

TEXAS STRESS, INC.



**QUALITY ASSURANCE
MANUAL FOR PREHEAT & POST
WELD HEAT TREATMENT (P.W.H.T.)**

2008 EDITION

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TEXAS STRESS, INC.

QUALITY ASSURANCE MANUAL PREHEAT & POST WELD HEAT TREATMENT

INTRODUCTION

The intent of this manual is to provide Quality Assurance to our clients that all projects completed by Texas Stress, Inc. are carried out in a professional manner, and that the employees carrying out these projects meet the necessary standards.

There are no industry qualification requirements for personnel in this business, however Texas Stress, Inc. has set down its own standards to ensure that only personnel knowledgeable in the field of Preheating and Post Weld Heat Treatment will perform the work.

The standards set forth in this manual shall be conformed to at all times and shall be the basis for all work carried out.

CODE REQUIREMENTS

Reference of relevant codes is the minimum procedures for heat treatment requirements and is intended to be a guide for our personnel and customers. They are not intended to take the place of procedures specified by clients, government agencies, authorized inspectors or any other parties having jurisdiction with regards to the work being carried out.

All heat treatment requirements should be prescribed in the clients Welding Procedure Specification (W.P.S.) or Welding Procedure Qualification (W.P.Q.)

STATEMENT

Texas Stress, Inc. will endeavor to provide all our clients with a level of professional services, and that the quality of all work shall be in accordance with the clients requirements and all relevant codes.

Gary Hager

President
Texas Stress, Inc.

SECTION I – EMPLOYEE STANDARDS

EMPLOYEE CLASSIFICATIONS

GENERAL:

This section outlines the job descriptions and the standards required for each level of proficiency of field employees.

JOB CLASSIFICATIONS:

- **Helper**
- **Technician - Level I**
- **Technician - Level II**
- **Technician - Level III**
- **Senior Technician - Level IV**

Employees with prior experience in the industry and who can meet the standards for each job description may be accelerated through the training program.

Employees who show considerable responsibility and a level of proficiency that meets the standards may also be accelerated through the training program.

Employees who are accelerated through the training program must pass all oral and written tests for each classification.

JOB CLASSIFICATIONS

HELPER

This is an entry-level position in the organization.

Basic Requirements:

- **Must possess a current driving license and have a good driving record.**
- **Must be willing to submit to a drug and alcohol test.**
- **Must be willing to travel and work non-standard hours.**
- **Must be willing to work in a construction environment that requires working at heights on scaffolds or working in confined spaces.**
- **Must be of clean appearance and show reliability.**

Basic Duties:

- **To work, under supervision, in the preparations of weldments that require heat treatment and to assist other personnel in maintenance of equipment on site.**

Basic Responsibilities:

- **To work safely and study company safety and training manuals.**
- **To show respect towards other personnel and to take care of company equipment.**
- **To participate in on-site training and demonstrate a desire to learn.**
- **Employees in this classification, who wish to advance to the next level, must attend training classes and successfully complete oral and written tests.**

Requirements for Advancement:

- **Demonstrate a positive attitude and a working knowledge of the following:**
 - **Company Safety Policy**
 - **Use and Installation of Insulating Materials**
 - **Use and Installation of Heater Pads**
 - **Use and Installation of Thermocouples**
 - **Use of Hardness Testing Equipment**
 - **Connection of Cables to Heaters**
 - **Completion of Time Sheets**
- **Upon completion of (3) three months in Field Operations and a good performance review, employees must pass the oral and written tests on the subjects covered in this section to advance to Technician Level I.**

TECHNICIAN - LEVEL I

To qualify for this position employees must have completed the requirements for the Helper Classification.

Basic Requirements:

- **Maintain safe working habits and a good driving record.**
- **Acquire a working knowledge of start-up procedures for generator equipment.**
- **Be able to set up simple weldments (pipe) for heat treatment.**
- **To understand the basic operation of company heat treatment equipment.**

Duties:

- **Work under supervision and assist helpers in preparations for heat treatment of weldments.**
- **Demonstrate a willingness to learn from more experienced personnel in company practices.**
- **Acquire basic electrical principles with regard to heat treatment equipment.**

Responsibilities:

- **Follow all company safety rules and those of our clients when working in the field.**
- **Participate in on-site training and in the maintenance of our equipment in the field.**

Requirements for Advancement:

- **Acquire practical knowledge of the following:**
 - **Safe operation of company equipment**
 - **Basic maintenance of company equipment (generators, trucks, cables, and heaters)**
 - **Operation of thermocouples and temperature recorders**
 - **Basic reasons for preheat and post weld heat treatment**
 - **Basic electricity**
 - **Basic codes used in our industry**
- **Upon completion of (6) six months in the field and showing proficiency in the items covered in this section, employees that successfully pass the required tests may advance to the next job classification of Technician - Level II, providing job openings exist.**

TECHNICIAN - LEVEL II

This position requires employees to have successfully completed all the qualifications for previous classifications.

