FIELD HEAT TREATMENT BASICS AND THE CERTIFIED TECHNICIAN

Bruce Stewart – Field Heat Treatment Training Coordinator
INTRODUCTION

The Quality Control Council of Canada is an organization that represents Non Destructive Testing Technicians and Field Heat Treatment Technicians across Canada.

We have two permanent training facilities based in Edmonton AB with a total of three classrooms and one shop area to accommodate practical training.

The Field Heat Treatment Training Program has been operating since May 2009 and is recognized through Alberta Apprenticeship and Industry Training (AIT)
HEAT TREATMENT BASICS

Heat treatment is used to avert or relieve the detrimental effects of high temperature and severe temperature gradients inherent in welding, and to relieve residual stresses created by bending and forming (ASME).

Field Heat Treatment consists of applying heat to welded joints and a limited volume of base metal adjacent to the joints (referred as local heating), as opposed to heating the complete component in a furnace or oven.
HEAT TREATMENT BASICS

The four main heat treatment processes are:
1. POST WELD HEAT TREATMENT (PWHT)
2. PREHEATING
3. BAKE OUT
4. POST HEATING

PWHT is the main process we will be focusing on and is the most commonly completed process in the Field Heat Treatment Occupation.

Preheat will also be discussed.
REASONS FOR PWHT

- The three primary benefits of PWHT are recognized as:
  - Relaxation of Residual Stresses
  - Tempering
  - Hydrogen Removal

- Consequential benefits such as: avoidance of hydrogen induced cracking, dimensional stability, as well as improved ductility, toughness and corrosion resistance result from the primary benefits.
HEAT TREATEMENT BASICS

- Electrical resistance is the most common field heat treatment method utilized for local heating of piping, tubing, pressure vessels and numerous other structures and components.
- In order to ensure Local PWHT is completed properly we must first understand the importance of the:
  - Soak Band
  - Heated Band
  - Gradient Control Band
  - Control Zones vs. Monitor Zones
HEAT TREATMENT BASICS

TYPICAL SET UP FOR LOCAL POST WELD HEAT TREATMENT

- High Temperature Non RCF Insulation extended past the Heated Band
- Weld Center Line
- Flexible Ceramic Pad Heater (30 watts/sq inch) Connected to microprocessor power supply
- Type K Thermocouple attached to microprocessor for accurate temperature control
- Insulated Gradient Control Band (GCB)
- Heated Band (HB)
- Soak Band (SB)

Heat Loss

Heat Loss
HEAT TREATMENT BASICS

• ASME Codes dictate soak bands but have limited or no information regarding Heated Bands, Gradient Control Bands or TC placement for Electrical Resistance Local Heating and reference the following:
  • Welding Research Council Bulletin 452 – Recommended Practices for Local Heating of Welds in Pressure Vessels
HEAT TREATMENT BASICS

- ASME is developing a standard (B 31P) that is solely intended for Preheat and PWHT
- ASME also has a task group working on heat treatment data analysis regarding heated bands/control methods (verifying D10.10 recommendations)
- EPRI has conducted Thermal Modeling for Robust Post-Weld heat treatment
- AWS developing a training program/certification process for Field Heat Treatment Technicians
HEAT TREATMENT BASICS

Local circumferential band PWHT of a Butt Weld 12” NPS, 1 inch wall thickness Pipe in the horizontal position (AWS D10.10 HB1 calculations)

- GCB = 21.6 in. (547mm)
- HB = 12.3 in. (312mm)
- SB = 3 in. (76 mm)
- W =
- t = 1 in. (25 mm)
- R = 5.375 in. (136.5 mm)
HEAT TREATMENT BASICS

AWS D.10.10 controlled gradient temperature diagram

\[ T_1 = \text{MAXIMUM REQUIRED SOAK BAND TEMPERATURE} \]
\[ T_2 = \text{MINIMUM REQUIRED SOAK BAND TEMPERATURE} \]
\[ T_3 = \text{MINIMUM REQUIRED PERCENTAGE OF T}_2 \]
HEAT TREATMENT BASICS

Figure 13—Minimum Number of Thermocouples (Monitoring and Control) Recommended for Local 360-Degree Band PWHT of a Butt Weld for Piping in the Horizontal Position with Pipe Sizes of 8 and up to 12 NPS (200 to 300 DN) and Two Control Zones
HEAT TREATMENT VERIFICATION

- The most common verification record for Field Heat Treatment is a controlled thermocouple strip chart that may be accompanied with a drawing showing work piece configuration along with TC placement.
- The chart verifies ramp rates, hold times and temperature with these controlled thermocouples were met and very little other information.
- Very few charts include monitor thermocouples that would verify axial temperature gradients, radial temperature gradients or that “heat sinks” have been controlled.
HEAT TREATMENT VERIFICATION

- It is extremely rare to hear of any inspector or QA/QC representative physically inspecting a heat treatment set up prior to, during or after heating.
- Monitor thermocouples are rarely utilized or required within heat treatment procedures.
- Knowledgeable Field Heat Treatment Technicians are amazed at these facts and realize that most charts used as verification really tell the customer very little.
CASE STUDY 12” NPS FLANGE

- Work piece is a standard 12” NPS schedule 80 P1 material
- 2 controlling thermocouples (#’s 1&2) along with 6 monitoring thermocouples (#’s 3-8)
- 1&2 Top and Bottom Centre on Weld Circumference
- 3&4 either side on Weld Circumference
- 5&6 Top and Bottom Centre of Heated Band
- 7 – 2” from #1 onto Flange area of Soak Band
- 8 – Inside bottom Centre of Weld Circumference
CASE STUDY 12” NPS FLANGE
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CASE STUDY 12” NPS FLANGE
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CASE STUDY 12” NPS FLANGE
CONTROLLED THERMOCOUPLES

Graph showing temperature readings at different temperatures.

