

Special Process: Heat Treat System Assessment
2nd Edition

ABOUT AIAG

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Founded in 1982, AIAG is a globally recognized organization where OEMs and suppliers unite to address and resolve issues affecting the worldwide automotive supply chain. AIAG's goals are to reduce cost and complexity through collaboration; improve product quality, health, safety and the environment; and optimize speed to market throughout the supply chain.

AIAG Organization

AIAG is made up of a board of directors, an executive director, executives on loan from member companies, associate directors, a full-time staff, and volunteers serving on project teams. Directors, department managers, and program managers plan, direct and coordinate the association's activities under the direction of the executive director.

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CQI-9

Special Process: Heat Treat System Assessment

Version 2, Issued 8/07



FOREWORD

Automotive Industry Action Group (AIAG) committees are made up of volunteers from member companies in the automotive industry. The work of preparing process audits is done by AIAG technical committees.

The main task of technical committees is to prepare Automotive Standards and System Requirements. Draft documents adopted by the technical committees are circulated to the Steering Committee for review and consensus approval. Publication of the documents requires approval by the Quality Steering Committee.

The Quality Steering Committee would like to acknowledge and thank the following individuals and their companies who have contributed time and effort to the development of this document.

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INTRODUCTION

General

The work of preparing CQI 9: Special Process: Heat Treat System Assessment (HTSA), Second Edition, was carried out through the AIAG Heat Treat Work Group. These heat treat requirements are complementary to customer and product standards.

The HTSA can be used to assess an organization's ability to meet the requirements in this assessment, as well as customer, regulatory, and the organization's own requirements. The HTSA can also be used between an organization and its suppliers.

In the HTSA, the word "shall" indicates a requirement for purposes of the self assessment. Failure to meet the requirements results in an assessment that is either "Not Satisfactory" or "Needs Immediate Action". The word "should" indicates a recommendation. Where the term "such as" is used, any suggestions given are for guidance only.

Process Approach

The HTSA supports the automotive process approach as described in ISO/TS 16949:2002.

Heat Treat System Assessment Goals

The goal of the HTSA is the development of a heat treat management system that provides for continual improvement, emphasizing defect prevention and the reduction of variation and waste in the supply chain.

The HTSA, coupled with an internationally recognized quality management system and applicable customer-specific requirements, defines the fundamental requirements for heat treat management systems.

The HTSA is intended to provide a common approach to a heat treat management system for automotive production and service part organizations.

Assessment Process

Ongoing assessments shall be conducted annually, unless otherwise specified by the customer, to re-examine the continuing compliance with the HTSA. Each assessment shall include a review of the organization's systems using the HTSA. Successive Job Audits (Section 4.0 of this document) shall sample parts from different automotive component manufacturers that require compliance to the HTSA document.

The assessment shall use the process approach to auditing as identified by the requirements of ISO/TS 16949:2002.

Assessor Qualifications

Assessor(s) shall have the following specific experience to conduct the HEAT TREAT SYSTEM ASSESSMENT:

1. Be an experienced quality management system (QMS) internal auditor (for example, ISO/TS 16949:2002, ISO 9001:2000).
2. Assessor shall possess heat treating knowledge. Evidence shall include a minimum of 5 years experience in heat treating or a combination of formal metallurgical education and heat treating experience totaling a minimum of 5 years.
3. Assessor shall possess knowledge of and be familiar with the application of automotive quality core tools including statistical process control, measurement systems analysis, part approval, failure mode and effects analysis, and advanced quality planning.

Note: If more than one assessor is required to meet the above qualifications, the lead assessor shall be the person meeting the requirements in item #1.

Other Requirements

The organization shall keep records as evidence of compliance to the requirements identified in the HTSA, as well as all appropriate action plans to address any unsatisfactory ratings. These records shall be readily available for review by any customer requiring compliance to the requirements within this document.

1 SCOPE

1.1 General

This document specifies process requirements for an organization or its suppliers performing applicable heat treating, who need to:

- demonstrate ability to consistently provide product that meets customer and applicable regulatory requirements, and
- enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system.

The Heat Treat System Assessment is applicable to sites where customer-specified parts for production and/or service are processed throughout the automotive supply chain.

1.2 Application

All requirements of the HTSA are generic and are intended to be applicable to all organizations performing the heat treat operations addressed in this document, regardless of type, size, and product. Note: Process Table E is only applicable to processes affecting the final characteristics of the part.

Five Process Tables have been developed and the appropriate table(s) is to be referenced during the assessment. The Process Tables are specific to heat treat processes as noted below:

Process Table A – Ferrous

- Carburizing
- Carbonitriding
- Carbon Restoration or Correction
- Neutral Hardening (Quench and Temper)
- Austempering
- Martempering
- Tempering
- Precipitation Hardening – Aging

Process Table B – Ferrous

- Nitriding (Gas)
- Ferritic Nitrocarburizing (Gas or Salt)

Process Table C – Aluminum Heat Treating

Process Table D – Induction Heat Treating – Ferrous

Process Table E - Annealing, Normalizing, and Stress Relieving

- Conformance to CQI-9 is required for all organizations that perform annealing, normalizing, or stress-relieving to achieve desired final characteristics of the part.

Note:
Material producers of primary or raw materials, or any intermediate thermal treating process step(s) that do not affect the final characteristics of the part are exempt from conforming to the requirements in CQI-9.

These Process Tables contain requirements for:

1. Process and Test Equipment
2. Pyrometry
3. Process Monitor Frequencies
4. In-Process/Final Test Frequencies
5. Quenchant and Solution Test Frequencies

The Process Tables specify the tolerances of process parameters and the frequencies for checking process control parameters and parts. The Requirements and Guidance in the HTSA form will notify the assessor when to refer to the Process Tables.

1.3 Reference

The following standards are referenced in this document. The applicability is limited to the subject matter referenced.

Standard Number	Title	Standard's Organization
AMS 2750D	Pyrometry	SAE Aerospace www.sae.org
SAE J415	Definition of Heat Treating Terms	SAE International www.sae.org
SAE J864	Surface Hardness Testing With Files	SAE International www.sae.org

2 THE HEAT TREAT SYSTEM ASSESSMENT PROCEDURE

1. Obtain current copy of CQI-9 Special Process: Heat Treat System Assessment, 2nd edition from AIAG.
2. Identify all heat treat processes to which CQI-9 Special Process: Heat Treat System Assessment, 2nd edition applies (see CQI-9, 1.2). Record these processes on the HTSA, Page 1.
3. Complete the HTSA, determining the level of compliance. A minimum of one job audit (Section 4) shall be performed during each assessment.
4. Address each "Not Satisfactory" item and determine corrective action, including root cause analysis and implementation of the corresponding corrective action(s). The corrective action(s) shall be completed within 90 days. Records of the corrective action, including verification, shall be maintained.
5. "Needs Immediate Action" requires immediate containment of suspect product. Address each "Needs Immediate Action" item and determine corrective action(s), including root cause analysis and implementation of the corresponding corrective action(s). The corrective action(s) shall be completed within 90 days. Records of the corrective action, including verification, shall be maintained.
6. Assessments shall be conducted annually unless otherwise specified by the customer.