Requirements:

Must have the ability to operate in a supervisory capacity and to be conversant with relevant codes used in our industry.

Duties:

- Be able to carry out heat-treating operations on simple projects without direct supervision.
- Be able to discuss heat-treating procedures with the client.
- Be proficient in completing documentation (daily work records).

Responsibilities:

- Ensure that employees under their supervision have the ability to operate equipment and use safe work practices.
- Be proficient in operation of all equipment used by Texas Stress, Inc. for heat treatment.

Requirements for Advancement:

- Acquire practical knowledge of the following:
 - All safety procedures
 - Quality Assurance procedures
 - Calibration of control instrumentation
 - Basic metallurgy
 - Basic engineering calculations
 - Welding practices
 - Code requirements
 - Client relations
 - Job planning
 - Setting of temporary furnaces
 - Troubleshooting of equipment in the field.
- Upon completion of (6) six months in the field, a Technician - Level I, showing proficiency in all items covered in this section, may proceed to the next level of advancement by successfully passing the required tests and demonstrating the ability to operate all equipment necessary at that level, providing job openings exist.

TECHNICIAN - LEVEL III

Individuals employed in this capacity must have successfully completed all the qualifications specified in the previous classifications of this section.

Requirements:

- Must have complete knowledge of safety practices, vessel and piping codes and demonstrate good supervisory skills.
- Must demonstrate strong communication skills in a client relation's environment, for the purpose of providing excellent customer service.

Duties:

- To carry out heat treatment on all types of components and complex weldments.
- To supervise other personnel and ensure that safety practices are followed.
- To participate in the training of other personnel with less experience.

Responsibilities:

- Safe operation of equipment and maintain awareness at all times that employees under their supervision adhere to safety regulations.
- Report any safety violations or potential safety hazards with equipment to the office.
- To ensure all heat treatment operations are performed in accordance with code requirements.
- Have the ability to convey procedures and productivity information to the clients.

Requirements for Advancement:

- Acquire practical and theoretical knowledge of the following:
Operation and maintenance of fuel firing equipment.
 - Operation and maintenance of fuel firing equipment.
 - Operation and maintenance of generators in the field.
 - Complete knowledge of code requirements for Preheat and Post Weld Heat Treatment (PWHT)
 - Advanced metallurgy
 - Advanced engineering calculations
 - Advanced electricity principles
- In addition to the above, an individual must show good supervisory skills on large projects and maintain strong communication skills with both company personnel and client relations.
- Demonstrate leadership qualities in training by example and experience.
- Upon completion of one year in the capacity of Technician - Level III, individuals meeting the requirements and demonstrating the abilities and skills required in all prior levels, may proceed to the next level of advancement, providing job openings exist.

SENIOR TECHNICIAN - LEVEL IV

Individuals employed in this capacity must have successfully completed all the requirements set forth in this section and in all previous classifications.

Requirements:

- **Must have comprehensive knowledge of all heat-treating practices used by Texas Stress, Inc.**
- **Must have extensive knowledge of all code requirements for these practices.**
- **Must demonstrate excellent supervisory and client relation's skills.**

Responsibilities:

- **Responsible for field operations, will assist in job costing and report directly to Operations Manager.**
- **Responsible for on-site safety and will attest to the practical experience of other personnel of their duties.**
- **Will be willing to travel overseas and promote the services provided by Texas Stress, Inc. to prospective clients.**

Requirements for Advancement:

Advancement from Technician - Level IV classification will depend on management requirements. An employee who wishes to achieve further advancement should continue their education and development on the following:

- **Welding Practices**
- **Design of Equipment**
- **Sales**
- **Operations / Superintendent**
- **Management**

SECTION II – HEAT TREATMENT OF WELDS

This section of the manual establishes the guidelines to provide Quality Assurance compliance in the completion of all Heat Treatment performed by Texas Stress, Inc.

SCOPE:

To ensure that all Materials, Documentation, Personnel and Procedures used by Texas Stress, Inc. in the performance of heat treatment are in accordance with the relevant codes or qualified procedures set forth by our clients or their representatives.

