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- 6.17.2 Additional thermocouples may be added to accommodate better control or as spares.
- 6.17.3 Where two thermocouples are used, one shall be placed at the expected hottest spot and one at the expected coldest spot.
- 6.17.4 When PWHT of socket welds is required, one thermocouple may be used, and shall be placed in the center of the weld.
- 6.18 Thermocouple placement shall be equally spaced around the pipe circumference on either side of the weld. Thermocouple placement for applications other than pipe shall be determined by the Welding Manager.
- 6.19 Shielded thermocouple insulators or ceramic putty shall be used for each thermocouple if necessary, to protect it from radiant heat.
- 6.20 Prior to the PWHT operation, the Welding Manager shall map the thermocouple placement on the recorder - time/temperature chart.
- 6.21 The area to be postweld heat treated shall be free of oil, grease, dirt and paint.
- 6.22 External support of piping or components may be required to prevent bending due to weight or cold spring. Care shall be taken to preserve alignment of components.
- 6.23 When performing PWHT of welds to valves, care shall be taken to avoid excess heating of the valve internals. The valve manufacturer's recommendations may require valve disassembly or unseating and shall be reviewed by the Welding Manager.
- 6.24 Care shall be exercised when applying PWHT to welds adjacent to quenched and tempered material. In such cases, the PWHT temperature shall not exceed 1150°F in order to retain the impact properties of the quenched and tempered material. In no case shall the maximum PWHT temperature exceed the final tempering temperature of the quenched and tempered material.

- 6.25 When materials of two different P-Numbers are joined by welding, the applicable PWHT holding temperature shall be specified for the material requiring the higher PWHT temperature range.
- 6.26 When non-pressure retaining materials are welded to pressure retaining materials, the PWHT temperature range of the pressure retaining materials shall govern.
- 6.27 Stress Relieving Methods that may be used, but not limited to, are as follows:
- 6.27.1 Electrical Resistance Heating per Attachment 11
- 6.27.2 Induction Heating
- 6.27.3 Gas Heating
- 6.27.4 Localized Heating
- 6.28 Postweld Heat Treatment Review
- 6.28.1 Prior to a field postweld heat treatment, a review shall be performed of all previous heat treatments, including those performed by the manufacturer, for individual welds, and base materials verifying that neither time nor temperature has or will (by the performance of another heat treatment) exceed the maximum qualified in accordance with requirements of the applicable Code(s). The review shall also determine if normalized and tempered, or quench and tempered materials will be postweld heat treated and review tempering temperatures so that the postweld heat treatment operation shall not exceed that allowance.
- 6.29 Functional Check Requirements
- 6.29.1 A functional check will be made prior to reaching 600°F to verify that all points recorded are not more than plus or minus 40°F. Above 600°F all points should be above the minimum holding temperature. The Welding Manager is to be notified if irregular chart readings are encountered which cannot be

corrected by checking or replacement of wires or thermocouple, adjustment to controller, or manual control take over. The verification for compliance shall be made as a functional check using a calibrated pyrometer traceable to National Bureau of Standards.

6.29.2 Chart rotation/travel speed shall be verified with a conventional watch for 10 minutes during the holding period. A variance of plus or minus 1 minute is acceptable. This check shall be noted on the strip chart.

6.30 Equipment Calibration Requirements

6.30.1 Calibrated multi-point recorders shall be utilized per the manufacturer's standard service instructions or by a specified written practice.

6.30.2 Recording equipment must bear identification and a sticker certifying date of calibration prior to use.

7.0 SPECIFIC CONSTRUCTION CODE REQUIREMENTS

7.1 ASME B31.1 Code:

7.1.1 Preheat requirements are listed in Attachments 1 and 5.

7.1.2 For inert gas tungsten arc root pass welding, a lower preheat temperature in accordance with the temperature established in the qualified welding procedure may be used.

7.1.3 After welding commences, the minimum preheat temperature shall be maintained until any required PWHT is performed on P-Nos 3, 4, 5 and 6, except when all of the following conditions are satisfied.

7.1.3.1 A minimum of at least 3/8" thickness of weld is deposited or 25% of the welding groove is filled, whichever is less (the weldment shall be sufficiently supported to prevent over-stressing the weld if the weldment is to be moved or otherwise loaded).

- 7.1.3.2 For P-No's 3, 4 and 5 (with a chromium content of 3.0% maximum) materials, the weld is allowed to cool slowly to room temperature.
- 7.1.3.3 For P-No. 5 (with a chromium content greater than 3.0%) and P-No. 6 materials, the weld is subjected to an adequate intermediate heat treatment with a controlled rate of cooling.
- 7.1.3.4 After cooling and before welding is resumed, visual examination of the weld shall be performed to assure that no cracks have formed.
- 7.1.3.5 Required preheat shall be applied before welding is resumed.
- 7.1.4 PWHT requirements are listed in Attachment 5.
- 7.1.4.1 All welds in materials included in Attachment 5 shall be PWHT except as provided in Paragraphs 7.1.5 and 7.1.6.
- 7.1.4.2 Welds in material not listed in Attachment 5 shall be PWHT in accordance with the qualified welding procedure.
- 7.1.5 When parts of two different P-Number groups are joined by welding, the PWHT shall be specified for the material requiring the higher PWHT temperature. When a nonpressure part is welded to a pressure part and PWHT is required for either part, the maximum PWHT temperature shall not exceed the maximum temperature acceptable for the pressure retaining part.
- 7.1.5.1 The Welding Manager shall ensure that the lower critical temperature of either material is not exceeded.
- 7.1.6 PWHT is not required for the following conditions:
- a) Welds in non-ferrous materials.
  - b) Welds exempted in Attachment 5.
  - c) Welds subject to temperatures above the lower critical temperature during fabrication provided the welding procedure

has been qualified with PWHT at the temperature range to be reached during fabrication.

7.1.7

PWHT Thickness Definitions

- a) "Nominal thickness" as used herein is the lesser thickness of (1) or (2) as follows:
1. The thickness of the weld.
  2. The thicker of the materials being joined at the weld.
- b) "Thickness of the weld," which is a factor in determining the nominal thickness, is defined as follows:
1. Full Penetration Groove Welds: The thicker of the two abutting ends after weld preparation, including I.D. machining.
  2. Fillet welds: The throat thickness of the weld.
  3. Partial penetration welds: The depth of the weld groove.
  4. Material repair welds: The depth of the cavity to be repaired.
  5. Branch welds: Shall be calculated by the Welding Manager, per Par 132.4.2 of B31.1.

7.1.8

PWHT Heating and Cooling Requirements

7.1.8.1

Above 600°F, the rate of heating and cooling shall not exceed 600°F per hour divided by 1/2 the maximum thickness of material in inches at the weld, but in no case shall the rate exceed 600°F per hour. (See Attachment 5 for cooling rate requirements for P-Nos. 7 and 10E materials.)

7.1.9

Heating Requirements

7.1.9.1

Heating an assembly in a furnace should be used when practical. An assembly may be postweld heat treated in more than one heat in

a furnace provided there is at least a 5 ft overlap of the heated sections and the portion of the assembly outside the furnace is shielded so that the temperature gradient is not harmful. Direct impingement of flame on the assembly is prohibited.

7.1.9.2 Welds may be locally PWHT, providing the following requirements are satisfied:

1. Welds locally PWHT'd shall have a circumferentially heated band around the entire component with the weld located in the center of the band.
2. For girth welds, the width of the band heated to the PWHT temperature shall be at least three times the wall thickness of the thickest part being joined at the weld.
3. For nozzle and attachment welds, the width of the band heated to the PWHT temperature shall extend beyond the nozzle weld or attachment weld on each side, at least two times the header thickness and shall extend completely around the header.

7.2 ASME B31.3 Code

7.2.1 Preheat temperatures are as listed in Attachment 2.

7.2.2 The necessity for preheating and the temperature to be used shall be as specified in the engineering design and demonstrated by procedure qualification. All types of welds require preheating, including tack welds, repair welds and seal welds of threaded joints.

7.2.3 If the ambient temperature is below 32°F., the recommendations of Attachment 2 are mandatory.

7.2.4 Preheat requirements for unlisted materials shall be specified in the WPS.

7.2.5 The thickness specified in Attachment 2 is that of the thicker member at the weld joint.

- 7.2.6 As a minimum, the preheat temperature shall be maintained in a zone extending 1" beyond each edge of the weld.
- 7.2.7 When dissimilar P-No. materials are joined by welding, the higher temperature from Attachment 2 shall be used.
- 7.2.8 In the event of an interruption in the welding activity, the rate of cooling shall be controlled or other means shall be used to prevent detrimental effects in the piping. The specified preheat shall be applied before resuming welding.
- 7.2.9 The preheat temperature shall be checked by the use of temperature indicating crayons, thermocouple pyrometers or other suitable means that ensures the temperature specified in the WPS is obtained prior to and maintained during welding.
- 7.2.10 Thermocouples may be temporarily attached to pressure containing components using the capacitor discharge welding method without utilizing a PQR or WPS. After thermocouples are removed, the areas shall be visually examined for evidence of defects to be repaired.
- 7.2.11 PWHT shall be in accordance with Attachment 6 with the following exceptions:
- 7.2.11.1 Where warranted by experience or knowledge of service conditions, alternative methods of PWHT or exceptions to the basic provisions may be specified.
- 7.2.11.2 Normalizing, or normalizing and tempering, or annealing may be applied in lieu of the required heat treatment after welding, bending, or forming, provided that the mechanical properties of any affected weld and base metal meet specification requirements after such treatment and that the substitution is approved by the designer.
- 7.2.11.3 Conditions more stringent may be specified by the designer.

