INTERNATIONAL STANDARD

ISO 22688

First edition
2020-04

Brazing — Quality requirements for brazing of metallic materials

Brasage fort — Exigences de qualité en brasage fort des matériaux métalliques

Reference number
ISO 22688:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by IIW, the *International Institute of Welding*, jointly with Commission XVII, *Brazing, soldering and diffusion bonding,* and Commission XVIII, *Quality management in welding and allied processes*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Brazing processes are widely used to manufacture many products from simple to complex. In some companies, brazing is the key fabrication process. Examples include several industry fields, such as automotive, aerospace, heat exchangers, refrigeration, air-conditioning, turbomachinery and other items.

These processes exert a profound influence on the cost of manufacture and quality of the product. It is important, therefore, to ensure that these processes are carried out in the most effective way and that appropriate control is exercised over all aspects of the operation.

This document is similar in scope and purpose to the ISO 3834 series and has been adapted for brazing quality management systems. This document can be a useful tool when a quality management system (e.g. ISO 9001) is applied by manufacturers.

Specification of quality requirements for brazing processes is important because the quality of these processes cannot be readily verified. Therefore, they are considered to be special processes as noted by ISO 9000.

Quality cannot be inspected into a product, it needs to be built in. Even the most extensive and sophisticated non-destructive testing does not improve the as-produced quality of the product. The use of non-destructive testing processes such as radiography, fluorescent penetrants and ultrasonics helps in rendering a decision as to the quality of the brazed joint.

For products to be free from serious problems in production and in service, it is necessary to provide controls, from the design phase, through material selection, into manufacture and subsequent inspection. For example, poor design can create serious and costly difficulties in the workshop, on site, or in service. Incorrect material selection can result in problems, such as failure of brazed joints.

To ensure sound and effective manufacturing, management needs to understand and appreciate the sources of potential trouble and to implement appropriate procedures for their control.

This document identifies measures that are applicable for different situations. Typically, they can be applied in the following circumstances:

— in contractual situations: specification of brazing quality requirements;

— by manufacturers: establishment and maintenance of brazing quality requirements;

— by committees drafting manufacturing codes or application standards: specification of brazing quality requirements;

— by organizations assessing brazing quality performance (e.g. third parties, customers or manufacturers).

This document may be adopted in full or partially by the manufacturer depending on the assembly concerned. This document provides a flexible framework for the control of brazing in the following applications.

— Case 1: To provide specific requirements for specifications which require the manufacturer to have a quality management system (e.g. ISO 9001).

— Case 2: To provide specific guidance for a manufacturer developing a quality management system for brazing.

— Case 3: To provide detailed requirements for specifications, regulations or product standards that require control of brazing activities.

This document can be used by internal and external organizations, including certification bodies, to assess the manufacturer's ability to meet customer, regulatory or the manufacturer's own requirements.

A similar series of documents, the ISO 3834 series, was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*.

Brazing — Quality requirements for brazing of metallic materials

1 Scope

This document defines two levels of quality requirements and selection criteria for brazing of metallic materials. It applies to manufacturing, both in workshops and at installation sites.

NOTE 1 This document is applicable to brazing industry quality management systems, similar in scope and purpose to the ISO 3834 series. This document provides complete sets of quality requirements for process control related to all listed brazing processes (for each process separately or in combination as specified) and lists the documents with which it is necessary to conform to these requirements. The requirements in this standard may be adopted for other brazing processes, with or without adjustments, under the responsibility of the manufacturer.

NOTE 2 These requirements can be used on their own by a manufacturer or in conjunction with a quality management system (e.g. ISO 9001).

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.

ISO 857-2, *Welding and allied processes — Vocabulary — Part 2: Soldering and brazing processes and related terms*

ISO 9000, *Quality management systems — Fundamentals and vocabulary*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 11745, *Brazing for aerospace applications — Qualification test for brazers and brazing operators — Brazing of metallic components*

ISO 13585, *Brazing — Qualification test of brazers and brazing operators*

ISO 17662, *Welding — Calibration, verification and validation of equipment used for welding, including ancillary activities*

ISO 17663, *Welding — Quality requirements for heat treatment in connection with welding and allied processes*

ISO 18279, *Brazing — Imperfections in brazed joints*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 857-2 and ISO 9000 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
application standard
standard applicable to a specific sector or type of product

EXAMPLE Standards specific to pressure vessels, process piping, structural fabrication or storage tanks.

Note 1 to entry: Application standards can be based on generic standards, in whole or partly, but provide additional, fewer or different requirements.

3.2
brazing coordination personnel
person or group of persons who coordinate manufacturing operations for all brazing and brazing-related activities

Note 1 to entry: Different personnel may be appointed by the *manufacturer* (3.5) for different brazing and related tasks.

