TECHNICAL REPORT

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

Soudage — Lignes directrices concernant les exigences de qualité relatives au traitement thermique en soudage et techniques connexes

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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

ISO/TR 17663 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Annex ZZ provides a list of corresponding International and European Standards for which equivalents are not given in the text.

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Foreword

This Technical Report has been prepared by the Technical Committee CEN/TC 121 "Welding", of which the Secretariat is held by DS, in collaboration with the Technical Committee ISO/TC 44 "Welding and allied processes".

The Technical Committee decided to publish this Technical Report.

1 Scope

This Technical Report proposes 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 may be used for other materials, as appropriate.

The purpose of this report is to form as a guidance for manufacturers which perform heat treatment or produce heat treated products or components. This report may also be used as a basis for assessing the manufacturer in respect to its heat treatment capability.

The requirements contained within this report may be adopted in full or may be selectively deleted by the manufacturer if not applicable to the construction concerned. They provide a flexible framework for the control of heat treatment in the following cases:

– Case 1

To provide specific requirements for heat treatment in contracts which require the manufacturer to have a quality system in accordance with EN ISO 9001 or EN ISO 9002.

– Case 2

To provide specific requirements for heat treatment in contracts which require the manufacturer to have a quality system other than EN ISO 9001 or EN ISO 9002.

– Case 3

To provide specific requirements for heat treatment as guidance to a manufacturer developing a quality system.

– Case 4

To provide specific requirements for post weld heat treatment when required by EN 729-2 or EN 729-3.

– Case 5

To provide specific requirements for references in application standards which uses heat treatment as part of its requirements or agreed in a contract between relevant parties.

2 Normative references

This Technical Report incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this Technical Report only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 729-2
Quality requirements for welding - Fusion welding of metallic materials - Part 2: Comprehensive quality requirements

EN 729-3
Quality requirements for welding - Fusion welding of metallic materials - Part 3: Standard quality requirements

EN 10052
Vocabulary of heat treatment terms for ferrous products

EN ISO 13916
Welding - Guidance of the measurement of preheating temperature, interpass temperature and preheat maintenance temperature (ISO 13916:1996)

3 Terms and definitions

For the purposes of this Technical Report, the terms and definitions in accordance with EN 10052 and EN ISO 13916 apply.

In addition the following terms and definitions apply.

3.1
manufacturer
firm which performs heat treatment or produces heat treated products or components.

3.2
post weld heat treatment
heat treatment carried out after welding in order to decrease residual welding stress and/or change the micro structure.

3.3
post forming heat treatment
heat treatment carried out after forming in order to regain the original properties of the material or reduce stresses caused by the forming.

3.4
loading temperature
temperature of the furnace at the stage when the product or component is put into the furnace.

3.5
holding temperature
temperature range in which the product or component is kept in order to achive specified properties. The holding temperature depends on the type of heat treatment and material. Normally it is expressed as a temperature range.

3.6
holding time
time the product or component is kept in the holding temperature. The holding time starts when the temperature in all measuring points has reached minimum value of the range of the holding temperature and stops when one of the measuring points falls below that temperature.

The holding time depends on the type of heat treatment, material and material thickness.

3.7
unloading temperature
temperature of the product or component when it is taken out e.g. of a furnace or when any other heat treatment is finished.

4 Contract review

4.1 General

The manufacturer should review the contractual requirements and the design 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 should affirm his capability to meet all heat treatment contract requirements and ensure adequate planning of all quality related activities. Contract review is carried out by the manufacturer to verify that the contract requirements are within his capability to perform, that sufficient resources are available to achieve delivery schedules and that documentation is clear and unambiguous. The manufacturer should ensure any variations between the contract and previous tender documentation are identified.

4.2 Contract review

The following items are typically considered at or before the time of the contract review. It should be ensured that all necessary information has been supplied by the purchaser.

a) the application standard to be used and appropriate drawings;

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

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

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

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

f) methods of heat treatment, e.g. which products or components are to be treated in a furnace and which products or components are 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 sub-contractor;

l) handling of non-conformances of heat treatment;

m) means of temperature measurement and recording;

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

o) heat treatment in the time table for the progress of work;

p) availability of sufficient energy;

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

5 Sub-contracting

Any sub-contractor should work under the order and responsibility of the contractor and should fully comply with the relevant requirements of this report. The contractor should ensure that the sub-contractor can comply with the quality requirements of the contract.

Information to be provided by the contractor to the sub-contractor should include all relevant data from the contract review (see 4.2).

