

Heat Treatment Services—Batch Type for Equipment Used in the Petroleum and Natural Gas Industry

API STANDARD 20H
FIRST EDITION, OCTOBER 2015



AMERICAN PETROLEUM INSTITUTE

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Heat Treatment Services—Batch Type for Equipment Used in the Petroleum and Natural Gas Industry

1 Scope

1.1 Purpose

This standard specifies requirements for the qualification of suppliers of heat treatment services used in the manufacture of equipment for the petroleum and natural gas industries.

1.2 Applicability

This standard is applicable to suppliers providing heat treatment services where API product standards require such services or otherwise specified as a requirement for conformance. The requirements of this standard apply to batch heat treatment operations that establish or affect the final mechanical properties and include stress relief operations. This standard applies to carbon steel, low-alloy steel, stainless steel, and nickel-base alloys. Case hardening, induction hardening, and flame hardening are not covered by this standard.

1.3 Heat Treatment Specification Levels (HSLs)

This standard establishes the requirements for three heat treatment specification levels (HSLs). These HSL designations define different levels of heat treatment technical, quality, and qualification requirements.

2 Normative References

The following referenced document is indispensable for the application of this standard. For undated references, the latest edition of the referenced document, including any amendments, apply.

SAE AMS2750¹, *Pyrometry*

3 Terms, Definitions, Acronyms, and Abbreviations

For purposes of this standard, the following terms, definitions, and acronyms apply.

3.1 Terms and Definitions

3.1.1

acceptance criteria

Defined limits placed on characteristics of materials, processes, products, or services.

3.1.2

case hardening

A generic term covering several processes applicable to steel that change the chemical composition of the surface layer by absorption of carbon, nitrogen, or a mixture of the two and, by diffusion, create a concentration gradient. The result is a thin layer on the surface that is harder than the metal beneath it. The processes commonly used are carburizing and quench hardening, cyaniding, nitriding, and carbon nitriding.

3.1.3

final inspection

The final visual examination and documentation release of the heat-treated material.

¹ SAE International, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001, www.sae.org.

3.1.4**flame hardening**

A process for hardening the surfaces of hardenable ferrous alloys in which an intense flame is used to heat the surface layers above the upper transformation temperature, whereupon the work-piece or area of the surface that has been heated by direct flame impingement is immediately quenched.

3.1.5**heat sink**

Metal of a defined cross section and similar heat transfer characteristics to the part(s) being heat treated and used to monitor the heat treatment temperature by the use of an embedded thermocouple.

3.1.6**induction hardening**

A surface hardening process in which only the surface layer of a suitable ferrous work-piece is heated by electromagnetic induction to a temperature above the upper critical temperature and immediately quenched.

3.1.7**marking**

Identification placed on the heat-treated material in accordance with this standard.

3.1.8**on-site activity**

Activity performed at the heat treatment supplier's facility.

3.1.9**receiving verification**

Inspection and review of incoming material and attendant documentation.

3.1.10**working zone**

Usable volume of a furnace as determined by the temperature uniformity survey.

3.2 Acronyms and Abbreviations

HSL	heat treatment specification level
MPS	manufacturing process specification
SAT	system accuracy test
TUS	temperature uniformity survey

4 Heat Treatment Supplier Qualification**4.1 General**

This standard establishes requirements for three heat treatment specification levels (HSLs) and four processing classes. The heat treatment supplier may qualify to one or more of the processing classes listed in Table 1 and one or more HSLs. The following paragraphs describe the conditions that, when met, allow the heat treatment supplier to receive the appropriate HSL classification level.