- 7.2.11.4 Conditions less stringent may be specified by the designer upon review of service conditions. The applicable WPS and PQR shall be qualified with the alternate PWHT.
- 7.2.12 PWHT shall be specified in the WPS and shall be used in qualifying the welding procedure.
- 7.2.13 When components are joined by welding, the thickness used in applying the requirements of Attachment 6 shall be that of the thicker component measured at the joint, except as follows;
- 7.2.13.1 Branch connections, reinforcement metal (pads or saddles) shall not be considered in determining PWHT requirements.
- 7.2.13.2 Where the thickness through the weld in any plane is twice the material thickness at the joint, PWHT is required.
- 7.2.14 For fillet welds at slip-on and socket welding flanges and piping connections NPS 2 and smaller, for seal welding of threaded connections on NPS 2 or smaller and for attachment of external nonpressure parts, PWHT is required when the thickness through the weld in any plane is more than twice the minimum material thickness requiring PWHT, except as follows;
- 7.2.14.1 PWHT is not required on P-No. 1 material when weld throat thickness is 5/8" or less regardless of base metal thickness.
- 7.2.14.2 PWHT is not required for P-No. 3, 4, 5 or 10A materials when the weld throat is 1/2" or less, regardless of base metal thickness, provided that the minimum preheat was applied and the specified minimum tensile strength is less than 71 ksi.
- 7.2.14.3 PWHT is not required on ferritic materials when welded with filler metal that does not air harden.

- 7.2.15 PWHT temperature shall be checked by thermocouple pyrometers or other suitable methods. Attachment and removal shall be in accordance with Par. 7.2.10.
- 7.2.16 Where a hardness test is specified in Attachment 6, at least 10% of the welds shall be tested.
- 7.2.16.1. Where dissimilar metals are joined by welding, the specified hardness limits shall be met for the weld material and base materials.
- 7.2.17 PWHT of welded joints between dissimilar ferritic metals or between ferritic materials using dissimilar ferritic filler metal shall be at the higher of the specified temperatures.
- 7.2.18 PWHT of welded joints including both ferritic and austenitic components and filler metals shall be as required for the ferritic material, unless otherwise specified in the engineering design.
- 7.2.19 Where a weldment is allowed to cool prior to PWHT, the rate of cooling shall be controlled or other means shall be used to prevent detrimental effects in the piping.
- 7.2.20 Where an entire piping system cannot be placed fully in a furnace, it is permissible to utilize more than one heat provided that there is a minimum one foot overlap between successive heats, and that parts of the assembly outside the furnace are protected from harmful temperature gradients.
- 7.2.21 Where localized PWHT is used, a circumferential band of the pipe run and branch, where applicable, shall be heated until the specified temperature range exists over the entire section extending a minimum of one inch beyond the toe of the weld.
- 7.3 ASME SECTION I
- 7.3.1 Preheat requirements are listed in Attachment 3.

- 7.3.1.1 Attachment 3 requirements are non-mandatory.
- 7.3.1.2 The WPS and PQR used for welding shall specify the minimum preheat temperature or specify this document.
- 7.3.2 Preheat may be applied by any method which does not harm the base material or deposited weld metal, or which introduces any material harmful to the weld.
- 7.3.3 PWHT requirements are listed in Attachment 7.
- 7.3.4 Flexible type staybolts having a cover cap weld need not be PWHT'd.
- 7.3.5 Welded connections may be added to a vessel after PWHT without being PWHT'd provided:
- 7.3.5.1 The diameter of the attachment opening in the vessel wall does not exceed 2" or that allowed by ASME Section I, whichever is less.
- 7.3.5.2 The inside and outside attachment welds do not exceed 3/8" throat dimension. This provision does not apply to connections that affect the shell thickness.
- 7.3.6 When pressure parts of two different P-Number groups are joined by welding, the PWHT shall be the higher of the specified PWHT per Attachment 7.
- 7.3.6.1 When nonpressure parts are welded to pressure parts, PWHT shall be as specified for the pressure parts.
- 7.3.7 Partial penetration and fillet welds attaching P-No. 5 tubes and pipe to headers of lower P-Number material may be PWHT at the temperature specified in Attachment 7 for the lower P-Number material provided the tubes or pipe comply with all the following conditions:
- 7.3.7.1 A maximum specified chromium content of 3.0%;
- 7.3.7.2 A maximum nominal outside diameter of 4";
- 7.3.7.3 A maximum thickness of 1/2";

- 7.3.7.4 A maximum specified carbon content of not more than .15%.
- 7.3.8 Nominal thickness is defined as follows:
- 7.3.8.1 Thickness of weld, pressure retaining material or the thinner of the sections being joined, whichever is least.
- 7.3.8.2 For fillet welds, the throat thickness.
- 7.3.8.3 For partial penetration and material repair welds, the depth of the groove or preparation.
- 7.3.9 The holding time at temperature specified in Attachment 7 need not be continuous.
- 7.3.10 The weldments shall be PWHT by any of the following methods:
- 7.3.10.1 Heating the complete assembly as a unit.
- 7.3.10.2 Heating sections of the assembly. When PWHT in sections, the PWHT of the final joints shall be performed by uniformly heating a circumferential band having a minimum width of 3 times the plate thickness on each side of the weld, uniformly around the band.
- 7.3.10.3 Nozzles or other welded attachments for which PWHT is required may be locally PWHT by heating a circumferential band around the entire vessel with the welded connection in the middle of the band. The width of the band shall be wider than the nozzle or other attachment weld by at least three times the wall thickness of the vessel, and shall be located in such a manner that the entire band will be heated to the temperature and held for the time specified.
- 7.3.10.4 Local PWHT of welded joints in pipes, tubes, and headers shall be by heating a circumferential band to the specified time and temperature at least 3 times the width of the widest part of the groove, but in no case less than twice the width of the reinforcement.

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7.3.11 For repair welds after PWHT, no further PWHT need be performed subject to the following limitations:

7.3.11.1 The depth of repair below the surface shall not exceed 10% of the drum or header thickness or 50% of the tube wall thickness, whichever is the smaller dimension.

7.3.11.2 The area to be repaired is preheated to the minimum temperatures indicated below.

<u>Material</u> <u>Welding P-Number Group</u>	<u>Minimum Preheat, °F</u> <u>For Rework Welding</u>
P-No. 1	200
P-No. 3	200
P-No. 4	250
P-No. 5	300

7.3.11.3 The tube shall not be greater than 4 in. O.D., except for P-No. 1 which shall not exceed 6-5/8 in. O.D.

7.3.11.4 The qualified welding procedure used must meet the requirements of Section IX with the omission of PWHT.

7.4 ASME SECTION III

7.4.1 Preheating of materials prior to welding shall be performed as listed in Attachment 4, 9 and para. 7.4.12 of this procedure. Preheat shall be based on the thicker of the materials being joined at the weld joint.

7.4.2 In cases where the qualified WPS specifies a preheat temperature other than what is listed in Attachment 4,9 and para. 7.4.12, the higher of the two preheats shall govern.

7.4.3 PWHT shall meet the requirements of Attachment 8 except as otherwise permitted.

7.4.4 Exemptions to mandatory PWHT are listed in Attachment 9 and para. 7.4.12.

7.4.5 PWHT nominal thickness of the weld shall be as follows:

- 7.4.5.1 The thickness of the weld, the pressure retaining material for structural attachment welds, or the thinner of the pressure retaining materials being joined, whichever is least.
- 7.4.5.2 For fillet welds the nominal thickness is the throat thickness.
- 7.4.5.3 Nominal thickness for partial penetration and material repair welds shall be the depth of the weld groove or preparation.
- 7.4.6 PWHT requirements when joining different P-Number materials shall be that specified in Attachment 8 for the higher temperature range.
- 7.4.7 General Requirements - Except as otherwise permitted in Attachment 9, all welds, including repair welds, shall be postweld heat treated. During PWHT, the metal temperature shall be maintained within the temperature range and for the minimum holding time specified in Attachment 8, except as otherwise permitted by alternate methods. PWHT shall be performed in temperature surveyed and calibrated furnaces, or PWHT shall be performed with thermocouples in contact with the material or attached to blocks in contact with the material. In addition, the requirements of the following subparagraphs shall apply.
- 7.4.8 Time-Temperature Recordings - Time-temperature recordings of all PWHT's shall be made available for review by the Inspector. Identification on the time-temperature recording may be provided for permanent records.
- 7.4.9 Holding Times at Temperature.
- 7.4.9.1 The holding time at temperature as specified in Attachment 8 shall be based on the nominal thickness of the weld. The holding time need not be continuous. It may be an accumulation of the times of multiple PWHT cycles.

