BRITISH STANDARD

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Welding — Quality requirements for heat treatment in connection with welding and allied processes (ISO 17663:2009)

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British Standards

National foreword

This British Standard is the UK implementation of EN ISO 17663:2009. It supersedes PD CR ISO 17663:2001 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/-/1, Briefing committee for welding.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN ISO 17663:2009) has been prepared by Technical Committee ISO/TC 44 "Welding and allied processes" in collaboration with Technical Committee CEN/TC 121 “Welding”, the secretariat of which is held by DIN.

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Foreword

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ISO 17663 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*.

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INTERNATIONAL STANDARD **ISO 17663:2009(E)**

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

1 Scope

This International Standard 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 International Standard provides guidance for manufacturers that perform heat treatment or produce heat-treated products or components. This International Standard 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 International Standard is intended to be a flexible framework to provide

— specific requirements for heat treatment by manufacturer 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 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 13916, *Welding — Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature*

IEC 60584-2, *Thermocouples — Part 2: Tolerances*

EN 10052, *Vocabulary of heat treatment terms for ferrous products*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13916 and EN 10052 and the following apply.

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

NOTE 2 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 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 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 may 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 essential 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, e.g. 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-conformances of heat treatment;

m) means of temperature measurement and recording;

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

o) schedule/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 comply with the relevant requirements of this International Standard. The manufacturer shall ensure that the subcontractor can comply with 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 his 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.

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

7 Inspection and testing

7.1 General

The manufacturer shall 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

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 may be carried out if

a) it is required by the application standard or contract;

b) the manufacturer decides to verify the properties for the product or component.

The destructive testing may be carried out on separate test pieces if they 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) personnel 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, for example

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 60584-2 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, e.g. 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
$300 \leqslant T < 700$	20	15	10
$700 \leqslant T < 1\,000$	30	20	15
$1\,000 \leqslant T < 1\,300$	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 above in paragraph 2 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 of at least 12 months[1)];

b) recording device: at intervals of at least 6 months;

c) measuring system: at intervals of at least 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 signal to ensure the specified temperature range.

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

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 they shall be kept on file in connection with quality documents. They shall be available whenever necessary.

A file shall be kept on validated equipment including the 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 shall be maintained of such tests.

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);

d) holding time (range, if necessary);

e) cooling rate;

f) unloading temperature.

9.3 Heat-treatment-procedure specification

The manufacturer shall prepare heat-treatment-procedure specifications. In case of welding activities, the heat-treatment procedure may be included in the welding-procedure specification or the welding-procedure specification may refer to the heat-treatment specification. The specification specifies how to carry out the work correctly.

The heat-treatment-procedure specification shall include following information, as appropriate:

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

b) method of heat treatment, e.g. furnace, inductive, resistance, ring snake burner;

c) location and number of measuring points for the temperature;

d) requirement 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.

j) range of heated zone and area of isolation.

Heat-treatment-procedure specifications shall be qualified in accordance with instructions given in application standards or contracts.

9.4 Work instructions

The heat-treatment specification or the welding-procedure specification may be used, as such, for work instructions. Alternatively, dedicated work instructions may be used. Such work instructions shall be prepared from a qualified heat-treatment-procedure specification and do not require separate qualification.

9.5 Number of measuring points

During the heat treatment, the temperatures shall, as appropriate, be determined at a minimum number of measuring points in accordance with Table 2 or Table 3. If the method of measurement requires, the thermocouples shall be covered in order to avoid direct heating. The temperatures at both ends of the heating zone may be measured, if specified.

Table 2 — Minimum number of measuring points in furnace atmosphere

Furnace volume V m^3	**Number of measuring points**
$V < 40$	2
$40 \leqslant V < 60$	3
$60 \leqslant V < 80$	4
$80 \leqslant V < 100$	5
$V \geqslant 100$	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 the measuring points shall be specified so that a uniform temperature is achieved.

The measuring points may be on the work piece, if specified. Thermocouples shall be attached with procedures not adversely affecting the work piece, e.g. using capacitor discharge stud welding.

Table 3 — Minimum number of measuring points for local heat treatment of circumferential components

Outside diameter of pipe D mm	Number of measuring points	Pitch °
$D < 170$	1	—
$170 \leqslant D < 370$	2	180
$370 \leqslant D < 550$	3	120
$D \geqslant 550$	4	90

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

For products consisting of several pipes, e.g. panels, it is enough to measure only the pipes placed at both ends.

9.6 General rules for local post weld heat treatment of welds in pipe work

It is permissible to heat treat separate sections of the product or component in the furnace, provided that the length, L, expressed in millimetres, of the overlap of the previously heat-treated sections is equal to the greater of 1 500 mm or the value of L as given in Equation (1):

$$L = 2{,}5\sqrt{(2D - 4t)t} \tag{1}$$

where

D is the outside diameter of the product or component, expressed in millimetres;

t is the nominal thickness at the weld, expressed in millimetres.

NOTE Equation (1) is equivalent to $\left(5\sqrt{Rt}\right)$ as given in European standards. Equation (1) is more user-friendly because only the outer diameter, D, is used instead of the inner or outer radius, R_i or R_e, respectively. An example is given in Annex A.

It is permissible to locally heat treat circumferential welds by inductive or resistance heating around the entire circumference of the product or component. The width of the heated zone, L_W, expressed in millimetres, shall not be less than the value of L as given in Equation (1) nor more than 12 t, with the weld being in the centre.

