INTERNATIONAL STANDARD

ISO 11745

First edition
2010-07-15

Brazing for aerospace applications — Qualification test for brazers and brazing operators — Brazing of metallic components

Brasage fort pour applications aérospatiales — Épreuve de qualification des braseurs et des opérateurs braseurs — Brasage fort des composants métalliques

Reference number
ISO 11745:2010(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 11745 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*.

Requests for official interpretations of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

Introduction

The application of this International Standard ensures that a qualification test can be carried out in accordance with a standard test specification on standard test pieces under standard conditions. A brazer or brazing operator qualification test properly passed in accordance with this International Standard ensures that the brazer or brazing operator concerned has proved possession of at least the minimum degree of manual skills and technical knowledge demanded by the state of the art.

Brazing for aerospace applications — Qualification test for brazers and brazing operators — Brazing of metallic components

1 Scope

This International Standard specifies a qualification test for brazers engaged in manual brazing of parts and brazing operators in aerospace construction.

NOTE 1 Success in the test is an essential precondition for the qualification of brazers (3.1) and brazing operators (3.2) in new production and repair work in aerospace. However, brazing equipment operators (3.3) need not be qualified according to this International Standard.

NOTE 2 This International Standard does not apply to general brazing applications covered by ISO 13585[3].

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18279:2003, *Brazing — Imperfections in brazed joints*

ANSI/AWS B2.2, *Brazing procedure and performance qualification*

EN 4179:2009, *Aerospace series — Qualification and approval of personnel for non-destructive testing*

EN 12799, *Brazing — Non-destructive examination of brazed joints*

EN 13134, *Brazing — Procedure approval*

3 Terms and definitions

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

3.1
brazer
person who performs the brazing in a manual operation and guides the heating means and ensures the introduction of the brazing filler material and verifies the braze joint configuration specified by the design

3.2
brazing operator
person who prepares the joint and sets up brazing equipment and thereby has direct influence on the brazed joint quality

NOTE Examples of brazing equipment are furnaces, salt baths, and induction equipment.

3.3
brazing equipment operator
person who only operates automatic brazing equipment and has no direct influence on the brazed joint quality

NOTE Examples of automatic brazing equipment are furnaces, salt baths and induction equipment that require no brazing operator intervention of the thermal process.

3.4
examiner
person appointed to verify compliance with the applicable standard

[ISO/TR 25901:2007[5], 2.119]

NOTE In certain cases, an external independent examiner is required. The acceptability of the examiner is at the discretion of the design or engineering authority.

3.5
examining body
organization appointed to verify compliance with the applicable standard

[ISO/TR 25901:2007[5], 2.120]

NOTE In certain cases, an external independent examining body is required. The acceptability of the examining body is at the discretion of the design or engineering authority.

3.6
design/engineering authority
organization that has the responsibility for the structural integrity or maintenance of airworthiness of the hardware and compliance with all relevant documents

[ISO 24394:2008[4], 3.7]

3.7
braze assembly
assembly of parts to be brazed with regard to fit-up procedures

NOTE Fit-up procedures can include precleaning and application of brazing filler material, stop-off material or flux.

3.8
brazing coordinator
person responsible and competent to perform brazing coordination

NOTE Different brazing coordinators can be required for different tasks.

4 Requirements for the brazing coordinator

The brazing coordinator shall be designated, in writing, as responsible for the brazer or brazing operator qualification test. The brazing coordinator shall have knowledge and experience relevant to the brazing process, and be acceptable to the responsible design authority or recognized examining body.

NOTE Example of relevant knowledge is International Welding Engineer (IWE) according to IIW IAB-002-2000/EWF-409[6].

The brazing coordinator may authorize another person to administer the brazer or brazing operator qualification test.

5 Conditions required for brazer and brazing operator qualification tests

Visual acuity (eyesight) shall be examined for near vision. Brazers and brazing operators shall have visual acuity of 20/30 or better in each eye, and shall be able to read the Jaeger No. 2 eye chart at 400 mm or to pass an equivalent test as specified by an optometrist. Corrected vision may be used to fulfil eye test requirements.