- Blue line: 1 °F
- Red line: 2 °F
CONTROLLED AND MONITOR TC’S

Centre of Heaters, Heated band hottest spot
TC #6 1300 F
TC #5 1275 F

#1&2 Controls
#3,4& 8 Monitors on Weld Area
TC#’S 1-4, 8 (1125F-1160F)

2” away from #1 control TC on Flange Soak Band Area
TC# 7 1000F
TEMPERATURE DIFFERENCES

TC #6  3 ½”  TC #1  2”  TC #7

1300 F  1150 F  1000 F
CASE STUDY CONCLUSIONS

- Controlled thermocouple charts are accepted as proof of proper heat treatment and may not always tell the whole story.
- To the untrained eye a heat treatment set up can look sufficient when it is actually unacceptable.
- Uniform heating and temperature control of soak bands, heated bands, gradient control bands, through thickness and axial temperature gradients are far more significant than a thermocouple verification chart.
PRE-HEAT/INTERPASS HEATING

Cross-Sectional View
Typical Preheat Setup

- Welding electrode
- Weld Center Line
- Welding Access Area
- Heat Loss

Type K thermocouple attached directly to work piece (capacitor discharge method)

Standard pad heater 30 watts/sq inch

High temperature insulation
AWS D10.10 PREHEAT 12” NPS

GCB = 25.6 in. (650 mm)

HB = 16.3 in. (414 mm)

SB = 7 in. (178 mm)

1 in. (25 mm)

W

INSULATION

t = 1 in. (25 mm)

R = 5.375 in. (136.5 mm)

HEAT SOURCE
TYPICAL FIELD PREHEAT SET UP
PROBLEMS
RESPONSIBILITIES?

- Heat Treatment Technician:
  - Completed recognized formal training?
  - Understanding Procedures?
  - Utilizing proper set up configurations?
- Quality Assurance Department/Inspectors:
  - Auditing Thermocouple placement, heated band widths, gradient control band widths?
  - Were different thicknesses, materials or “heat sinks” controlled?
  - What information are you getting from a chart?
OCCUPATION AWARENESS

- Field Heat Treatment Technician is a designated occupation in New Brunswick (1995) and Alberta (2008). The Quality Control Council of Canada is a recognized training provider for Field Heat Treatment Technicians through Alberta Apprenticeship and Industry Training (AIT).

- Industrial Field Heat treatment is one of the most critical aspects of achieving design intentions for welded structures and components. Despite numerous articles, case studies and journal references that prove the serious negative effects of improper Pre-Heat and Post-Weld Heat Treatment, the occupation remains underappreciated.
A training program has been established for Field Heat Treatment Technicians based on the competency profile put together with Alberta Apprenticeship and Industry Training (AIT).

The technician is trained through a combination of mentoring in the field / workplace along with formal, structured classroom instruction.

AWS D10.10 is utilized as the governing document for specialized Field Heat Treatment Technician training.
30” OD WITH 16” OD ATTACHMENT AND RE-PAD
LARGE CLOSING SEAM FIELD SET UP FOR PWHT
OCCUPATION AWARENESS

Level 1
1800 hrs &
1 calendar year
40 hrs formal training

Level 2
1800 hrs &
1 calendar year
40 hrs formal training

Level 3
1800 hrs &
1 calendar year
80 hrs formal training

Level 4
1800 hrs &
1 calendar year
80 hrs formal training

Write Provincial
Occupational
Certificate Exam
OCCUPATION AWARENESS

OCCUPATIONAL CERTIFICATE

THIS IS TO CERTIFY THAT

DAVID SCOTT FONG

HAS ACHIEVED THE STANDARDS ESTABLISHED BY THE ALBERTA APPRENTICESHIP AND INDUSTRY TRAINING BOARD UNDER THE APPRENTICESHIP AND INDUSTRY TRAINING ACT IN THE DESIGNATED OCCUPATION OF

FIELD HEAT TREATMENT TECHNICIAN

ISSUED: December 17th, 2008

Honourable Doug Horner, Minister of Advanced Education and Technology

Shirley Dall, Executive Director of Apprenticeship & Industry Training
Occupational Awareness
CLOSING STATEMENT

Once we understand that proper Pre and Post Weld Heat Treatment are critical in achieving design intentions we must then recognize and control any and all shortcomings.

Owners, Contractors and Quality Assurance departments must ensure Heat Treatment applications are meeting requirements. This can only be achieved through a cohesive effort of all parties involved.