3 SPECIAL PROCESS: HEAT TREAT ASSESSMENT

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Instructions for completing the Cover Sheet

1. **Facility Name:** Name of the facility being assessed.
One form shall be used for each facility. The facility may have several buildings or physical locations in the same general area. If there is a separate management team (Quality Manager and Metallurgist) or different management system, then these locations shall be considered as separate facilities.
2. **Address:** The street address of the facility being assessed; P.O. Box numbers may be given as additional information.
3. **Phone Number:** The phone number of the facility.
If there is no common phone number for the facility, the phone number of the Operations Manager or Quality Manager shall be used.
4. **Fax Number:** The fax number of the facility.
5. **Number of Heat Treat Employees at this Facility:** The number of employees, salaried and hourly, associated with the heat treat operation at this facility.
6. **Captive Heat Treater (Y/N):** Enter "Y" if this facility heat treats components for their own company. Enter "N" if the company does not heat treat any components for their own company.
7. **Commercial Heat Treater (Y/N):** Enter "Y" if this facility heat treats components for companies other than their own company. Enter "N" if this facility does not heat treat any components for other companies.
8. **Date of Assessment:** Enter the date(s) of the assessment. An alphanumeric format shall be used to avoid confusion with different numeric formats.
Example: May 3 – 4, 2006
9. **Date of Previous Assessment:** List the date of the previous CQI-9 Special Process: Heat Treat System Assessment of this facility.
10. **Type(s) of Thermal Processing at this Facility:** Place a checkmark to designate all thermal process(es) performed at this facility. This information determines the appropriate Process Table that shall be used during the assessment. Processes not listed on the cover sheet are not part of the Heat Treat System Assessment.
11. **Current Quality Certification(s):** The heat treater shall list their current quality certifications, e.g., ISO/TS 16949:2002, ISO 9001:2000. Certifications may be from 3rd party sources or customer quality certifications. If customer quality certification is given, then the year of the last assessment by the customer shall also be given.
12. **Date of Re-assessment (if necessary):** If "Not Satisfactory" findings were observed from the original assessment, then the heat treater shall address each item and determine correct action, including root cause analysis and implementation of the corresponding corrective action(s).
The date of the re-assessment shall be given here, and the appropriate Question(s) from Sections 1 – 4, in the original assessment, shall be modified to reflect that the evidence, relating to the implementation of the corrective action(s), has been observed. Also, the "Number of Not Satisfactory Findings" shall be modified as appropriate.
13. **Personnel Contacted:** List the name(s), title(s), phone number(s), and email address(es), if available, of the principal participants from the heat treater's organization.

14. **Auditors/Assessors:** List the name(s), Company(ies), phone number(s) and email address(es), if available, of the auditor/assessor(s).
15. **Number of “Not Satisfactory” Findings:** Enter the number of “Not Satisfactory” findings observed during the assessment.
16. **Number of “Needs Immediate Action” Findings:** Enter the number of “Needs Immediate Action” findings observed during the assessment.
17. **Number of “Fail” Findings in the Job Audit(s):** Enter the number of “Fail” findings observed from the job audit.

Special Process: Heat Treat System Assessment

Facility Name: _____
Address: _____

Phone Number:		Type(s) of Thermal Processing at this Facility:	
Fax Number:		Process Table A - Ferrous	
		Carburizing	
Number of Heat Treat Employees at this Facility:		Carbonitriding	
		Carbon Correction	
Captive Heat Treater (Y/N):		Neutral Hardening	
		Quench & Temper	
Commercial Heat Treater (Y/N):		Austempering / Martempering	
		Tempering	
Date of Assessment:		Precipitation Hardening / Aging	
Date of Previous Assessment:			

		Process Table B - Ferrous	
		Nitriding (Gas)	
		Ferritic-Nitrocarburizing (Gas or Salt)	
		Process Table C - Aluminum	
		Aluminum Heat Treatment	
		Process Table D - Ferrous	
		Induction Heat Treating	
		Process Table E	
		Annealing	
		Normalizing	
		Stress-Relieving	

Current Quality Certification(s): _____
Date of Re-assessment (if necessary): _____

Personnel Contacted:			
Name:	Title:	Phone:	Email:

Auditors/Assessors			
Name:	Company:	Phone:	Email:

Number of "Not Satisfactory" Findings: _____

Number of "Needs Immediate Action" Findings: _____

Number of "Fail" Findings in the Job Audit(s): _____

Instructions for completing Sections 1 – 3

Sections 1 - 3 contain questions and the requirements and guidance for each question. The Sections are:

- Section 1 – Management Responsibility & Quality Planning
- Section 2 – Floor and Material Handling Responsibility
- Section 3 – Equipment

The assessor shall assess the heat treater's compliance to Sections 1 – 3 by comparing the evidence presented by the heat treater to the requirements listed in the "Requirements and Guidance" column.

NOTE 1:	In the "Requirements and Guidance" column, the word "shall" indicates a requirement and the term "such as" indicates that any suggestions given are for guidance only.
NOTE 2:	The "Requirements and Guidance" column will indicate to the assessor when the Process Tables are pertinent to the Questions. When the Process Tables are pertinent to the Question, the assessor shall assess the heat treater's compliance to the specified section(s) in the Process Tables.
NOTE 3:	If the question is not applicable to the heat treater, then the assessor shall place a checkmark in the "N/A" Assessment column. If the observed evidence is in compliance to the question, the assessor shall note the evidence in the "Objective Evidence" column and place a check mark in the "Satisfactory" column. If the observed evidence is not in compliance to the question, then the assessor shall note the non-compliance in the "Objective Evidence" column and place a check mark in the "Not Satisfactory" column.
NOTE 4:	Where nonconforming product is identified in the assessment of a given question the assessor shall place a check mark in the "Needs Immediate Action" (NIA) column. NIA requires immediate containment of suspect product.

General Notes for AMS 2750D

AMS 2750D is referenced in the Pyrometry Section (Section 2.0) of the Process Tables. Organizations and suppliers shall comply with the sections of AMS 2750D that reference thermocouples, the calibration of thermocouples and instrumentation, and the procedure for conducting furnace temperature uniformity surveys (TUS) see below.

Exceptions to this requirement are listed below in the respective sections.

Thermocouples and Instrumentation

- Section 3.1 – Temperature Sensors (Thermocouples)
- Section 3.2 – Instrumentation – Note: Frequency reductions per AMS 2750D are not allowed by CQI-9

Exceptions (Compliance to the following sections are not required by CQI-9)

Section Number	Explanation
3.2.5.1 & 2	Temperature controlling instruments purchased prior to 1 year after the release of AMS 2750D are exempt of 3.2.5.1 and 3.2.5.2.
3.2.5.3.1	One point sensor input is acceptable.
3.2.5.5	Sensitivity checks during calibration are not required.

System Accuracy Test (SAT) Procedure (Section 3.4)

- SAT shall be performed by one of the two methods listed below.
- CQI-9 requires either a (1) comparative check of the control temperature sensor (CTS) to a calibrated test temperature sensor (CTTS) or (2) resident thermocouple (R-T/C), per AMS 2750D.
 - (1) The CTS shall be +/- 5C (or +/- 10F) of the CTTS at a typical operating temperature range; this check shall be performed monthly. The procedure shall follow AMS 2750D Section 3.4.
 - (2) The relationship between the CTS and R-T/C at the operating temperature range shall be within +/- 1C (or +/- 2F) of their relationship determined at the time of the most recent temperature uniformity survey; this check shall be performed weekly. SAT per AMS 2750D Section 3.4 is not required with this method.
- Any actions to correct a failing reading or validate a test result shall be documented.
- Type K and N thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed annually at a minimum.
- Type K and N thermocouples shall be checked quarterly for equipment operating below 760C (1400F) and changed every two years at a minimum.
- Type R and S thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed every two years at a minimum.

Furnace Temperature Uniformity Survey (TUS)

- Section 3.5.2 – Multiple Qualified Operating Temperature Ranges
- Section 3.5.3 – Furnace Modifications
- Section 3.5.4 – Furnace Repairs

- Section 3.5.5 – Initial TUS
 - Minimum and maximum temperature ranges shall be tested per AMS 2750D. Exception: If the operating range of the Qualified Work Zone is equal to or less than 85C (153F) then only one temperature is required to be tested. The temperature shall be within the operating range of the Qualified Work Zone.
- Section 3.5.6 – Periodic TUS (For CQI-9, a minimum of once per year periodic TUS is required)
 - Minimum and maximum temperature ranges shall be tested per AMS 2750D. Exception: If the operating range of the Qualified Work Zone is equal to or less than 85C (153F) then only one temperature is required to be tested. The temperature shall be within the operating range of the Qualified Work Zone.
- Section 3.5.8 – Furnace Parameters During TUS
- Section 3.5.9 – Furnace Temperature at Insertion of TUS Sensors (Thermocouples)
- Section 3.5.10 – Load Condition
- Section 3.5.11 – Furnace Atmosphere During TUS
- Section 3.5.13 – Batch Furnaces, Salt Baths, Controlled Temperature Liquid Baths, and Fluidized Bed Furnaces EXCEPT:
 - 3.5.13.3.2: CQI-9 requires that data from the TUS sensors is automatically recorded.
- Section 3.5.14 – Continuous and Semi-Continuous Furnaces
- Section 3.5.15 – Alternative Testing Methods for Continuous and Semi-Continuous Furnaces or Furnaces with Retorts or Muffles
- Section 3.5.16 – Temperature Uniformity Survey Sensor Failures
- Section 3.5.18 – Relocation of Hot or Cold Recording Sensors for Class A or C Instrumentation
- Section 3.5.20 – Temperature Uniformity Survey Instrumentation
- Section 3.5.21 – Temperature Uniformity Survey Report