Table 1—Processing Classes and Material Grades

Processing Class	Description	Material Grade	Typical Examples
1	— Normalizing — Normalizing and Tempering — Annealing — Stress Relieving	— Carbon/Low Alloy Steels — Martensitic Stainless Steels	<u>Carbon Steels</u> (UNS G1xxxx) <u>Cr-Mo-Low Alloy Steels</u> (UNS G41xxx) <u>Martensitic Steels</u> 410 SS (UNS S41000), F6NM (UNS S41500, S42400)
2	— Austenitizing, Quenching, and Tempering/Aging — Normalizing, Austenitizing, Quenching, and Tempering	— Carbon/Low Alloy Steels — Martensitic Stainless Steels — Precipitation-hardening Stainless Steels	<u>Cr-Mo-Low Alloy Steels</u> (UNS G41xxx) <u>Ni-Cr-Mo Medium Carbon Alloys</u> (UNS G43xxx) <u>Cr-Ni-Mo Low Alloy Steels</u> (UNS G86xxx) <u>2¹/₄ Cr-1 Mo Steel</u> (ASTM A182/A336 Grade F22/UNS K21590) <u>9Cr-1 Mo Steel</u> (ASTM A182 Grade F9/UNS K90941) ASTM A707 Grades (modified) <u>Martensitic 410 SS</u> (UNS S41000), F6NM (UNS S41500, S42400) <u>17-4PH</u> (UNS S17400), 15-5PH (UNS S15500)
3	— Solution Annealing and Quenching — Annealing and Quenching	— Austenitic Stainless Steels	<u>Austenitic Stainless Steel</u> UNS S31603, S30400
4	— Solution Annealing, Quenching — Solution Annealing, Quenching, and Aging	— Solution Annealed Nickel-based Alloys — Duplex and Super Duplex Stainless Steels — Precipitation-hardened Nickel-based Alloys	<u>Solution Annealed Nickel-based Alloys</u> UNS N06625, N08825 <u>Duplex</u> UNS S31803, UNS S32205 <u>Super Duplex</u> UNS S31260, S32750, S32760, S39277 <u>Precipitation Hardened</u> UNS N07716, N07718, N07725, N09925, N09935, N09945

4.2 Qualification Requirements

4.2.1 Qualification shall consist of a completed heat treatment operation with one or more HSLs and processing classes. Acceptance criteria shall be in full conformance with the requirements of the governing material specification. Processing class qualification shall be in accordance with Table 2.

Table 2—Processing Class Qualification Limitations

Processing Class	HSL Required	Class Qualified
Class 1	HSL 1, HSL 2, or HSL 3	Class 1
Class 2	HSL 1, HSL 2, or HSL 3	Class 1 and Class 2
Class 3	HSL 1, HSL 2, or HSL 3	Class 1 and Class 3
Class 4	HSL 2 or HSL 3	Class 1, Class 3, and Class 4
NOTE Qualification to Processing Classes 2 and 4 qualifies the heat treatment supplier to Processing Classes 1, 2, 3, and 4.		

4.3 Heat Treatment Specification Levels

4.3.1 Heat Treatment Specification Level 1 (HSL-1)

4.3.1.1 The pyrometric requirements for heat treatment equipment in conformance with HSL-1 shall be in accordance with 8.2.

4.3.1.2 A temperature uniformity survey (TUS) shall be performed every 12 months minimum for the full temperature operating range of the furnace in accordance with 8.2.

4.3.1.3 The heat treatment supplier shall record the quench media temperature at start, peak, and finish of the quench cycle. Records shall be maintained.

4.3.2 Heat Treatment Specification Level 2 (HSL-2)

The requirements of HSL-1 apply with the following modifications.

4.3.2.1 A TUS shall be performed every six months minimum for the full temperature operating range of the furnace in accordance with 8.2.

4.3.2.2 Quench media temperature shall be recorded during the entire quench process. Records shall be maintained.

4.3.2.3 Additional temperatures shall be added to the TUS, as required, to ensure that no two adjacent survey temperatures are greater than 600 °F (335 °C) apart.

4.3.2.4 Thermocouples shall be verified for accuracy or replaced at least every three months, in accordance with the heat treatment supplier's written procedure. Records shall be maintained.

4.3.3 Heat Treatment Specification Level 3 (HSL-3)

4.3.3.1 The pyrometric requirements for heat treatment equipment in conformance with HSL-3 shall be in accordance with 8.3.

4.3.3.2 Quench media temperature shall be recorded during the entire quench process. Records shall be maintained.

4.3.3.3 The heat treatment supplier shall have the capability of using multiple contact or heat sink thermocouples.

4.3.4 Conformance to the requirements of HSL-3 also qualifies as HSL-1 or HSL-2.

4.4 Processing Class

4.4.1 Table 1 specifies the processing classes and material grades that define the heat treatment supplier's capabilities.