MATERIALS

TEMPERATURE RECORDERS

All temperature-recording instruments shall be of multipoint, and potentiometer models, using a Type K (chromel/alumel) calibration.

➤ Limits of Error (L.O.E.)

Manufacturers state that all instruments shall have an accuracy of at least 0.5% of span.

Example:

- At 500°F accuracy shall be $\pm 2.5^\circ\text{F}$
- At 1200°F accuracy shall be $\pm 6.0^\circ\text{F}$

➤ Frequency of Calibration

All instruments shall be calibrated at least every 12 months or whenever any repairs are carried out on the instrument.

➤ Documentation

- Calibration stickers shall be placed on the instruments to verify calibration dates.
- Calibration certificates shall be kept in the Quality Assurance Master Calibration File and copies shall be issued to clients for their Quality Control Files.

THERMOCOUPLES

All thermocouples shall be of Type K (chromel/alumel) calibration and shall comply with the standards established in A.N.S.I. MC 96.1 1982

➤ Limits of Error (L.O.E.)

Manufacturers state that all thermocouples meet a standard for accuracy of not greater than $\pm 0.75\%$ of span.

Example:

- At 500°F accuracy shall be $\pm 3.75^\circ\text{F}$
- At 1200°F accuracy shall be $\pm 9.0^\circ\text{F}$

➤ **Calibration**

- In general only batch calibration of materials used in the manufacture of thermocouples is required.
- A client may specify individual calibration of thermocouples where critical temperature tolerances are required.

➤ **Documentation**

- All vendor information pertaining to conformance of materials used in the manufacture of thermocouples shall be kept in the Quality Assurance Master Calibration File.
- Thermocouples requiring individual calibration shall be sent to an Approved Testing Laboratory for calibration. All of these would be individually marked and issued along with calibration certificates.

THERMOCOUPLE EXTENSION CABLES

Thermocouple extension cable shall be shielded Type K (chromel/alumel) calibration and shall comply with A.N.S.I. MC 96.1 – 1982 Color Code:

<u>Alloy</u>	<u>Color Code</u>	<u>Polarity</u>	<u>Remarks</u>
Chromel	Yellow	+	Non Magnetic
Alumel	Red	-	Magnetic

➤ **Limits of Error (L.O.E.)**

The limits of error for thermocouple extension cable are the same as the specifications for thermocouples: (Not greater than $\pm 0.75\%$ of span)

- At 500°F accuracy shall be $\pm 3.75^\circ\text{F}$
- At 1200°F accuracy shall be $\pm 9.0^\circ\text{F}$

➤ **Calibration**

- In general only batch calibration of materials used in the manufacture of thermocouples is required.
- A client may specify individual calibration of thermocouples where critical temperature tolerances are required.

➤ **Documentation**

- All vendor information pertaining to conformance of materials used in the manufacture of thermocouples shall be kept in the Quality Assurance Master Calibration File.
- Thermocouples requiring individual calibration shall be sent to an Approved Testing Laboratory for calibration. All of these would be individually marked and issued along with calibration certificates.

CALIBRATION POTENTIOMETER (Master)

Texas Stress, Inc. subcontracts the calibration certification of all its temperature recording instruments to PDS-Bar Tech, Inc. PDS-Bar Tech, Inc. certifies that all instruments are calibrated using standards traceable to the National Institute of Standards and Technology (N.I.S.T.) and complies with its specifications. The Master Calibration Potentiometer of record is: **FGH Controls – Model #Ezecal Mk5 – Serial #5068**

NIST Test No. 90100305

Each instrument is provided with a Certification of Calibration and states that “Calibration traceable to the National Institute of Standards and Technology has been performed on the instrument described, with standards maintained by PDS, Incorporated. The accuracy and stability of all instruments owned by PDS, Incorporated are traceable to national standards maintained by N.I.S.T. in Washington, D.C. and Boulder, Colorado.”

➤ **Limits of Error (L.O.E.)**

This instrument shall maintain an accuracy of at least $\pm 2^{\circ}\text{F}$.

➤ **Frequency of Calibration**

This instrument shall be sent to an Approved Testing Facility every twelve (12) months.

➤ **Documentation**

Calibration certificates showing the vendor’s name, calibration method, along with the sources used and their trace ability to the National Bureau of Standards (N.B.S.) shall be kept in the Quality Assurance Master Calibration File. A client or his representative may review these or request copies of such.