For torch brazing and titanium brazing, colour perception shall be examined, e.g. according to the Ishihara test.

Vision shall be tested to these requirements at least every two years.

6 Qualification test requirements

6.1 Brazing processes

This International Standard covers qualification testing for the following brazing processes with their reference numbers according to ISO 4063[2]:

— 911 infrared brazing;

— 912 flame brazing, torch brazing;

— 916 induction brazing;

— 918 resistance brazing;

— 919 diffusion brazing;

— 921 furnace brazing;

— 922 vacuum brazing;

— 923 dip-bath brazing;

— 924 salt-bath brazing.

NOTE Other brazing processes not yet specified in ISO 4063[2] may be covered.

6.2 Material

The brazer or brazing operator qualification tests are performed according to the material groups specified below. A brazer or brazing operator qualification test is only valid for the material group applied in the qualification test. It does not include any other material group.

Material group A: Unalloyed steels, low-alloyed steels, high-alloyed ferritic steels.

Material group B: High-alloyed austenitic and martensitic steels, nickel and nickel alloys, cobalt alloys.

Material group C: Titanium and titanium alloys.

Material group D: Aluminium and aluminium alloys, magnesium and magnesium alloys.

Material group E: Materials that do not conform to material groups A to D (e.g. molybdenum, tungsten, copper alloys).

Qualification of material group B also qualifies material group A.

6.3 Material thickness

For the brazer qualification test only, a test brazement with parent material of nominal thicknesses t_1 and t_2 shall qualify brazements within a thickness range from $0{,}9t_1$ to $1{,}1t_2$, with $t_1 \leqslant t_2$.

6.4 Brazing position

For the brazer qualification test only, the test pieces (see 9.3.4) shall be brazed in the following brazing positions:

a) test pieces TP1 and TP3: flat flow (horizontal flow of braze filler material);

b) test piece TP2: vertical tube[1)] axis (vertical upflow of braze filler material).

These brazing positions and flow directions qualify for any brazing position and any flow direction.

6.5 Filler material

For manual brazing, the range of qualification for brazing filler material application and liquidus temperatures are given in Tables 1 and 2.

Table 1 — Range of qualification for brazing filler material application

Test piece brazing filler material application	Range of qualification
manually or mechanically fed	manually or mechanically fed and preplaced
preplaced	preplaced

Table 2 — Range of qualification for brazing filler material liquidus temperatures

Test piece brazing filler material liquidus temperature	Range of qualification
< 850 °C	< 850 °C
⩾ 850 °C	All

7 Special qualification tests

7.1 General requirements

Any changes to the requirements defined in this International Standard are classified as special qualification tests.

As required by actual production, the brazing coordinator specifies test pieces with defined brazing processes and material thickness. A special qualification test only qualifies for brazing under the specific conditions represented by the qualification test.

If test methods are not in accordance with this International Standard, they shall be defined by the brazing coordinator. The brazing coordinator shall define additional test methods and also increase the quality requirements as defined by the design or engineering authority.

A special qualification test shall be marked in the designation with an “X”.

1) The word “tube”, alone or in combination, is used to mean “pipe”, “tube” or “hollow section”.

7.2 Special qualification tests for brazers

Examples are qualifications for:

a) brazing with special condition for restricted accessibility;

b) brazing on dissimilar material groups;

c) brazing on plated surfaces;

d) brazing performed on actual production parts;

e) application of filler material different to that specified for standard test pieces.

7.3 Special qualification tests for brazing operators

Examples are:

a) qualification for brazing on dissimilar material groups;

b) restriction to braze assembly work only;

c) restriction to brazing operation only (i.e. excluding braze assembly work);

d) brazing operator qualification performed on actual production parts.

8 Designation for qualification test

The designation of a brazer qualification test is composed in the sequence:

a) “brazer qualification test”;

b) number of this International Standard;

c) brazing process code number according to ISO 4063[2];

d) material group;

e) test piece thickness combination.