3.3
brazing operator
person who controls or adjusts any brazing parameter for mechanized brazing or automatic brazing

3.4
competent personnel
personnel with the demonstrated ability to apply knowledge and skills to achieve the intended results

Note 1 to entry: A qualification test may be required for specific tasks and responsibilities.

3.5
manufacturer
organization responsible for brazing production

3.6
specification
requirements for products specified by customers or by the *manufacturer* (3.5) in anticipation of customer requirements or other documents

Note 1 to entry: The requirements for products and in some cases associated processes can be contained in, for example, technical specifications, product standards, process standards, contractual agreements or other documents.

3.7
sub-contractor
supplier of products, services and/or activities to the *manufacturer* (3.5) in a contractual situation

[SOURCE: ISO 3834-1:2005, 3.5]

4 General

This document specifies quality requirements suitable for the following listed brazing processes:

a) brazing with local heating, including:

- infrared brazing;
- flame brazing (torch brazing, USA);
- laser beam brazing;
- electron beam brazing;
- induction brazing;

- resistance brazing;
- diffusion brazing; and

b) brazing with global heating, including:

- furnace brazing;
- vacuum brazing;
- dip-bath brazing;
- salt-bath brazing;
- flux-bath brazing;
- immersion brazing
- diffusion brazing; and

c) weld brazing (braze welding, USA), including:

- gas weld brazing (gas braze welding, USA);
- arc weld brazing (arc braze welding, USA);
- gas metal arc weld brazing (gas metal arc braze welding, USA);
- gas tungsten arc weld brazing (gas tungsten arc braze welding, USA);
- plasma arc weld brazing (plasma arc braze welding, USA);
- laser weld brazing (laser braze welding, USA);
- electron beam weld brazing (electron beam braze welding, USA).

NOTE Controlled Atmosphere Brazing (CAB) is considered furnace brazing.

The requirements contained within this document may be adopted for other brazing processes.

These requirements relate only to those aspects of the quality of the products that can be influenced by the brazing process, without being assigned to any specific product group.

Therefore, this document provides a method to demonstrate the capability of a manufacturer to produce products of the specified quality.

These requirements:

a) are independent of the type of assembly manufactured;

b) define quality requirements for brazing in workshops and/or at installation sites;

c) provide guidance for describing a manufacturer's capability to produce assemblies to meet specified requirements;

d) provide a basis for assessing a manufacturer’s brazing capability.

These requirements are appropriate when demonstration of a manufacturer's capability to produce brazed assemblies, fulfilling specified quality requirements, is specified in one or more of the following:

- a specification;
- a product standard;
- contracts or other documents.

5 Selection of the appropriate level of quality requirements

The selection of the comprehensive quality requirements (see Clause 6) or the elementary quality requirements (see Clause 7) shall consider the product standard, specification, contract or other documents.

To fulfil the comprehensive quality requirements, the manufacturer is required to comply with the requirements of the relevant documents cited in Clause 6. To fulfil the elementary quality requirements, the manufacturer is required to comply with the requirements of the relevant documents cited in Clause 7.

The requirements of this document can be applied in a variety of situations. The manufacturer shall also consider the comprehensive quality requirements, or the elementary quality requirements, based on the following criteria related to products:

— the extent and significance of safety-critical products;

— the extent and significance of product performance;

— the complexity of manufacture;

— the range of products manufactured;

— the range of different materials used;

— the extent to which metallurgical problems, such as erosion, liquation, overaging, resolutionizing, etc., can affect product performance;

— the extent to which manufacturing imperfections (e.g. misalignment, distortion or brazed joint imperfections such as macroporosity, lack of braze coverage, lack of bonding, etc.) can affect product performance.

NOTE 1 Because these requirements can be used in a variety of situations and for different applications, definitive rules on the level of quality requirements to be adopted in individual circumstances are not given in this clause.

A manufacturer that demonstrates compliance with the comprehensive quality requirements is considered to have established compliance with the elementary quality requirements without further demonstration.

NOTE 2 Table A.1 lists criteria that assists in the selection of the appropriate quality level, using Clauses 6 and 7 of these requirements.

6 Comprehensive quality requirements

6.1 General

This clause defines comprehensive quality requirements for brazing, both in workshops and at installation sites.

In certain situations, where particular operations such as heat treatment are not undertaken, the requirements related to that operation detailed in this clause may be selectively amended or deleted.

Otherwise, the requirements contained within this clause shall be adopted in full.

6.2 Review of requirements and technical review

6.2.1 General

The manufacturer shall review the contractual requirements and any other requirements, together with any technical data provided by the purchaser or in-house data when the assembly is designed by the manufacturer. The manufacturer shall establish that all information necessary to carry out the manufacturing operations is complete and available prior to the commencement of the work. The manufacturer shall affirm its capability to meet all requirements and shall ensure adequate planning of all quality-related activities.