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
Section 1 - Management Responsibility & Quality Planning						
1.1	Is there a dedicated and qualified heat treat person on-site?	To ensure readily available expertise, there shall be a dedicated and qualified heat treat person on site. This individual shall be a full-time employee and the position shall be reflected in the organization chart. A job description shall exist identifying the qualifications for the position including metallurgical and heat treat knowledge. The qualifications shall include a minimum of 5 years experience in heat treat operations or a combination of a minimum of 5 years of formal metallurgical education and heat treat experience.				
1.2	Does the heat treater perform advanced quality planning?	The organization shall incorporate a documented advance quality planning procedure. A feasibility study shall be performed and internally approved for each part. Similar parts can be grouped into part families for this effort as defined by the organization. After the part approval process is approved by the customer, no process changes are allowed unless approved by the customer. The heat treater shall contact the customer when clarification of process changes is required. This clarification of process changes shall be documented.				
1.3	Are heat treat FMEA's up to date and reflecting current processing?	The organization shall incorporate the use of a documented Failure Mode and Effects Analysis (FMEA) procedure and ensure the FMEA's are updated to reflect current part quality status. The FMEA shall be written for each part or part family or they may be process-specific and written for each process. In any case, they shall address all process steps from part receipt to part shipment and all key heat treat process parameters as defined by the organization. A cross-functional team shall be used in the development of the FMEA. All special characteristics, as defined by the organization and its customers, shall be identified, defined, and addressed in the FMEA.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
1.4	Are heat treat process control plans up to date and reflecting current processing?	<p>The organization shall incorporate the use of a documented Control Plan procedure and ensure the Control Plans are updated to reflect current controls.</p> <p>The Control Plans shall be written for each part or part family or they may be process-specific and written for each process. In any case, they shall address all process steps from part receipt to part shipment and identify all equipment used and all key heat treat process parameters as defined by the organization.</p> <p>A cross-functional team, including a production operator, shall be used in the development of Control Plans, which shall be consistent with all associated documentation such as work instructions, shop travelers, and FMEA's. All special characteristics, as defined by the organization and its customers, shall be identified, defined, and addressed in the Control Plans.</p> <p>Sample sizes and frequencies for evaluation of process and product characteristics shall also be addressed consistent with the minimum requirements listed in the Process Tables, Sections 3.0 and 4.0.</p>				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
						Needs Immediate Action
1.5	Are all heat treat related and referenced specifications current and available? For example: SAE, AIAG, ASTM, General Motors, Ford, and DaimlerChrysler.	To ensure all customer requirements are both understood and satisfied, the organization shall have all related heat treat and customer referenced standards and specifications available for use and a method to ensure that they are current. Such standards and specifications include, but are not limited to, those relevant documents published by SAE, AIAG, ASTM, General Motors, Ford, and DaimlerChrysler. The organization shall have a process to ensure the timely review, distribution, and implementation of all customer and industry engineering standards / specifications and changes based on customer-required schedule. Timely review should be as soon as possible and shall not exceed two working weeks. The organization shall document this process of review and implementation, and it shall address how customer and industry documents are obtained, how they are maintained within the organization, how the current status is established, and how the relevant information is cascaded to the shop floor within the two-week period. The organization shall identify who is responsible for performing these tasks.				
1.6	Is there a written process specification for all active processes?	The heat treater shall have written process specifications for all active processes and identify all steps of the process including relevant operating parameters. Examples of operating parameters include process temperatures, cycle times, load rates, atmosphere or gas flow settings, belt speeds, quench agitation speeds, etc. Such parameters shall not only be defined, they shall have operating tolerances as defined by the organization in order to maintain process control. All active processes should have a written process specification. These process specifications may take the form of work instructions, job card, computer-based recipes, or other similar documents.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
1.7	Has a valid product capability study been performed initially and after process equipment has been relocated, or had a major rebuild?	To demonstrate each process is capable of yielding acceptable product the organization shall perform product capability studies for the initial validation of each process, after relocation of any process equipment, & after a major rebuild of any equipment. The organization shall define what constitutes a major rebuild. Initial product capability studies shall be conducted for all heat treat processes per furnace line defined in scope of work & in accordance with customer requirements. A furnace line may include a combination of equipment that is integrated in the performance of a heat treatment process, e.g., hardening, quenching, and tempering. Capability study techniques shall be appropriate for the heat treat product characteristics, e.g., tensile strength, case depth, hardness. Any specific customer requirements shall be met, in the absence of customer requirements, the organization shall establish acceptable ranges for measures of capability. An action plan shall exist to address the steps to followed in case capability indices fall outside customer requirements or established ranges.				
1.8	Does the heat treater collect and analyze data over time, and react to this data?	The analysis of products and processes over time can yield vital information for defect prevention efforts. The organization shall have a system to collect, analyze, and react to product or process data over time. Methods of analysis shall include ongoing trend or historical data analysis of product or process parameters. The organization shall determine which parameters to include in such analysis.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
1.9	Is management reviewing the heat treat monitoring system every 24 hours?	Management shall review the furnace monitoring systems at intervals not to exceed 24 hours. The heat treat monitoring system includes but is not limited to temperature strip charts, atmosphere strip charts, computer data logs, furnace and operator logs, etc. The management review shall include efforts to detect out-of-control conditions or alarm conditions. The process of reviewing the furnace data shall be documented and this requirement also applies to computerized data.				
1.10	Are internal assessments being completed on an annual basis, at a minimum, using AIAG HTSA?	The organization shall conduct internal assessments on an annual basis, at a minimum, using the AIAG HTSA.				
1.11	Is there a system in place to authorize reprocessing and is it documented?	The quality management system shall include a documented process for reprocessing that shall include authorization from a designated individual. The reprocessing procedure shall describe product characteristics for which reprocessing is allowed as well as those characteristics for which reprocessing is not permissible. Any reprocessing activity shall require a new processing control sheet issued by qualified technical personnel denoting the necessary heat treat modifications. Records shall clearly indicate when and how any material has been reprocessed. The Quality Manager or a designee shall authorize the release of reprocessed product.				
1.12	Does the Quality Department review, address, and document customer and internal concerns?	The quality management system shall include a process for documenting, reviewing, and addressing customer concerns and any other concerns internal to the organization. A disciplined problem-solving approach shall be used.				

