

Post Weld Heat Treatment Procedure

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POST WELD HEAT TREATMENT PROCEDURE

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ATTACHMENT *Follows*

1.0 Scope

- 1.1 This procedure states explicitly in detail the minimum requirement for the external load, Post Weld Heat Treatment (PWHT) shall be carried out by the electrical resistance method for vessels, nozzles, pipes & exchanges.
- 1.2 This procedure covers description of the equipment, method of heating, location and type of heating elements temperature measurement and thermocouple location.
- 1.3 Post Weld Heat Treatment (PWHT) shall be in accordance with ASME B31.3, ASME B31.4 and ASME B 31.8 latest edition.

2.0 References

Unless stated otherwise all codes and standards referenced in this procedure shall be of the latest issue (including revisions – addenda and supplements) and the following documents shall be referred to along with this procedure.

- | | |
|---------------------------------|--|
| a) ASME Section VIII Division 1 | - Boiler & Pressure Vessels code, |
| b) ASME B31.3 | - Chemical Plant and Petroleum Refinery Piping |
| c) ASME B31.4 | - Liquid Petroleum Transportation Piping Systems |
| d) ASME B31.8 | - Gas Transmission and Distribution Piping Systems |

3.0 Person handling the PWHT activities

3.1 Health & Safety

All personals working in the heat treatment shall be trained and cautioned about the possible plungers in PWHT work.

It shall be the responsibility of the employed PWHT operator to ensure personal safety & to ensure whether the facilities with respect to scaffolding, lighting are fully sufficient, before commencement of any job. All cables shall be tied up properly & neatly to avoid damages to cables & personnel injuries to operators.

3.2 Qualification

The basic requirement for PWHT operator shall be that he should either be a science/technical graduate or an electrical apprentice high school graduate with basic electrical knowledge to undertake the heat treatment at the site.

4.0 Description of Required Equipment & Materials

4.1 Equipment

The equipment shall be of a proper make & it should be bearing proper electrical power input/output.

Power distribution (supply) shall be of 380/440V Ph, with either single phase secondary output or step down transformer secondary output (heat treatment unit) supplying low voltage circuits. The temperature control equipment shall be operated manually or through regulators or it shall be (made) operated

automatically with the help of modular controls. The chart type temperature recorder shall be used for recording temp.

The frequency of calibration of temp recorder shall be three months & a proper valid sticker shall be displayed on the temp recorder.

4.2 **Materials**

All the connection materials required for the heat treatment, shall be of standard quality & it shall be selected free of defects.

5.0 **Surface Conditions**

The welds to be heat treated shall be prepared free of greases, lubricants dust and coatings to avoid damage & short circuiting of accessories equipments.

Prior to the start of the PWHT, component shall be checked to ensure that all restrains are removed and the component is free to expand and contract and suitable and sufficient supports are used.

During heat treatment it shall be necessary to protect from oxidation the mechanical surfaces line flange faces, threaded holes, threads by the application of coating such as deoxaluminite or any other suitable coating material.

PWHT shall follow all welding and repairs but shall be performed prior to any hydro test or other load test.

Where practicable, open pipe ends of component shall be closed off to prevent the cooling effects associated with draughts (chimney effects).

Heating elements shall be securely fixed in contact with the work piece by stainless steel or mild steel banding to suit the application. Under no circumstances shall galvanized wire or other fixings likely to be detrimental to the pipe material be utilized.

Upon completion of the Post Weld Heat Treatment, the thermocouple shall be removed and the areas of attachment dressed by either grinding or filling before being non-destructively examined using either dye penetrate or magnetic particle inspection methods by Client (if required) Client's representative will sign and date the column inspection after Heat Treatment.

6.0 Method

The procedure for PWHT has to be followed for the various steel grades as mentioned below.