The review of requirements is carried out by the manufacturer to verify that the work content is within its capability to perform, that sufficient resources are available to achieve delivery schedules and that documentation is clear and unambiguous.

The manufacturer shall ensure that any variations from the original requirements are identified and the purchaser notified of any programme, cost or engineering changes that can result.

When a contract does not exist (e.g. items made for stock), the manufacturer shall take into consideration the requirements of 6.2.2 while carrying out the technical review (see 6.2.3).

NOTE 1 Items in 6.2.2 are typically considered at or before the time of the review of requirements. Items in 6.2.3 usually form part of the technical review and are considered during the initial planning stage.

NOTE 2 Annex D lists criteria to be provided and agreed on.

6.2.2 Review of requirements

Aspects to be considered shall include the following:

a) the product standard to be used, together with any supplementary requirements;

b) contractual requirements or other documents;

c) any additional requirements determined by the manufacturer or purchaser;

d) the capability of the manufacturer to meet the prescribed requirements.

6.2.3 Technical review

Technical requirements to be considered shall include the following:

a) parent material(s), braze metal and/or flux specification and brazed joint properties;

b) quality and acceptance requirements for brazed joints;

c) location, accessibility and sequence of joints, including accessibility for inspection and for non-destructive testing;

d) the preparation of work instructions;

e) the specification of brazing procedures (including cleaning), non-destructive testing procedures and heat-treatment procedures, when required;

f) the approach to be used for the qualification of brazing procedures;

g) the qualification of personnel;

h) selection, identification and/or traceability (e.g. for materials, brazed joints);

i) quality control arrangements, including any involvement of an independent inspection body;

j) inspection and testing;

k) sub-contracting;

l) post-braze heat treatment;

m) other brazing requirements (e.g. batch testing of consumables, ageing, use of peening, surface finish, brazed joint profile);

n) use of special methods (e.g. to achieve full penetration/bonding/complete coverage);

o) dimensions and details of joint preparation and completed brazed joint;

p) where joining processes will be carried out (workshop or installation site);

q) environmental conditions relevant to the application of the process (e.g. very low temperature ambient conditions, prevention of condensation, any necessity to provide protection against adverse weather conditions, and proper temperature in the place where brazing consumables such as paste/powder are stored);

r) requirements of manufacturing steps related to brazing (e.g. short timeframe between cleaning of parent material and brazing process);

s) handling of non-conformances.

6.3 Sub-contracting

When a manufacturer intends to use sub-contracted services or activities (e.g. brazing, inspection, destructive testing, non- destructive testing, heat treatment), information necessary to meet applicable requirements shall be supplied by the manufacturer to the sub-contractor.

The information to be provided by the manufacturer to the sub-contractor shall include all relevant data from the review of requirements (see 6.2.2) and the technical review (see 6.2.3). Additional requirements may be specified as necessary to ensure sub-contractor compliance with technical requirements.

A sub-contractor shall work under the order and responsibility of the manufacturer and shall fully comply with the relevant requirements of this clause. The manufacturer shall ensure that the sub-contractor can comply with the quality requirements as specified.

The sub-contractor shall provide such records and documentation of its work as may be specified by the manufacturer.

6.4 Brazing personnel

6.4.1 General

The manufacturer shall have at its disposal sufficient and competent personnel for the planning, performing and supervising of the brazing production according to specified requirements.

6.4.2 Brazers and brazing operators

Brazers and brazing operators shall be qualified by an appropriate test.

Brazers and brazing operators for brazing processes listed in Clause 4 shall be qualified in accordance with ISO 13585 or ISO 11745, as applicable.

6.4.3 Brazing coordination personnel

The manufacturer shall have at its disposal appropriate brazing coordination personnel. Such persons having responsibility for quality activities shall have sufficient authority to enable any necessary action to be taken. The tasks and responsibilities of such persons shall be clearly defined.

NOTE ISO 14731 can be used as a guide for brazing coordination personnel.

6.5 Inspection and testing personnel

6.5.1 General

The manufacturer shall have at its disposal sufficient and competent personnel for planning, performing, and supervising the inspection and testing of the brazing production according to specified requirements.

For direct, unaided visual testing, a qualification test may not be required. When a qualification test is not required, competence shall be verified by the manufacturer.

6.5.2 Non-destructive testing personnel

Non-destructive testing personnel, including those performing indirect or aided visual testing, shall be qualified in accordance with ISO 9712 or equivalent.