Where the attaching butt weld is at a distance, L_{BW}, expressed in millimetres, greater than the value of L as given in Equation (1) 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, L_{BW}, less than the value of L as given in Equation (1) from the branch/stub to the shell weld, the post-weld heat treatment shall be applied simultaneously to the butt weld and the branch/stub to shell weld.

Care shall be taken during welding and post-weld heat treatment of the butt weld to ensure that harmful temperature gradients do not occur locally to the weld between the shell and the branch/stub. The temperature at the end of the heating area shall be at least 50 % of the maximum holding temperature.

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

10 Heat treatment record

The heat-treatment personnel shall 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 shall be given, as appropriate:

a) identification of the product or component;

b) information of material (material designation, dimensions);

c) heat-treatment equipment (identification);

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

e) method of heat treatment (e.g. furnace, inductive, resistance, ring snake burner);

f) loading temperature;

g) heating rate;

h) holding temperature;

i) holding time;

j) cooling rate;

k) cooling method;

l) unloading temperature;

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

n) place and date of heat treatment.

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

11 Non-conformance and corrective actions

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

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

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

12 Quality records

The manufacturer and the subcontractor shall establish procedures for controlling the relevant quality records.

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

a) record of requirements review (4.2) and technical review (4.3);

b) heat-treatment-procedure specifications, welding-procedure specification and their qualification records (9.3);

c) competence of heat treating personnel (Clause 6);

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

e) heat treatment records (Clause 10);

f) validation reports for measuring devices (8.4);

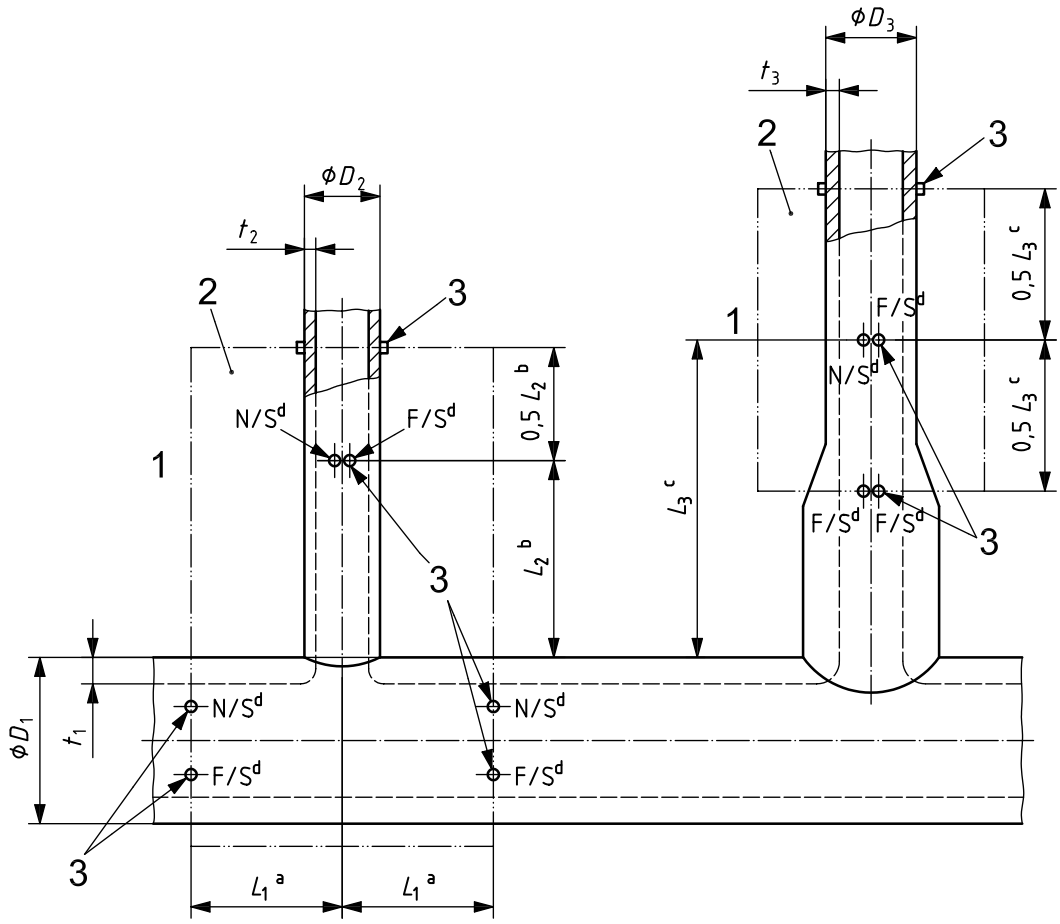
g) correction procedures and reports (Clause 11);

h) non-conformance reports (Clause 11).

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

Annex A
(informative)

Example of local heat treatment



Key

1 site weld
2 heated zone
3 thermocouples

a $L_1 \geq 1,25\sqrt{(2D_1 - 4t_1)t_1}$

b $L_2 \geq 2,5\sqrt{(2D_2 - 4t_2)t_2}$

c $L_3 \geq 2,5\sqrt{(2D_3 - 4t_3)t_3}$

d Minimum requirements are one near-side (N/S) and one far-side (F/S) per position as indicated.

Figure A.1 — Minimum heated band-width for local heat treatment
(from EN 12952-5)

Bibliography

[1] ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

[2] ISO 3834-3, *Quality requirements for welding — Fusion welding of metallic materials — Part 3: Standard quality requirements*

[3] ISO 9001, *Quality management systems — Requirements*

[4] EN 12952-5, *Water-tube boilers and auxiliary installations — Part 5: Workmanship and construction of pressure parts of the boiler*

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Chiswick High Road,
London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
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