Special Process: Heat Treat System Assessment

Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
1.13	Is there a continual improvement plan applicable to each process defined in the scope of the assessment?	The heat treater shall define a process for continual improvement for each heat treat process identified in the scope of the HTSA. The process shall be designed to bring about continual improvement in quality and productivity. Identified actions shall be prioritized and shall include timing (estimated completion dates). The organization shall show evidence of program effectiveness.				
1.14	Does the Quality Manager or designee authorize the disposition of material from quarantine status?	The Quality Manager is responsible for authorizing and documenting appropriate personnel to disposition quarantined material.				
1.15	Are there procedures or work instructions available to the heat treat personnel that define the heat treating process?	There shall be procedures or work instructions available to heat treat personnel covering the heat treating process. These procedures or work instructions shall include methods of addressing potential emergencies (such as power failure), equipment start-up, equipment shut-down, product segregation (See 2.8), product inspection, and general operating procedures. These procedures or work instructions shall be accessible to shop floor personnel.				
1.16	Is management providing employee training for heat treating?	The organization shall provide employee training for all heat treating operations. All employees, including backup and temporary employees, shall be trained. Documented evidence shall be maintained showing the employees trained and the evidence shall include an assessment of the effectiveness of the training. Management shall define the qualification requirements for each function, and ongoing or follow-up training shall also be addressed.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
1.17	Is there a responsibility matrix to ensure that all key management and supervisory functions are performed by qualified personnel?	The organization shall maintain a responsibility matrix identifying all key management and supervisory functions and the qualified personnel who may perform such functions. It shall identify both primary and secondary (backup) personnel for the key functions (as defined by the organization). This matrix shall be readily available to management at all times.				
1.18	Is there a preventive maintenance program? Is maintenance data being utilized to form a predictive maintenance program?	The organization shall have a documented preventive maintenance program for key process equipment (as identified by the organization). The program shall be a closed-loop process that tracks maintenance efforts from request to completion to assessment of effectiveness. Equipment operators shall have the opportunity to report problems, and problems shall also be handled in a closed-loop manner. Company data, e.g., downtime, quality rejects, first time-through capability, recurring maintenance work orders, and operator-reported problems, shall be used to improve the preventive maintenance program. Furnaces and generators shall be scheduled for burn-out at frequencies determined by the organization (see Section 1 of the Process Tables). Maintenance data shall be collected and analyzed as part of a predictive maintenance program.				
1.19	Has the Heat Treater developed a critical spare part list and are the parts available to minimize production disruptions?	The heat treater shall develop and maintain a critical spare parts list and shall ensure the availability of such parts to minimize production disruptions.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
Section 2 - Floor and Material Handling Responsibility						
2.1	Does the facility ensure that the data entered in the receiving system matches the information on the customer's shipping documents?	<p>It is critical that all customer requirements and lot identification be adequately transferred to internal heat treat documents. The facility shall ensure that the data entered in the receiving system match the information on the customer's shipping documents. Documented processes and evidence of compliance shall exist, e.g., shop travelers, work orders, etc. Sometimes the material received does not precisely correspond to customer shipping documents. The facility shall have a detailed process in place to resolve receiving discrepancies.</p> <p>The requirements stated above also apply to captive heat treat departments. This process refers to receiving and shipping the parts in and out of the heat treat department.</p>				
2.2	Is product clearly identified and staged throughout the heat treat process?	<p>Procedures for part and container identification help to avoid incorrect processing or mixing of lots. Appropriate location and staging within the facility also help to ensure that orders are not shipped until all required operations are performed. Customer product shall be clearly identified and staged throughout the heat treat process. Non-heat treated, in-process, and finished product shall be properly segregated and identified. All material shall be staged in a dedicated and clearly defined area.</p>				
2.3	Is lot traceability and integrity maintained throughout all processes?	<p>Out-going lot(s) shall be traceable to the incoming lot(s). The discipline of precisely identifying lots and linking all pertinent information to them enhances the ability to do root cause analysis and continual improvement.</p>				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
2.4	Are procedures adequate to prevent movement of non-conforming product into the production system?	The control of suspect or non-conforming product is necessary to prevent inadvertent shipment or contamination of other lots. Procedures shall be adequate to prevent movement of non-conforming product into the production system. Procedures shall exist addressing proper disposition, product identification, and tracking of material flow in and out of the hold area. A non-conforming hold area shall be clearly designated to maintain segregation of such material.				
2.5	Is there a system to identify trap points in the entire heat treat process to reduce risk of mixed parts (inappropriate, non-heat treated, or improperly heat treated parts)?	Heat-treating furnaces and other processing equipment contain areas that have a risk of trapping or holding parts. Such trapping of parts can lead to damage, improperly processed parts or lot mixing/contamination. A system shall exist to identify trap points in the entire heat treat process to reduce risk of mixed parts (inappropriate, non-heat treated, or improperly heat treated parts). The heat treater shall have documented procedures to identify and monitor trap points for each process/equipment. Monitoring of potential trap points shall occur for every part changeover.				
2.6	Are containers free of inappropriate material?	Containers handling customer product shall be free of inappropriate material. After emptying and before re-using containers, containers shall be inspected to ensure that all parts and inappropriate material have been removed. The source of inappropriate material shall be identified and addressed. This is to ensure that no nonconforming heat treated parts or inappropriate material contaminate the finished lot.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
2.7	Is furnace loading specified, documented and controlled?	Furnace loading parameters shall be specified, documented, and controlled. Examples include feed rate, belt speed, number of parts per fixture, and load weight. Refer to Process Tables, Section 3.0, for frequency of checks.				
2.8	Are operators trained in material handling, containment action and product segregation in the event of an equipment emergency including power failure?	Unplanned or emergency downtime greatly raises the risk of improper processing. Operators shall be trained in material handling, containment action, and product segregation in the event of an equipment emergency including power failure. Training shall be documented. Work instructions specifically addressing potential types of equipment emergencies and failures shall be accessible to and understood by equipment operators. These instructions shall address containment actions related to all elements of the heat-treating process, e.g., loading, austenitizing, quenching, tempering.				
2.9	Is the handling, storage and packaging adequate to preserve product quality?	Handling, storage, and packaging shall be adequate to preserve product quality. The heat treater's furnace loading system, in-process handling, and shipping process shall be assessed for risk of part damage or other quality concerns. Some equipment includes conveyors and other moving components that may not be able to handle all part configurations. Other practices such as stacking of overbanded containers can also increase the risk of part damage.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
2.10	Are plant cleanliness, housekeeping, environmental and working conditions conducive to control and improved quality?	Plant cleanliness, housekeeping, environmental and working conditions shall be conducive to controlling and improving quality. The heat treater should evaluate such conditions and their effect on quality. A housekeeping policy shall be clearly defined and executed. The facility shall be reviewed for conditions that are detrimental to quality processing such as loose parts on floor, oil around quench tanks, inadequate plant lighting, smoke, etc.				
2.11	Are parts free from contaminants that would be detrimental to the heat treatment of the product?	Many heat-treated parts are subjected to surface finish or appearance operations such as plating or coating after heat treatment. Parts shall be free from contaminants that are detrimental to subsequent processes or the product. Pre-wash (if applicable) and post-wash parameters shall be monitored and documented. Oils and other contaminants or residues can be difficult to remove once subjected to the heat treatment process. Review the chemical supplier's recommendation for cleaning the system. Parts shall be free of rust, burrs, chips, detrimental amounts of drawing compound, cutting fluids, rust preventing oils, lubricants, etc., prior to heat treat. Note: Refer to the appropriate heat treater's requirements and specifications to determine acceptability. Refer to Process Table, Section 5.0, for frequency of checking washer solutions.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
2.12	Is the quenching system monitored, documented, and controlled?	The quenching system shall be monitored, documented, and controlled. The temperature, agitation, level, concentration (if applicable), time in the quenchant, and additions shall be controlled to the heat treater's specifications. Refer to Process Tables, Sections 3.0 and 5.0, for frequency of checks. Computer-monitoring equipment, with alarms and alarm logs, satisfy the verification requirement. Quench delay tolerance and alarm is required for furnaces with integral quench tanks. Temper delay time shall be specified by the heat treater for parts that are quenched and tempered, e.g., carburizing, carbonitriding, neutral hardening, solution treating and aging.				
2.13	Is soluble oil or other rust preventive monitored and controlled if applicable?	Parts are often dipped in or sprayed with rust preventive solutions immediately after the heat treating process. Soluble oil solutions or other rust preventive solutions shall be monitored and controlled, if applicable. The heat treater shall have and maintain documented tolerances for the solutions. Refer to Process Tables, Section 5.0, for frequency of checks.				
2.14	Are process control parameters monitored per frequencies specified in Process Tables?	Process control parameters shall be monitored per frequencies specified in Process Tables. Refer to Process Tables, Section 3.0. Computer monitoring equipment with alarms and alarm logs satisfy the verification requirement. A designated floor person shall verify the process parameters, e.g., by initialing a strip chart or data log. Management review is required per Question 1.9.				
2.15	Are In-Process / Final Test Frequencies performed as specified in Process Tables?	In-Process / Final Test Frequencies shall be performed as specified in Process Tables. Refer to Process Tables, Section 4.0.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
2.16	Is product test equipment verified?	Product test equipment shall be verified. Test equipment shall be verified/calibrated per applicable customer-specific standard or per an applicable consensus standard such as those published by ASTM, DIN, EN, ISO, JIS, NIST, SAE etc. Verification/calibration results shall be internally reviewed, approved, and documented. Refer to Process Tables, Section 1.0, for frequency of checks.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
Section 3 - Equipment						
3.1	Do furnaces, generators, and quench systems have proper process control equipment?	The heat-treat furnaces, generators, and quench systems shall have proper process controls and related equipment. Examples include temperature, carbon potential/dew point, gas flows, quench monitoring system including agitation, temperature control and quenching oil analysis, etc. as listed in the applicable Process Tables, Section 1.0.				
3.2	Are process equipment calibrations and/or verification certified, posted, and current?	The calibration and certification of the process equipment shall be checked at regular specified intervals. Refer to the applicable Process Tables, Sections 1.0 and 2.0, for equipment calibration or certification time tables.				
3.3	Are thermocouples & protection tubes checked or replaced per Process Tables?	The thermocouples and protection tubes shall be checked or replaced in compliance to a preventive maintenance schedule. Refer to the applicable Process Tables, Section 2.0.				
3.4	Are temperature uniformity surveys performed per requirements in Process Tables?	Temperature uniformity surveys shall be conducted per the requirements in the applicable Process Tables, Section 2.0. The frequency reductions allowed in AMS 2750D are not allowed under this document. Certain furnace designs, e.g., rotary retorts preclude direct temperature profiles. Alternate test methods per AMS 2750D 3.5.15 are acceptable for furnaces where temperature uniformity studies are not possible.				
3.5	Is the variation of the furnace controlled thermocouple from set point within the requirements in the Process Table?	The variation between the furnace-control thermocouple and the set point temperature shall be within the limits defined in the applicable Process Tables, Section 2.0. This does not apply to the first zone of a multi-zone continuous furnace.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
3.6	Are the process & equipment alarm checks being tested quarterly or after any repair or rebuild?	<p>The heat treater shall have a list of heat treat process and equipment alarms. These alarms shall be independently tested quarterly at a minimum, and after any repair or rebuild. These checks shall be documented.</p> <p>Generator and furnace atmosphere carbon potential/dew point shall be continuously monitored, automatically controlled, and documented. This requirement is specific to Process Table 1, Sections 1.0 and 3.0, for carburizing, carbonitriding, and neutral hardening.</p> <p>Continuous monitoring and automatic control of the carbon potential/dew point is required for all generators and atmosphere furnaces except rotary retort and shaker furnaces that preclude in situ control and monitoring. For rotary retort and shaker furnaces, the method described in AMS 2750D 3.5.15.2 "Property Surveys" shall be used to ensure adequate control of the furnace atmosphere. If generators are not used, the flow rates of the supplied atmosphere gases shall be monitored and controlled. The assessor shall verify the effectiveness of the atmosphere control system per customer requirements, the heat treater's control plan, and internal procedures.</p>				
3.7	Are generators and furnace atmospheres continuously monitored, automatically controlled, and documented?	<p>The atmosphere control system shall maintain the atmosphere dew point/carbon potential set point within the parameters specified in the control plan or internal procedures. The heat treater shall have a back-up method of checking the carbon potential/dew point. Examples are dew point, electrical wire resistance, gas analysis, shunt stock, carbon bar, etc. The automatic and continuous atmosphere control system shall consist of sensors such as oxygen probes or on-line infrared (IR) gas analysis. See Process Table A, Sect. 3.0 for verification frequencies.</p>				