- 7.4.9.2 Holding time temperatures in excess of the minimum requirements may be used, provided that specimens so heat treated are tested.
- 7.4.9.3 Alternatively, when it is impractical to PWHT at the temperature range specified in Attachment 8, it is permissible to perform the PWHT of certain materials at lower temperatures for longer periods of time in accordance with the alternate table in Attachment 8.
- 7.4.10 PWHT Requirements for Non-pressure-Retaining Parts - When non-pressure-retaining material is welded to pressure retaining material, the PWHT temperature range of the pressure retaining material shall control.
- 7.4.11 Exemptions to Mandatory Requirements - PWHT in accordance with this Sub-article is not required for:
- 7.4.11.1 nonferrous material;
  - 7.4.11.2 welds exempted in Attachment 9;
  - 7.4.11.3 welds subjected to temperatures above the PWHT temperature range specified in Attachment 8, provided the Welding Procedure Specification is qualified in accordance with Section IX and the base material and the deposited weld filler material have been heat treated at the higher temperature;
  - 7.4.11.4 welds connecting nozzles to components or branch to run piping provided the requirements in 7.4.12 are met;
  - 7.4.11.5 weld repairs to vessels, provided the requirements for temper bead weld repair are met;
  - 7.4.11.6 weld repairs to cladding after final PWHT provided the requirements for temper bead weld repair are met;
  - 7.4.11.7 weld repairs to dissimilar metal welds after final PWHT, provided the requirement for temper bead weld repair are met;

- 7.4.12 Requirements for Exempting PWHT of Nozzles to Component Welds and Branch to Run Piping Welds - Welds connecting nozzles or branch piping of P-No. 1 materials to components or run piping of P-No. 1 or P-No. 3 materials that are not exempted from PWHT, need not be given a postweld heat treatment if the requirements of 7.4.12.1 below are met for partial penetration and 7.4.12.2 below are met for full penetration welds.
- 7.4.12.1 The partial penetration welds are made with A-No. 8 or non-air-hardening nickel-chromium-iron weld metal after:
- 7.4.12.1.1 the ferritic materials to be joined are buttered or built-up with A-No. 8 or non-air-hardening nickel-chromium-iron weld metal having a minimum thickness of 1/4 in., and
- 7.4.12.1.2 the heat affected zones of the buttered or built-up ferritic materials are postweld heat treated without the PWHT exemptions being applied, prior to making the final welds.
- 7.4.12.2 The full penetration welds are made with A-No. 1 or A-No. 2 weld metal provided that:
- 7.4.12.2.1 the component or run pipe is built-up or buttered in the area of the attachment with A-No. 1 or A-No. 2 metal having a minimum thickness of 1/4";
- 7.4.12.2.2 the A-No. 1 or A-No. 2 weld metal buildup or buttering is postweld heat treated in accordance with NB-4620 for P-No. 1 or P-No. 3 materials without the PWHT exemptions being applied;
- 7.4.12.2.3 the welds do not penetrate through the component or run pipe thickness;
- 7.4.12.2.4 weld metal with A-No. 1 or A-No. 2 analysis is used to join the nozzle or branch pipe of P-No. 1 material the weld buildup or buttering;

- 7.4.12.2.5 the nominal thickness of the weld joining the nozzle or branch pipe to the component or run pipe does not exceed 1-1/2 in. and the maximum reported carbon content of the nozzle or branch piping connection does not exceed 0.30%;
- 7.4.12.2.6 a 200°F minimum preheat is maintained during welding whenever the nominal thickness of the weld exceeds:
- 7.4.12.2.6.1 1-1/4 in. and the maximum reported carbon content of the material of the nozzle or branch pipe is 0.30% or less, or
- 7.4.12.2.6.2 3/4 in. and the maximum reported carbon content of material of the nozzle or branch pipe connection exceeds 0.30%.
- 7.4.13 PWHT heating & cooling rate requirements:
- 7.4.13.1 Above 800°F. the rate of heating and cooling in any hourly interval shall not exceed 400°F. divided by the maximum thickness in inches, but shall not exceed 400°F. and need not be less than 100°F per hour. There shall not be a greater variation in temperature, within 15 feet of weld length, than 250°F., with the following exceptions:
- 7.4.13.1.1 P-No. 6 material may be cooled in air from the PWHT holding temperature as specified in Attachment 8.
- 7.4.13.1.2 For P-No. 7 material the cooling rate at temperatures above 1200°F shall not exceed 100°F. per hour, after which the cooling rate shall be sufficiently rapid to prevent embrittlement.
- 7.4.14 The PWHT shall be performed in accordance with the requirements of one of the following subparagraphs.
- 7.4.14.1 Furnace Heating (One Heat) - Heating the item in a closed furnace in one heat is the preferred procedure and should be used whenever practical. The furnace atmosphere shall be controlled so as to avoid excessive

oxidation and direct impingement of flame on the component or item is prohibited.

7.4.14.2 Furnace Heating (More Than One Heat) - The item may be heated in more than one heat in a furnace, provided the furnace atmosphere control requirements apply and overlap of the heated sections of the component or item is at least 5 ft. When this procedure is used, the portion of the component or item outside the furnace shall be shielded so that the temperature gradient is not harmful. The cross section where the component or item projects from the furnace shall not intersect a nozzle or other structural discontinuity.

7.4.14.3 Local Heating - Welds may be locally postweld heat treated when it is not practical to heat treat the entire component or item. Local PWHT shall consist of heating a circumferential band around the component or item at temperature within the ranges specified in this Sub-article. The minimum width of the controlled band at each side of the weld, on the face of the greatest weld width, shall be the thickness of the weld or 2 in., whichever is less. The temperature of the component or item from the edge of the controlled band outward shall be gradually diminished so as to avoid harmful thermal gradients. This procedure may also be used for PWHT after repairs.

7.4.14.4 Heating Items Internally - The component or item may be heated internally by an appropriate means and with adequate indicating and recording temperature devices to aid in the control and maintenance of a uniform distribution of temperature in the item. Previous to this operation, the item should be fully enclosed with insulating material.

7.5 ASME SECTION VIII DIV. 1

7.5.1 Preheat temperatures are listed in Attachment 3.

- 7.5.1.1 Where the preheat temperature of the qualified WPS is different than the temperature listed in Attachment 3, the WPS temperature shall be used.
- 7.5.2 Ferritic materials up to and including 1/2 inch shall be preheated to 100°F minimum; 200°F minimum above 1/2 inch to and including 1-1/2 inch; 300°F above 1-1/2 inches. Preheat shall be maintained for a period of 2 hours after completion of welding.
- 7.5.3 The required temperatures and holding times for PWHT of various base materials are listed in Attachment 10.
- 7.5.4 When pressure parts of two different P-Number groups are joined by welding, the PWHT shall be that specified for the material requiring the higher PWHT temperature.
- 7.5.4.1 When non-pressure parts are welded to pressure parts, the PWHT requirements of the pressure part shall control.
- 7.5.4.2 Ferritic steel parts, when used in conjunction with austenitic chromium-nickel stainless steel parts or austenitic/ferritic duplex steel, shall not be subjected to solution heat treatment.
- 7.5.5 Nominal thickness, as used herein, is the thickness of the welded joint.
- 7.5.5.1 When the welded joint connects parts of the same thickness using a full penetration butt weld, the nominal thickness is the total depth of the weld exclusive of any permitted reinforcement.
- 7.5.5.2 For groove welds, the nominal thickness is the depth of the groove.
- 7.5.5.3 For fillet welds, the nominal thickness is the throat dimension. If a fillet is used in conjunction with a groove weld, the nominal thickness is the depth of the groove or the throat dimension, whichever is greater.

- 7.5.5.4 For stud welds, the nominal thickness shall be the diameter of the stud.
- 7.5.5.5 When a welded joint connects parts of unequal thicknesses, the nominal thickness shall be the following:
- 7.5.5.5.1 The thinner of two adjacent butt-welded parts including head to shell connections.
- 7.5.5.5.2 The thickness of the shell or the fillet weld, whichever is greater for connections to intermediate heads.
- 7.5.5.5.3 The thickness of the shell in connections to tube sheets, flat heads, covers, flanges, or similar constructions.
- 7.5.5.5.4 The thickness of the weld across the nozzle neck or shell or head or reinforcing pad attachment fillet weld, whichever is the greater.
- 7.5.5.5.5 The thickness of the nozzle neck at the joint in the nozzle neck to flange connection.
- 7.5.5.5.6 The thickness of the weld at the point of the attachment when a nonpressure part is welded to a pressure part.
- 7.5.5.5.7 The thickness of the weld in tube to tube sheet connections.
- 7.5.5.5.8 For repairs, the nominal thickness is the depth of the repair weld.
- 7.5.6 The postweld heat treatment shall be performed, using one of the following procedures:
- 7.5.6.1 Heating the vessel as a whole in an enclosed furnace. This procedure is preferable and should be used whenever practicable.
- 7.5.6.2 Heating the vessel in more than one heat in a furnace provided the overlap of the heated sections of the vessel is at least 5 feet. When this procedure is used the portion outside of the vessel shall be shielded so that the temperature gradient is not harmful.