Material Grade	Temperature Range	Heating/Soaking Time	Rate of Heating	Rate of Cooling
Alloy Steels ASTM A 335 P4	705 ⁰ - 749 ⁰	2 Hrs/ 25mm wall thickness soaking 2 hrs minimum	100 ⁰ C / Hrs/25mm wall thickness	100 ⁰ C /hrs / 25mm wall thickness
	705 ⁰ - 760 ⁰	2 Hrs/ 25mm wall thickness soaking 2 hrs minimum	100 ⁰ C / Hrs/ 25mm wall thickness	100 ⁰ C /hrs / 25mm wall thickness
	705 ⁰ - 749 ⁰	2 Hrs/ 25mm wall thickness soaking 2 hrs minimum	100 ⁰ C / Hrs/ 25mm wall thickness	100 ⁰ C /hrs / 25mm wall thickness
	730 ⁰ - 790 ⁰	2 Hrs/ 25mm wall thickness soaking 2 hrs minimum	100 ⁰ C / Hrs/ 25mm wall thickness	100 ⁰ C /hrs / 25mm wall thickness
	590 ⁰ - 650 ⁰	1 Hrs/ 25mm wall thickness soaking 1 hrs minimum	222 ⁰ C / Hrs/ 25mm wall thickness	222 ⁰ C /hrs / 25mm wall thickness

7.0 Basic Requirements to carryout PWHT and the methodology

7.1 Thermocouples

- a) The thermocouples shall be of the type 'K' i.e. nickel-chromium / nickel – aluminum type in accordance with BS 1041. Part – 4. The thermocouples should have initial calibration check.
- ❖ All the thermocouple wires should have valid certificate of conformance with a tolerance of <+/- 0.75% between the temperature ranges 400⁰ C to 800⁰ C.
- ❖ The general 'K' type thermocouple wire shall have dimension 1/0.71 mm of Ni-Cr/Ni-Al. The +ve & -ve charges should be marked properly.

Compensating Cable

The cable recommended shall be twin type wore PVC coated copper/constantan connection to thermocouple, with proper plug & socket. Copper constantan compensating cable shall be used for connecting thermocouple wires & the temperature recorder. Connect the copper lead (+ve white) to nickel-chromium conductor (non magnetic yellow) and the constantan lead (-ve) to the nickel –aluminum conductor (magnetic red)

Compensation Cable Specification

Description:

2 x 13/0.2 mm Cu/Con compensating cable type V, with colour code as per BS 1843

+ve –ve –white

-ve - blue

& sheath red cover

The compensating cable specification should conform to international thermocouple reference tables BSEN – 60584 – 1 of 1996.

- b) The thermocouples shall be attached in the following manner.
Capacitance discharged direct wire, & the gap between the wires should not be more than 6mm. The junction has to be insulated by using thermocouple high temperature putty in order to protect it from direct heat source.
The thermocouple to extension cable connection shall be minimum of 0.5m outside the heated zone & the acceptable junction temperature should not be more than 80°C.
- c) Minimum numbers of equally spaced recording thermocouple (T/C), which are required for any local Post Weld Heat Treatment (PWHT) shall be as follows
- I. For pipes having diameter 305mm or less;- 2 T/C.
 - II. For pipes having diameter > 305mm ≤610 – 3 T/C.
 - III. For pipes having diameter > 610; - 4 T/C.
- If multiple heating zones are used being not monitored by a primary T/C, then additional requirements of T/C should be done.
- d) For localized PWHT of vessels it should be monitored using a minimum of four sets of thermocouples, with each set having one T/C on the inside & outside surfaces. The positioning of each set shall be done on the weld center line at 90° spacing around the vessel circumference. We may require additional T/C if multiple heating zones are used & when it is not monitored by a primary set of T/C.
As per client's requirement or as per code additional thermocouples shall be fixed to confirm hot zone or gradient limitation.
- e) Thermocouple extension cable should be necessarily of copper-constantan compensating cable with connection through plug & socket as
Copper lead (+ve) to nickel chromium (Non Magnetic)
Constantan lead (-ve) to nickel aluminum (Magnetic)
- f) The thermocouples & positions shall be identified on the particular temperature recording chart by number of colour / symbol of stamp
- g) After the completion of PWHT remove the thermocouples & ground smoothly the area, to clean & we thus achieve sound metal. As per the specification / instruction of the inspector the areas are to be examined by MT or PT after grinding.

