



[ISO/TC 44/SC 10](#)

Unification of requirements in the field of metal welding

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Secretariat: DIN

ISO/DTR 14745 - Observed comments and updated draft (2014-03)

Date of document	2014-04-30
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Background

ISO/DTR 14745 "Welding - Post-weld heat treatment parameters for steels"

Note: A ballot has been created on the [Committee Internal Balloting Portal](#).

Please vote by 2014-06-12 at the latest if you agree to adopt the enclosed draft for publication.

Template for comments and secretariat observations

Date: 2014-03-04	Document: ISO/TC 44/SC 10/WG 8 N 42	ISO/PRF TR 14745 (ISO/TC 44/SC 10 N 1200)
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MB/ NC ¹	Line number	Clause/ Subclause	Paragraph/ Figure/ Table/	Type of comment ²	Comments	Proposed change	Observations of the secretariat
BE				GE	We regret that this document went from CD to Final stage, skipping the DIS.		This is a technical report without any CD or DIS stages.
BE				Te/ge	The proposed document contains lots of confusions, already between title, scope and contents. A Technical Report should not put forward recommendations. There is no understanding of the need or intent of the document. Many recommendations contradict requirements of existing codes. As such it is unapplicable. The comment about the risk of PWHT above tempering is subject to misinterpretation, as it is the total heat treatment in the tempering range that has an effect . The Pcritis also do not match the recommended treatment ranges.	The document should be rejected.	Noted Vice versa. A technical report gives recommendations. Not requirements. The attempt with this report is to harmonize the different requirements existing in different codes and product standards. The following clause will be added into clause 6 (after the 7th paragraph): The whole PWHT cycle consisting from heating rate, holding temperature, holding time and cooling rate may have an essential influence on the mechanical properties. The data for heating and cooling can be taken out of the relevant product standards. If required by application standards or specifications the PWHT cycle should be qualified by a procedure test including parent metal. This belongs especially for multi PWHT cycles.

¹ **MB** = Member body / **NC** = National Committee (enter the ISO 3166 two-letter country code, e.g. CN for China; comments from the ISO/CS editing unit are identified by **)

² **Type of comment:** **ge** = general **te** = technical **ed** = editorial

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MB/ NC ¹	Line number	Clause/ Subclause	Paragraph/ Figure/ Table/	Type of comment ²	Comments	Proposed change	Observations of the secretariat
JP					This DTR is standardized for proof strength oriented design, not for tensile strength oriented design.		This is correct, because for the moment only European materials have been overtaken in this TR (mostly for elevated temperatures)
FR			Table 1	te	As it is written, France cannot accept this document. In order to obtain a more useful and pertinent document it is necessary : - to simplify the reading and nevertheless, cover all steels used ; - to take into account progress made by steel producers ; - to take into account progress made on heat treatment process ; - to enlarge the possibility to proceed without PWHT ; - to limit possible additional cost resulting from new qualification procedures.	For example, the conditions for groups 1.1, 1.2 and 1.3, for groups 4.1 and 4.2, etc. should be the same.	The general part of the comment is noted. For the specific proposal it has been difficult to get consensus through history. E.g. EN 13445. For group 1 materials it is not possible to use temperatures above 600°C.
FI		3.5		ed		Change PTHW to PWHT	Agreed
BE		3.5		ed	post-weld heat treatment (PTHW)		See above
BE		5		ed	Equipment used for the PWHT should be suitable according to ISO 17663. It should permit the temperature control of the component with adequate accuracy and uniformity The PWHT of products...	Equipment used for the PWHT should be suitable according to ISO 17663. It should permit the temperature control of the component with adequate accuracy and uniformity. The PWHT of products	Agreed
FI		7.2	Table 1 5.1 and 5.2	ed		Delete the over lined text (Vanadium content).	Agreed

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MB/ NC ¹	Line number	Clause/ Subclause	Paragraph/ Figure/ Table/	Type of comment ²	Comments	Proposed change	Observations of the secretariat
SE		7.2	Table 1	te	Use the same note as we already have in EN 13480-4, table 9.4.1.-1 for material group 5.1 and 5.2. Is there any reason/motivation to change this?	EN 13480-4, table 9.4.1-1 For material group 5.1 and 5.2 e PWHT may not be necessary for dimension $d_a \leq 114,3$ mm and $w \leq 7,1$ mm, when the preheat temperature is 200 °C or above and the service does not require PWHT.	Footnote f covers this. The footnote will be added to group 5.1

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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.