4.4.2 Heat treatment of Processing Class 4 shall be performed by a HSL-2 or HSL-3 heat treatment supplier. Records of Qualification

The following records are required to document the qualification of heat treatment.

- Records required by Section 13.
- Records required by Section 14.

5 Responsibilities and Duties

It is the responsibility of the heat treatment supplier to ensure that it:

- performs all heat treatment in accordance with specified standards and applicable quality control criteria;
- performs only heat treatment for which it is adequately equipped and staffed;
- performs only heat treatment for which its employees are adequately qualified;
- assures equipment is calibrated and personnel are qualified in accordance with the requirements of the supplier's written procedure;
- assures facility and equipment is properly maintained;
- informs the purchaser of any discrepancy or limitation imposed on the requested heat treatment by such factors as size, traceability, form, shape, material, or procedure;
- calls to the attention of the purchaser any irregularity or deficiency noted in the procurement documents;
- promptly submits formal reports of all heat treatment to the purchaser; and
- informs the purchaser of noncompliance of the specified standards or procurement document requirements.

6 Personnel Training Requirements

Personnel performing heat treatment shall be trained and qualified in accordance with requirements of the heat treatment supplier's written procedure. Records of training and qualification shall be maintained.

7 Heat Treatment Facility Capability

7.1 General

The heat treatment supplier shall complete and maintain a current list of equipment used in heat treatment to this standard. The required data and a sample data format are listed in Annex A.

7.2 Identification and Traceability

The heat treatment supplier shall have a documented procedure for control of identification and traceability throughout the process. The procedure shall include, as a minimum:

- a) the method for verifying traceability upon receipt of material,
- b) the method for marking the product,
- c) the method for ensuring traceability of product after any processing where the original marking could be removed, and
- d) requirements for maintenance or replacement of identification or traceability marks.

8 Heat Treatment Equipment Temperature Uniformity Survey (TUS) and Calibration

8.1 Calibration

Equipment used to record heat treatment or other equipment necessary to control heat treatment operations shall be identified, controlled, calibrated, and adjusted at specified intervals to maintain the accuracy required by this standard. Calibration shall be performed in accordance with documented instructions, which are consistent with nationally or internationally recognized standards specified by the heat treatment supplier. Records shall be maintained.

8.2 HSL-1 and HSL-2 Furnace TUS and Instrumentation Calibration

8.2.1 TUS Temperature Tolerances (High Heat Only)

The temperature at any point in the working zone of a furnace used for austenitizing, normalizing, annealing, or solution annealing shall not vary by more than $\pm 25^{\circ}\text{F}$ ($\pm 14^{\circ}\text{C}$) from the furnace set-point temperature after the furnace working zone has been brought up to temperature.

8.2.2 TUS Temperature Tolerances (Low Heat Only)

Furnaces used for tempering, aging, and/or stress-relieving shall not vary by more than $\pm 15^{\circ}\text{F}$ ($\pm 8^{\circ}\text{C}$) from the furnace set-point temperature after the furnace working zone has been brought up to temperature.

8.2.3 TUS Temperature Tolerances (Combined Low and High Heat Furnaces)

For furnaces used for both the heat treatment operations specified in 8.2.1 and 8.2.2, the heat treatment supplier shall define the temperature range for each operation. The furnace temperature tolerance shall conform to the requirements specified in 8.2.1 or 8.2.2, as appropriate.

8.2.4 TUS Method for Batch-type Furnaces

8.2.4.1 A TUS within the furnace working zone(s) shall be performed on each furnace at the maximum and minimum temperatures for each range for which the furnace is being used.

- a) A minimum of nine thermocouple test locations shall be used for all furnaces having a working zone greater than 10 ft^3 (0.3 m^3). For each 125 ft^3 (3.5 m^3) of furnace working zone surveyed, at least one thermocouple test location shall be used, up to a maximum of 40 thermocouples. See Figures 1 and 2 for examples of thermocouple locations.
- b) For furnaces having a working zone less than 10 ft^3 (0.3 m^3), the temperature survey may be made with a minimum of three thermocouples located either at the front, center, and rear or at the top, center, and bottom of the furnace working zone.

