Qualification based on previous welding experience

This method specifies how a welding procedure can be qualified by demonstration of previous satisfactory welding ability.

A manufacturer may have a pWPS qualified by referring to previous experience in welding on condition that he can prove by appropriate authentic documentation of an independent nature that he has previously satisfactorily welded the type of joint and materials in question.

Only welding procedures known from experience to be reliable should be used in such cases.

EN ISO 15611 defines the method of qualification by reference to previous welding experience for the following welding processes:

- arc welding;
- gas welding;
- electron beam welding;
- laser beam welding;
- resistance welding.

Qualification by this method for other welding processes and for special applications may be also covered by specific standards, for example:

- for stud welding, see EN ISO 14555;
- for friction welding, see EN ISO 15620.

6.5 Qualification based on a standard welding procedure

This method specifies how a welding procedure can be qualified by use of a standard welding procedure.

A pWPS prepared by a manufacturer is qualified if the ranges for all variables are within the range permitted by a standard welding procedure.

A standard welding procedure shall be issued as a specification in the format of a WPS or WPQR based on a qualification to the relevant part of prEN ISO 15614 for welding procedure tests. Issue and amendment of standard welding procedures shall be made by the examiner or examining body taking responsibility for the initial qualification.

Application of a standard welding procedure is also subject to conditions to be satisfied by the user.

prEN ISO 15612 defines the method of qualification by use of a standard welding procedure for the following welding processes:

- arc welding;
- gas welding;
- electron beam welding;
- laser beam welding;
- resistance welding.

Qualification by this method for other welding processes and for special applications may be covered by specific standards.

6.6 Qualification based on a pre-production welding test

This method specifies how a welding procedure can be qualified by pre-production welding tests.

This method is the only reliable method of qualification for some welding procedures, in which the resulting properties of the weld strongly depend on certain conditions such as; component, special restraint conditions, heat sinks etc., which cannot be reproduced by standardized test pieces.

Qualification by a pre-production welding test may be used where the shape and dimensions of standardized pieces do not adequately represent the joint to be welded, e.g. attachment weld to thin pipe. In such cases, one or more special test pieces shall be made to simulate the production joint in all essential features. The test shall be carried out prior and under the conditions to be used in production.

Inspection and testing of the test piece shall be carried out in accordance with the appropriate standard for procedure testing, but this testing may need to be supplemented or replaced by special tests according to the nature of the joint in question. EN ISO 15613 defines the method of qualification by pre-production welding tests for the following welding processes:

- arc welding;
- gas welding;
- electron beam welding;
- laser beam welding;
- resistance welding.

Qualification by this method for other welding processes and for special applications may be also covered by specific standards.

7 Validity

A qualification is valid indefinitely for the ranges qualified unless otherwise specified.

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Annex A (informative)

New numbering system - Details of the standards dealing with specification and qualification of welding procedures

See Table A.1.

Table A.1 — Details of the standards dealing with specification and qualification of welding procedures

Process	Arc welding	Gas welding	Electron beam welding	Laser beam welding	Resistance welding	Stud welding	Friction welding
EN ISO 15607							
Guidelines for a grouping system							
		CR ISO/TR 15608		Not applied		CR ISO/TR 15608	
WPS	EN ISO 15609-1	EN ISO 15609-2	EN ISO 15609-3	EN ISO 15609-4	EN ISO 15609-5	EN ISO 14555	EN ISO 15620
Tested consumables	EN ISO 15610		Not applied				
Previous welding experience	EN ISO 15611			EN ISO 15611 EN ISO 14555		EN ISO 15611 EN ISO 15620	
Standard procedure	prEN ISO 15612			Not applied			
Pre-production test	EN ISO 15613						
Welding procedure test	<u>prEN ISO 15614</u> Part 1: Steel/Nickel Part 2: Aluminium Part 3: Cast iron Part 4: Finishing welding of aluminium castings Part 5: Titanium/zirconium Part 6: Copper Part 7: Overlay welding Part 8: Tube to tube sheet Part 9: Wet hyperbaric Part 10: Dry hyperbaric	<u>prEN ISO 15614</u> Part 1: Steel/Nickel Part 3: Cast iron Part 6: Copper Part 7: Overlay welding	<u>prEN ISO 15614</u> Part 7: Overlay welding Part 11 : Electron beam/Laser beam	<u>prEN ISO 15614</u> Part 12 : Spot, seam and protection Part 13 : Flash and butt	EN ISO 14555		