The contractor who orders heat treatment should supply all relevant specifications and requirements concerning these work to the sub-contractor. The sub-contractor should provide records and documentation of his work as may be specified by the contractor.

6 Personnel

The manufacturer should 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 will carry out heat treatment should be confirmed by the manufacturer.

7 Inspection and testing

7.1 General

The manufacturer should have at his 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

The final non-destructive testing should be carried out at the stage of heat treatment if specified in the application standard or otherwise after the final heat treatment.

7.3 Destructive testing

Destructive testing may be carried out if:

a) the application standard or contract requires;

b) for the product or component the heat treatment is extremely demanding.

The destructive testing can be carried out on separate test pieces if they are of the same material as the product and the work activities should be the same as was done during production.

8 Equipment for heat treatment

8.1 Equipment and measurement

Following equipment should be available when necessary:

a) furnace and/or heating equipment;

b) programmer for the heating process;

c) equipment for measuring and recording of temperature;

d) cooling equipment;

e) lifting and transport devices;

f) personnel protective equipment and other safety equipment;

8.2 Description of facilities

The manufacturer and/or sub-contractor should maintain a list of essential equipment, used for heat treatment. This list should identify items of major equipment, essential for an evaluation of workshop capacity and capability. This includes for example:

a) maximum load and dimensions of the furnace and temperature-range (°C);

b) heat treatment equipment and their capacity;

c) programmers and their capacity;

d) equipment for temperature measurement and their capacity, e.g. type of measurement, capacity and recording devices;

e) type of thermo-couple to be used and type of attaching;

f) quench tanks;

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

8.3 Suitability of equipment

Equipment should be adequate for the application concerned.

8.4 Checking of heat treatment equipment

8.4.1 General

The uniformity of the furnace temperature should be checked by regularely performed measurements of uniform temperature. All devices used for adjustment and recording the temperature should be suitably checked at specified intervals by calibrated measuring instruments.

8.4.2 Measurement of uniform furnace temperature

The measurement is performed in an empty furnace with calibrated thermo couples. The temperature should be measured by a calibrated recording device. The thermo couples should be located in such a way that for different types of furnaces the possible biggest difference of temperatures can be measured, e.g. at a distance of 300 mm from the loading area. The number of measurement should be at least four, two at the top of the furnace and two at the bottom. They should be located in the opposite corners.

The measurement should be carried out at a minimum of two temperature ranges; one equal to the maximum working temperature of the furnace and another about half of that temperature.

The temperature should be increased up to the measurement temperature and kept there for 15 minutes where after the results of the measurements should be recorded.

The differences between the temperature at the different measuring points should not deviate more than ±20 °C.

The measurement of the uniformity of temperature should be performed at an interval of 36 months or when a major repair or rebuild of the furnace is carried out.

As an alternative the measurement could also be carried out during loaded conditions with a typical load. The measuring points should be the same as stated above.

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

8.4.3 Calibration of adjustment and recording devices

The devices used for adjustment and recording of the temperature should be calibrated at specified intervals as follows:

a) temperature regulator at least 12 months[1)];

b) recording device at least 6 months;

c) thermo couples at least 12 months (at least 4 months for temperature above 800 °C).

For stationary furnaces the intervals may be extended to twice the time.

Calibration reports should be prepared and they should be kept on file in connection with quality documents. They should be available whenever necessary.

A file should be kept on calibrated equipment including the validity.

1) In case of local heat treatment the interval should be as specified by the equipment manufacturer.

8.5 New equipment

After installation of new or refurbished equipment appropriate tests of the equipment should be performed. The tests should verify the correct function of the equipment. Records should be maintained of such tests.

8.6 Maintenance

The manufacturer should have documented programs for the maintenance of equipment. The plan should ensure maintenance checks of those items in the equipment which controls variables listed in the relevant heat treatment specifications. The maintenance plan should also include inspections on safety matters.

9 Heat treatment activities

9.1 General

The heat treatment should, whenever possible, 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 should be specified, as appropriate:

a) loading temperature;

b) heating rate;

c) holding temperature;

d) holding time;

e) cooling rate;

f) unloading temperature.

9.3 Heat treatment specification

The manufacturer should prepare heat treatment specifications, which in case of welds, are recommended to be included in the welding procedure specification. The specification will specify that work can be carried out correctly.