8.2.4.2 After insertion of the temperature-sensing devices, readings shall be taken at least once every three minutes to determine when the temperature of the furnace working zone approaches the bottom of the temperature range being surveyed.

8.2.4.3 Once the furnace temperature has reached the set-point temperature, the temperature of all test locations shall be recorded at 2-minute intervals, maximum, for at least 10 minutes. Then, readings shall be taken at 5-minute intervals, maximum, for sufficient time (at least 30 min) to determine the recurrent temperature pattern of the furnace-working zone.

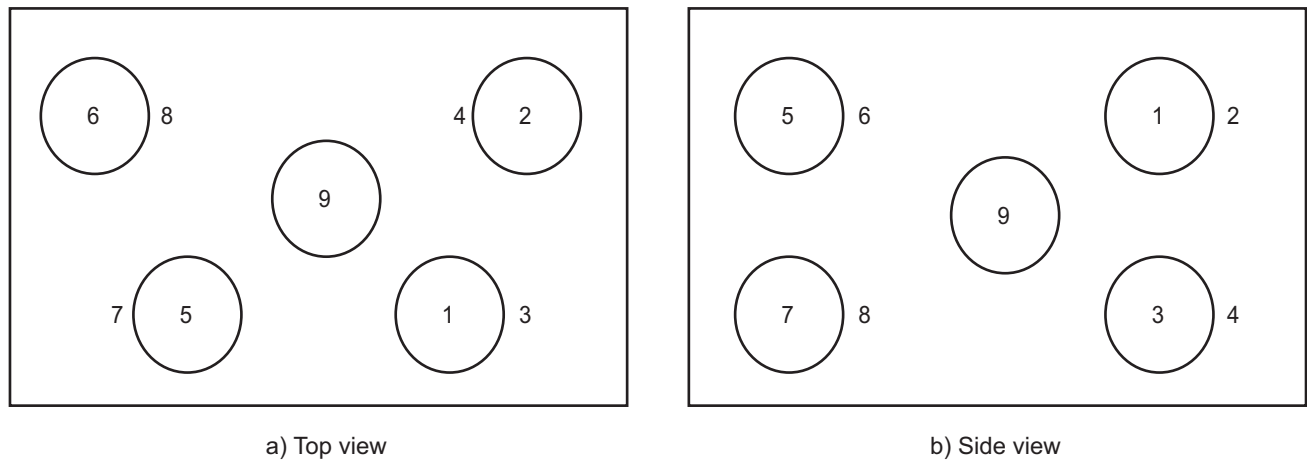


Figure 1—Thermocouple locations—Rectangular furnace (working zone)