EXAMPLE 1 Qualification test for manual torch brazing (912) of steel, material group B, test piece thickness combination of t_1 with 1 mm and t_2 with 4 mm, qualifying any thickness combination between 0,9 mm and 4,4 mm, see 6.3:

Brazer qualification test ISO 11745 - 912 - B - 1 - 4

EXAMPLE 2 Qualification test for manual torch brazing (912) of steel, material group B, test piece thickness combination of t_1 with 1 mm and t_2 with 4 mm, qualifying any thickness combination between 0,9 mm and 4,4 mm, see 6.3. X indicates a special test (for examples see 7.2):

Brazer qualification test ISO 11745 - 912 - B - 1 - 4 - X

EXAMPLE 3 Qualification test for brazing operator, furnace brazing (921), material group B:

Brazing operator qualification test ISO 11745 - 921 - B

9 Performing the brazer and brazing operator qualification test

9.1 General

In the qualification test, the brazer or brazing operator shall demonstrate job knowledge in compliance with 9.2 and practical skills in accordance with 9.3.

All limitations or extensions to the conditions specified in this International Standard shall be considered as special qualification tests.

9.2 Theory test

A theory test is required. The content of the theoretical test and the grading shall be at the discretion of the person responsible for conduction of brazer or brazing operator qualification tests. See Annex E for guidelines.

9.3 Practical testing

9.3.1 General

All practical testing shall be conducted under the surveillance of an authorized person (see Clause 4).

9.3.2 Brazer

The brazer shall braze the test pieces according to 9.3.4 (TP1 to TP3) or according to special qualification test(s) (see Clause 7), in accordance with the brazing procedure specification (BPS), see EN 13134 or ANSI/AWS B2.2. All test pieces shall be clearly identified and traceable to the brazer.

The brazing coordinator shall choose a representative material from the material group used for production brazing.

Brazing filler material, heat source, and type of flux shall be as used in production work for the respective material group and as defined in the BPS.

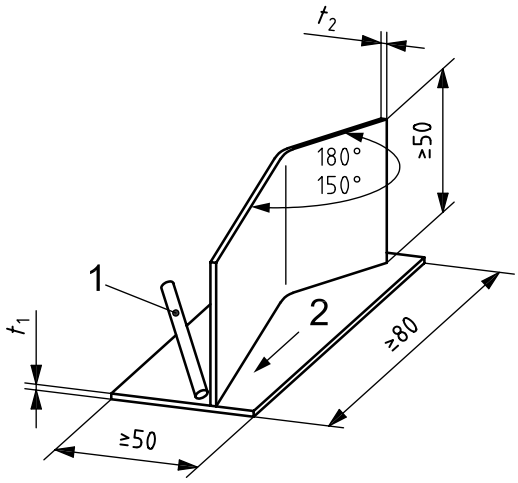
9.3.3 Brazing operator

The brazing operator shall demonstrate compliance to the BPS of a typical production part or the BPS of a specific brazing test piece representative for production parts.

9.3.4 Test pieces

Test pieces TP1 to TP3 are illustrated in Figures 1 to 3.

Dimensions in millimetres



Key

1 rod (filler material applied)

2 heat supply

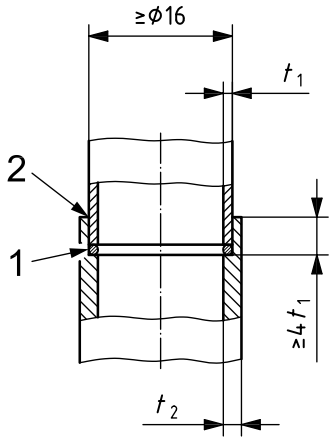
t_1 material thickness of horizontal plate

t_2 material thickness of vertical plate

NOTE Before bending, the vertical sheet has the same size as the horizontal sheet.

