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Welding — Quality requirements for heat treatment in connection with welding and allied processes

Soudage — Exigences de qualité relatives au traitement thermique associé au soudage et aux techniques connexes

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Foreword

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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).

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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 Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 17663:2009), which has been technically revised.

The main changes are as follows:

— normative references updated;

— arc stud welding added in 9.5;

— Figure A.1 revised.

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. Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

Welding — Quality requirements for heat treatment in connection with welding and allied processes

1 Scope

This document provides quality requirements for heat treatment in air or controlled atmospheres carried out in workshops and on site in connection with welding and forming. It applies mainly to ferritic steels but can be used for other materials as appropriate.

This document provides guidance for manufacturers that perform heat treatment or produce heat-treated products or components. This document can also be used as a basis for assessing the manufacturer in respect to its heat treatment capability.

The fulfilment of a requirement can be waived where justification can be provided that a specific requirement is not applicable to a specific process. This document is intended to be a flexible framework to provide:

— specific requirements for heat treatment by manufacturers in order to have a quality system in accordance with ISO 9001;

— specific requirements for heat treatment in specifications which require the manufacturer to have a quality system other than ISO 9001;

— specific guidance for a manufacturer developing a quality control system for heat treatment;

— specific guidance for post-weld heat treatment for manufacturers adopting ISO 3834-2 or ISO 3834-3;

— detailed requirements for specifications, regulations or product standards that require control of heat treatment activities.

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 4885, *Ferrous materials — Heat treatments — Vocabulary*

ISO 13916, *Welding — Measurement of preheating temperature, interpass temperature and preheat maintenance temperature*

IEC 60584-1, *Thermocouples — Part 1: EMF specifications and tolerances*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4885 and ISO 13916 and the following apply.

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

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

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

3.1
manufacturer
person or organization responsible for heat treatment of products or components

3.2
loading temperature
temperature of the furnace at the stage when the product or component is put into the furnace

3.3
holding temperature
temperature at which the product or component is kept in order to achieve the specified properties

Note 1 to entry: The holding temperature depends on the type of heat treatment, type of material and material thickness.

Note 2 to entry: Normally, the holding temperature is expressed as a temperature range.

3.4
holding time
time the product or component is kept at the holding temperature

Note 1 to entry: The holding time starts when the temperature at all measuring points has reached the minimum value of the range of the holding temperature and stops when one of the measuring points falls below that temperature.

Note 2 to entry: The holding time depends on the type of heat treatment, material and material thickness.

3.5
unloading temperature
temperature of the product or component when it is taken out of a furnace or when the heat source is removed or switched off in any other heat treatment, e.g. local heat treatment

3.6
section temperature range
temperature range with a specified linear distance that can vary between two adjacent measuring points

4 Review of requirements and technical review

4.1 General

The manufacturer shall review the contractual requirements and any other requirements together with any technical data. This is to ensure that all information necessary to carry out the heat treatment operations is available prior to the commencement of the work. The manufacturer shall affirm its capability to meet all requirements and 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 variations between the contract and previous quotation are identified.

4.2 Review of requirements

Aspects for consideration shall include the following:

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

b) statutory and regulatory requirements;

c) any additional requirement determined by the manufacturer;

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

4.3 Technical review

It shall be ensured that all necessary information has been supplied by the purchaser. Aspects for consideration shall include the following:

a) application standard being used and appropriate drawings;

b) location and accessibility of the product or component being heat treated;

c) type of marking of the product or component being heat treated;

d) heat treatment specifications (appropriate heat treatment values) and inspection procedures for heat treatment;

e) connection between heat treatment specifications and welding and/or forming-procedure specifications;

f) methods of heat treatment, for example which products or components are being treated in a furnace and which products or components are being subjected to local heat treatment;

g) competence of personnel;

h) suitability of equipment;

i) heat treatment documentation;

j) control and inspection arrangements;

k) quality requirements for the subcontractor;

l) handling of non-conformity of heat treatment;

m) means of temperature measurement and recording;

n) quality requirements and testing of heat treatment, if any;

o) schedule or sequence of heat treatment;

p) availability of sufficient energy;

q) other special agreements, e.g. supporting of the product or component.

5 Subcontracting

Any subcontractor shall work under the orders and responsibility of the manufacturer and shall fully conform to the relevant requirements of this document. The manufacturer shall ensure that the subcontractor can conform to the quality requirements of the specification.

Information that the manufacturer provides to the subcontractor shall include all relevant data from the technical review (see 4.3).

The manufacturer who orders heat treatment shall supply all relevant specifications and requirements concerning these works to the subcontractor. The subcontractor shall provide records and documentation of its work as specified by the manufacturer.

6 Personnel

The manufacturer shall appoint a sufficient number of competent personnel for the planning, performing and supervising of the heat treatment work according to specified requirements.

The competence of personnel who carry out the heat treatment shall be confirmed by the manufacturer (method of confirmation: support tracing the process).

The personnel shall be trained and be able to read, understand and implement heat treatment instructions, such as programming the regulation, installation of thermocouples or control of measuring line.