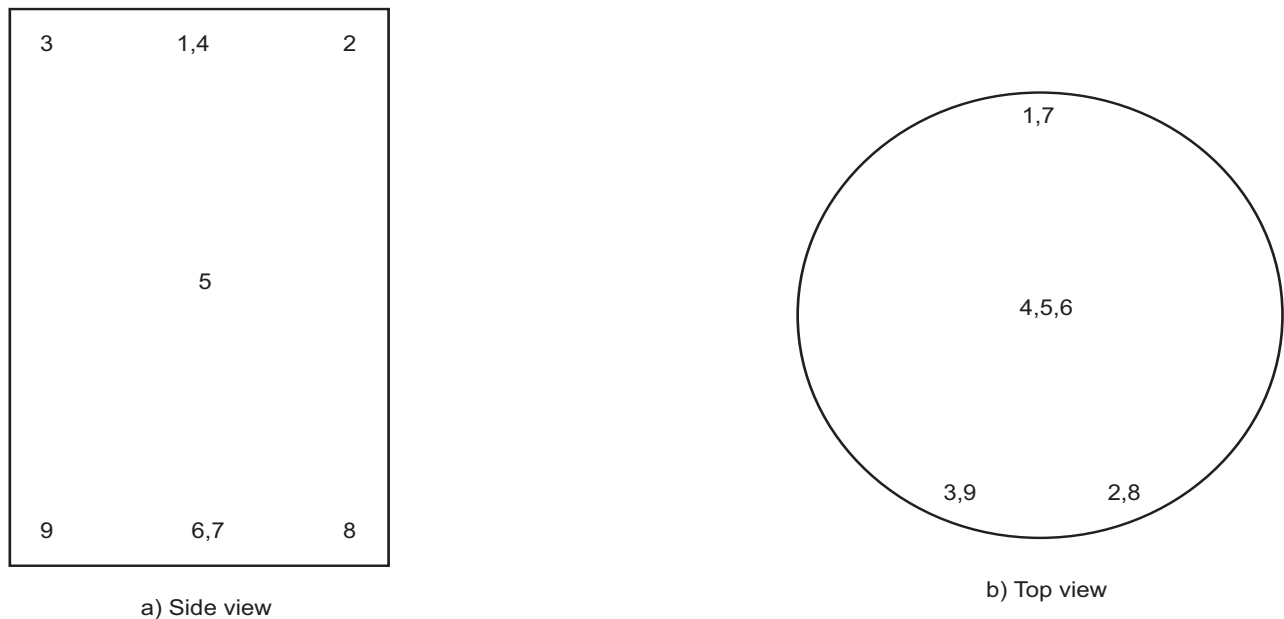


Figure 2—Thermocouple locations—Cylindrical furnace (working zone)

8.2.4.4 Before the furnace set-point temperature is reached for austenitizing, normalizing, or solution annealing, none of the temperature readings shall exceed the set-point temperature by more than 25 °F (14 °C). Before the furnace set-point temperature is reached for tempering or aging, none of the temperature readings shall exceed the set-point temperature by more than 15 °F (8 °C).

8.2.4.5 After the furnace control set-point temperature is reached, no temperature reading shall vary beyond the limits specified.

8.2.4.6 When a furnace is repaired or rebuilt, a new temperature survey shall be carried out before the furnace is used for heat treatment, except for minor repairs as noted below.

Minor repairs or replacement of damaged or malfunctioning components or scheduled preventive maintenance that restores the furnace to its original condition and are not expected to affect the temperature uniformity characteristics of the furnace shall not require repeating the TUS. Examples include, but are not limited to, the following:

- a) replacing a burner or tile with another duplicate burner or tile,
- b) refractory repair using material with similar thermal properties,
- c) replacing a control or monitoring sensor to its previously documented location,
- d) replacing heating system components (e.g. gas regulator, valve, metering device, heating elements, etc.),
- e) restoring original combustion pressure settings and tuning constants,
- f) replacing a controller with an identical controller with the same tuning constants,
- g) system accuracy test failure,
- h) correction of furnace pressure control problem, and/or
- i) repair of furnace door seals.

8.2.4.7 All furnace repairs shall be documented. The organization responsible for quality assurance shall make the determination whether an additional TUS is required based on the repairs made and the particular furnace configuration before returning the furnace to service.

8.2.5 Instruments

8.2.5.1 General

Automatic controlling and recording instruments shall be used. Thermocouples shall be located in the furnace working zone(s) and protected from furnace atmosphere by means of suitable protective devices.

8.2.5.2 Accuracy

The controlling and recording instruments used for heat-treatment processes shall be accurate to $\pm 0.3\%$ of the maximum survey temperature or $\pm 2^\circ\text{F}$ ($\pm 1.1^\circ\text{C}$), whichever is greater.

8.2.5.3 Calibration

Temperature controlling and recording instruments shall be calibrated at least once every three months.

8.2.5.4 Equipment used to calibrate production equipment shall be accurate to $\pm 0.1\%$ of reading or $\pm 1^\circ\text{F}$ ($\pm 0.6^\circ\text{C}$), whichever is greater.

8.3 HSL-3 Furnace TUS and Instrumentation Calibration

8.3.1 General

The pyrometric requirements for heat treatment equipment used for heat treatment in conformance with HSL-3 shall be in accordance with AMS 2750, *Pyrometry*, raw material furnace Classes 1 through 5 for normalizing, austenitizing,

and solution annealing or raw material furnace Classes 1 through 3 for tempering, precipitation hardening, aging, and stress relieving.

8.3.2 Pyrometry Procedure Requirements

The heat treat supplier shall have a documented procedure addressing the technical requirements of AMS 2750. These requirements shall include the following.