HARDNESS TESTING

Texas Stress, Inc. uses the Telebrineller Hardness Tester. This tester uses calibrated test bars. The hardness of each test bar is etched in the ends of the bars. It is an impact instrument. A 1 ½ to 2 Lb. hammer is the recommended tool for making the ideal range of indentation in the work piece. A comparison of the diameters of both the indentations in the test bar and the work piece on a Telebrineller computer gives the resultant hardness of the work piece.

This result is based on the following formula:

- **Diameter of Impression in Bar**

Diameter of Impression in Material

(2 X BHN of Bar = BHN of Material)

- BHN is Brinell Hardness Number

➤ **Limits of Error (L.O.E.)**

The limits of error for the Telebrineller Hardness Tester, as claimed by the manufacturer are $\pm 5\%$ accuracy.

➤ **Calibration**

The manufacturers of the brinell test bars state that these products meet the stated standards, but do not supply calibration certificates with these products. If there appears to be inaccuracies, samples may be sent to a metallurgical laboratory for independent testing.

➤ **Documentation**

All hardness tests shall be documented along with the work piece number, isometric number and the weld number on the Daily Work Records. All discrepancies from the required B.H.N. shall be brought to the attention of the clients Quality Control Department or their delegates.

DOCUMENTATION

TEMPERATURE CHARTS

Since these are the only records of any heat treatment the following information **MUST** be placed on the chart:

- Chart Speed
- Date
- Clients Name
- Clients Job Reference Number
- Code or Procedure
- Thermocouple Trace Number
- Weld Number or Piece Number
- Isometric Number, when working on pipe
- Vessel Serial Number and National Board Number when applicable
- Temperature and Duration of Soak Period
- Technicians Signature

CALIBRATION RECORDS

➤ **Calibration Potentiometer (Master)**

The calibration documents for this instrument shall be kept in the Quality Assurance Master File. It is not necessary to issue these to a client, but a client may request them for their Quality Control Files.

These documents show direct trace ability to National Bureau of Standards (N.B.S.) for the calibration of the Potentiometer.

PERSONNEL

GENERAL

It is the intention of Texas Stress, Inc. to supply our clients with competently trained and safety conscious personnel. All employees are required to attend the Houston Area Contractors Council Program. Additionally they must conform to the Safety Manual and the Drug and Alcohol Policy.

EMPLOYEE CLASSIFICATION

- **Helpers**
- **Technicians - Level I**
- **Technicians - Level II**
- **Technicians - Level III**
- **Technicians - Level IV**

Upon attaining the necessary experience and successfully passing the required tests, an employee may advance to the next level, providing job openings exist.

ON-SITE STANDARDS

The minimum standards an employee must attain before working on a job without supervision will be Technician Level II, and this will be restricted to straight forward piping jobs. All other type work must be carried out under the supervision of Technicians Level III or Level IV.

CLASSIFICATION CERTIFICATION

The Operations Manager will keep certification of employees on file. Clients who require certification shall contact the Operations Manager.

SECTION II – HEAT TREATMENT OF WELDS

(Continued)

HEAT TREATMENT PROCEDURES

GENERAL

All heat treatment carried out by Texas Stress, Inc. shall be in accordance with the relevant code requirement for the given material and for the service in which it shall be used. As specialists in the field we can recommend heat treatment practices when a client is unsure of the most effective heat treatment. However, the heat treatment prescribed in the clients Welding Procedure Specification (W.P.S.) or Welding Procedure Qualification (W.P.Q.) takes precedence to code requirement.

HEAT TREATMENT STANDARDS

The following standards shall be maintained for heat treatment operations using:

- The heating of a vessel, pipe or any fabricated component or any portion of same by means of internal or external methods.
- The heating of a vessel, pipe or fabricated component in a furnace.
- When no heating or cooling rates are given the maximum heating rate shall be 400° F/ hours, and the maximum cooling rate shall be 500° F/ hours.
- There shall be at least one thermocouple per every fifteen feet of surface being heat-treated.
- When heating with electric heaters one thermocouple shall be used for each secondary power circuit.
- Protective coating shall be applied to all machined surfaces and threaded connections.
- Manufacturers specifications or recommendations shall be obtained before heat-treating valves, strainers or similar apparatus.
- Specific procedures must be obtained prior to any heat treatment being carried out on stainless steel elements to prevent Sensitization or the formation of Sigma Phase.
 - Sensitization takes place when austenitic steels are held for sufficient time between 800°F and 1600°F. Chromium carbides tend to precipitate preferentially at the austenite grain boundaries. Intergranular corrosion takes place when a sensitized material is exposed to sufficiently strong corrosive medium for a long enough time.
 - Sigma Phase is formed under favorable conditions in the temperature range of 1050°F and 1700°F. Factors contributing to the formation of sigma phase include the presence of ferrite, prior cold working, variation in composition due to progressive solidification, and the presence of ferreters, – particularly molybdenum, columbium, and titanium. Sigma Phase may be transformed into austenite and ferrite by suitable heating and quenching.
- The heat treatment of heat treatable low alloy steels (HTLA), e.g. AISI 4130, 4140, 5130, 8630, 8640 require specific procedures especially for cooling rates to enhance the mechanical strengths of these materials.