6.6 Equipment

6.6.1 Production and testing equipment

The following equipment shall be available, when necessary:

a) power sources and other machines;

b) ovens, quivers, shakers, etc., used for mixing and treatment of brazing consumables;

c) equipment for cutting, including thermal cutting, surface preparation (machining and cleaning) and joining;

d) equipment for preheating and post-heat treatment including temperature indicator;

e) equipment for dispensing brazing materials (e.g. paste, fluxes, filler metal);

f) jigs and fixtures;

g) cranes and handling equipment used for the production;

h) personal protective equipment and other safety equipment, directly associated with the applicable manufacturing process;

i) destructive and non-destructive testing facilities.

6.6.2 Description of equipment

The manufacturer shall maintain a list of essential equipment used for the production. This list shall identify items of major equipment, essential for an evaluation of workshop capacity and capability. This includes, for example:

a) maximum capacity of crane(s);

b) size of components that the workshop is able to handle;

c) capacities of rolling, bending, cleaning, machining and cutting equipment;

d) capability of mechanized or automatic brazing equipment;

e) dimensions and maximum temperature, vacuum levels, partial pressure and dew point levels of furnaces for brazing and post-braze heat treatment;

f) capacities of pressure applying equipment (e.g. for diffusion brazing);

g) destructive and non-destructive testing equipment.

Other equipment needs to be specified only by approximate total numbers which cover each general type (e.g. total number of power sources for the different processes).

6.6.3 Suitability of equipment

The equipment shall be adequate for the application concerned.

Brazing equipment shall be calibrated, verified and validated in accordance with the requirements of ISO 17662.

6.6.4 New and refurbished equipment

After installation of new or refurbished equipment, appropriate tests of the equipment shall be performed. The tests shall verify the correct function of the equipment. The tests shall be carried out and documented in accordance with appropriate standards, whenever relevant.

NOTE 1 Qualification of the equipment can be performed to verify the output of the equipment.

NOTE 2 Requalification of brazing and heating equipment, once qualified, is not normally required.

6.6.5 Equipment maintenance

The manufacturer shall have documented plans for the maintenance of equipment. The plan shall ensure maintenance checks of those items that control variables listed in the relevant brazing procedure specifications. The plans may be limited to those items that are essential for ensuring the quality of the product. Defective equipment shall not be used.

Examples of these items are as follows:

a) condition of guides in equipment for mechanised fixtures;

b) condition of ammeters and voltmeters, flow meters used for the operation of the brazing equipment;

c) condition of cables, hoses, connectors;

d) condition of control system in mechanised and/or automatic brazing unit;

e) condition of temperature measurement instruments;

f) condition of wire feeders and conduits;

g) condition of furnaces (e.g. cleanliness, contaminated hot zones, vacuum seals);

h) verification of necessary vacuum level for brazing in vacuum furnaces;

i) verification of furnace uniform temperatures.

6.7 Brazing and related activities

6.7.1 Production planning

The manufacturer shall carry out adequate production planning. Items to be considered shall include, as a minimum:

a) specification of the sequence by which the assembly shall be manufactured (e.g. as single parts or sub-assemblies, and the order of subsequent final assembly);

b) identification of the individual processes required to manufacture the assembly;

c) reference to the appropriate procedure specifications for brazing and allied processes;

d) sequence in which the brazed joints are to be made;

e) order and timing in which the individual processes are to be performed;

f) environmental conditions (e.g. protection from wind and rain);

g) identification by batches, components or parts, as appropriate;

h) allocation of qualified personnel;

i) arrangement for any production test;

j) specification for inspection and testing, including the involvement of any independent inspection body.

6.7.2 Brazing procedure specifications

The manufacturer shall prepare the brazing procedure specification(s) and shall ensure that these are used correctly in production.

6.7.3 Qualification of the brazing procedures

Brazing procedures shall be qualified prior to production. The method of qualification shall be in accordance with relevant product standards or as stated in the specification.

NOTE Qualification of other procedures can be required in the relevant product standards and/or the specification(s).

6.7.4 Work instructions

The manufacturer may use the brazing procedure specification directly for work instruction purposes. Alternatively, dedicated work instructions may be used. Such dedicated work instructions shall be prepared from a qualified brazing procedure specification and do not require separate qualification.

NOTE Work instructions can need re-qualification if new information is added to the original brazing procedure specification.

6.7.5 Procedures for preparation and control of documents

The manufacturer shall establish and maintain procedures for the preparation and control of relevant quality documents (e.g. brazing procedure specification, brazing procedure qualification record, brazers and brazing-operators qualification certificates).

6.8 Brazing consumables

6.8.1 Storage and handling

The manufacturer shall prepare and implement procedures for storage, handling, identification and use of brazing consumables that avoid moisture pick-up, oxidation, damage, etc. The procedures shall be in accordance with the supplier's recommendations.