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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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 14745 was prepared by Technical Committee ISO/TC 44, Welding and allied processes, Subcommittee SC 10, Unification of requirements in the field of metal welding.

Requests for official interpretations of any aspect of this Technical Report should be directed to the Secretariat of ISO/TC 44/SC 10 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

Welding — Post-weld heat treatment parameters for steels

1 Scope

This Technical Report provides recommendations for post-weld heat treatment (PWHT) of steels with recommendations for holding temperatures and holding times for different materials and material thicknesses. These recommendations are limited to stress relieving for non-alloy steels (group 1, 2, 3, 4 and 11) and to tempering for Cr-Mo-(Ni) steels (group 5 and 6) and martensitic stainless steels (group 7.2), and are independent of type of product or location. The recommendations do not supersede any guidance given in material supplier specifications, e.g. thermomechanically treated fine-grain steels.

This Technical Report does not specify when PWHT is required. Such requirements are given in product standards, material specifications or material data sheets.

2 Normative references

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

ISO/TR 15608, *Welding — Guidelines for a metallic materials grouping system*

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

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 EN 10052 and the following apply.

3.1

cooling rate

variation in temperature as a function of time during cooling cycle

[SOURCE: ISO 4885:1996,^[1] definition 3.37]

3.2

heating rate

variation in temperature as a function of time during heating cycle

[SOURCE: ISO 4885:1996,^[1] definition 3.78]

3.3

holding temperature

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

[SOURCE: ISO 17663:2009, definition 3.3]

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

[SOURCE: ISO 17663:2009, definition 3.4]

Note 1 to entry: The holding time starts when the temperature in 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

post-weld heat treatment (PWHT)

heat treatment carried out after welding in order to decrease residual welding stress, and/or to adjust to desired properties and/or the microstructure

4 Symbols and abbreviated terms

4.1 Symbols

P Hollomon–Jaffe parameter

t material thickness, in mm

NOTE Symbols other than those specified here are used in other International Standards.

4.2 Abbreviated terms

NT normalized and tempered

PWHT post-weld heat treatment

QT quenched and tempered

5 General information

PWHT should be performed in accordance with a written procedure which describes the parameters critical to the PWHT process.

Equipment used for the PWHT should be suitable according to ISO 17663. It should permit the temperature control of the component with adequate accuracy and uniformity. The PWHT of products or components should be recorded by the manufacturer indicating the holding temperature, holding time, the heating- and cooling-rate.

6 Heat treatment conditions

PWHT, with the exception of those materials mentioned in Clause 8, should be applied to steels in accordance with Table 1 on completion of welding. If PWHT of materials, not listed in Table 1, is considered necessary, the PWHT holding time and holding temperature should take into account recommendations

from the of the application standard, as well as the recommendations of the material and welding consumable manufacturer to achieve the required material properties.

Where welded joints are connecting parts with different in thicknesses, the thickness to be used in applying the requirements for PWHT should be:

- a) for butt welds (excl. in T joints) the thickest part of the weld ~~of the two parts~~ (see figure 1);

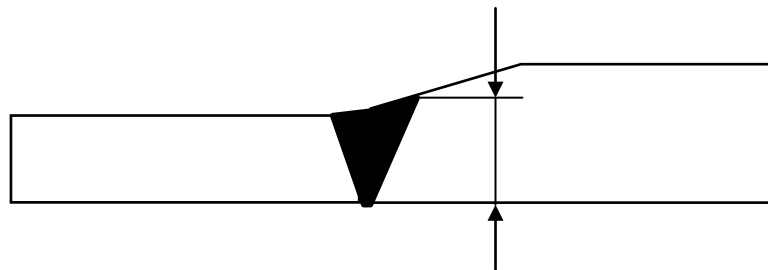


Figure 1 Example of thickest part of the weld

- b) for butt welds in T joints the thickness of the weld;
 c) for fillet welds the throat thickness of the weld.
 d) for butt welded set-on nozzles the thickness of the nozzle;
 e) for set-through nozzles the thickness of the plate or shell;
 f) for set-in nozzles the thickness of the weld;

PWHT may be carried out on steels of thickness lower than specified by Table 1. Such instances may include products subject to stress corrosion cracking or at risk of brittle fracture.