7.2 Elements

- I. The circumferential band width which has to be heated shall be minimum Six (6) times the thickness of the shell material being welded from each edge of the weld, but not less than 25mm, whichever is greater.
- II. The material temperature shall exceed half the heat treatment temperature over a band at least $2.5 \sqrt{Rt}$ where 'R' is the bore radius & 't' is the nominal wall thickness on each side of the weld times.
For welds on pipes diameter $\geq 250\text{mm}$, the elements shall be divided into two or more control zones, being top & bottom with pads applied symmetrically.
- III. If the elements arrangement is not being capable of desired configuration then.
The center time circumferential gap between two bands shall not exceed 30mm or 't' whichever is lesser.
The longitudinal gaps between elements shall not be more than the wall thickness or 50mm, whichever is less. We should be careful to ensure that there are no gaps in 6'O clock position.
- IV. If the welds are of two separate wall thickness then the elements should be so arranged to give side to side control in addition to top & bottom control.
- V. In the case of inclined or vertical welds the pads shall be arranged about the weld to give independent control above & below weld centerline.
Elements are attached by - Black annealed iron wire
- Mild steel 12mm wide banding strap.

7.3 Thermal Insulation

- I. Thermal insulation should be achieved by following means.
With ceramic fiber, usually in stainless steel mesh as form of mat, minimum density of Wool, mineral with minimum density of 80Kg / m^3
 96Kg / m^3
- II. The insulation distance shall be up to a minimum distance of 305mm beyond the edges of the heating bands or up to a distance determined by the product of bore radius times the maximum wall thickness whichever is less.
- III. The number of layers & extent of insulated area shall be dependent on
 - * Wall thickness
 - * Pipe or fitting diameter
 - * Gradient requirement
 - * Site conditionsIn all cases the minimum requirement shall be two (2) layers for densities (80Kg / m^3 & 96Kg / m^3)
- IV. Insulation shall be fixed using black annealed iron wire taking care, not damaging or cutting into the insulation.
- V. By following proper PWHT cycles, the item or the particular joint shall be completed & the cooling rate should be controlled under insulation.

7.4. Temperature Recording

- I. Temperature recorders shall be calibrated after every three months or after repair. The calibration certificate should be kept & a sticker should be stuck on the instrument.
- II. The temperature recorder shall be of the potentiometric self-compensating type. The chart should also be attached to record all readings.
- III. The speed of the chart should be adjusted at 25mm / hr, recording all monitoring of thermocouples, it should also be giving information's of the difference in temperatures and the different trends during the heating & cooling cycle.
- IV. The time temperature chart should be recording the heat treatment of those welds undergoing the same cycle for any particular section.

8.0. PWHT (Post Welded Heat Treatment)

- I. Applicable codes shall be adhered to while demy stress relieving reductions in soak temperature, which are allowed by ASME sec. vii (Dir 1), are not permitted if heat treatment is required due to service condition (sour service) or in cases where hardness controls are specified.
- II. Stress relieving time temperature shall be applicable over an area of min $6t$ inches (t = wall thickness of pipe) on both sides of the weld but it should not be less than 1" on both sides.
- III. Start the heat treatment cycle on an auto program where in heating rate shall not more than 222°C per hour, divided by maximum material thickness in inches, but in no case above 222°C on reaching 316°C .
- IV. The soak temperature is determined or adjusted as a mean difference in the upper & lower limits. The maximum variation in temperature should not be more than 40°C . Soaking time starts when all thermocouples achieve this temperature.
- V. The cooling rates should not be more than 222°C / hr divided by maximum material thickness in inches but no case above 222°C .
- VI. After attaining 316°C power could be turned off & on cooling the weld to below 150°C the insulation / elements could be removed.
- VII. The minimum soaking time shall be one hour. The PWHT soak period shall be in accordance with the 80% limitations as applicable to the PQR's used during fabrication. The contractor's PQR could be referred while doing PWHT.

9.0. Precautions

- I. Check all cable connections using proper plugs & sockets.
- II. Protect the power cables & thermocouple cable from damage.

10.0. Documentations

- I. Procure the approval of the PWHT cycle & assignment for the weld joint to be heat treated. The details to be included in the work sheet are as follows: Material, wall thickness of shell, heating & cooling rates, soaking temperature & time.
- II. Inform the client if you notice any deviation in the heat treatment cycle.

11.0. Report & Records

The heat treatment cycle chart shall be treated as the proof & record for any h.t - completion.

ISB technicians will fill out the record sheets of Heat Treatment (sample attached) prior to start of any PWHT and client shall authorize specifications complying with governing code. On completion, the record of the Heat Treatment along with chart will be submitted to the client, as minimum the following information will be provided:

- a. Client Identity
- b. Contract/Job Identity
- c. Specification Details
- d. Spool number, diameter and weld numbers
- e. Material specification
- f. Thermocouple locations
- g. Heating and Cooling Rate
- h. Soaking (holding) time
- i. Technician name
- j. Location map of particular vessels
- k. Date and Chart speed

Records shall be maintained for a maximum of three months with all charts & documents.