- 7.5.6.3 Heating of shell sections and/or portions of vessels to postweld heat treat longitudinal joints or complicated weld details before joining to make a complete vessel. The circumferential joints requiring PWHT may be locally postweld heat treated by heating a circumferential band which includes such joints. The width of the heated band on each side of the greatest width of the finished weld shall be two times the shell thickness.
- 7.5.6.4 The vessel may also be heated internally by any appropriate means. The vessel should be fully enclosed with insulation material and have adequate indicating and recording temperature devices to maintain control and maintenance of the heat through the vessel wall.
- 7.5.6.5 Heating a circumferential band containing nozzles or other welded attachments that require PWHT, in such a manner that the band shall attain the required temperature uniformly and be held for the required time. The circumferential band shall extend around the entire vessel and its width shall be at least six times the plate thickness beyond the welded joint on either side. The portion of the vessel outside of the circumferential band shall be protected so that the temperature gradient is not harmful.
- 7.5.6.6 Heating the circumferential joints of pipe or tubing by any appropriate means over a band having a width on each side of the center line of not less than three times the greatest width of the finished weld. The portion outside of the heated band shall be protected so that the temperature gradient is not harmful.
- 7.5.7 PWHT operations shall meet the following requirements:
- 7.5.7.1 The temperature of the furnace if used, shall not exceed 800°F at the time the vessel or part is placed in it.



- 7.5.8.3 All welds are examined by nondestructive examination in accordance with provisions of the Part UHT (ASME Sec. VIII).
- 7.5.9 Weld repairs on vessels that have been PWHT shall require PWHT after repairs except as permitted below:
  - 7.5.9.1 When higher preheat temperatures are utilized;
  - 7.5.9.2 When the half temper bead technique is performed;
  - 7.5.9.3 Weld repairs to P-No. 1 Group Nos. 1, 2, and 3 materials and to P-No. 3 Group Nos. 1, 2, and 3 materials and to the weld metals used to join these materials may be made after the final PWHT but prior to the final hydrostatic test, without additional PWHT, provided that PWHT is not required as a service requirement. The welded repairs shall meet the requirements of (7.5.9.3.1) through (7.5.9.3.6) below. These requirements do not apply when the welded repairs are minor restorations of the material surface, such as those required after removal of construction fixtures, and provided that the surface is not exposed to the vessel contents.
    - 7.5.9.3.1 PCI shall give prior notification of the repair to the user or to his designated agent and shall not proceed until acceptance has been obtained. Such repairs shall be recorded on the Data Report.
    - 7.5.9.3.2 The total repair depth shall not exceed 1-1/2 in. for P-No. 1 Group Nos. 1, 2, and 3 materials and 5/8 in. for P-No. 3 Group Nos. 1, 2, and 3 materials. The total depth of a weld repair shall be taken as the sum of the depths for repairs made from both sides of a weld at a given location.
    - 7.5.9.3.3 After removal of the defect, the groove shall be examined, using either the magnetic particle or the liquid penetrant examination methods.

- 7.5.9.3.4 In addition to the requirements of Section IX for qualification of Welding Procedure Specifications for groove welds, the following requirements shall apply.
- 7.5.9.3.4.1 The weld metal shall be deposited by the manual shielded metal arc process using low hydrogen electrodes. The electrodes shall be properly conditioned in accordance with Section II, Part C, SFA-5.5, Appendix A5.6. The maximum bead width shall be four times the electrode core diameter.
- 7.5.9.3.4.2 For P-No. 1 Group Nos. 1, 2, and 3 materials, the repair area shall be preheated and maintained at a minimum temperature of 200°F during welding.
- 7.5.9.3.4.3 For P-No. 3 Group Nos. 1, 2, and 3 materials, the repair weld method shall be limited to the half bead weld repair and weld temper bead reinforcement technique. The repair area shall be preheated and maintained at a minimum temperature of 350°F during welding. The maximum interpass temperature shall be 450°F. The initial layer of weld metal shall be deposited over the entire area using 1/8 in. maximum diameter electrodes. Approximately one-half the thickness of this layer shall be removed by grinding before depositing subsequent layers. The subsequent weld layers shall be deposited using 5/32 in. maximum diameter electrodes in such a manner as to assure tempering of the prior weld beads and their heat affected zones. A final temper bead weld shall be applied to a level above the surface being repaired without contacting the base material but close enough to the edge of the underlying weld bead to assure tempering of the base material heat affected zone. After completing all welding, the repair area shall be maintained at a temperature of 400°F-500°F for a minimum period of 4 hours. The final temper bead reinforcement layer shall be removed substantially flush with the surface of the base material.
- 7.5.9.3.5 After the finished repair weld has reached ambient temperature, it shall be inspected

using the same nondestructive examination that was used in 7.5.8.3 above, except that for P-No. 3, Group No. 3 materials, the examination shall be made after the material has been at ambient temperature for a minimum period of 48 hours to determine the presence of possible delayed cracking of the weld. If the examination is by the magnetic particle method, only the alternating current yoke type is acceptable. In addition, welded repairs greater than 3/8 in. deep in materials and in welds that are required to be radiographed shall be radiographically examined.

7.5.9.3.6 The vessel shall be hydrostatically tested after making the welded repair.

7.6 ASME SECTION XI

7.6.1 Repair welding by the Temper Bead Technique shall meet the following requirements:

7.6.1.1 Repairs shall be performed as specified in the Owner's Repair Program.

7.6.1.2 Welding procedure specifications shall be approved by the Owner's Quality Assurance Program.

7.6.1.3 The Welding Manager shall review all documents to insure compliance with the applicable code sections.

7.7 NATIONAL BOARD INSPECTION CODE

7.7.1 Recommended preheating temperatures shall be in accordance with Attachment 3.

7.7.2 Preheat temperatures listed on the qualified Welding Procedure Specification shall list the preheat temperature. In such cases where this temperature is different than the temperature listed on Attachment 3, the WPS shall govern.

7.7.3 Postweld heat treat requirements shall be in accordance with the applicable section of the ASME Code.

- 7.7.4 Under certain conditions and approval by the Authorized Inspector, alternate methods to PWHT may be used as follows:
- 7.7.4.1 Higher preheat temperature
- 7.7.4.1.1 Applicable to P-No. 1, Groups 1, 2, and 3; P-No.3, Groups 1 and 2 (except Mn-Mo steels) only.
- 7.7.4.1.2 Preheat temperature of 300°F minimum, a minimum distance of 4 inches or four times the material thickness (whichever is greater) on each side of the joint.
- 7.7.4.1.3 The maximum interpass temperature shall not exceed 450°F.
- 7.7.4.1.4 When a partial penetration weld is made, the preheat and interpass temperature need only be maintained a distance of 4 inches on each side of the joint or four times the depth of the repair weld, whichever is greater.
- 7.7.4.1.5 These provisions apply where toughness characteristics in the as welded condition are adequate at operating pressure test temperatures.
- 7.7.4.2 Half-bead temper welding technique. Use of this technique requires approval from the Welding Manager.

## 8.0 DOCUMENTATION

- 8.1 The Welding Manager shall prepare an instruction to the PWHT Technician for weld specific PWHT requirements as described in Attachment 12.
- 8.2 Documentation of time and temperature as required by the applicable Code and design document shall be maintained on each PWHT. For PWHT, time-temperature charts with the following information shall be included as a minimum:
- 8.2.1 Date and time of PWHT (including start and completion time).

- 8.2.2 Weld number
- 8.2.3 Item/component identification (equipment piece number, valve number, etc.)
- 8.2.4 Welder(s) symbol.
- 8.2.5 Calibrated recorder identification
- 8.2.6 Applicable scale indications for chart (i.e., travel speed).
- 8.2.7 Required holding temperature and time.
- 8.2.8 Heat treatment operator's name.
- 8.2.9 Heat treatment procedure and applicable revision.
- 8.2.10 Map of thermocouple placement for ASME Code items.
- 8.3 Flow of documentation:
  - 8.3.1 After completion of the PWHT, the Welding Manager shall review the documentation to ensure that the Code and WPS requirements have been satisfied. He shall sign and date the documents and forward them to Quality Control.
  - 8.3.2 Quality Control shall review, sign and date the documents ensuring that the PWHT was properly conducted, instruments used were calibrated when required and Hold Points have been satisfied. These documents shall be made available for the Authorized Inspector's review.

9.0 ATTACHMENTS

- 9.1 Preheat Requirements for ASME B31.1.
- 9.2 Preheat Requirements for ASME B31.3
- 9.3 Non-Mandatory Preheats ASME Section I and VIII (Division I).
- 9.4 Non-Mandatory Preheats for ASME Section III, Appendix D.
- 9.5 Postweld Heat Treatment Requirements for ASME B31.1.
- 9.6 PWHT Requirements for ASME B31.3.
- 9.7 PWHT Requirements for ASME Section I.
- 9.8 ASME Section III Requirements for PWHT of Welds.
- 9.9 ASME Section III Exemptions to PWHT Requirements.
- 9.10 PWHT Requirements for ASME Section VIII.
- 9.11 Electrical Resistance PWHT Example.
- 9.12 Weld Specific PWHT Requirements.