When additional welds or weld repairs have been made after PWHT, a further heat treatment is normally carried out. The thickness to be used in defining the holding time required at temperature should be the thickness of the weld applied after the PWHT.

In Table 1, a P_{crit} value is introduced. This parameter, a critical Hollomon–Jaffe value, should not be exceeded without proving the mechanical properties.

PWHT as per Table 1 particularly in the upper range of holding temperature and/or holding time may unduly impair the physical properties, e. g. yield strength, tensile strength, and toughness of the material.

A higher PWHT temperature than tempering temperature for NT- and QT-materials could impair the mechanical properties of the material.

The whole PWHT cycle consisting from heating rate, holding temperature, holding time and cooling rate may have an essential influence on the mechanical properties. The data for heating and cooling can be taken out of the relevant product standards. If required by application standards or specifications the PWHT cycle should be qualified by a procedure test including parent metal. This belongs especially for multi PWHT cycles.

The additional effect of multiple heating cycles should be considered. This effect is explained by the Hollomon-Jaffe parameter, P (Reference [4]), as given in

$$P = T_s(20 + \lg t_h) \times 10^{-3}$$

where

T_s is the holding temperature, in Kelvin;

t_h is the holding time, in hours.

NOTE The Hollomon-Jaffe parameter describes the effect of tempering for a certain time t , at a certain temperature T and a parameter C that is unique to the material used. This mathematical relationship has proved to be of particular value in highly complex welding procedure qualifications where considerable costs may arise by application of multiple stage PWHT in the production process. The Hollomon-Jaffe parameter may be used in the calculation and application of more cost effective single cycle PWHT

7 Application of PWHT

7.1 General

PWHT can be applied with a furnace or with local heating (e.g. induction or resistance). Reference should be made to ISO 17663 for the methods of application.

The PWHT temperatures and times should be in accordance with Table 1.

7.2 Heating and cooling

During the heating and cooling periods, for temperatures up to 500 °C, variation in temperature throughout the product or component should not exceed 150 °C within 4 500 mm and the temperature gradient should be gradual. Above 500 °C, this variation should not exceed 100 °C.

When the product or component has attained a uniform holding temperature (see Table 1), this temperature should be held for the period specified in Table 1.

Table 1 — PWHT parameters for steel

Material group (ISO/TR 15608)	Material	Holding temperature	Material thickness ^a <i>t</i>	Holding time	<i>P</i> _{crit} (see Clause 6)
		°C	mm	min	
1.1	Steels with <i>R</i> _{eH} ≤ 275 MPa	550–600	<i>t</i> ≤ 35 ^a	30	17,5
	— 16Mo3	550-620	35 < <i>t</i> ≤ 90 <i>t</i> > 90	<i>t</i> – 5 40 + 0,5 <i>t</i>	
1.2	Steels with 275 MPa < <i>R</i> _{eH} ≤ 360 MPa				
	— delivery condition M	530–580	<i>t</i> ≤ 35 ^a 35 < <i>t</i> ≤ 90 <i>t</i> > 90	30 <i>t</i> – 5 40 + 0,5 <i>t</i>	17,3
	— delivery condition QT	550–600 ^b			17,5
	— delivery condition N (except 16Mo3)	550–600			17,5
	— 16Mo3, 18MnMo4-5 and 18 Mo5	550–620			17,5
1.3	Normalized fine-grain steels with <i>R</i> _{eH} > 360 MPa	530–580			17,3