- a) Temperature Sensors (thermocouples):
 - 1) Thermocouple usage,
 - 2) Sensor calibration,
 - 3) Reuse of thermocouples,
 - 4) Type of thermocouple used for various applications,
 - 5) Calibration procedure and frequency of calibration for the types of thermocouples used.
- b) Instrumentation:
 - 1) Instrument types used by the heat treatment supplier,
 - 2) Instrument calibration frequency and required calibration accuracy,
 - 3) Instrument calibration procedure.
- c) System Accuracy Tests (SATs):
 - 1) Instrumentation and sensors used for SATs,
 - 2) Frequency of SATs,
 - 3) Procedure for conducting the SAT,
 - 4) Maximum allowable SAT difference.
- d) Furnace Temperature Uniformity Surveys (TUSs):
 - 1) The surveyed volume (working zone) of each furnace,
 - 2) The operating temperature range of each furnace.
 - 3) Procedure for conducting TUSs (initial and periodic) to include:
 - i) Survey temperatures to be used,
 - ii) Furnace load condition,
 - iii) Number of thermocouples to be used,
 - iv) Location of survey thermocouples,
 - v) Data collection procedure.

8.4 Records

Records of furnace calibration and surveys shall be maintained for a period of not less than five (5) years.

9 Heat Treatment Procedures

The heat treatment supplier shall maintain documented procedures that describe the controls associated with heat treatment services and the applicable requirements of this standard.

Heat treatment shall be performed in accordance with a procedure that includes a description of the methods used for heat treatment and the methods used for data recording, data processing, data reporting and for certification of the results.

9.1 Furnace Atmosphere

When a controlled atmosphere is required, the heat treatment supplier shall have a written procedure addressing the following process control variables:

- a) management of atmospheres,
- b) instrumentation,
- c) calibration of atmospheric controllers,
- d) verification of atmosphere,
- e) safety.

9.2 Process Validation

Demonstration of the mechanical properties and/or order requirements obtained on production parts shall be considered satisfactory evidence of process validation.

10 Furnace Loading

10.1 Material shall be loaded in the furnace in a manner that provides for sufficient spacing to ensure that there is adequate furnace airflow and circulation. Parts shall not be stacked or bundled.

10.1.1 Material shall be placed on racks or supports to ensure exposure of all surfaces to heating and quenching media and to minimize warpage during heating and quenching. Long parts shall be supported, as needed, to prevent sagging.

10.1.2 Material shall not be placed directly on the furnace hearth (floor).

10.1.3 Metal trays, piers, or fixtures that allow the furnace atmosphere to circulate around and under the part(s) shall be used.

10.1.4 For complex geometries, special fixtures may be needed.

10.2 Material shall be within the working volume of the furnace that was established in the TUS. In gas-fired furnaces, the material shall be loaded in such a manner that avoids any flame impingement from the burners.

10.3 Completed furnace loads should be inspected to ensure that doors/openings are properly sealed, and that there are no excessive hot spots in the furnace walls. Racks and supports should be inspected for functional capability.

10.4 When required by the purchaser or referenced specification, a furnace loading diagram shall be prepared for each load heat treated, showing the part geometry and contact or heat sink thermocouple location(s).

11 Heat Treatment Quench Requirements

11.1 Quench tanks should be located in close proximity to the austenitizing furnace and be easily accessible. This will minimize transfer time and heat loss of the load during the transfer.

11.2 The transfer time from furnace to the quench tank should be as quick as possible, but shall be no more than 90 seconds for all materials other than the duplex class of stainless steel.

11.3 For duplex and super duplex stainless steel, the maximum transfer time to quench shall be 60 seconds.

11.4 The transfer time shall be measured from the time the furnace door is fully opened or the furnace roof is fully removed until the component(s) is completely submerged into the quenching bath.

11.5 The water quench media temperature shall not exceed 100 °F (40 °C) at the start of the quench, and shall not exceed 120 °F (50 °C) at any time during the quench cycle.

11.6 Water quench tanks shall be adequately sized for the loads. This may require the use of supplemental heat exchangers or chillers. At a minimum, at least one of the following two methods shall be used to assure adequate and timely heat removal from the load being quenched.

11.6.1 Quench tanks shall have a minimum of one US gallon (3.785 liters) of quench water for every pound (.454 kilograms) of load being quenched.