7 Inspection and testing

7.1 General

The manufacturer shall have at its disposal a sufficient number of competent personnel for planning and performing, inspection, testing and assessing of the heat treatment activities according to specified requirements.

7.2 Non-destructive testing

Non-destructive testing shall be carried out at the stage of heat treatment specified in the application standard.

7.3 Destructive testing

Destructive testing after heat treatment shall be carried out if required by the application standard or contract. It can be performed voluntarily if the manufacturer decides to verify the properties for the product or component.

The destructive testing may be carried out on separate test pieces if these are of the same material as the product and were subjected to the same production and heat treatment sequences.

8 Equipment for heat treatment

8.1 Production and testing equipment

The following equipment shall be available, when necessary:

a) furnace and/or heating equipment;

b) programmer for the heating process;

c) equipment for measuring and recording the temperature;

d) cooling equipment;

e) lifting and transport devices;

f) personal protective equipment and other safety equipment.

8.2 Description of facilities

For an evaluation of workshop capacity and capability, the manufacturer and/or subcontractor shall maintain a list of essential equipment used for heat treatment. This list shall identify items of major equipment, including:

a) furnace dimensions, maximum load and temperature range, in degrees Celsius;

b) heat treatment equipment and its capacity;

c) programmers and their capacity;

d) temperature-measurement equipment and its capacity, method of measurement, area of reading, accuracy, number of measuring channels and recording devices;

e) thermocouple type and tolerance class in accordance with IEC 60584-1 and method of attachment;

f) cooling devices, e.g. quenching tank, fan, compressed air;

g) other equipment required for heat treatment and its inspection.

8.3 Suitability of equipment

Equipment shall be adequate for the application concerned.

8.4 Verification of heat treatment equipment

8.4.1 General

All devices used for adjusting, measuring and recording the temperature shall be suitably validated at specified intervals by calibrated measuring instruments.

8.4.2 Measurement of the uniformity of furnace temperature

The uniformity of the furnace temperature shall be verified by regularly performed measurements of the temperature.

The measurement is performed in an empty furnace with thermocouples. The temperature shall be measured by a validated recording device. The thermocouples shall be located in such a way that, for different types of furnaces, the largest possible temperature differences be measured, for example at a distance of 300 mm from the loading area. At least four measurements shall be taken, two at the top of the furnace and two at the bottom. They shall be located in opposite corners.

The measurements shall be carried out over a minimum of two temperature ranges: one equal to the maximum working temperature of the furnace and another about half of that temperature. When the furnace is used only for post-weld heat treatment, only one measurement of the uniformity is needed.

The temperature shall be increased up to the measurement temperature and kept there for 15 min; thereafter, the results of the measurements shall be recorded.

The differences between the temperatures at the different measuring points shall be in accordance with Table 1.

Table 1 — Permissible temperature variation range at different measuring points

Measurement temperature T °C	Section temperature range for quality class °C		
	I	II	III
$T < 300$	15	10	6
$300 \leq T < 700$	20	15	10
$700 \leq T < 1\,000$	30	20	15
$1\,000 \leq T < 1\,300$	40	30	20

The measurement of the uniformity of temperature in the working zone shall be performed with an interval of no more than 36 months since the first validation date, or after a major repair or rebuild of the furnace is carried out.

As an alternative, the measurement can also be carried out during loaded conditions with a typical load. The measuring points shall be the same as stated in the second paragraph of this subclause.

A test report of the measurement results shall be prepared. The report shall be kept on file in connection with quality documents.

8.4.3 Validation of setting and recording devices

The devices used for temperature setting and recording shall be validated at specified intervals as follows:

a) temperature regulator: at intervals not exceeding 12 months (in the case of local heat treatment, the interval shall be as specified by the equipment manufacturer);

b) recording device: at intervals not exceeding 6 months;

c) measuring system: at intervals not exceeding 12 months.

For stationary furnaces, the intervals may be extended to twice the interval.

For transportable heat treatment equipment, the temperature recording devices shall be verified by a validated setpoint signal to ensure the specified temperature range.

Thermocouples are stable and accurate and do not need any validation.

NOTE Thermocouples are usually delivered with a batch certificate, including value of classes.

Validation reports shall be prepared and kept on file in connection with quality documents. They shall be available whenever necessary.

A file shall be kept on validated equipment, including the dates of validity.

8.5 New 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. Records of such tests shall be maintained.

8.6 Maintenance

The manufacturer shall have documented programmes for the maintenance of equipment. The plan shall ensure maintenance checks of those items in the equipment that control the variables listed in the relevant heat treatment specifications. The maintenance plan shall also include inspections on safety matters.

9 Heat treatment activities

9.1 General

The heat treatment shall, as appropriate, be carried out in furnaces.

9.2 Heat treatment parameters

The manufacturer of the product or component is responsible for determining the heat treatment parameters. The parameters are related to the type and thickness of material.

Depending on the type of heat treatment, the following parameters shall be specified, as appropriate:

a) loading temperature;

b) heating rate;

c) holding temperature (range, if necessary);