WELDING PREHEATS FOR ASME B31.1

NOTES:

- 1) The preheat requirements listed herein are mandatory minimum values.
- 2) When welding two different P-Number materials, the minimum preheat temperature required shall be the higher temperature of the material to be welded.
- 3) Thickness referred to is the greater of the nominal thicknesses at the weld for the parts to be joined.
- 4) The preheat temperature shall be checked by use of temperature-indicating crayons, thermocouple pyrometers, or other suitable methods to assure that the required preheat temperature is obtained prior to and uniformly maintained during the welding operation.

PREHEAT REQUIREMENTS

P-No. 1

175°F for material which has both a specified maximum carbon content in excess of 0.30% and a thickness at the joint in excess of 1 inch;

50°F for all other materials having this P-Number.

P-No. 3

175°F for material or product form which has either a specified minimum tensile strength in excess of 60,000 psi, or a thickness at the joint in excess of 1/2 inch;

50°F for all other materials having this P-Number.

P-No. 4

250°F for material or product form which has either a specified minimum tensile strength in excess of 60,000 psi, or a thickness at the joint in excess of 1/2 inch;

50°F for all other materials having this P-Number.

P-No. 5

400°F for material which has either a specified minimum tensile strength in excess of 60,000 psi, or has both a specified minimum chromium content above 6.0% and a thickness at the joint in excess of 1/2 inch; 300°F for all other materials having this P-Number.



WELDING PREHEATS FOR ASME B31.1

P-No. 6

400°F for all materials.

P-No. 7

50°F for all materials.

P-No. 8

50°F for all materials.

P-No. 9

250°F for P-No. 9A materials.

300°F for P-No. 9B materials.

P-No. 10E

300°F with an interpass temperature of 450°F maximum.

Materials not listed on Attachment 1 shall be preheated in accordance with the qualified welding procedure.

ASME B31.3

PREHEAT TEMPERATURES  
POOR QUALITY ORIGINAL

Base Metal P. No. Note(1)	Weld Metal Analysis A. No.	Base Metal Group	Nominal Wall Thickness	Specified Min. Tensile Strength, Base Metal		Min. Temperature Required Recomm	
				in	ksi	°F	°F
1	1	Carbon Steel	< 1	≤ 71	..	50	
			≥ 1	All	...	175	
			All	> 71	...	175	
3	2, 11	Alloy Steels, Cr ≤ 1/2%	< 1/2	≤ 71	...	50	
			≥ 1/2	All	...	175	
			All	> 71	...	175	
4	3	Alloy Steels 1/2% < Cr ≤ 2%	All	All	300	...	
5	4, 5	Alloy Steels 2-1/4% ≤ Cr ≤ 10%	All	All	350	...	
6	6	High Alloy Steels Martensitic	All	All	...	300 <sup>2</sup>	
7	7	High Alloy Steels Ferritic	All	All	...	50	
8	8, 9	High Alloy Steels Austenitic	All	All	...	50	
9A, 9B	10	Nickel Alloy Steel	All	All	...	200	
10	..	Cr-Cu Steel	All	All	300-400	...	
10A	...	Mn-V Steel	All	All	...	175	
10E	...	27Cr Steel	All	All	300 <sup>3</sup>	...	
11A SG 1	...	8Ni, 9Ni Steel	All	All	...	50	
11A SG 2	...	5Ni Steel	All	All	50	...	
21-51	...	...	All	All	...	50	

NOTES:

- 1) Special P-Numbers (SP-1, SP-2, SP-3, SP-4 and SP-5) require special consideration. The required thermal treatment for Special P-Numbers shall be established by the engineering design and demonstrated by the welding procedure qualification.
- (2) Maximum interpass temperature 600°F.
- (3) Maintain interpass temperature between 350°F-450°F.



NON-MANDATORY PREHEAT REQUIREMENTS  
ASME SECTION I AND VIII (DIVISION I)

P-No. 1, Group No. 1, 2, 3

175°F for material which has both a specified maximum carbon content in excess of 0.30% and a thickness at the joint in excess of 1 in.;

50°F for all other materials in this grouping.

P-No. 3, Group No. 1, 2, 3

175°F for material which has either a specified minimum tensile strength in excess of 70,000 psi or a thickness at the joint in excess of 5/8 in.;

50°F for all other materials in this grouping.

P-No. 4, Group 1, 2

250°F for material which has either a specified minimum tensile strength in excess of 60,000 psi or a thickness at the joint in excess of 1/2 in.;

50°F for all other materials in this grouping.

P-No. 5, Group No. 1, 2

400°F for material which has either a specified minimum tensile strength in excess of 60,000 psi or has both a specified minimum chromium content above 6.0% and a thickness at the joint in excess of 1/2 in.;

300°F for all other materials in this grouping.

P-No. 6, Group No. 1, 2, 3

400°F.

P-No. 7, Group No. 1, 2

None.

P-No. 8, Group No. 1, 2

None.

P-No. 9A, Group No. 1

250°F.



NON-MANDATORY PREHEAT REQUIREMENTS  
ASME SECTION I AND VIII (DIVISION I)

P-No. 9B, Group No. 1

300°F.

P-No. 10 Group

- 175°F for P-No. 10A Gr. No. 1 materials;
- \* 250°F for P-No. 10B Gr. No. 2 materials;
- \* 175°F for P-No. 10C Gr. No. 3 materials;
- \*\* 300°F for P-No. 10E (with interpass maintained between 350°F and 450°F)
- \* 250°F for P-No. 10F Gr. No. 6 materials;
- \* For P-No. 10C Gr. No. 3 materials, preheat is neither required nor prohibited, and consideration shall be given to the limitation of interpass temperature for various thicknesses to avoid detrimental effects on the mechanical properties of heat treated material.
- \* For P-No. 10D Gr. No. 4 and P-No. 10E Gr. No. 5 materials, 300°F with interpass temperature maintained between 350°F and 450°F.

\* P-No. 11 Group

- a) P-No. 11A Group
  - Group No. 1 - None (see Note).
  - Group No. 2 - Same as for P-No. 5 (see Note).
  - Group No. 3 - Same as for P-No. 5 (see Note).
  - Group No. 4 - 250°F.
- b) P-No. 11B Group
  - Group No. 1 - Same as for P-No. 3 (see Note).
  - Group No. 2 - Same as for P-No. 3 (see Note).
  - Group No. 3 - Same as for P-No. 3 (see Note).
  - Group No. 4 - Same as for P-No. 3 (see Note).
  - Group No. 5 - Same as for P-No. 3 (see Note).
  - Group No. 6 - Same as for P-No. 5 (see Note).
  - Group No. 7 - Same as for P-No. 5 (see Note).

**NOTE:** Consideration shall be given to the limitation of interpass temperature for various thicknesses to avoid detrimental effects on the mechanical properties of heat treated materials.

- \* Denotes Section VIII (Division I) recommendations only.
- \*\* Denotes Section I recommendations only.



NON-MANDATORY PREHEAT REQUIREMENTS  
ASME SECTION III, APPENDIX D

P-Number 1, Group 1

200°F is suggested for material that has a maximum carbon content of 0.30% or less and a thickness in excess of 1-1/2 inch. 250°F is suggested for material that has both a maximum carbon content in excess of 0.30% and a thickness in excess of 1 inch. This does not apply to fillet welds 1/2 inch and less in size that are used to attach insulation clips and other parts not carrying loadings due to internal pressure.

50°F is suggested for all other materials in this group.

P-Number 1, Group 2

200°F is suggested for material that has a maximum carbon content of 0.30% or less and a thickness in excess of 1 inch.

250°F is suggested for material that has a maximum carbon content in excess of 0.30% and a thickness in excess of 1 inch.

P-Number 1, Group 3 and P-Number 3 and P-Number 11A

250°F is suggested for material that has either a specified maximum tensile strength in excess of 70.0 ksi or a thickness at the joint in excess of 5/8 inch.

50°F is suggested for all other materials in this group.

P-Number 4

300°F is suggested for material that has either a specified minimum tensile strength in excess of 60.0 ksi or a thickness at the joint in excess of 1/2 inch.

50°F is suggested for all other materials in this group.

P-Number 5

400°F is suggested for material that has either a specified minimum tensile strength in excess of 60.0 ksi or has both a specified minimum chromium content above 6.0% and a thickness at the joint in excess of 1/2 inch.

300°F is suggested for all other materials in this group.

NON-MANDATORY PREHEAT REQUIREMENTS  
ASME SECTION III, APPENDIX D

P-Number 6

400°F is suggested for all materials.

P-Number 7 and P-Number 8

None is suggested.

P-Number 9

300°F is suggested for all materials.