2.1	Thermomechanically treated fine-grain steels with $360 \text{ MPa} < R_{eH} \leq 460 \text{ MPa}$	530–580			17,3
2.2	Thermomechanically treated fine-grain steels with $R_{eH} > 460 \text{ MPa}$	— ^d			
3.1	Quenched and tempered fine-grain steels with $R_{eH} > 360 \leq 690 \text{ MPa}$				
	— 20MnMoNi4-5 ^c	550–620 ^b			17,5
	— 360 MPa < $R_{eH} \leq 500 \text{ MPa}$ ^a	530–580 ^b			—
	— 500 MPa < $R_{eH} \leq 690 \text{ MPa}$	— ^d			
3.2	Quenched and tempered fine-grain steels with $R_{eH} > 690 \text{ MPa}$	— ^d			
4.1	Low vanadium alloyed Cr-Mo-(Ni) steels with, by mass: Mo ≤ 0,7 %; V ≤ 0,1 %; Cr ≤ 0,3 %; Ni ≤ 0,7 %				
	— 18NiCuMoNb5-5	580–640 ^b	$t \leq 15$ ^c $15 < t \leq 60$ $35 < t \leq 90$ $t > 90$	30 2t 120	—
	— 15MnCrMoNiV5-3		^d		
4.2	Low vanadium alloyed Cr-Mo-(Ni) steels with, by mass: Mo ≤ 0,7 %; V ≤ 0,1 %; Cr ≤ 0,7 %; Ni ≤ 1,5 %				
	— 15NiCuMoNb5-6-4	530–620	$t \leq 20$ $20 < t \leq 35$ $35 < t \leq 90$ $t > 90$	30 60 t, min. 60 40 + t	
5.1	Cr-Mo-steels free of vanadium with, by mass: 0,75 % < Cr ≤ 1,5 %; Mo ≤ 0,7 % ^{a, f}				
	— 25CrMo4, 26CrMo4-2	— ^e			
	— 13CrMoSi5-5	620–680 ^b	$t \leq 15$	30	18,7
	— 13CrMo4-5	630–700 ^g	$15 < t \leq 60$	2t	
	— All others	620–680 ^g	$t > 60$	60 + t	18,5
5.2	Cr-Mo-steels free of vanadium with, by mass: 1,5 % < Cr ≤ 3,5 %; 0,7 % < Mo ≤ 1,2 % ^f				
	— 10CrMo9-10 ^h	670–730	$t \leq 15$	30	19,2
	— 11CrMo9-10 ^h	660–720 ^b	$15 < t \leq 60$ $t > 60$	2t 60 + t	
	— 12CrMo9-10	660–720 ^{b, i}	$t \leq 125$ $t > 125$	2,4t 225 + 0,6t	19,3
5.3	Cr-Mo-steels free of vanadium with, by mass: 3,5 % < Cr ≤ 7 %; 0,4 % < Mo ≤ 0,7 %				
	— X11CrMo5, X12CrMo5	680–750	$t \leq 15$	30	19,5