6.8.2 Batch testing

Batch testing of brazing consumables shall be required only if specified in the contract documents or product specifications.

6.9 Storage of parent materials

Storage shall be such that the material, including material supplied by the client, is not adversely affected. Storage procedures shall be in accordance with the supplier's recommendations.

Identification shall be maintained during storage.

6.10 Brazing and post-brazing heat treatment

The manufacturer shall be fully responsible for the specification and the performance of any brazing and post-brazing heat treatment. The procedure shall be compatible with the parent material, brazed joint assembly, etc., and shall be in accordance with the product standard and/or specified requirements.

For the processes listed in Clause 4, post-brazing heat treatment, if performed, shall be performed in accordance with ISO 17663, as applicable.

A record of the heat treatment shall be made during the process. The record shall demonstrate that the specification has been followed and shall be traceable to the particular product.

6.11 Inspection and testing

6.11.1 General

Applicable inspections and tests shall be implemented at appropriate points in the manufacturing process to ensure conformity with contract requirements or product standards. Location and frequency of such inspections and/or tests shall be determined based on the contract and/or product standard, the brazing process and the type of assembly (see 6.2.2 and 6.2.3).

NOTE The manufacturer can carry out additional inspections and tests without restriction. Reporting of such inspections and tests is not required.

6.11.2 Inspection and testing before brazing

Before brazing, the following shall be checked:

a) suitability and validity of brazers' and brazing operators' qualification records;

b) suitability of brazing procedure specification;

c) identification of parent materials;

d) identification of brazing consumables;

e) joint preparation (e.g. machining, shape and dimensions, cleaning, mechanical or chemical pickling);

f) fit-up, jigging and tacking;

g) any special requirements in the brazing procedure specification (e.g. prevention of distortion);

h) suitability of working conditions for brazing, including environment.

6.11.3 Inspection and testing during brazing

During brazing, the following shall be checked at suitable intervals or by continuous monitoring:

a) essential brazing parameters (e.g. brazing temperature, brazing time, joint gap, and surface preparation);

b) cleaning, placement and shapes of the brazing filler metal, especially if the form of the brazing filler metal is foil, wire, preforms, tape, etc.;

c) brazing sequence;

d) correct use and handling of brazing consumables;

e) control of distortion;

f) any intermediate examination (e.g. checking of dimensions).

6.11.4 Inspection and testing after brazing

After brazing, the compliance with relevant acceptance criteria shall be checked by the listed method(s), as applicable:

a) direct, unaided visual inspection;

b) non-destructive testing, including indirect or aided visual testing;

c) destructive testing;

d) verifying form, shape and dimensions of the assembly;

e) analysing results and records of post-brazing operations (e.g. diagrams of thermal cycles of post-brazing heat treatments, solution, annealing, austenitizing, tempering, stress relieving, ageing).

6.11.5 Inspection and test status

Measures (e.g. by marking of the item or use of a routing card) shall be taken, as appropriate, to indicate the status of inspection and testing of the brazed assembly.

6.12 Acceptance criteria

For brazing processes listed in Clause 4, brazed joints shall satisfy the requirements of ISO 18279, as applicable.

6.13 Non-conformance and corrective actions

Measures shall be implemented to recognize and control items or activities that do not conform to specified requirements to prevent their inadvertent acceptance.

When repair and/or rectification is undertaken by the manufacturer, descriptions of appropriate procedures shall be available at all workstations where repair or rectification is performed.

When repair is carried out, the items shall be re-inspected, tested and examined in accordance with the original requirements.

Measures shall also be implemented to avoid recurrence of non-conformances.

6.14 Calibration and validation of measuring, inspection and testing equipment

The manufacturer shall be responsible for the appropriate calibration or validation of measuring, inspection and testing equipment. All equipment used to assess the quality of the assembly shall be suitably controlled and shall be calibrated or validated at specified intervals as recommended by the equipment manufacturer or supplier.

Calibration and validation of measuring, inspection and testing equipment shall be done in accordance with ISO 17662.

6.15 Identification and traceability

Identification and traceability shall be maintained throughout the manufacturing process, if required.

Documented systems to ensure identification and traceability of the brazing operations shall include, if required:

a) identification of production plans;

b) identification of routing cards;

c) identification of brazed joint locations in the assembly;

d) identification of non-destructive testing procedures and personnel;

e) identification of brazing consumables (e.g. designation, trade name, manufacturer of consumables and batch or cast numbers);

f) identification and/or traceability of parent materials (e.g. type, cast number);

g) identification of location of repairs;

h) identification of location of temporary attachments;

i) traceability of fully mechanised and automatic brazing units to specific brazed joints;

j) traceability of brazer and brazing operators to specific brazed joints;

k) traceability of brazing procedure specifications to specific brazed joints.