STRESS RELIEF – STRESS ANNEAL

The localized and rapidly moving heat source, characteristic of welding processes, causes distortion and residual stresses in welds. Metals expand when heated and contract when cooled; if they are in any way constrained during the temperature changes, the result is some kind of permanent deformation. In addition to normal lattice expansion, the volume changes accompanying allotropic transformation and weld metal solidification contribute to the over-all distortion of welds. Because of the permanent nature of some of the deformation, there is usually some degree of residual stress in the weldment after it completely cools. Residual stresses can be harmful and may cause premature failure in service or reduce the effective strength of a weld. Therefore, it is common to attempt to reduce or remove residual stresses before a welded component is placed in service. The removal of these stresses can

be obtained by either penning or by heat treatment. The more widely used method is process heat treatment.

- Stress relief is a form of internal relaxation with no significant change in the microstructure, and with very little change in the properties of the material.
- Annealing on the other hand, involves considerable change in both microstructure and properties, in addition to the stress relief. The changes accompanying the stress relief during annealing include softening, malleabilizing and the formation of a new array of grains.

If metal is heated to progressively higher temperatures, several things happen. At low temperatures (200°F to 400°F), there is a steady decline in the level of residual stresses, but virtually no change in structure or strength. At about 400°F to 450°F a very low level of stress remains, the microstructure still has little change, the strength is relatively unchanged and the ductility, while improved is still low. This can be attributed to the metallurgical phenomenon called recovery, the process that produces stress relief. When metal is heated above 450°F, property changes become apparent, as do structural changes. The old grain structure is consumed by the new grain structure and eventually the old deformed grain is replaced by new grain. This new microstructure resembles the original structure before work took place and is softer and more ductile. This process is called recrystallization and is a necessary part of all ANNEALING procedures. The higher the temperature is taken the more the grain structure grows and the properties change. That is why it is important to review all heat treatment procedures prior to commencing any welding operation. It is therefore important to look at the role preheat plays in the removal of residual stresses set up during the welding operations.

These illustrations provide specific examples:

- Figure 1 - illustrates the effects of welding in setting up by internal restraint residual stresses.
- Figure 2 - illustrates the grain structure of the completed weld and its “Heat Affected Zone” (HAZ).
- Figure 3 - illustrates the effect of preheat in assisting to remove stresses and in producing desirable property changes in the weld and the heat affected zone (HAZ).

CODE REFERENCES

Heat treatment carried out under the following code requirements are based on the latest ASME Section IX QW-422 P numbers. (Grouping of Base Metals for Qualifications)

- **A.A.R. Association of American Railroads**
- **ANSI B31.1. Pressure Piping, Power Piping**
- **ANSI B31.3. Refinery Piping Code**
- **ANSI B31.4. Liquid Petroleum Transportation Piping Code**
- **ANSI B31.8. Gas Transmission & Distribution Piping Code**
- **ASME Section I Welded Boilers**
- **ASME Section VIII, Division I**
- **ASME Section VIII, Division II**
- **API 620 Appendix R.7.3. Storage Tanks**
- **API 650 Appendix D.6. Storage Tanks**
- **API 1104 Pipelines**
- **AWS D.1.1. Structural Code**

Excerpts from these codes relating to heat treatment requirements are too extensive to be presented in this format, but are available in written form.

SUMMATION

While this manual endeavors to cover the scope of work Texas Stress, Inc. carries out in the field of Heat Treatment, it is not possible to completely establish all procedures encountered in this field. The relevant excerpts from the codes commonly used by our industry are meant as a guide, to be used when stated by the clients Welding Procedure Specifications (W.P.S.). It is the responsibility of the client to establish all heat treatment procedures.

The Heat Treatment Procedures contained in the Codes are minimum standards and should be reviewed when complex heat treatment is required.