Special Process: Heat Treat System Assessment

Special Process: Heat Treat System Assessment

Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
3.8	<p>When the back-up verification check of the atmosphere does not agree or correlate within pre-established limits with the primary control method (carbon potential/dew point reading), is correlation of the carbon-bearing atmosphere to the primary control method re-established?</p>	<p>This issue is specific to Process Table 1: carburizing, carbonitriding, and neutral hardening. When the back-up verification check of the atmosphere does not agree or correlate within pre-established limits with the primary control method (carbon potential/dew point reading), the heat treater shall resolve the out-of-limit discrepancy. The back-up atmosphere monitoring system reading and the automatically controlled atmosphere dew point/carbon potential reading shall be maintained within the correlation limits specified in the control plan or internal procedures. These range tolerances vary with the specific heat treat process and the equipment used. The heat treater shall make appropriate technical adjustments and corrections and then re-establish/demonstrate the correlation of the actual atmosphere carbon potential/dew point reading to the primary control and back-up atmosphere reading. The range tolerances for correlation between the two readings shall be in the control plan or internal procedures. The back-up carbon potential/dew point reading shall be established using one or more of the following methods:</p> <ul style="list-style-type: none"> • Carbon bar or slug • Shim stock • 3-gas analyzer • Dew point • Hot wire resistance 				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
3.9	Are all ammonia lines equipped with quick disconnects or a three valve fall safe vent system?	<p>All ammonia lines to furnaces shall be equipped with quick disconnects or a three-valve fall-safe vent system. Normal valves may allow ammonia to leak through even when they are closed. This can be undesirable and detrimental in heat treat processes not specifying/requiring ammonia.</p> <ul style="list-style-type: none"> A quick disconnect shall be present in any ammonia line going to a furnace. This line shall be disconnected after carbonitridding (or any other process using ammonia) before another heat treating operation not specifying/using ammonia begins. An alternative three-valve ammonia "fall-safe" vent system is permitted. See the definition "Three Valve Fall-Safe Vent" and diagram in the glossary. Documentation shall show when ammonia lines are disconnected for non-ammonia bearing atmosphere processes. 				
3.10	For fasteners and small metal parts, is a minimum of 3 hours allocated for an oxidizing burn-out prior to processing product not requiring ammonia?	<p>This is applicable to fasteners and small metal parts. The heat treater shall perform a minimum 3 hours oxidizing burn-out prior to processing product not requiring ammonia as an addition. Ammonia pick-up can be undesirable in parts and heat treat processes not specifying/requiring ammonia as an addition. Log book, data logger, or other records shall document the actual oxidizing burn-out time and that sufficient time has been allocated to remove ammonia from the furnace prior to processing parts in heat treat processes not specifying ammonia.</p>				
3.11	Do all atmosphere furnaces and generators have flow scopes or flow meters for all gases?	<p>All atmosphere furnaces and generators (output trim/adjustment gas) shall have flow scopes or flow meters for all gases. Flow scopes and meters shall be periodically serviced per the heat treater's preventive maintenance program. Cleaning and proper re-assembly procedures shall be documented.</p>				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
3.12	For threaded fasteners, are all continuous belt furnaces equipped with sight glass inspection ports and infrared pyrometers at discharge end of the hardening furnaces?	Infrared temperature pyrometers are required at the exit end of continuous belt furnaces running threaded fasteners to monitor for under temperature parts. The temperature alarm shall be within 28C (50F) of the furnace set point temperature. Results shall be strip charted or continuously data logged. Infrared (IR) units shall be calibrated annually at a minimum and certified. All sight glasses shall be cleaned per the preventive maintenance schedule.				
3.13	Is salt chemistry in the austenizing salt bath monitored?	Applicable to ferritic-nitrocarburizing, austempering, and neutral hardening in salt. The heat treater shall check the salt chemistry in the austenizing salt bath, or part decarburization, daily. Refer to the applicable Process Tables, Section 3.0, for frequency of checks.				
3.14	Is the quenching medium analyzed?	The heat treater shall periodically have the quenching medium analyzed for specific quenching characteristics, e.g., cooling curve, water content, salt concentration, as specified in the applicable Process Tables, Section 5.0. • The quench media characteristic tolerances shall be specified by the quench medium supplier or the heat treater. • Analysis shall be reviewed for conformance by the heat treater. This review shall be documented.				

Special Process: Heat Treat System Assessment						
Question Number	Question	Requirements and Guidance	Objective Evidence	Assessment		
				N/A	Satisfactory	Not Satisfactory
FOR INDUCTION HEAT TREATING						
3.15	Is the positioning of each part being controlled?	A method to detect proper part position, such as the use of proximity switches, optical sensors, mechanical probes, etc., is required for each part.				
3.16	Does the heat treater control the energy or power for each part?	The heat treater shall control the energy or power for each part. <ul style="list-style-type: none"> • A signature monitor for each machine is preferred. A signature monitor gives the energy unit (voltage, kilowatt, etc.) vs. time or distance (for scanning systems). • An energy monitor or equivalent is acceptable if approved by the authorized customer representative. 				
3.17	Does the supplier have a coil management system? Coil refers to the heating coil and the quench plenum.	The heat treater shall have a coil management system. Coil refers to the heating coil and the quench plenum. <ul style="list-style-type: none"> • Spare coils for each part shall be available on-site. • Coils shall conform to the approved original design. • Engineering change approval from the customer is required whenever the coil design is changed. 				
3.18	Is quench system automatic?	The quench system shall be an automatic operation. No manual quenching is allowed unless specifically approved by the authorized customer representative. Quenching shall be automatically initiated and controlled.				
3.19	Does each lot of parts have first piece set-up?	The heat treater shall perform first piece set-up for each lot of parts.				

Instructions for completing the Job Audit

The organization is to complete a minimum of one heat treat part job audit during each assessment. This should be done preferably on a part identified for one of the customers requiring compliance to this document. More part job audits may be done if time permits. Preferably, safety or critical parts should be audited. This may not be easily determined with fasteners, especially if the fastener manufacturer does not identify the end customer (auto manufacturer, tier one, etc.). It is recommended that the job audit be performed at the end of the heat treat system assessment.