6.16 Quality records

Quality records shall include, when applicable:

a) record of requirement/technical review;

b) production plan

c) material inspection documents;

d) brazing consumable inspection documents;

e) brazing procedure qualification records (BPQR);

f) brazing procedure specifications (BPS);

g) brazer or brazing operator qualification certificates;

h) heat-treatment procedure specification and records;

i) dimensional reports;

j) non-destructive testing personnel certificates;

k) non-destructive testing and destructive testing procedures and reports;

l) records of repairs and non-conformance reports;

m) equipment maintenance records;

n) other documents, if required.

Quality records shall be retained for a minimum period of five years in the absence of any other specified requirements.

7 Elementary quality requirements

7.1 General

This clause defines elementary quality requirements for brazing, both in workshops and at installation sites.

In certain situations, where particular operations such as heat treatment are not undertaken, the requirements detailed in this clause related to that operation may be selectively amended or deleted.

Otherwise, the requirements contained within this clause shall be adopted in full.

7.2 Review of requirements and technical review

7.2.1 General

The manufacturer shall review the contractual requirements and any other requirements, together with any technical data provided by the purchaser or in-house data when the assembly is designed by the manufacturer. The manufacturer shall establish that all information necessary to carry out the manufacturing operations is complete and available prior to the beginning of the work. The manufacturer shall affirm its capability to meet all requirements and shall ensure adequate planning of all quality-related activities.

The review of requirements is carried out by the manufacturer to verify that the work content is within its capability to perform, that sufficient resources are available to achieve delivery schedules and that documentation is clear and unambiguous.

The manufacturer shall ensure that any variations from the original requirements are identified and the purchaser notified of any programme, cost or engineering changes that can result.

NOTE Annex D lists criteria to be provided and agreed on.

7.2.2 Review of requirements

Aspects to be considered shall include the following:

a) the product standard to be used, together with any supplementary requirements;

b) any additional requirements determined by the manufacturer or purchaser.

7.2.3 Technical review

Technical requirements to be considered shall include the following:

a) parent material(s) specification, braze metal and/or flux specification and brazed joint properties;

b) quality and acceptance criteria for brazed joints;

c) location, accessibility and sequence of joints, including accessibility for inspection and for non-destructive testing;

d) the preparation of work instructions;

e) the specification of brazing procedures (including cleaning), non-destructive testing procedures and heat-treatment procedures, when required;

f) the approach to be used for the qualification of brazing procedures, when qualification is required;

g) the qualification of personnel;

h) inspection and testing;

i) sub-contracting;

j) dimensions and details of joint preparation and completed brazed joint;

k) environmental conditions relevant to the application of the process (e.g. very low temperature ambient conditions, any necessity to provide protection against adverse weather conditions, and proper temperature in the place where brazing consumables such as paste/powder are stored).

7.3 Sub-contracting

When a manufacturer intends to use sub-contracted services or activities (e.g. brazing, inspection, non-destructive testing, heat treatment), information necessary to meet applicable requirements shall be supplied by the manufacturer to the sub-contractor.

A sub-contractor shall work under the order and responsibility of the manufacturer and shall fully comply with the relevant requirements of this clause. The manufacturer shall ensure that the sub-contractor can comply with the quality requirements as specified.

The sub-contractor shall provide such records and documentation of its work as may be specified by the manufacturer.

7.4 Brazing personnel

7.4.1 General

The manufacturer shall have at its disposal sufficient and competent personnel for the planning, performing and supervising of the brazing production according to specified requirements.

7.4.2 Brazers and brazing operators

Brazers and brazing operators shall be qualified by an appropriate test.

Brazers and brazing operators for brazing processes listed in Clause 4 shall be qualified in accordance with the requirements of ISO 13585 or ISO 11745, as applicable.

7.5 Inspection and testing personnel

7.5.1 General

The manufacturer shall have at its disposal sufficient and competent personnel for planning, performing, and supervising the inspection and testing of the brazing production according to specified requirements.

For direct, unaided visual testing, a qualification test may not be required. When a qualification test is not required, competence shall be verified by the manufacturer.

7.5.2 Non-destructive testing personnel

Non-destructive testing personnel, including those performing indirect or aided visual testing, shall be qualified in accordance with ISO 9712 or equivalent.

7.6 Equipment

Brazing equipment shall be available and maintained in proper working order.

7.7 Brazing and related activities

7.7.1 Brazing work instructions

The manufacturer shall prepare brazing work instructions and shall ensure that these are used correctly in production. The manufacturer may use the brazing procedure specification directly for work instruction purposes.