	— X16CrMo5-1	700–750	$15 < t \leq 60$ $t > 60$	$2t$ $60 + t$	—
5.4	Cr-Mo-steels free of vanadium with, by mass: $7 \% \leq \text{Cr} \leq 10 \%$; $0,7 \% < \text{Mo} \leq 1,2 \%$	740–780	$t \leq 12$ $12 < t \leq 60$ $t > 60$	30 $2,5t$ $90 + t$	—
6.1	High vanadium alloyed Cr-Mo-(Ni) steels with, by mass: $0,3 \% < \text{Cr} \leq 0,75 \%$; $\text{Mo} \leq 0,7 \%$; $\text{V} \leq 0,35 \%$	680–730	all	$90 + t$, min. 180	—
6.2	High vanadium alloyed Cr-Mo-(Ni) steels with, by mass: $0,75 \% < \text{Cr} \leq 3,5 \%$; $0,7 \% < \text{Mo} \leq 1,2 \%$; $\text{V} \leq 0,35 \%$				
	— 12CrMoV12-10	690–710 ^b	$t \leq 125$	$2,4t$	19,4
	— 13CrMoV12-10		$t > 125$	$225 + 0,6t$	
6.3	High vanadium alloyed Cr-Mo-(Ni) steels with, by mass: $3,5 \% < \text{Cr} \leq 7,0 \%$; $\text{Mo} \leq 0,7 \%$; $0,45 \% < \text{V} \leq 0,55 \%$	— ^d			
6.4	High vanadium alloyed Cr-Mo-(Ni) steels with, by mass $7,0 \% < \text{Cr} \leq 12,5 \%$; $0,7 \% < \text{Mo} \leq 1,2 \%$; $\text{V} \leq 0,35 \%$				
	— X10CrMoVNb9-1	730–770 ^j	$t \leq 12$ $12 < t \leq 60$ $t > 60$	30 $2t$, min 60 $90 + t$	20,5
	— X10CrWMoVNb9-2	740–770 ^j	$t \leq 12$ $12 < t \leq 60$ $t > 60$	30 $2t$, min 60 $90 + t$	
	— X20CrMoV11-1 — X20CrMoNiV 11-1 — X20CrMoV12-1	730–770 ^j	$t \leq 12$ $12 < t \leq 60$ $t > 60$	30 $2,5t$ $90 + t$	—
7.2	Martensitic stainless steels with, by mass $\text{C} \leq 0,35 \%$; $10,5 \% \leq \text{Cr} \leq 30 \%$				
	— X3CrNi13-4	530–570	all	240	—
8.1	Austenitic stainless steels with $\text{Cr} \leq 19 \%$	Generally not applicable ^d			
8.2	Austenitic stainless steels with $\text{Cr} > 19 \%$				
9.1	Ni alloy steels with $\text{Ni} \leq 3,0 \%$	530–580	$t \leq 35^{\text{a}}$ $35 < t \leq 90$ $t > 90$	30 $t - 5$ $40 + 0,5t$	—
9.2	Ni alloy steels with $3,0 \% < \text{Ni} \leq 8,0 \%$ ^{b, k}				
9.3	Ni alloy steels with $8,0 \% < \text{Ni} \leq 10 \%$	e			
10.1	Austenitic ferritic stainless steels with $\text{Cr} \leq 24 \%$	Generally not applicable ^d			
10.2	Austenitic ferritic stainless steels with $\text{Cr} > 24 \%$				
^a For thickness ≤ 35 mm, post-weld treatment is normally only necessary in special cases [e.g. to reduce the danger of stress corrosion cracking or hydrogen-induced cracking (sourgas)].					
^b Higher temperatures can be applied, subject to conditions given in application standards.					

c	For thickness ≤ 15 mm, PWHT is optional.
d	If PWHT is considered necessary, the PWHT holding time and holding temperature should take into account recommendations from the material manufacturer, as well as the welding consumable manufacturer to achieve the required materials properties.
e	Normally welded with austenitic filler metal; in view of possible carbon diffusion, PWHT should be avoided.
f	According to EN 13480-4, ^[2] no PWHT is required if all the following conditions are fulfilled: — tubes with outside diameter $\leq 114,3$ mm; — nominal wall thickness $\leq 7,1$ mm; — minimum pre-heating temperature 200 °C.
g	According to EN 13445-4, ^[3] no PWHT is required if all the following conditions are fulfilled: — tubes with nominal diameter < 120 mm; — nominal wall thickness < 13 mm.
h	According to EN 13445-4, ^[3] no PWHT is required if all the following conditions are fulfilled: — tubes with nominal diameter < 120 mm; — nominal wall thickness < 13 mm; — design temperature > 480 °C.
i	In case of intermediate stress relieving (ISR): 630–650 °C
j	Intermediate cooling of the weld below the M_f temperature (typically 90–100 °C) should take place before PWHT to ensure full transformation to martensite.
k	After the welding of the 3,5 % by mass Ni steels with thicknesses over 35 mm, it is permitted to weld, without new heat treatment, components that are not subject to pressure provided the following conditions are met: — the weld dimensions (weld thickness or corner joint throat) are ≤ 12 mm; — a pre-heating temperature of minimum 100 °C is applied during the welding operation.

7.3 Heating in a furnace

In addition to clause 7.2 in the case of furnace PWHT, the temperature of the furnace at the time when the product or component is placed in or taken out of the furnace should not exceed:

- 400 °C for simple products or components of uncomplicated shape and $t < 60$ mm thickness;
- 300 °C for complex products or components of complicated shape or $t \geq 60$ mm thickness.

The rate for heating or cooling of the product or component should not exceed the following:

- for thickness $t \leq 25$ mm: 220 °C/h;
- for thickness $25 \text{ mm} < t \leq 100 \text{ mm}$: $(5\,500/t)$ °C/h;
- for thickness $t > 100 \text{ mm}$: 55 °C/h.

The temperature specified should be the actual temperature of any part of the product or component being heat treated.

