

## TABLE OF CONTENTS

### Volume 1, GENERAL WELDING STANDARDS

GWS 1-08 POST WELD HEAT TREATMENT..... 2  
 1.0 PURPOSE AND SCOPE ..... 2  
 2.0 REFERENCES ..... 2  
 3.0 ACRONYMS AND DEFINITIONS ..... 2  
 4.0 GENERAL..... 2  
 5.0 PROCEDURE..... 2  
 6.0 ATTACHMENTS..... 6  
     Attachment 1: Post Weld Heat Treatment Instruction Sheet ..... 6  
     Attachment 2: Thermocouple Placement Sketches..... 6

### RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	8/16/04	Initial issue.	Kelly Bingham, <i>FWO-DECS</i>	Gurinder Grewal, <i>FWO-DO</i>
1	10/27/06	Organization updates from LANS transition. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Other administrative changes.	Kelly Bingham, <i>FM&amp;E-DES</i>	Kirk Christensen, <i>CENG</i>

**Contact the Welding Standards POC for upkeep, interpretation, and variance issues**

<b>GWS 1-08</b>	<a href="#"><u>Welding POC/Committee</u></a>
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## GWS 1-08 POST WELD HEAT TREATMENT

### 1.0 PURPOSE AND SCOPE

- A. The purpose of this procedure is to provide instructions for Post Weld Heat Treatment (PWHT) of welded joints.
- B. The scope of this section applies to Post Weld Heat Treatment activities conducted and in connection with welding activities performed at LANL.

### 2.0 REFERENCES

None.

### 3.0 ACRONYMS AND DEFINITIONS

Acronym / Term	Description
<p style="text-align: center;"><b>PWHT</b> Post Weld Heat Treatment</p>	<p>PWHT is “stress-relief heat treatment...the uniform heating of a structure (<i>component</i>) or a portion thereof to a sufficient temperature to relieve the major portion of the residual stresses, followed by uniform cooling.” (from AWS A3.0, italics added)</p>

### 4.0 GENERAL

#### 4.1 Responsibilities

- A. The assigned **LANL Facility, Project, Program Manager or SSS designee** is responsible for ensuring that PWHT is performed in accordance with this procedure and the temperature range specified on the appropriate Welding Procedure Specification (WPS) or Welding Technique Sheet (WTS).

### 5.0 PROCEDURE

#### 5.1 General

- A. The LANL Facility, Project, Program Manager, or SSS designee shall complete a PWHT Instruction Sheet (Attachment 1) prior to each PWHT operation. Instructions for completing the PWHT Instruction Sheet are included in Attachment 1.

#### 5.2 Temperature Measurement

- A. Thermocouples shall be attached so that there is firm contact between the sensing tip and the assembly being heat treated by use of thermocouple attachment devices or capacitor discharge attachment devices.

- B. Thermocouple attachment devices shall be tack welded by a qualified welder using a WPS / WTS compatible with the material to be welded. When using capacitor discharge attachment devices, the manufacturer's instructions should be followed and qualification of the operator is not required.
- C. A minimum of 6 thermocouples are required on pipe diameters over NPS 8 (DN 200): 2 recording and 2 recording spares, plus 1 control and 1 control spare. Additional control and control spare thermocouples may be added to allow for zone or quadrant control.
- D. A minimum of 4 thermocouples are required on pipe diameters NPS 8 (DN 200) and less: 1 recording and 1 recording spare; 1 control and 1 control spare. Additional control and control spare thermocouples may be added to allow for zone or quadrant control.
- E. Thermocouples shall be placed in accordance with the appropriate sketches identified in Attachment 2.
- F. The temperature recorder shall be calibrated in accordance with the manufacturer's recommendations.