Figure 1 — Test piece TP1: modified T-joint

Dimensions in millimetres



Key

1 preplaced filler material

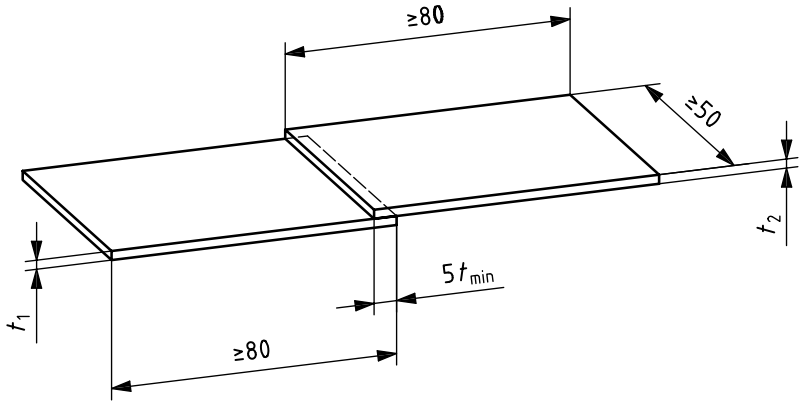
2 joint gap (material groups A, B, C, E: 0,10 mm to 0,15 mm, material group D: 0,2 mm to 0,3 mm)

t_1 material thickness of inserted tube (0,8 mm to 2 mm)

t_2 material thickness of recessed tube (1,2 mm to 3 mm)

Figure 2 — Test piece TP2: tube lap joint

Dimensions in millimetres



Key

t_1 thickness of lower sheet

t_2 thickness of upper sheet

t_{min} thickness of the thinner sheet

Figure 3 — Test piece TP3: lap joint with manually-fed filler material

10 Examination and testing

10.1 General

For the brazer qualification test, the test pieces shall be examined and tested according to Table 3. The test results shall be documented in the brazer qualification test record according to Annex A.

Table 3 — Method of inspection or testing

Method of inspection/testing	Test piece		
	TP1	TP2	TP3
Visual examination	×	×	×
Peel test	—	—	×[a]
Radiographic examination	—	×[a]	×[a]
Metallographic examination	×	×[a]	—
× required inspection method — method not required			
[a] Only one of these methods is required for each test piece as determined by the brazing coordinator.			

For the brazing operator qualification test, the assessment according to the applicable engineering document for the production part shall apply. The test results shall be documented.

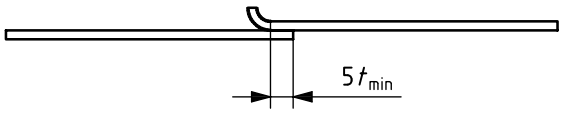
10.2 Visual and dimensional examination

Visual examination for external imperfections or features shall be performed at up to 10 times magnification, and with an angled mirror, if required. Examination results shall be recorded.

Compliance with the specified test piece dimensions shall be checked.

10.3 Peel test

The objective of this test is to examine the internal quality of the joint (see ISO 18279). In order to do this, any suitable separation technique as authorized by the welding coordinator may be applied to separate parts. If desired, a curved geometry may be applied to test piece TP3, see Figure 4. After brazing, the test piece may be cut into sections with a minimum width of 15 mm, all of which shall be tested.



Key

t_{min} thickness of the thinner sheet

Figure 4 — Optional modification of test piece TP3 for the peel test

10.4 Radiographic examination

The objective of this test is to examine the internal quality of the joint (see ISO 18279). Radiographic examinations shall be defined in accordance with EN 4179:2009, approved level 3 or equivalent, carried out according to EN 12799 or equivalent.

10.5 Metallographic examination

When metallographic examination is required (see Table 3), a minimum of two cross-sections shall be prepared. Cross-sections at 90° to the longitudinal direction of the brazed joint shall be ground and polished until the brazed joint is clearly visible. The sections shall be examined at a minimum of 10 times magnification for internal imperfections.

11 Acceptance criteria

11.1 General

The test pieces shall be checked for internal and external imperfections or features in accordance with ISO 18279:2003, acceptance level B.