7.7.2 Brazing procedure specifications

If brazing procedure specifications are required, the manufacturer shall prepare the brazing procedure specification(s) and shall ensure that these are used correctly in production.

7.7.3 Qualification of the brazing procedures

If used, brazing procedure specifications shall be qualified prior to production. The method of qualification shall be in accordance with relevant product standards or as stated in the specification.

NOTE Qualification of other procedures can be required in the relevant product standards and/or the specification(s).

7.8 Brazing consumables

The manufacturer shall ensure that appropriate brazing consumables are stored and used in accordance with the supplier's recommendations.

7.9 Inspection and testing

7.9.1 General

Inspections shall be implemented at appropriate points in the manufacturing process to ensure conformity with any applicable contract requirements or product standards. Location and frequency of such inspections shall be determined based on the contract and/or product standard, the brazing process and the type of assembly (see 7.2.2 and 7.2.3).

NOTE The manufacturer can carry out additional tests without restriction. Reporting of such tests is not required.

7.9.2 Inspection and testing before brazing

Before brazing, the following shall be checked:

a) suitability and validity of brazers' and brazing operators' qualification records;

b) suitability of brazing procedure specification, if required;

c) identification of parent materials;

d) identification of brazing consumables;

e) joint preparation (e.g. cleaning, shape and dimensions);

f) fit-up, jigging and tacking;

g) any special requirements in the brazing work instructions;

h) suitability of working conditions for brazing, including environment.

7.9.3 Inspection and testing during brazing

During brazing, the following shall be checked at suitable intervals or by continuous monitoring:

a) essential brazing parameters (e.g. brazing temperature, brazing time, joint gap, joint clearance, surface preparation);

b) cleaning, placement and shapes of the brazing filler metal, especially if the form of the brazing filler metal is foil, wire, preforms, tape, etc.;

c) correct use and handling of brazing consumables;

d) brazing sequence.

7.9.4 Inspection and testing after brazing

After brazing, the compliance with relevant acceptance criteria shall be checked by the listed methods, as applicable:

a) direct, unaided visual inspection;

b) verifying form, shape and dimensions of the assembly.

7.10 Non-conformance and corrective actions

Measures shall be implemented to recognize and control items or activities that do not conform to specified requirements to prevent their inadvertent acceptance. Measures shall also be implemented to ensure that conditions adverse to quality of the assembly are promptly identified and corrected.

7.11 Quality records

Quality records shall include, when applicable:

a) record of requirement/technical review;

b) parent material certificates;

c) brazing consumable certificates;

d) brazing procedure qualification records (BPQR), when required;

e) brazing procedure specifications (BPS), when required;

f) brazing work instructions;

g) brazer or brazing operator qualification certificates;

h) heat-treatment procedure specification and records, when required;

i) non-destructive testing personnel certificates;

j) non-destructive testing and destructive testing procedures and reports, when required;

k) records of repairs and non-conformance reports, when required;

l) other documents, when required.

Quality records shall be retained for a minimum period of five years in the absence of any other specified requirements.

8 Documents required to claim compliance to these quality requirements

8.1 General

Manufacturers may claim compliance with the quality requirements of this document either by:

— adoption of the ISO standards referenced in Clause 6 or Clause 7, as applicable; or

— adoption of other standards or documents that provide technically equivalent conditions to the ISO documents listed in Clause 6 or 7.

It is the responsibility of the manufacturer to demonstrate that the standards or documents selected provide technically equivalent conditions to those in the corresponding ISO standards.

Other standards that can be applied are listed in Annex B, Table B.1 to B.8.

NOTE The contents of Tables B.1 to B.8 in Annex B do not establish that the standards listed are technically equivalent, which remains the responsibility of the manufacturer.

8.2 Declaration of compliance

A manufacturer claiming compliance with these requirements shall list the applicable supporting standards or documents.

Annex A
(informative)

Criteria to assist in the selection of the appropriate quality requirements

NOTE The use of "when required" indicates when required by a specification, product standard, application standard, contract or other document.

Table A.1 — Criteria to assist in the selection of the appropriate quality requirements