11.6.2 The heat treatment supplier shall establish a documented procedure that validates the effectiveness of the quench when the parameters of 11.6.1 are not met. This procedure shall be supplemented by actual test data showing the heat removal properties of the quench bath on a heat treatment lot of product.

11.7 The heat treatment supplier shall have a documented quench process procedure addressing the method of tank agitation, use of chillers and recirculation systems, and method of controlling quench media temperature.

11.8 The quenching bath should be free from contamination that could affect the quenching process. Bath maintenance programs shall be established in accordance with the heat treatment supplier's written procedure.

11.9 Proper agitation is critical. Quench tanks shall have a mechanical means (propellers, pumps, etc.) of circulating the quench media to optimize the cooling rate. Agitators shall be placed so that adequate circulation is maintained throughout the quench tank when a load is being quenched.

11.10 An agitation system check shall be made in accordance with the heat treatment supplier's written procedure to ensure the adequacy of the agitation system.

11.11 Air agitation alone is not permitted.

NOTE In the case of water quenching, agitation should be sufficient to break up the steam blanket that forms at the surfaces of the hot, immersed part. The steam blanket will act as an insulator and greatly reduce the cooling rate. A quench tank with proper agitation will normally have a noticeable rise in the level of quench media when the agitators are turned on. A quench tank with a single pump located at one end, for example, might not be acceptable because part of the load could be shielded from the quench media flow.

11.12 When oil quenching is performed, only oil formulated by the quench oil manufacturer specifically for heat treatment quenching operations shall be used. Additionally, oil quench media shall be maintained within the manufacturer's recommended temperature range. These requirements are necessary to minimize the possibility of oil quench tank fires.

11.13 Polymer quench media shall be maintained within the manufacturer's recommended temperature range.

11.13.1 The concentration of the polymer shall be checked by the heat treatment supplier, on at least a weekly basis, by means of a refractometer or similar means in accordance with the heat treatment supplier's written procedure and adjusted as necessary. Results shall be documented.

11.13.2 The heat treatment supplier shall have the polymer checked by the polymer manufacturer or independent laboratory for concentration, viscosity, and contamination at least once every six months. The results shall be documented and comply with the heat treatment supplier's written procedure.

11.13.3 Products shall be quenched in single layers. If this is not practical, spacers or an arrangement of products shall be used to assure that the products are not directly upon each other and there is good flow of quenchant around the products during quenching.

11.13.4 The heat treatment supplier shall have a documented procedure or work instruction defining the required minimum time a part is held in the quench tank.

12 Heat Treatment Equipment Maintenance

The heat treatment supplier shall have a documented and fully implemented preventative maintenance procedure that addresses the following equipment, as a minimum:

- a) transfer system/loading systems,
- b) furnaces,
- c) quench systems,
- d) thermocouples, and
- e) temperature recording and controlling devices.

13 Manufacturing Process Specification

13.1 General

The heat treatment supplier shall maintain a manufacturing process specification (MPS) to include, as a minimum, allowable levels for all heat treatment parameters including the process control variables listed in 13.2, the quench variables listed in 13.3, and the inspection and test requirements listed in 13.4. Heat treatment variables, quench variables, and inspection and test results shall be documented.

13.2 Heat Treatment Variables

The following are heat treatment parameters, as applicable:

- furnace loading diagram, orientation, quantity or maximum weight, and spacing of parts;
- heat treatment times and temperatures for each processing cycle;
- method of monitoring temperature;
- temperature ramp up rate;
- temperature ramp down rate;
- dimensions at time of heat treatment;
- cool down rate; and/or
- furnace atmosphere requirements.

13.3 Quench Variables

The following are quench parameters, as applicable:

- quench media and type of agitation (water/polymer, forced, horizontal or vertical quench, ID/OD, etc.);
- quench media start, peak, and finish temperature;
- transfer time to quench; and/or
- time in quench.

13.4 Inspection and Test Requirements

The following are inspection and test parameters, as applicable:

- visual examination,
- final hardness test,
- nondestructive examination,
- mechanical testing,
- straightness inspection,
- as-quenched hardness test, and/or
- traceability and marking.

14 Heat Treatment Records

14.1 General

The records required by this standard are necessary to substantiate that all services provided meet this standard and conform to the specified requirements.