11.2 Brazer qualification test

If a test piece fails to meet the acceptance criteria (see ISO 18279), one substitute test piece may be brazed. If this test piece also fails to meet the acceptance criteria, the test has been failed. The extent of inspection or testing is specified in Table 3. The test results shall be assessed by the inspecting authority and shall be recorded on a brazer qualification test record as shown in Annex A.

If the brazer fails the test, the brazing coordinator shall decide if and when a new test can be allowed, provided that the brazer has had further training or practice.

11.3 Brazing operator qualification test

If the brazing operator fails the test, the brazing coordinator shall decide if and when a new test can be allowed, provided that the brazing operator has had further training or practice.

12 Qualification test certificate

A brazer qualification test certificate (for an example of a form, see Annex C) or a brazing operator qualification test certificate (for an example of a form, see Annex D) shall be used to document that the brazer or brazing operator has passed the qualification test. The qualification test designations according to Clause 8 shall be stated. Special conditions (see Clause 7) and limitations (e.g. for filler materials in 6.5) shall be stated under “Notes”.

The brazer or brazing operator qualification test certificate is only valid when supplied with a comprehensive brazer or brazing operator qualification test record (for examples, see Annex A and Annex B). The brazer or brazing operator qualification test record shall identify the materials used, test piece thicknesses, special qualification test data (if applicable) and test results.

If actual production parts have been used for the requalification, the parts shall be clearly defined and all test records, including but not limited to X-ray images, shall be retained and traceable until expiration of the brazer or brazing operator qualification.

Test documents and test pieces or test specimens shall be retained until expiration of the period of validity of the brazer or brazing operator qualification.

The brazer or brazing operator qualification test certificate shall be signed and dated by the brazing coordinator or the examining body. The qualification test record shall be signed and dated by either the examiner or the examining body.

In the case of a limited extent of qualification (e.g. preplaced filler material only), the qualification test shall be identified by an “X” (brazer qualification test ISO 11745 - B X). Any limitation shall be documented in the qualification test certificate and a short explanation about the limitation shall be added.

13 Period of validity of the qualification

The brazer or brazing operator qualification is valid for a period of two years, expiring at the end of the month of the qualification test. By way of a requalification test, the qualification for brazing with the corresponding processes, material groups and product/semi-finished product types can be extended for another period of two years.

At any time during the period of validity, a requalification test shall be requested if any of the following circumstances apply:

a) if there is a reason to question the ability of the brazer or brazing operator to meet the requirements for qualification;

b) the brazer or brazing operator has not been working for more than six months with the brazing process for which the brazer or brazing operator is qualified;

c) unacceptable results of representative components.

14 Requalification test

For the requalification test, the same requirements as for the initial qualification tests apply.

Successful requalification tests shall be entered into the brazer or brazing operator qualification test certificate on the basis of the brazer or brazing operator qualification test record.

For the theoretical part of the test, see Annex E.

Annex A
(informative)

Brazer qualification test record according to this International Standard

Name of brazer: Date of birth:

Address:

Company/Plant:

Identification of test piece(s):

Brazing process/BPS No.:

Special test conditions, if applicable:

Test piece	(Used for the test pieces)				(Assessment)[a]			
	Material(s)	Dimensions	Filler material/ max. liquidus temperature	Flux	Visual examination	Radiographic examination	Metallographic examination	Peel test
TP1								
TP2								
TP3								

[a] p: pass; f: fail.

Signed: Date:

Examiner/examining body

(The user is allowed to copy this form.)

Annex B
(informative)

Brazing operator qualification test record according to this International Standard

Name of brazing operator: Date of birth:

Address:

Company/Plant:

Identification of test piece(s):

Brazing process/BPS No.:

Special test conditions, if applicable:

Illustration of joint configuration (sketch or attached drawing No. or photograph):

Part number/ Test piece	**(Used for the test pieces)**				**(Assessment)**[a]			
	Material(s)	Dimensions	Filler material	Flux	Visual examination	Radiographic examination	Metallographic examination	Peel test

[a] p: pass; f: fail.