### **5.3 Heating Elements / Furnaces**

- A. The required number of heating elements and power supplies shall be determined. This may be accomplished by referring to the manufacturer's requirements and/or by using the following formulas as a guide:
  - Kilowatts Required = Diameter x Thickness
  - One Heating Element = 3.2 Kilowatts
  - 24 Heating Elements = One 500 Amp Power Supply
- B. Locate and fasten heating elements in accordance with the manufacturer's instructions and the following requirements:
  1. For fabrication codes other than ASME Section III and Section VIII, welds shall be post weld heat treated by heating a circumferential band around the pipe or component. The width of the band shall be at least 3 times the thickness at the weld of the thicker member being joined.
  2. For ASME Section VIII, post weld heat treatment may be accomplished by heating the vessel as a whole in an enclosed furnace or by heating shell sections, portions of vessels, longitudinal joints, or complicated welded details before joining to make a completed vessel. Any circumferential welds not previously post weld heat treated may be thereafter locally post weld heat treated by heating a circumferential band around the vessel. The width of the heated band on each side of the greatest width of finished weld shall not be less than 3 times the shell thickness. For heating a circumferential band containing nozzles or other welded attachments that require post weld heat treatment, the circumferential band shall extend around the entire vessel, shall include the nozzle or welded attachment, and shall extend at least 6 times the plate thickness beyond the weld which connects the nozzle or other attachment to the vessel.

3. For ASME Section III, post weld heat treatment may be accomplished by heating the vessel as a whole in an enclosed furnace or by heating a circumferential band around the pipe or component. The width of the band shall be at least three times the thickness at the weld of the thicker member being joined. Heating the item in a closed furnace in one heat is the preferred method 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. The item may be heated in more than one heat in a furnace, provided the overlap of the heated sections of the item is at least 5 ft. (1.5 m). 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.

**Note:** Use of ASME Section III is not anticipated.

- C. On pipe diameters greater than NPS 12 (DN 300), the heating elements shall be placed to provide 4-quadrant control.
- D. Wrap at least one layer of insulation around the joint for all wall thicknesses, leaving only the thermocouple leads and heater element leads exposed.

#### 5.4 Heating Process

- A. For ASME / ANSI fabrication codes, other than ASME Section III and VIII, heat-up and cool-down shall be controlled above 600 °F (315 °C) at a rate not exceeding 600 °F/hr (315 °C/hr) for thicknesses less than or equal to 2 in. (50 mm). On materials greater than 2 in. (50 mm) in thickness, the rate shall not exceed 600 °F/hr (315 °C/hr) divided by one-half the thickness of the thicker joint member.
- B. For ASME Section III and Section VIII, heat-up and cool-down shall be controlled above 600 °F (316 °C) at a rate not exceeding 400 °F/hr. (205 °C/hr.) for thicknesses less than or equal to 1 in. (25 mm). On materials greater than 1 in. (25 mm) in thickness, the rate shall not exceed 400 °F/hr (205 °C/hr) divided by the thickness of the thicker material being heat treated. The rate need not be less than 100 °F (38 °C) in any hourly interval. During the heating and cooling period there shall not be a greater variation in temperature than 250 °F (120 °C) within any 15 ft. (4.5 m) interval of weld length.

**Note:** The WPS / WTS and/or fabrication code may establish heating and cooling rates that are more restrictive for some materials and service conditions.

- C. For AWS D1.1
  1. The temperature of the furnace shall not exceed 600°F (315°C) at the time the welded assembly is placed in it.
  2. Above 600°F the rate of heating shall not be more than 400°F (220°C) per hour divided by the maximum metal thickness of the thicker part, in inches, but in no case more than 400°F per hour. During the heating period, variation in temperature throughout the portion of the part being heated shall be no greater than 250°F (140°C) within any 15 ft interval of length. The rates of heating and cooling need not be less than 100°F (55°C) per hour. However consideration of closed chambers and complex structures may indicate reduced heating and cooling to avoid structural damage due to excessive thermal gradients.