The heat treatment specification should include following information, as appropriate:

a) type of heat treatment, e.g. preheating, stress relieving, normalization;

b) method of heat treatment, e.g. furnace, local heat treatment;

c) location and number of measuring points;

d) need for shielding gas;

e) heat treatment parameters;

f) supporting and loading of the product(s) or component(s);

g) type of cooling;

h) identification of the product or component, e.g. designation, numbering;

i) environmental conditions, e.g. protection from wind and rain.

Specifications should be approved in accordance with instruction given in application standards or contract.

9.4 Work instruction

The heat treatment specification or the welding procedure specification may be used as such for instruction purposes. Alternatively dedicated work instructions may be used. Such work instructions should be prepared from an approved heat treatment specification and do not require separate approval.

9.5 Number of measuring points

During the heat treatment the temperatures should whenever possible be determined at a minimum number of measuring points according to table 1 or table 2. If the method of measurement requires, the thermo couples should be covered in order to avoid direct heating.

Table 1 - Minimum number of measuring points for furnace heat treatment.

Volume of furnace m^3	Number of measuring points
< 40	2
40 to 60	3
60 to 80	4
80 to 100	5
> 100	6

If the furnace is divided into heating sections, e.g. back, middle and front, at least one measuring point per section is recommended.

For furnace heat treatment the location of measuring points should be specified so that a uniform temperature is achieved.

Table 2 - Minimum number of measuring points for local heat treatment of pipes

Outside diameter of pipe mm	Number of measuring points	Pitch °
< 170	1	–
170 to 370	2	180
370 to 550	3	120
> 550	4	90

For local heat treatments of other products the location of the measuring points should be specified in a drawing or sketch.

9.6 General rules for local post weld heat treatment of pipework

It is permissible to heat treat seperate sections of the product or component in furnace, providing the overlap of the previously heat treated sections is at least 1500 mm or 2,5 $\sqrt{}$ in mm, whichever is the greater (where "D" is the outside diameter of the product or component and "t" is the nominal thickness at the weld).

It is permissible to locally heat treat circumferential welds by heating an insulated conductor band around the entire circumference of the product or component. The width of the heated zone should not be less than 2,5 $\sqrt{}$ in mm, the weld being in the centre.

Where the attaching butt weld is at a distance not less than 2,5 $\sqrt{}$ in mm from the branch/stub to shell weld it may be post weld heat treated in isolation. Where the attaching butt weld is at a distance less than 2,5 $\sqrt{}$ in mm from the branch/stub to shell weld the post weld heat treatment should be applied simultaneously to the butt weld and the branch/stub to shell weld.

Care should be taken during welding and post weld heat treatment of the butt weld to ensure harmful temperature gradients do not occur local to the weld between the shell and the branch/stub.

When a component is heat treated by internal means it should be fully encased with thermal insulating material.

10 Heat treatment record

The heat treatment personnel should prepare a heat treatment record for each product or component that has been heat treated. Unless otherwise stated in the application standard the following information should be given, as appropriate:

a) identification of the product or component;

b) information of material (dimensions, chemical composition, ladle number);

c) heat treatment equipment;

d) type of heat treatment;

e) method of heat treatment;

f) heating rate;

g) loading temperature;

h) holding temperature;

i) holding time;

j) unloading temperature;

k) cooling method;

l) cooling rate;

m) type of temperature measurement and number of measuring points;

n) place and date of performance.

The heat treatment record should be signed by the appointed person.

11 Non-conforming and corrective action

If the heat treatment does not conform to specified requirements the acceptance of the product or component should not be assessed. In such cases the purchaser should be informed. If necessary, corrective actions should be carried out. A report of the non-conforming should be prepared and filed together with the quality records.

The satisfactory result of any corrective heat treatment should be demonstrated.

The corrective actions should be carried out in accordance with a prepared specification. When preparing specification it has to be considert that the corrective action does not have any adverse influence on the product or component. A report from the action should be prepared and the product or component should be re-inspected, tested and examined in accordance with the original requirements.

12 Quality records

The manufacturer and the sub-contractor should establish procedures for controlling the relevant quality records.

Quality records, according to the contract requirements, should include, when necessary:

a) record of contract review (4.2);

b) heat treatment specifications/welding procedure specification and their approval records (9.3);

c) competence of heat treating personnel (6);

d) records of measurement of heat treatment equipment (8.4.2, 8.5 and 8.6);

e) heat treatment records (10);

f) calibration reports for measuring devices (8.4);

g) correction procedures and reports (11);

h) non conformity reports (11).

Quality records should be retained for a minimum period of 5 years in the absence of any other specifed requirements.