P-Number 10

175°F is suggested for P-Number 10A. 250°F is suggested for P-Number 10B. Preheat and interpass temperatures should be controlled for various thicknesses to avoid detrimental effects on the mechanical properties of heat treated material.

300°F is suggested for P-Number 10D and P-Number 10E with interpass at 300-450°F.



POST WELD HEAT TREATMENT REQUIREMENTS  
FOR ASME B31.1

00006

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 1 Gr. Nos. 1, 2, 3	1100 to 1200	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

**NOTES:**

- I. PWHT of P-No. 1 materials is not mandatory, provided that all of the following conditions are met:
  - a) The nominal thickness, as defined in Paragraph 7.1.7, is 3/4 in. or less;
  - b) A minimum preheat of 200°F is applied when the thickness of either of the base metals exceeds 1 inch.
- II. When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures for longer periods of time in accordance with the alternate table at the end of this attachment.

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 3 Gr. Nos. 1, 2,	1100 to 1200	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

**NOTES:**

- I. PWHT of P-No. 3 materials is not mandatory, provided that all of the following conditions are met:
  - a) The nominal thickness, as defined in Paragraph 7.1.7, is 5/8 in. or less;

POST WELD HEAT TREATMENT REQUIREMENTS  
FOR ASME B31.1

- b) A minimum preheat of 200° F is applied when the thickness of either of the base metals exceeds 5/8 inch;
- c) The specified carbon content of the P-No. 3 base material is 0.25% or less.

II. When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures for longer periods of time in accordance with the alternate table at the end of this attachment.

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 4 Gr. Nos. 1, 2,	1300 to 1375	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

NOTES:

- I) PWHT is not mandatory for P-No. 4 material under the following conditions:
  - a) Welds in pipe or attachment welds to pipe complying with all of the following conditions:
    - 1. A maximum nominal pipe size of 4 inches;
    - 2. A maximum material thickness of 1/2 inch;
    - 3. A maximum specified carbon content of the material to be welded of 0.15%;
    - 4. Application of 250° F minimum preheat during welding.
  - b) For seal welding of threaded or other mechanical joints provided:
    - 1. The seal weld has a throat thickness of 3/8 in. or less;
    - 2. A minimum preheat of 250° F during welding is applied.

POST WELD HEAT TREATMENT REQUIREMENTS  
FOR ASME B31.1

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 5 Gr. Nos. 1, 2,	1300 to 1400	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

NOTES:

- I. PWT is not mandatory for P-No. 5 material under the following conditions:
- a) Welds in pipe or attachment welds to pipe complying with all of the following conditions:
    1. A maximum nominal pipe size of 4 inches;
    2. A maximum material thickness of 1/2 inch;
    3. A maximum specified chromium content of materials to be welded of 3.0%;
    4. A maximum specified carbon content of the material to be welded of 0.15%;
    5. Application of 300°F minimum preheat during welding.

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 6 Gr. Nos. 1, 2, 3	1400 to 1475	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

NOTES:

- I. PWT is not mandatory for P-No. 6 material under the following conditions:
- a) For Type 410 material provided:
    1. The specified carbon content is not more than 0.08%;
    2. The maximum material thickness is 3/8 inch;
    3. The weld is made with A-No. 8, A-No. 9, or F-No. 43 filler metal.

POST WELD HEAT TREATMENT REQUIREMENTS  
FOR ASME B31.1

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 7 Gr. Nos. 1, 2	1350 to 1425	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

NOTES:

- I. In lieu of the cooling rate in Paragraph 7.1.8, P-No. 7 material cooling rate shall be 100°F per hour maximum in the range above 1200°F after which the cooling rate shall be sufficiently rapid to prevent embrittlement.
- II. PWHT is not mandatory for P-No. 7 material under the following conditions:
  - a) For Type 405 material provided:
    1. The specified carbon content is not more than 0.08%;
    2. The maximum material thickness is 3/8 inch;
    3. The weld is made with A-No. 8, A-No. 9, or F-No. 43 filler metal.

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 8 Gr. Nos. 1, 2, 3	None	None	

NOTES:

- I. PWHT is neither required nor prohibited for joints between P-No. 8 austenitic stainless steels.

POST WELD HEAT TREATMENT REQUIREMENTS  
FOR ASME B31.1

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 9A Gr. No. 1	1100 to 1200	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

NOTES:

- I. When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures for longer periods of time in accordance with the alternate table at the end of this attachment. However, the minimum PWHT shall not be less than 1000° F.
- II. PWHT is not mandatory for P-No. 9A material under the following conditions:
  - a) Welds on pipe or attachment welds to pipe complying with all other the following conditions:
    1. A maximum nominal pipe size of 4 inches;
    2. A maximum material thickness of 1/2 inch;
    3. A maximum specified carbon content of the material to be welded of 0.15%;
    4. Application of 250° F minimum preheat during welding.

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 9B Gr. No. 1	1100 to 1175	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

NOTES:

- I. When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures for long periods of time in accordance with the alternate table at the end of this attachment. However, the minimum PWHT temperature shall not be less than 1000° F.

POST WELD HEAT TREATMENT REQUIREMENTS  
FOR ASME B31.1

II. PWHT of P-No. 9B material is not mandatory for material thickness of 5/8 in. or less providing the Welding Procedure Qualification has been made using material of thickness equal to or greater than the production weld.

P-Number	Holding Temperature Range, F	Holding Time Based on Nominal Thickness	
		Up to 2 in.	Over 2 in.
P-No. 10E Gr. No. 5	1250 to 1300	1 hour/inch 15 min. minimum	2 hr. plus 15 min. for each additional inch over 2 in.

NOTES:

I. In lieu of the cooling rate in Paragraph 7.1.8, the P-No. 10E material cooling rate shall be 100°F per hour minimum in the range above 1200°F after which the cooling rate shall be sufficiently rapid to prevent embrittlement.

Alternate Postweld Heat Treatment  
Requirements For Carbon and Low Alloy Steels

Decrease in Temperatures Below Minimum Specified Temperature °F	Minimum Holding Time at Decreased Temperature hr/in [Note (3)]
50	2
100	4
150 (Note 2)	10
200 (Note 2)	20

NOTES:

1. Postweld heat treatment at lower temperatures for longer periods of time, in accordance with this table, shall be used only where permitted in the tables of this Attachment.
2. A decrease of more than 100°F. below the minimum specified temperature is allowable only for P-No. 1, Gr. Nos. 1 and 2 materials.
3. Times shown apply to thickness up to 1 in. Add 15 min/in. at thickness for thicknesses greater than 1 in.

## ATTACHMENT 6

Attachment 6  
Page 1 of 1ANSI/ASME B31.3  
TABLE  
REQUIREMENTS FOR HEAT TREATMENT

Base Metal P-Number (Note (1))	Weld Metal Analysis A-Number	Base Metal Group	Nominal Wall Thickness	Specified Min. Tensile Strength, Base Metal	Metal Temperature Range	Welding Time		
						in.	ksi	°F
1	1	Carbon Steel	≤3/4	All	None	...	...	...
			>3/4	All	1100-1200	1	1	...
3	2,11	Alloy steels, Cr <sub>1</sub> /2%	≤3/4	≤71	None	...	...	...
			>3/4	All	1100-1325	1	1	225
			All	>71	1100-1325	1	1	225
4	3	Alloy steels, 1/2%Cr-2%	≤1/2	≤71	None	...	...	...
			>1/2	All	1300-1375	1	2	225
			All	>71	1300-1375	1	2	225
5	4,5	Alloy steels, 2-1/4%Cr-10% (≤3%Cr, ≤0.15%C) (>3%Cr or >0.15%C or)	≤1/2	All	None	...	...	...
			>1/2	All	1300-1400	1	2	241
6	6	High alloy steels martensitic A 240 Gr. 429	All	All	1350-1650	1	2	241
			All	All	1150-1225	1	2	241
7	7	High alloy steels ferritic	All	All	None	...	...	...
8	8,9	High alloy steels austenitic	All	All	None	...	...	...
9A, 9B	10	Nickel alloy steels	≤3/4	All	None	...	...	...
...	...	...	>3/4	All	1100-1175	1/2	1	...
10	...	Cr-Cu steel	All	All	1400-1500 <sup>3</sup>	1/2	1/2	...
10A	...	Mn-V steel	≤3/4	≤71	None	...	...	...
...	...	...	>3/4	All	1100-1300	1	1	225
...	...	...	All	>71	1100-1300	1	1	225
10E	...	27 Cr steel	All	All	1225-1300 <sup>4</sup>	1	1	...
10W	...	Cr-Ni-Mo steel	All	All	Note (5)	1/2	1/2	...
11A 9C1	...	8Ni, 9Ni steel	≤2	All	None	...	...	...
...	...	...	>2	All	1025-1085 <sup>6</sup>	1	1	...
11A 9C2	...	5 Ni steel	>2	All	1025-1085 <sup>6</sup>	1	1	...

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Material	Minimum Holding Temperature, ° F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 1 Group No. 1,2,3	1100	1hr/in. 15 min. minimum	2 hr plus 15 min. for each addi- tional inch over 2 in.	2 hr plus 15 min. for each additional inch over 2 in.