The job audit is not the only or main focus of the HTSA. The other three sections on Management Responsibility and Quality Planning, Floor and Material Handling Responsibility, and Equipment are equally if not even more important. The job audit of one part, one heat process, and one furnace is not sufficient to use as a basis to complete the other sections of the complete HTSA.

The job audit is a compliance type audit/review of a specific part and its related paperwork and processing, including heat treat equipment and processing records for that job from the beginning receipt of a part through processing in the heat treat operation and inspection to packaging. Parts shall be taken from the shipping area at the dock or the end of the heat treat operation. If an automotive manufacturer's part is not available or identifiable, then parts from other customers requiring compliance with this document shall be used for the assessment.

The part or lot checked shall represent a major heat treat operation such as quench and tempering, carburizing and tempering, induction hardening for steel, solution treating and aging of aluminum, etc. In subsequent heat treat system assessments, different parts and heat treat processes shall be checked.

The specific heat treat processing parameters (applies to 4.7 in the Job Audit) that are required in the job audit shall be added to the job audit form. This can be done by reviewing the customer specification(s), the Control Plan, the FMEA, and the floor work/job order. Each processing step shall be reviewed for proper production records/compliance/inspection. These steps can be compared to those in the Heat Treat System Assessment for the actual job/heat treat process being reviewed for compliance. The heat treat and furnace records for the actual time frame/shift etc. that the job was processed shall also be checked. The actual furnace equipment and instrumentation certification shall be verified as being in compliance to the appropriate equipment requirements in the equipment section.

Section 4 - Job Audit

Job Identity: _____
 Customer: _____
 Shop Order Number: _____
 Part Number: _____
 Part Description: _____
 Material: _____
 Heat Treat Requirements: _____

Question #	Job Audit Question	Related HTSA Question #	Customer or Internal Requirement	Job (Shop) Order or Reference Documentation Requirement	Actual Condition (Objective Evidence)	Pass / Fail / N/A
4.1	Are contract review, advance quality planning, FMEA, control plans, etc., performed by qualified individuals?	1.2 1.3 1.4 1.17		N/A		
4.2	Does the heat treat facility have the customer specifications for the part?	1.5		N/A		
4.3	Is a shop traveler created to meet customer requirements?	1.6 2.1				
4.4	Is material identification (part numbers, lot numbers, heat numbers, contract numbers, etc.) maintained throughout the heat treat process?	2.2 2.3 2.4				
4.5	Is there documented evidence of Receiving Inspection?	2.1				
4.6	Are the Loading / Racking requirements identified?	1.6 2.7 2.9				
4.7	Is the proper recipe or process specification (cycle times, temperature, atmosphere, etc.) used? Refer to Process Tables, Section 3.0, for specific parameters. List parameters that were verified in this audit in the spaces provided below.	1.5 1.6 2.1 2.14 2.15				

Section 4 - Job Audit

Job Identity: Customer: _____
 Shop Order Number: _____
 Part Number: _____
 Part Description: _____
 Material: _____
 Heat Treat Requirements: _____

Question #	Job Audit Question	Related HTSA Question #	Customer or Internal Requirement	Job (Shop) Order or Reference Documentation Requirement	Actual Condition (Objective Evidence)	Pass / Fail / N/A
4.8	What are the product inspection requirements?	2.15				
4.8.1	Requirement: (1) Test Method: Test frequency or quantity: Selection of samples: Specification:					
4.8.2	Requirement: (2) Test Method: Test frequency or quantity: Selection of samples: Specification:					
4.8.3	Requirement: (3) Test Method: Test frequency or quantity: Selection of samples: Specification:					
4.8.4	Requirement: (4) Test Method: Test frequency or quantity: Selection of samples: Specification:					

Section 4 - Job Audit

Job Identity: _____
 Customer: _____
 Shop Order Number: _____
 Part Number: _____
 Part Description: _____
 Material: _____
 Heat Treat Requirements: _____

Question #	Job Audit Question	Related HTSA Question #	Customer or Internal Requirement	Job (Shop) Order or Reference Documentation Requirement	Actual Condition (Objective Evidence)	Pass / Fail / N/A
Operator or Inspector Responsibilities						
4.9	Were appropriate process steps signed off?	1.4 2.2 2.3 2.14				
4.10	Were all inspection steps, as documented in the control plan performed?	1.2 1.4				
4.11	Were steps/operations performed that were not documented in the control plan?	1.2 1.4 1.6				
4.12	If additional steps were performed, were they authorized?	1.2 1.4 1.6 1.11 1.17				
4.13	Does the governing specification allow reprocessing or rework?	1.11				
4.14	If the order was certified, did the certification accurately reflect the process performed?	2.14 2.15				
4.15	Was the certification signed by an authorized individual?	1.17				
4.16	Are the parts and containers free of inappropriate objects or contamination?	2.6 2.11				

Section 4 - Job Audit

Job Identity: _____
 Customer: _____
 Shop Order Number: _____
 Part Number: _____
 Part Description: _____
 Material: _____
 Heat Treat Requirements: _____

Question #	Job Audit Question	Related HTSA Question #	Customer or Internal Requirement	Job (Shop) Order or Reference Documentation Requirement	Actual Condition (Objective Evidence)	Pass / Fail / N/A
Packaging Requirements						
4.17	Are packaging requirements identified?	2.9				
4.18	Are parts packaged to minimize mixed parts (for example, parts packed over height of container)?	2.9				
Shipping Requirements						
4.19	Were the parts properly identified?	2.3				
4.20	Were the containers properly labeled?	2.9				

APPENDIX A – PROCESS TABLES

PROCESS TABLE A:	
CARBURIZING / CARBONITRIDING / CARBON CORRECTION / NEUTRAL HARDENING / AUSTEMPERING / MARTEMPERING / TEMPERING / PRECIPITATION HARDENING – AGING	43
PROCESS TABLE B:	
NITRIDING (GAS) AND FERRITIC-NITROCARBURIZING (GAS OR SALT)	48
PROCESS TABLE C:	
ALUMINUM HEAT TREATMENT	54
PROCESS TABLE D:	
INDUCTION HEAT TREATING	58
PROCESS TABLE E:	
ANNEALING / NORMALIZING / STRESS-RELIEVING	62

**PROCESS TABLE A - Carburizing / Carbonitriding / Carbon Correction / Neutral Hardening /
 Austempering / Martempering / Tempering / Precipitation Hardening - Aging**

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.
 ** Does not apply to furnaces operating below 760C (1400F).
 ---- indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
1.0		PROCESS AND TEST EQUIPMENT REQUIREMENTS			
A1.1	3.1 3.7	All furnaces, generators and quench systems shall have temperature indicating instruments.	Yes	Yes	Yes
A1.2	3.1 3.7	Continuous strip charts and/or data loggers are required for temperature and carbon monitoring unit, e.g., dew point, oxygen probe, IR gas analyzer, etc.	Yes	Yes	Yes
A1.3	1.18	A program for furnace and generator burnout is required (applies to carbon bearing atmospheres).	Yes	Yes	Yes
A1.4	3.2	Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum.	Yes	Yes	----
A1.5	3.2	Dew pointers, 3-gas analyzers, spectrometers, and carbon IR combustion analyzers (shim stock analysis), used to verify carbon potential in furnaces, shall be calibrated annually at a minimum.	----	----	----
A1.6	3.2	Verification of calibration of spectrometers, and carbon IR combustion analyzers, shall be checked daily or prior to use.	----	----	----
A1.7	3.2	Verification of calibration of 3-gas analyzers with zero gas and span gas shall be performed weekly at a minimum.	----	----	----
A1.8	3.2	Oxygen probe controllers shall be calibrated quarterly at a minimum.	Yes	Yes	Yes
A1.9	2.16	All hardness test equipment (for each scale used) shall be calibrated semi-annually minimum, and verified daily minimum per the applicable ASTM standard.	----	----	----
A1.10	2.16	Files shall be verified daily (or prior to use) with provers per SAE J864.	----	----	----
A1.11	3.2	Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified daily (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum.	----	----	----

**PROCESS TABLE A - Carburizing / Carbonitriding / Carbon Correction / Neutral Hardening /
Austempering / Martempering / Tempering / Precipitation Hardening - Aging**