No.	Element	Comprehensive	Elementary
1	Review of requirements	review required (see 6.2.2, 7.2.2)	
		quality record required [see 6.16 a), 7.11 a)]	
2	Technical review	review required (see 6.2.3, 7.2.3)	
		quality record required [see 6.16 a), 7.11 a)]	
3	Sub-contracting	treat like a manufacturer for the specific subcontracted product, services and/or activities, however final responsibility for quality remains with the manufacturer (see 6.3, 7.3)	
4	Brazers and brazing operators	qualification required (see 6.4.2, 7.4.2)	
5	Brazing coordination personnel	required (see 6.4.3)	no specific requirement
6	Inspection and testing personnel	qualification required, except for direct unaided visual testing (see 6.5, 7.5)	
7	Production and testing equipment	adequate and available as required for preparation, process execution, testing, transport, lifting in combination with safety equipment and personal protective equipment (see 6.6.1, 6.6.3, 6.6.4)	brazing equipment as required (see 7.6)
8	Equipment maintenance	documented plans and records required [see 6.6.5, 6.16 k)]	in proper working order (see 7.6)
9	Description of equipment	list required (see 6.6.2)	no specific requirement
10	Production planning	required (see 6.7.1)	no specific requirement
		plans and records required [see 6.16 b)]	
11	Work instructions	not required (see 6.7.4)	required [brazing procedure specifications may be used] (see 7.7.1)
12	Brazing procedure specifications, including cleaning	required (see 6.7.2)	if required (see 7.7.2)
13	Qualification of brazing procedures	required (see 6.7.3)	if required (see 7.7.3)
14	Batch testing of consumables	if required (see 6.8.2)	no specific requirement
15	Storage and handling of brazing consumables	procedure required in accordance with supplier recommendations (see 6.8.1)	in accordance with supplier recommendations (see 7.8)

Table A.1 *(continued)*

No.	Element	Comprehensive	Elementary
16	Storage of parent materials	protection required in accordance with supplier recommendations (see 6.9)	no specific requirement
		identification maintained during storage (see 6.9)	
17	Brazing and post-brazing heat treatment	specification and performance in accordance with product standard or specified requirements (see 6.10)	no specific requirement
		procedure, record and traceability of the record to the product are required [see 6.10, 6.16 h)]	
18	Inspection and testing before, during and after brazing	required (see 6.11, 7.9)	
19	Non-conformance and corrective actions	measures to recognize and control implemented (see 6.13, 7.10)	
		procedures for repair and/or rectification required (see 6.13)	no specific requirement
20	Calibration or validation of measuring, inspection and testing equipment	required (see 6.14)	no specific requirement
21	Identification during process	if required (see 6.15)	no specific requirement
22	Traceability	if required (see 6.15)	no specific requirement
23	Quality records	when applicable (see 6.16, 7.11)	

Annex B
(informative)

Corresponding national standards

NOTE The contents of Tables B.1 to B.8 do not establish any technical equivalence between the standards listed.

Tables B.1 to B.8 show the national standards corresponding to the ISO standard(s) referenced in this document.

Table B.1 — Filler metals and fluxes

ISO standard(s) referenced in this document	ISO 3677 ISO 17672
Australia and New Zealand	AS/NZS 1167.1
China	JB/T 6045 GB/T 6418 GB/T 10046 GB/T 10859 GB/T 13815 GB/T 18762
Europe	EN 1045
Japan	JIS Z 3261 JIS Z 3262 JIS Z 3263 JIS Z 3264 JIS Z 3265 JIS Z 3266 JIS Z 3267 JIS Z 3268 WES 5602
USA	AWS A5.8/A5M AWS A5.31 SAE AMS 2662 SAE AMS 2664 SAE AMS 2665 SAE AMS 2675 SAE AMS 3410 SAE AMS 3412

Table B.2 — Qualification of brazing procedures

ISO standard(s) referenced in this document	
Australia and New Zealand	AS/NZS 3992
China	GB/T 11364
Europe	EN 13134
Japan	
United States of America	ASME Boiler and Pressure Vessel Code, Section IX AWS B2.2/B2.2M

Table B.3 — Qualification of brazing personnel

ISO standard(s) referenced in this document	ISO 11745 ISO 13585
Australia and New Zealand	AS/NZS 3992
China	
Europe	
Japan	JIS Z 3891 WES 8291
United States of America	ASME Boiler and Pressure Vessel Code, Section IX AWS B2.2/B2.2M

Table B.4 — Production

ISO standard(s) referenced in this document	ISO 17662
Australia and New Zealand	
China	
Europe	
Japan	JIS Z 3621
United States of America	AWS C3.3 AWS C3.4M/C3.4 AWS C3.5M/C3.5 AWS C3.6M/C3.6 AWS C3.7M/C3.7 AWS C3.9M/C3.9 AWS C3.13M/C3.13 SAE AMS 2670 SAE AMS 2672 SAE AMS 2678

Table B.5 — Inspection and testing

ISO standard(s) referenced in this document	
Australia and New Zealand	
China	GB/T 11363
Europe	EN 12797 EN 12799
Japan	JIS H 0321 JIS Z 3192 JIS Z 3900 JIS Z 3901 JIS Z 3902 JIS Z 3903 JIS Z 3904 JIS Z 3905 JIS Z 3906 LWS T 8801
United States of America	AWS C3.8M/C3.8