**NOTES:**

- (1) Postweld heat treatment is not mandatory for P-No. material under the following conditions:
  - (a) for circumferential welds in pipe, tubes or headers when the pipe, tubes or headers comply with a nominal wall thickness of 3/4 in. or less at the joint
  - (b) for fillet welds used on slip-on and socket welding flanges and fittings when the following conditions are met:
    - (1) a fillet weld throat thickness of 1/2 in. or less, regardless of base metal thickness
    - (2) a minimum preheat of 200°F when the thickness of a pressure part at the weld exceeds 3/4 in.
  - (c) for fillet welds attaching nonpressure parts to pressure parts that have a throat thickness of 1/2 in. or less, provided preheat to a minimum temperature of 200°F is applied when the thickness of the pressure part exceeds 3/4 in.
  - (d) for welds used to attach extended heat absorbing surface to tubes and insulation attachment pins to pressure parts
  - (e) for tubes or pressure retaining handhole and inspection plugs or fittings that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of 3/8 in or less.
  - (f) for studs welded to pressure parts for purposes not included in (d) above, provided preheat to a minimum temperature of 200°F is applied when the thickness of the pressure part exceeds 3/4 in.

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- (g) for tube-to-tubesheet welded attachment of P-No. 1, Group Nos. 1 and 2 material in firetube boilers if the depth of the weld groove or preparation does not exceed 0.375 in., provided a minimum preheat of 200° F is applied when the tubesheet thickness exceeds 3/4 in.
- (2) When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures for long periods of time in accordance with the alternate table at the end of this attachment.
- (3) For P-No. 1 Group No. 1 materials, the postweld heat treatment requirement for tubes welded to tubular manifolds or headers is not mandatory when all of the following conditions are met:
- (a) the tubes do not exceed 2 in. O.D.
  - (b) the header does not exceed 8 in. nominal pipe size
  - (c) the header thickness does not exceed 1/2 in.
  - (d) a minimum preheat of 200° F is applied.

Material	Minimum Holding Temperature, ° F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 3 Group No. 1, 2, 3	1100	1 hr/in. 15 min. minimum	2 hr plus 15 min. for each additional inch over 2 in.	2 hr plus 15 min. for each additional inch over 2 in.

NOTES:

- (1) Except for P-No. 3 Group No. 3, postweld heat treatment of P-No. 3 materials is not mandatory under the following conditions (postweld heat treatment is mandatory for P-No. 3 Group No. 3 materials for all thicknesses):
- (a) for circumferential welds in pipe, tubes, or headers where the pipe, tubes, or headers comply with both a nominal wall thickness of 5/8 in. or less, and a specified maximum carbon content (SA material specification carbon content, except when further limited by the

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Purchaser to a value within the specification limits) of not more than 0.25%.

- (b) for fillet welds used on socket welding fittings when the following conditions are met:
- (1) a fillet weld throat thickness of 1/2 in. or less, regardless of base metal thickness
  - (2) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.25%.
  - (3) a minimum preheat of 200°F when the thickness of a pressure part at the weld exceeds 5/8 in.
- (c) for fillet welds attaching nonpressure parts having a specified maximum carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.25% that have a throat thickness of 1/2 in or less, provided preheat to a minimum temperature of 200°F is applied when the pressure part exceeds 5/8 in.
- (d) for welds used to attach extended heat-absorbing surface to tubes and insulation attachment pins to pressure parts.
- (e) for tubes or pressure retaining handhole and inspection plugs or fittings that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of 3/8 in. or less.
- (f) postweld heat treatment is not mandatory for studs welded to pressure parts for purposes not included in (d) above and which have a specified maximum carbon content of not more than 0.25% (SA material specification carbon content, except when further limited by Purchaser to a value within the specification limits), provided a preheat to a minimum temperature of 200°F is applied when the thickness of the pressure part exceeds 5/8 in.
- (2) When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures for long periods of time in accordance with the alternate table at the end of this attachment.
- (3) Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

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Material	Minimum Holding Temperature, ° F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 4 Group No. 1, 2	1100	1 hr/in 15 min minimum	1 hr/in.	5 hr plus 15 min. for each additional inch over 5 in.

**NOTES:**

- (1) Postweld heat treatment is not mandatory for P. No. 4 materials under the following conditions:
  - (a) for circumferential welds in pipe or tubes where the pipe or tubes comply with all of the following conditions:
    - (1) a maximum nominal outside diameter of 4 in.
    - (2) a maximum thickness of 5/8 in.
    - (3) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%.
    - (4) a minimum preheat of 250° F. This minimum preheat is not required for SA-213 Grade T11 tube materials with a maximum outside diameter of 1.5 in. and a maximum thickness of 0.165 in. when butt welded using a multipass GTAW process.
  - (b) for fillet welds used on socket welding fittings, when the following conditions are met:
    - (1) a fillet weld throat thickness of 1/2 in. or less, regardless of base metal thickness.
    - (2) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%.
    - (3) a minimum preheat of 250° F.
  - (c) for pipe and tube materials meeting the requirements of (a)(1), (a)(2), and (a)(3) above and having either fillet welds attaching nonpressure parts to them, provided the fillet weld has a throat thickness of 1/2 in. or less and the material is preheated to 250° F minimum; or heat-absorbing surfaces and non-load-carrying studs attached to them, provided the material is preheated to 250° F minimum. A lower preheating temperature may be used, provided specifically

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controlled procedures necessary to produce sound joints are used. Such procedures shall include but shall not be limited to the following:

- (1) The throat thickness of fillet welds shall be 1/2 in. or less.
  - (2) The maximum continuous length of fillet welds shall be not over 4 in.
  - (3) Electrodes or filler metal shall be dry and shall provide a low-hydrogen weld deposit. Chrome-moly filler metals shall have a maximum specified chromium content of not more than 2.50% and a maximum specified carbon content of not more than 0.05%.
  - (4) The thickness of the test plate used in making the welding procedure qualification shall not be less than that of the material to be welded.
- (d) for tubes or pressure retaining handhole and inspection plugs or fittings that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of 3/8 in. or less.
- (2) Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

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Material	Minimum Holding Temperature, °F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 5 Group No. 1,2	1250	1 hr/in. 15 min minimum	1 hr/in.	5 hr. plus 15 min. for each additional inch over 5 in.
P-No. 5 Group No. 4	1300	1 hr/in. 15 min minimum	1 hr/in	5 hr. plus 15 min. for each additional inch over 5 in.

**NOTE:**

- (1) Except for P-No. 5 Group No. 4, postweld heat treatment is not mandatory for P-No. 5 materials under the following conditions:
  - (a) for circumferential welds in pipe or tubes where the pipe or tubes comply with all of the following conditions:
    - (1) a maximum specified chromium content of 3%
    - (2) a maximum nominal outside diameter of 4"
    - (3) a maximum thickness of 5/8"
    - (4) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%
    - (5) a minimum preheat of 300°F
  - (b) for fillet welds used on socket welding fittings, when the following conditions are met:
    - (1) a maximum specified chromium content of 3.0%.
    - (2) a fillet weld throat thickness of 1/2 in. or less, regardless of base metal thickness
    - (3) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%
    - (4) a minimum preheat of 300°F
  - (c) for pipe and tube materials meeting the requirements of (a)(1), (a)(2), (a)(3), and (a)(4) above having either fillet welds attaching nonpressure parts to them, provided the fillet weld has a throat thickness of 1/2 in. or less and the material is preheated to 300°F

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minimum; or heat-absorbing surfaces and non-load carrying studs attached to them, provided the material is preheated to 300°F minimum. A lower preheating temperature may be used, provided specifically controlled procedures necessary to produce sound joints are used. Such procedures shall include but shall not be limited to the following:

- (1) The maximum throat thickness of fillet welds shall be 1/2 in.
  - (2) The maximum continuous length of fillet welds shall be not over 4 in.
  - (3) Electrodes or filler metal shall be dry and shall provide a low-hydrogen weld deposit. Chrome-moly filler metals shall have a maximum specified chromium content of not more than 2.50% and a maximum specified carbon content of not more than 0.05%.
  - (4) The thickness of the test plate used in making the welding procedure qualification, shall not be less than that of the material to be welded.
- (d) for tubes or pressure retaining handhole and inspection plugs or fittings with a specified maximum chromium content of 6% that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness of 3/8 in. or less
- (2) Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

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Material	Minimum Holding Temperature, ° F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 6 Group No. 1,2,3	1400	1 hr/in. 15 min minimum	1 hr/in.	5 hr. plus 15 min. for each additional inch over 5 in

**NOTES:**

- (1) Postweld heat treatment is not mandatory for P-No.6 materials under the following conditions:
  - (a) for Type 410 material where the material and construction shall comply with the following conditions:
    - (1) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.08%
    - (2) the electrodes used shall produce an austenitic chromium-nickel weld deposit, or non-air-hardening nickel-chromium-iron weld deposit, and provided the following additional requirements are met:
      - (a) the material thickness at the welded joint does not exceed 3/8 in.
      - (b) for material thickness over 3/8 in. through 1-1/2 in., the following additional conditions shall be required:
        - (1) a preheat of 450° F shall be maintained during welding.
        - (2) the welded joints shall be fully radiographically examined.
- (2) Note (1) does not apply to welds using the inertia and continuous drive friction welding processes. Postweld heat treatment is mandatory for all thicknesses of materials welded using inertia and continuous drive friction welding.