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

** Does not apply to furnaces operating below 760C (1400F).

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
2.0		PYROMETRY			
A2.1	3.2 3.3	Thermocouples and calibration of thermocouples shall conform to AMS 2750D.	Yes	Yes	Yes
A2.2	3.2 3.3	Instrument Calibration per AMS 2750D shall be quarterly at a minimum. Frequency reductions per AMS 2750D are not allowed.	Yes	Yes	Yes
A2.3	3.2 3.3	CQI-9 requires a comparative check of the control temperature sensor (CTS) in the Qualified Work Zone to a (1) calibrated test temperature sensor (CTTS) or, (2) resident thermocouple (R-T/C). (1) The CTS shall be within an operating temperature range of +/- 5C (or +/-10F) of the CTTS. This check shall be performed monthly. (2) Within the operating temperature range the difference between the CTS and R-T/C readings shall be no more than +/- 1C (or +/-2F) as determined at the time of the most recent temperature uniformity survey. This check shall be performed weekly. Any actions to correct a failing reading or validate a test result shall be documented. Additionally, Type K and N thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed annually at a minimum. Type K and N thermocouples shall be checked quarterly for equipment operating below 760C (1400F) and changed every two years at a minimum. Type R and S thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed every two years at a minimum. Protection Tubes shall be visually checked at the same frequency as thermocouples.	Yes	Yes	Yes
A2.4	3.4	Temperature Uniformity Survey (TUS): refer to AMS 2750D for procedures. TUS frequency shall be annual and after major rebuild. Temperature uniformity tolerance for hardening furnaces shall be +/- 14 C (or +/- 25 F). Temperature uniformity tolerance for tempering furnaces shall be +/- 11 C (or +/- 20 F). Minimum and maximum temperature ranges shall be tested per AMS 2750D. Exception: If the operating range of the Qualified Work Zone is equal to or less than 85 C (153 F) then only one temperature is required to be tested. The temperature shall be within the operating range of the Qualified Work Zone. Frequency reductions per AMS 2750D are not allowed.	Yes	Yes - In Qualified Work Zone	—
A2.5	3.5	Recorded temperature(s) for austenizing processes shall be controlled within +/- 9C (or +/- 15F) of the set point as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above).	Yes	Yes - In Qualified Work Zone	—

PROCESS TABLE A - Carburizing / Carbonitriding / Carbon Correction / Neutral Hardening / Austempering / Martempering / Tempering / Precipitation Hardening - Aging

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.
 ** Does not apply to furnaces operating below 760C (1400F).
 —— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
A2.6	3.5	Recorded temperature(s) for tempering and precipitation hardening processes shall be controlled within +/- 6C (or +/- 10F) of the set point as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above).	Yes	Yes - In Qualified Work Zone	——
A2.7	3.2	Infrared pyrometers shall be calibrated to a black body furnace annually.			——

**PROCESS TABLE A - Carburizing / Carbonitriding / Carbon Correction / Neutral Hardening /
Austempering / Martempering / Tempering / Precipitation Hardening - Aging**

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

** Does not apply to furnaces operating below 760C (1400F).

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
3.0		PROCESS MONITOR FREQUENCIES			
A3.1	1.4 2.14	Monitor primary temperature control instrument(s).	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each lot or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each Shift
A3.2	1.4 2.14 3.7	Monitor generator atmospheres.	----	----	Continuous
A3.3	1.4 2.14 3.7	Monitor primary furnace atmosphere control(s)**.	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	----
A3.4	1.4 2.14 3.7	Verify primary atmosphere control method by back-up method**.	Daily	Daily	Daily
A3.5	1.4 2.14 3.13	For austenizing salt baths: Salt chemistry (soluble oxides) or decarburization on the parts shall be checked daily.	Daily	Daily	----
A3.6	1.4 2.12	Quench Media Process Parameters			
		- Temperature	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each lot or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	----
		- Quench Level	Daily	Daily	----
		- Agitation	- Daily visual check is required. - Monitor each load in the absence of an alarm system.	- Daily visual check is required. - Monitor every 2 hours in the absence of an alarm system.	----
A3.7	1.4 2.14	Monitor time in furnace, cycle time or belt speed.	Each batch	Twice/shift & after any change in the belt speed.	----
A3.8	1.4 2.7	Monitor load size or fixturing or loading rate as applicable.	Each batch	Twice/shift & after any change in loading rate.	----
A3.9	1.4 2.12	Quench Delay Time - Alarm system shall be based on the time that the load exits the furnace to the time the load is at the bottom of the quench tank.	Each batch	Each basket for pusher-type continuous furnaces. Not applicable for belt furnaces.	----

PROCESS TABLE A - Carburizing / Carbonitriding / Carbon Correction / Neutral Hardening / Austempering / Martempering / Tempering / Precipitation Hardening - Aging

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

** Does not apply to furnaces operating below 760C (1400F).

— Indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
4.0		IN-PROCESS/FINAL TEST FREQUENCIES			
A4.1	1.4 2.15	Microstructure	Daily per furnace	Daily per furnace	----
A4.2	1.4 2.15	Surface hardness	Each batch	Every 2 hours minimum	----
A4.3	1.4 2.15	Core hardness (when specified)	Each batch	Every 4 hours	----
A4.4	1.4 2.15	Case depth (when specified)	Each batch	Every 4 hours	----
5.0		QUENCHANT AND SOLUTION TEST FREQUENCIES			
A5.1	2.12 3.14	Polymer Quench Media			
		- Concentration	Daily	Daily	----
		- Quenchability Check; e.g., cooling curve, viscosity, or titration	Every six months	Every six months	----
A5.2	2.12 3.14	Water Quench Media			
		- Suspended solids	Every six months	Every six months	----
A5.3	2.12 3.14	Salt Quench Media			
		- Analysis & Contaminants	Every six months	Every six months	----
A5.4	2.12 3.14	Brine or Caustic Quench Media			
		- Concentration and/or Specific Gravity	Daily	Daily	----
		- Suspended solids	Every six months	Every six months	----
A5.5	2.12 3.14	Oil Quench Media			
		- Water content, suspended solids, viscosity, cooling curve, total acid, and flash point.	Quarterly	Quarterly	----
A5.6	2.13	Rust Preventive - Soluble Oil			
		- Concentration	2x / week	2x / week	----
A5.7	2.11	Washers			
		- Concentration of cleaner	Daily	Daily	----
		- Temperature of solution (required if temperature is specified to be above ambient temperature).	Each shift	Each shift	----

PROCESS TABLE B - Nitriding (Gas) and Ferritic-Nitrocarburizing (Gas or Salt)

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.
 --- indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace*	Generators	Salt Bath
1.0		PROCESS AND TEST EQUIPMENT REQUIREMENTS				
B1.1	3.1 3.7	All furnaces, generators and quench systems shall have temperature indicating instruments.	Yes	Yes	Yes	Yes
B1.2	3.1 3.7	Continuous strip charts and/or data loggers are required for temperature and carbon monitoring unit, e.g., dew point, oxygen probe, IR gas analyzer, etc.	Yes	Yes	Yes	Yes - For temperature only
B1.3	1.18	A program for furnace and generator burnout is required. Not required for retort gas nitriding.	Yes	Yes	Yes	---
B1.4	3.12 3.13	For austenitizing salt baths: Salt chemistry (soluble oxides) or decarburization on the parts shall be checked daily.	---	---	---	Yes
B1.5	3.2	Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum.	Yes	Yes	---	---
B1.6	3.2	Dew pointers and gas analyzers, used to verify proper atmosphere in furnaces, shall be calibrated annually at a minimum.	---	---	---	---
B1.7	2.16	All hardness test equipment (for each scale used) shall be calibrated semi-annually minimum, and verified daily minimum per the applicable ASTM standard.	---	---	---	---
B1.8	2.16	Files shall be verified daily (or prior to use) with provers per SAE J864.	---	---	---	---
B1.9	3.2	Refractometers (typically used to check polymer quenchant and washer solutions) shall be verified daily (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum.	---	---	---	---

PROCESS TABLE B - Nitriding (Gas) and Ferritic-Nitrocarburizing (Gas or Salt)