3. After a maximum temperature of 1100°F (600°C) is reached on quenched and tempered steels, or a mean temperature range between 1100°F and 1200°F (650°C) is reached on other steels, the temperature of the assembly shall be held within the specified limits for not less than specified in AWS D1.1 Table 5.2 based on weld thickness. When the specified stress relief is for dimensional stability, the holding time shall be not less than specified in AWS D1.1 Table 5.2 based on the thickness of the thicker part. During the holding period there shall be no difference greater than 150°F (85°C) between the highest and the lowest temperature throughout the portion of the assembly being heated.
  4. Above 600°F, cooling shall be done in a closed furnace or cooling chamber at a rate no greater than 500°F (260°C) per hour divided by the maximum metal thickness of the thicker part in inches, but in no case more than 500°F per hour. From 600°F the assembly may be cooled in still air.
  5. Alternative PWHT - Alternatively, when it is impractical to PWHT to the temperature limitations stated in 5.M.1 through 5.M.4 above, welded assemblies may be stress-relieved at lower temperatures for longer periods of time as given in AWS D1.1 Table 5.3
- D. For AWS D1.6 - PWHT requirements must be specified in the WPS and is limited to non-qualified welding procedures.
- E. For ASME B31.8 –
1. Welds in carbon steel having carbon content in excess of 0.32% (ladle analysis) or a carbon equivalent (C+ ¼ Mn) in excess of 0.65% ladle analysis shall be stress relieved as prescribed in ASME BPV Code, Section VIII. Stress relieving may also be advisable for welds having lower carbon content or carbon equivalent when adverse conditions cool the weld too rapidly.
  2. Welds in all carbon steels shall be stress relieved when the nominal wall thickness exceeds 1 ¼ inch.
  3. When welded joint connects parts of different thicknesses but similar materials, the thickness to be used in applying the rules in paragraphs 5.0.1 and 5.0.2 shall be:
    - The thicker of the two parts being joined, measured at the weld joint.
    - The thickness of the pipe run or header in case of branch connections, slip-on flanges, or socket weld fittings.
  4. If either material in welds between dissimilar materials requires stress relieving, the joint shall require stress relieving.
  5. A welding of connections and attachments shall be stress relieved when the pipe is required to be stress relieved by the rules of 5.0.3 with the following exceptions:
    - Fillet and groove welds not over 1/2 inch leg size that attach connections not over NPS 2 inch pipe size.
    - Fillet and groove welds not over 3/8 inch groove size that attach supporting members or other non-pressure attachments.
  6. Stress Relieving Temperature
    - Stress relieving shall be performed at a temperature of 1100°F or greater for carbon steel and 1200° F or greater for ferritic alloy steels. The exact temperature range shall be stated in the procedure specification.
    - When Stress relieving takes place in a joint between dissimilar metals having different stress relieving requirements, the material requiring the higher stress relieving temperature shall govern.

- The parts heated shall be brought slowly to the required temperature and held at that temperature for a period of time proportioned on the basis of at least 1hr/in. of pipe wall, but in no case less than 1/2 hr, and shall be allowed to cool slowly and uniformly.

7. Methods of Stress Relieving

- Heat the complete structure as a unit
- Heat a complete section containing the weld or welds to be stress relieved before attachment to other sections of work
- Heat a part of the work by slowly heating a circumferential band containing the weld at the center. The width of the band that is heated to the required temperature shall be at least 2 in. greater than the width of the weld reinforcement. Care should be taken to obtain a uniform temperature around the entire circumference of the pipe. The temperature shall diminish gradually outward from the edges of this band.
- Branches or other welded attachments for which stress relief is required may be locally stress relieved by heating a circumferential band around the pipe on which the branch or attachment is welded with the attachment at the middle of the band. The width of the band shall be at least 2 in. greater than the weld joining the branch or attachment to the header. The entire band shall be brought up to the required temperature and held for the time specified.

**5.5 Records**

- A. Upon completion of the PWHT operation, the LANL Facility, Project, Program Manager or SSS designee shall attach the PWHT Instruction Sheet (Attachment 1) to the recorder chart and file along with the associated weld records in the construction site files.

**5.6 Subcontracted Services**

- A. Subcontracted PWHT services shall be performed in accordance with this Section or in accordance with the Subcontractor's procedures as accepted by LANL.
- B. The LANL Facility, Project, Program Manager or SSS designee shall monitor the PWHT Subcontractor to assure compliance with the engineering specification and applicable procedures.

**6.0 ATTACHMENTS**

Attachment 1: Post Weld Heat Treatment Instruction Sheet

Attachment 2: Thermocouple Placement Sketches