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Material	Minimum Holding Temperature, °F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 7 Group No. 1,2	1350	1 hr/in. 15 min. minimum	1 hr/in.	5 hr. plus 15 min. for each additional inch over 5 in.

**NOTES:**

- (1) Postweld heat treatment for P-No. 7 material shall be performed, except that the cooling rate shall be a maximum of 100° F/hr in the range above 1200° F after which the cooling rate shall be sufficiently rapid to prevent embrittlement.
- (2) Postweld heat treatment is not mandatory for P-No.7 materials under the following conditions:
  - (a) for Type 405 material where the material and construction shall comply with the following conditions:
    - (1) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification) of not more than 0.08%
    - (2) the electrodes used shall produce an austenitic chromium-nickel weld deposit, or a non-air-hardening nickel-chromium-iron weld deposit, and provided the following additional requirements are met:
      - (a) the material thickness at the welded joint does not exceed 3/8 in.
      - (b) for material thickness over 3/8 in. through 1-1/2 in., the following additional requirements are met:
        - (1) a preheat of 450° F shall be maintained during welding
        - (2) the welded joints shall be fully radiographically examined

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Material	Minimum Holding Temperature, °F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 8, 31 or 45	None	None	None	None

NOTES:

- (1) Postweld heat treatment is neither required nor prohibited for joints between austenitic stainless steels of the P-No. 8 group, P-No. 31 group or P-No. 45 group.

Material	Minimum Holding Temperature, °F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 9A Group No. 1	1100	1 hr/in. 15 min minimum	1 hr/in.	5 hr. plus 15 min. for each additional inch over 5 in.

NOTES:

- (1) When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures (1000°F minimum) for long periods of time in accordance with the alternate table at the end of this attachment.
- (2) Postweld heat treatment is not mandatory for P-No. 9A materials under the following conditions:
- (a) for circumferential welds in pipe or tubes where the pipe or tubes comply with all of the following conditions:
- (1) a maximum nominal outside diameter of 4 in.
  - (2) a maximum thickness of 1/2 in.

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- (3) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%.
- (b) for fillet welds used on socket welding fittings, when the following conditions are met:
  - (1) a fillet weld throat thickness of 1/2 in. or less, regardless of base metal thickness
  - (2) a maximum specified carbon content (SA material specification carbon content, except when further limited by the Purchaser to a value within the specification limits) of not more than 0.15%.
  - (3) a minimum preheat of 250°F when the thickness of a pressure part at the weld exceeds 1/2 in.
- (c) for pipe or tube materials meeting the requirements of (a)(1), (a)(2), and (a)(3), above having attachments fillet welded to them, provided:
  - (1) the fillet welds have a throat thickness of 1/2 in. or less.
  - (2) the material is preheated to 250°F minimum. A lower preheating temperature may be used provided specifically controlled procedures necessary to produce sound welded joints are used. Such procedures shall include but shall not be limited to the following:
    - (a) the throat thickness of fillet welds shall be 1/2 in or less.
    - (b) the maximum continuous length of fillet welds shall be not over 4 in.
    - (c) the thickness of the test plate used in making the welding procedure qualification of Section IX, shall not be less than that of the material to be welded.
- (d) for tubes or pressure retaining handhole and inspection plugs or fittings that are secured by physical means (rolling, shoulder construction, machine threads, etc.) and seal welded, provided the seal weld has a throat thickness 3/8 in or less.

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Material	Minimum Holding Temperature, °F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 9B Group No. 1	1100	1 hr/in. 15 min. minimum	1 hr/in.	5 hr. plus 15 min. for each additional inch over 5 in.

**NOTES:**

- (1) When it is impractical to PWHT at the temperature range specified, it is permissible to perform the PWHT of this material at lower temperatures (1000° F maximum) for long periods of time in accordance with the alternate table at the end of this attachment.
- (2) For postweld heat treatment of P-No. 9B materials, the holding temperature shall not exceed 1175° F.
- (3) Postweld heat treatment of P-No. 9B materials is not mandatory for materials up to and including 5/8 in. in thickness, providing a welding procedure qualification has been made in equal or greater thickness than production weld.

Material	Minimum Holding Temperature, °F.	Minimum Holding Time at Normal Temperature for Weld Thickness (Nominal)		
		Up to 2 in.	Over 2 in. to 5 in.	Over 5 in.
P-No. 10E Group No. 1	1250	1 hr/in. 15 min. minimum	1 hr/in.	1 hr/in.

**NOTE:**

- (1) Postweld heat treatment for P-No. 10E(SA-268 TP446 material only) shall be performed, except that the cooling rate shall be a maximum of 100° F/hr above 1200° F after which the cooling rate shall be sufficiently rapid to prevent embrittlement.

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ALTERNATE POSTWELD HEAT TREATMENT  
REQUIREMENTS FOR CARBON AND  
LOW ALLOY STEELS  
(Applicable only when permitted in the preceding tables)

Decrease in Temperature Below Minimum Specified Temperature, °F	Minimum Holding Time at Decreased Temperature, hr/in. of thickness	Notes
50	2	...
100	4	...
150	10	(1)
200	20	(1)

NOTE:

- (1) These lower postweld heat treatment temperatures permitted only for P-No. 1, Group 1 and 2 materials.

**ASME SECTION III**

**MANDATORY REQUIREMENTS FOR POSTWELD HEAT TREATMENT OF WELDS<sup>1</sup>**

P-No.	Holding Temperature Range, °F <sup>2</sup>	Minimum Holding Time at Temperature For Weld Thickness (Nominal)			
		1/2 in. or less	Over 1/2 in. to 2 in.	Over 2 in. to 5 in.	Over 5 in.
1, 3	1100-1250	30 min.	1 hr./in.	2 hr. plus 15 min each additional inch over 2"	2 hr. plus 15 min each additional inch over 2"
4	1100-1250	30 min.	1 hr./in.	1 hr./in.	5 hr. plus 15 min each additional inch over 5"
5, 6 except P-No. 6	1250-1400	30 min.	1 hr./in.	1 hr./in.	5 hr. plus 15 min each additional inch over 5"
Gr. 4					
Gr. 6	1050-1150				
7	1300-1400	30 min.	1 hr./in.	1 hr./in.	5 hr. plus 15 min each additional inch over 5"
9A Gr. 1	1100-1250	30 min.	1 hr./in.	1 hr./in.	5 hr. plus 15 min each additional inch over 5"
9B Gr. 1	1100-1175				
10F Gr. 1	1100-1250	30 min.	1 hr./in.	1 hr./in.	5 hr. plus 15 min each additional inch over 5"
10I Gr. 1	1300-1400				
11A Gr. 4	1000-1050	30 min.	1 hr./in.	1 hr./in.	1 hr./in.

P-Nos. 8, 34, 42, 43, 45 and hard surfacing on P-No. 1 base metal whose reported carbon content is not more than 0.30%

PMHT neither required nor prohibited.

**NOTES:**

- 1) Exemptions to the mandatory requirements of this Attachment are defined in Attachment "9".
- 2) All temperatures are metal temperatures.



ASME Section III

ALTERNATIVE HOLDING TEMPERATURES AND TIMES

Material P-No.	Alternative Minimum Holding Temperatures (°F)	Alternative Minimum Holding Times [Note (1)]
1, 3, 9A Gr.1, 9B Gr. 1	1050	2 hr/in. thick
1,3, 9A Gr.1 9B Gr. 2	1000	4 hr/in. thick

NOTE:

(1) All other requirements for time and temperature shall apply.

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**ASME SECTION III**

**EXEMPTIONS TO MANDATORY PWHT<sup>1</sup>**

P-No.	Type of Weld (Note 5)	Nominal Thickness	Max. Reported Carbon, % (Note 6)	Min. Preheat Req'd ° F
1	Vessels Circumferential butt and socket welds connecting pipe and tubes to nozzles where the materials being joined are 1-1/2 in. and less	1-1/4 in. & less	0.30 or less	....
		Over 1-1/4 in. to 1-1/2 in.	0.30 or less	200
		3/4 in. or less	over 0.30	....
		Over 3/4 in. to 1-1/2 in.	over 0.30	200
	Fillet Welds	3/4 in. or less	....	200
	All welds, except repair welds and fillet welds, provided welding procedure qualification is made using equal or greater thickness base material than the production weld	5/8 in. or less	0.25 or less	200
Other Components	All welds where the materials being joined are 1-1/2 in. and less	1-1/4 in. and less	0.30 or less	....
		Over 1-1/4 in. to 1-1/2 in.	0.30 or less	200
		3/4 in. or less	Over 0.30	....
		Over 3/4 in. to 1-1/2 in.	Over 0.30	200
	All welds in material over 1-1/2 in.	3/4 in. or less	....	200