TABLE 1

**Typical Application
For Ceramic Heating Elements**

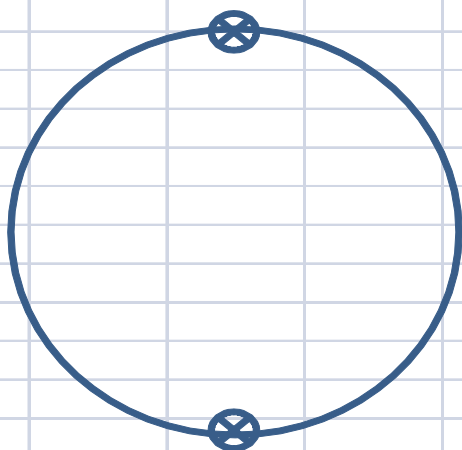
Element	Identity	Dimensions * W x L	Electrical	
			Volts	KW
CP3	Heavy wall heating elements	75 x 670	60	2.7
CP4		100 x 500	60	2.7
CP6		150 x 330	60	2.7
CP8		205 x 250	60	2.7
CP10		255 x 205	60	2.7
CP12	Standard heating elements	305 x 165	60	2.7
CP15		380 x 145	60	2.7
CP16		410 x 125	60	2.7
CP21		535 x 100	60	2.7
CP24		610 x 85	60	2.7
CP48	Long strip heating elements	1200 x 45	60	2.7
CP10L	Short strip heating elements	255 x 85	30	1.35
CP20L		500 X 45	30	1.35
CP24H		635 X 330	220	9.9

* The width **W** – denotes the distance across the tails in mm
L – denotes the length in mm

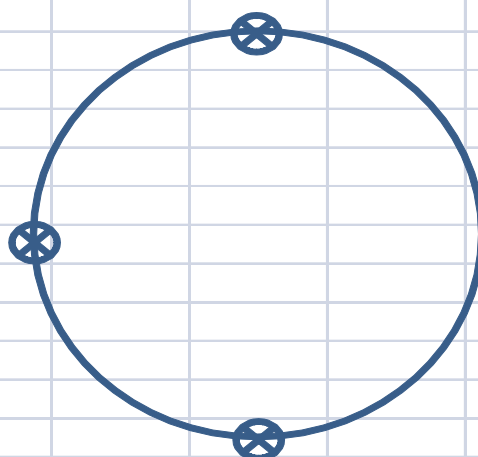
IBRAHIM BIN S. AL BRAHIM EST.	EXAMINATION PROCEDURE
Document#	Page
Approved by: General Manager	Issue date:

ATTACHMENT

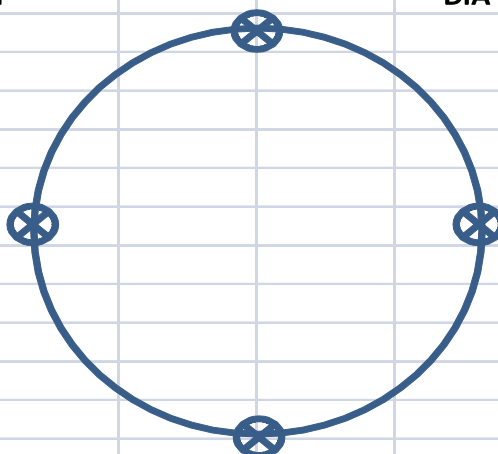
THERMOCOUPLE LOCATIONS



DIA ≤ 305 MM



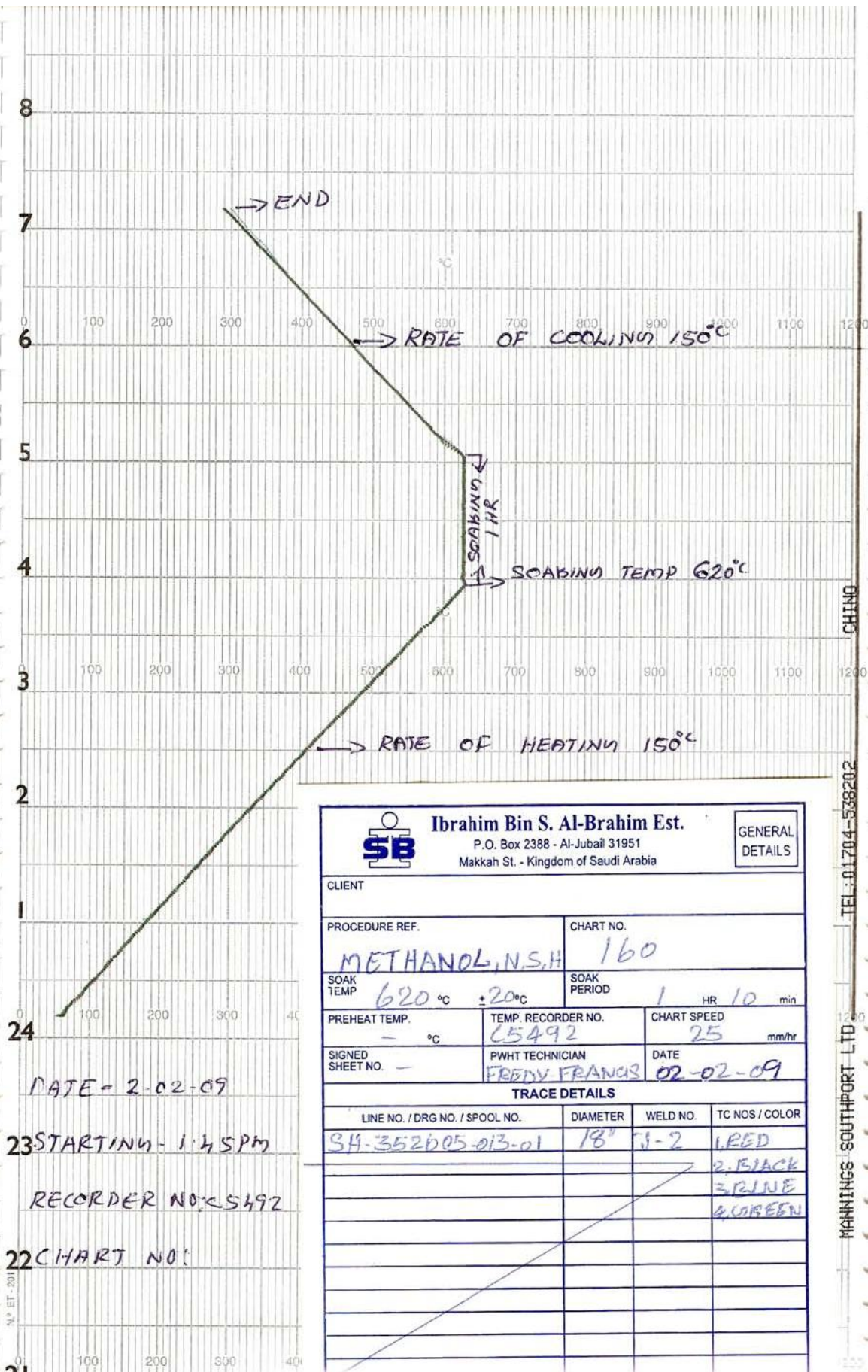
DIA > 305 MM ≤ 610 MM




DIA > 610 MM

NOTE:

1. "X" is Thermocouple Location
2. Additional Thermocouple will be used if multiple heat control zones are used, in which a control zone is monitored by any of the Primary Thermocouple.



 Ibrahim Bin S. Al-Brahim Est. P.O. Box 2388 - Al-Jubail 31951 Makkah St. - Kingdom of Saudi Arabia				GENERAL DETAILS	
CLIENT					
PROCEDURE REF.			CHART NO.		
METHANOL, N.S.H			160		
SOAK TEMP 620 °C ± 20 °C			SOAK PERIOD 1 HR 10 min		
PREHEAT TEMP. - °C		TEMP. RECORDER NO. C5492		CHART SPEED 25 mm/hr	
SIGNED SHEET NO. -		PWHT TECHNICIAN FREDY FRANCIS		DATE 02-02-09	
TRACE DETAILS					
LINE NO. / DRG NO. / SPOOL NO.		DIAMETER	WELD NO.	TC NOS / COLOR	
34-352605-013-01		18"	J-2	1 RED	
				2 BLACK	
				3 BLUE	
				4 GREEN	

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