14.2 Document Control

The heat treatment supplier shall establish and maintain documented procedures to control the documents and data required by this standard.

14.3 Records to be Maintained by Heat Treatment Supplier

The following records shall be maintained by the heat treatment supplier:

- heat treatment process records,
- heat treatment procedure,
- heat treatment procedure process qualification record (records of testing results),
- heat treatment personnel qualification records,
- records required by this document.

14.4 Requirements for Heat Treatment Certificates

Heat treatment certificates shall contain the following:

- name of heat treatment supplier,
- address of heat treatment supplier,
- date of certification,
- authorized signature and title of signatory,
- number of parts/components/joint level serialization per heat treatment load, when required by product specification,
- heat treatment lot number/job number/traveler number,
- material heat number/re-melt ingot number,
- material type, grade, or alloy designation,
- description of material being heat treated (dimension, shape, part number, serial number, if applicable),
- description of heat treatment process (solution annealing, age hardening, etc.):
 - heat treatment temperatures,
 - time at specified temperature,
 - quench media - temperature at start, peak, and finish of the quench,
 - transfer time, if required,

- continuous quench media temperature record, if required,
- method of temperature monitoring (furnace thermocouple, attached thermocouple, heat sink thermocouple),
- furnace charts, if required,
- furnace identification, if required,
- applicable heat treatment criteria/specification,
- furnace loading map per heat treatment load, if required.

14.5 Record Retention

Records required by this standard shall be maintained for a minimum of five (5) years. Documents and data may be in any type of media (hard copy or electronic) and shall be:

- signed and dated;
- maintained to demonstrate conformance to specified requirements;
- legible;
- retained and readily retrievable;
- stored in an environment to prevent damage, deterioration, or loss; and
- available and auditable by the purchaser.

15 Handling, Storage, and Shipping

Heat treated material shall be packaged for storage or transit in accordance with the documented procedure of the heat treatment supplier or the customer's purchasing document.

16 Minimum Facility Requirements

The activities that shall be performed at the heat treatment supplier's facility are listed in Table 3..

Table 3—Minimum Facility Requirements

Item	Process Activity	Location
1	Receiving Verification	On-Site Activity
2	Final Heat Treatment	On-Site Activity
3	Marking	On-Site Activity
4	Final Inspection	On-Site Activity

The heat treatment facility shall have the on-site equipment and the personnel to perform the required processes needed to perform the heat treatment of product under the scope of this standard. Subsequent processing such as finish machining, painting, or testing is beyond the scope of this standard.

Annex A
(informative)

Sample Heat Treatment Facility Capability Forms

Form 1 - Heat Treatment Facility Furnace Capability

Furnace ID(s): _____

HSL: _____

Position of the Burners: Top Fired, Bottom Fired	
Working Zone Dimensions: Width, Depth, Height (in)	
Heating process: Gas Fired/Electric	
Type of Furnace: Car Bottom, Clam Shell, Box Shell Lift, Front Door Access.	
Furnace Wall and Hearth Lining: Brick, Fiber	
TUS Frequency	
Handling Equipment Weight Limitations	
Furnace Weight Limitations	
Temperature Range of the Furnace Survey (Min/Max degrees)	
Temperature Tolerance of the Furnace Survey	
Method of Transfer to Quench Tank	
Method of Furnace Temperature Monitoring (Contact, Heat Sink, Furnace Set Point)	
Furnace Atmospheres	
List Quench Tanks That the Material Can Be Transferred To From This Furnace In </ = 60 Seconds	
List Quench Tanks That the Material Can Be Transferred To From This Furnace In >60 Seconds and </= 90 Seconds	

Form 2 - Heat Treatment Facility Quench Capability

Quench Tank ID(s): _____

Type of Quench Tank. Oil/Water/Polymer	
Quench Tank Dimensions: Width, Length, Depth (If irregular provide map)	
Quench Tank Capacity in Gallons	
Describe Agitation System	
Method Employed to Lower Material in the Tank. (Immersion Table, Cranes, Manipulator)	
Cooling Towers or Chillers Utilized?	
Continuous Quench Temperature Monitoring Capability?	
How monitored? (Digital Readout, Charts, Analog)	



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