During the heating and holding periods, the furnace atmosphere should be controlled so as to avoid excessive oxidation of the surface of the product or component. There should be no direct impingement of flame on the product or component.

NOTE 1 1°C is equivalent to 1°K when defining temperature gradients.

NOTE 2 A complex component is one that may incorporate different materials having significant differences in thickness or involve a design containing multiple weldments”

8 Post weld heat treatment of dissimilar ferritic joints

8.1 General

Where a product or component is manufactured from dissimilar ferritic steels, special consideration should be given to the effect of PWHT parameters on the mechanical properties.

8.2 Holding temperature

Where the temperature ranges in Table 1 for each material do not overlap, consideration should be given to redesigning the dissimilar weld to include a suitable transition material, or using a non-ferritic weld buttering e.g. stainless steel or high nickel weld metal.

When the maximum temperature allowed in Table 1 of one material in the dissimilar combination is lower than the minimum temperature allowed for the second, then one of the routes a) to c) should be followed:

- a) Where the temperature ranges in Table 1 for each material overlap, tests should be carried out to verify the properties of the dissimilar weld at the PWHT range specified.
- b) Redesign the combination to include a transition piece that overlaps the temperature range.
- c) Butter the higher PWHT temperature range steel with the suitable filler material and PWHT the higher temperature range. On completion, make the joint weld between the butter weld and the second steel and PWHT at the lower temperature range.

Annex A

Additional information about PWHT

A.1 General

The following heating treatments can be applied after welding:

- Normalizing (N) with complete microstructural transformation (via G-O-S) in weld area and the neighbouring unaffected base material or partial microstructural transformation (within the Alpha-Gamma-Area of EKD) with process-related heating treatments like multistage warming of welding components between 800-900 °C, e.g. enamelling process.
- Stress relief annealing (S) usually performed in the range of 450 – 650 °C aiming a moderate internal stress reduction without microstructural transformation.
- Tempering Annealing (PWT) is usually performed in a range of 530 – 780 °C depending on the type of steel alloy, to form special carbide and to completely eliminate martensitic structures. As a side effect internal stress reduction will be achieved.
- Precipitation hardening (PH) for a special type of steel is usually performed in a range of 480 – 760 °C with one or two-stage precipitation hardening processes.

A.2 Special heat treatment

- Soaking:
Hydrogen-relief annealing in the range of 250 – 300 °C, usually before a final heat treatment (S or PWT)
- Stress reduction treatment:
Stress reduction and improvement of the internal stress field in the area of welds around 300 °C. Not applicable for aging-prone and non-alloy structural steels.
- Flame-straightening:
Elimination of distortions / deformations by local rapid brief heating up to 650 – 850 °C. This heat affection can also be performed in the area of welding seams.

During the preparation if possible a heating treatment of the complete component has to be achieved. A proper heating treatment can be subjected even to large components. During this process it is important to avoid deformation of the component by its own weight.

As heating treatment of large components isn't possible on sites assembly welds are treated by local PWHT processes as resistance heating or induction heating.

Essentially the principles of practical heating treatment, such as the requirements for ISO 17663 should be considered.

For assessing the mechanical-technological properties in the weld procedure qualification tests according to ISO 15614-1 have to be carried out in combination with the applicable specifications and regulations.

It may be that due to the special heating treatment (e.g. normalizing) the mechanical-technological properties of the unaffected materials by welding have to be demonstrated.

Because of further engineer standards, codes, customer specifications and production experience it may be that variations in height and soaking time of annealing temperature (depending on the wall thickness welded) have to be taken into account.

Especially for steel groups 1.3, 2 and 3 acc. ISO/TR 15608, the definition of the preheating temperature shall take into account e.g. the information and guidance of ISO/TR 17671 -1 and ISO/TR 17671-2. Guidance values for energy input per unit length for specific steel groups are found e.g. in ISO/TR 17671-2 and ISO/TR 17671-3 In addition, it may be necessary to follow cooling time regulations ($t_{8/5}$ or $t_{12/8}$) of e.g. various material standards.

For the determination of cooling time the application of Welding -TTT-diagrams is recommended. For multi-run weld and increased wall thicknesses conventional TTT-diagrams can also be used.

Bibliography

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