Signed: Date:

Examiner/examining body

(The user is allowed to copy this form.)

Annex C
(informative)

Brazer qualification test certificate

Examiner/examining body

_____

Certification of brazer qualification test according to ISO 11745

Qualification test certificate No.: _____ Brazer's identity number: _____

Surname, first name: _____

Date of birth: _____

has successfully passed the qualification test for brazing on aerospace construction according to the brazer qualification designation:

_____

- ☐ preplaced filler material
- ☐ manually/mechanically fed filler material
- ☐ liquidus temperature < 850 °C
- ☐ liquidus temperature $\geqslant 850$ °C

Test date: yyyy-mm-dd:_____

Description of special test conditions or limitations, if applicable:

_____

_____

_____

_____

_____

_____

This certificate expires at the end of yyyy-mm (end of month of its date of test + 2 years), unless renewed by notation on the reverse side after passing a repeat test.

Place and date of issue: _____

_____

Brazing coordinator or examining body

(The user is allowed to copy this form.)

Annex D
(informative)

Brazing operator qualification test certificate

Examiner/examining body

_____

Certification of brazing operator qualification test according to ISO 11745

Qualification test certificate No.: _____ Brazing operator identity number: _____

Surname, first name: _____

Date of birth: _____

has successfully passed the qualification test for brazing on aerospace construction according to the brazing operator qualification designation:

_____

Test date: yyyy-mm-dd:_____

Description of special test conditions or limitations, if applicable:

_____

_____

_____

_____

_____

_____

This certificate expires at the end of yyyy-mm (end of month of its date of test + 2 years), unless renewed by notation on the reverse side after passing a repeat test.

Place and date of issue: _____

_____

Brazing coordinator or examining body

(The user is allowed to copy this form.)

Page ….. of ….. pages

Qualification test certificate No.: _____ Brazer / Brazing operator identity number: _____

Name, first name: _____

Requalification test successfully passed on:	Amendments to preceding test
Place and date of verification:	
Brazing coordinator/examining body	

Requalification test successfully passed on:	Amendments to preceding test
Place and date of verification:	
Brazing coordinator/examining body	

Requalification test successfully passed on:	Amendments to preceding test
Place and date of verification:	
Brazing coordinator/examining body	

Requalification test successfully passed on:	Amendments to preceding test
Place and date of verification:	
Brazing coordinator/examining body	

Annex E
(informative)

Guidelines for the theory test

E.1 General

In the theory test, the brazer or brazing operator shall demonstrate the knowledge necessary to carry out the work in a manner that is technically correct and to ensure health and safety aspects.

This annex outlines the job knowledge that a brazer or brazing operator shall have to ensure that procedures are followed and common practices are complied with. 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 below, relevant to the brazer or brazing operator qualification test.

The actual tests of a brazer's or brazing 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) demonstration or observation testing following a written set of criteria.

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

In a requalification test, it is sufficient that knowledge of health and safety requirements can be demonstrated.

E.2 Subjects to be reviewed

The following subjects should be reviewed:

a) safe operation of brazing equipment;

b) preparation of work pieces for brazing;

c) avoidance of imperfections on brazed joints;

d) influence of the brazing parameters on the brazing result;

e) designation and processing of relevant parent and filler materials, fluxes and gases;

f) knowledge on drawing symbols according to ISO 2553[1];

g) visual inspection criteria;

h) health and safety requirements.

Bibliography

[1] ISO 2553, *Welded, brazed and soldered joints — Symbolic representation on drawings*

[2] ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*

[3] ISO 13585, *Brazing — Brazer qualification*

[4] ISO 24394:2008, *Welding for aerospace applications — Qualification test for welders and welding operators — Fusion welding of metallic components*

[5] ISO/TR 25901:2007, *Welding and related processes — Vocabulary*

[6] IIW IAB-002-2000/EWF-409, *International Welding Engineer (IWE)*

ICS 25.160.01

Price based on 17 pages