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace*	Generators	Salt Bath
2.0		PYROMETRY				
B2.1	3.2 3.3	Thermocouples and calibration of thermocouples shall conform to AMS 2750D.	Yes	Yes	Yes	Yes
B2.2	3.2 3.3	Instrument Calibration per AMS 2750D shall be quarterly at a minimum. Frequency reductions per AMS 2750D are not allowed.	Yes	Yes	Yes	Yes
B2.3	3.2 3.3	<p>CQI-9 requires a comparative check of the control temperature sensor (CTS) in the Qualified Work Zone to a (1) calibrated test temperature sensor (CTTS) or, (2) resident thermocouple (R-T/C).</p> <p>(1) The CTS shall be +/- 5C (or +/- 10F) of a CTTS at the operating temperature range; this checked shall be performed monthly.</p> <p>(2) The relationship between the CTS and R-T/C at the operating temperature range shall be within +/- 1C (or +/- 2F) of their relationship determined at the time of the most recent temperature uniformity survey; this checked shall be performed weekly.</p> <p>Any actions to correct a failing reading or validate a test result shall be documented.</p> <p>Additionally, Type K and N thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed annually at a minimum. Type K and N thermocouples shall be checked quarterly for equipment operating below 760C (1400F) and changed every two years at a minimum.</p> <p>Type R and S thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed every two years at a minimum.</p> <p>Protection Tubes shall be visually checked at same frequency as thermocouples.</p>	Yes	Yes	Yes	Yes

PROCESS TABLE B - Nitriding (Gas) and Ferritic-Nitrocarburizing (Gas or Salt)

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

--- indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace*	Generators	Salt Bath
B2.4	3.4	<p>Temperature Uniformity Survey (TUS): refer to AMS 2750D for procedures. TUS frequency shall be annual and after major rebuild.</p> <p>Temperature uniformity tolerance shall be +/- 9 C (15 F).</p> <p>Minimum and maximum temperature ranges shall be tested per AMS 2750D. Exception: If the operating range of the Qualified Work Zone is equal to or less than 85 C (153 F) then only one temperature is required to be tested. The temperature shall be within the operating range of the Qualified Work Zone.</p> <p>Frequency reductions per AMS 2750D are not allowed.</p>	Yes	Yes - In Qualified Work Zone	---	Yes
B2.5	3.5	<p>Recorded temperature(s) shall be controlled within +/- 9C (or +/- 15F) of the set point as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above).</p>	Yes	Yes - In Qualified Work Zone	---	Yes
B2.6	3.2	<p>Infrared pyrometers shall be calibrated to a black body furnace annually.</p>				

PROCESS TABLE B - Nitriding (Gas) and Ferritic-Nitrocarburizing (Gas or Salt)

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace*	Generators	Salt Bath
3.0		PROCESS MONITOR FREQUENCIES				
B3.1	1.4 2.14	Monitor primary temperature control instrument(s).	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each lot or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each Shift	Every 2 hours & after any change
B3.2	1.4 2.14 3.7	Monitor generator atmospheres, if applicable.	—	—	Continuous	—
B3.3	1.4 2.14 3.7	Monitor primary furnace atmosphere control(s).	Each batch (rotary furnaces only) or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	—	Daily
B3.4	1.4 3.7	Dissociation of ammonia shall be checked in gas nitriding.	Each batch and every 4 hours minimum	Every 4 hours	Daily	N/A
B3.5	1.4 3.7	Gas ratios for ferritic nitrocarburizing shall be checked.	Each batch	Every 2 hours minimum		
B3.6	1.4 2.14 3.13	Check salt chemistry (soluble oxides) in salt baths used for austenitizing, or decarburization on the parts.	—	—	—	Daily

PROCESS TABLE B - Nitriding (Gas) and Ferritic-Nitrocarburizing (Gas or Salt)

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements; e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

— Indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace*	Generators	Salt Bath
B3.7	1.4 2.12	Quench Media Process Parameters				
		- Temperature	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each lot or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	—	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.
		- Quench Level	Daily	Daily	—	Daily
		- Agitation	- Daily - Monitor each load in the absence of an alarm system.	- Daily - Monitor every 2 hours in the absence of an alarm system.	—	Daily
B3.8	1.4 2.14	Monitor time in furnace, cycle time or belt speed.	Each batch	Twice/shift & after any change in the belt speed.	—	Each batch
B3.9	1.4 2.7	Monitor load size or fixturing or loading rate as applicable.	Each batch	Twice/shift & after any change in loading rate.	—	Each batch
B3.10	1.4 2.12	Quench Delay Time if applicable - Alarm system shall be based on the time that the load exits the furnace to the time the load is at the bottom of the quench tank.	Each batch	Each basket if applicable.	—	Each batch
4.0		IN-PROCESS/FINAL TEST FREQUENCIES				
B4.1	1.4 2.15	Microstructure.	Daily per furnace	Daily per furnace	—	Daily per furnace
B4.2	1.4 2.15	Surface hardness	Each batch	Every 2 hours minimum	—	Each batch
B4.3	1.4 2.15	Core hardness (when specified)	Each batch	Every 4 hours	—	Each batch
B4.4	1.4 2.15	Case depth (when specified)	Each batch	Every 4 hours	—	Each batch

PROCESS TABLE B - Nitriding (Gas) and Ferritic-Nitrocarburizing (Gas or Salt)

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace*	Generators	Salt Bath
5.0		QUENCHANT AND SOLUTION TEST FREQUENCIES				
		Quench Media Controls If Applicable				
B5.1	2.12 3.14	Polymer Quench Media				
		- Concentration	Daily	Daily	----	----
		- Quenchability Check; e.g., cooling curve, viscosity, or titration.	Every six months	Every six months	----	----
B5.2	2.12 3.14	Water Quench Media				
		- Suspended solids	Every six months	Every six months	----	----
B5.3	2.12 3.14	Salt Quench Media				
		- Analysis & Contaminants	Every six months	Every six months	----	Every six months
B5.4	2.12 3.14	Brine or Caustic Quench Media				
		- Concentration and/or Specific Gravity	Daily	Daily	----	----
		- Suspended solids	Every six months	Every six months	----	----
B5.5	2.12 3.14	Oil Quench Media				
		- Water content, suspended solids, viscosity, cooling curve, total acid, and flash point.	Quarterly	Quarterly	----	----
B5.6	2.13	Rust Preventive - Soluble Oil				
		- Concentration	2x / week	2x / week	----	2x / week
B5.7	2.11	Washers				
		- Concentration of cleaner	Daily	Daily	----	Daily
		- Temperature of solution (required if temperature is specified to be above ambient temperature).	Each shift	Each shift	----	Each shift

PROCESS TABLE C - Aluminum Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

*Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.
 --- indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Solution Treating and Aging Furnaces	Continuous Solution Treating and Aging Furnaces	Annealing Furnace
1.0		PROCESS AND TEST EQUIPMENT REQUIREMENTS			
C1.1	3.1 3.7	All furnaces and quench systems shall have temperature indicating instruments.	Yes	Yes	Yes
C1.2	3.1 3.7	Continuous strip charts and/or data loggers are required for temperature sensors.	Yes	Yes	Yes
C1.3	2.16	All hardness test equipment (for each scale used) shall be calibrated semi-annually minimum, and verified daily minimum per the applicable ASTM standard.	---	---	---
C1.4	3.2	Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum.	Yes	Yes	Yes
C1.5	3.2	Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified daily (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum.	---	---	---

PROCESS TABLE C - Aluminum Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

*Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.
— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Solution Treating and Aging Furnaces	Continuous Solution Treating and Aging Furnaces	Annealing Furnace
2.0		PYROMETRY			
C2.1	3.2 3.3	Thermocouples and calibration of thermocouples shall conform to AMS 2750D.	Yes	Yes	Yes
C2.2	3.2 3.3	Instrument Calibration per AMS 2750D shall be quarterly at a minimum. Frequency reductions per AMS 2750D are not allowed.	Yes	Yes	Yes
C2.3	3.2 3.3	CQI-9 requires a comparative check of the control temperature sensor (CTS) in the Qualified Work Zone to a (1) calibrated test temperature sensor (CTTS) or, (2) resident thermocouple (R-T/C). (1) The CTS shall be +/- 5C (or +/- 10F) of a CTTS at the operating temperature range; this checked shall be performed monthly. (2) The relationship between the CTS and R-T/C at the operating temperature range shall be within +/- 1C (or +/- 2F) of their relationship determined at the time of the last temperature uniformity survey; this checked shall be performed weekly. Any actions to correct a failing reading or validate a test result shall be documented. Additionally, Type K and N thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed annually at a minimum. Type K and N thermocouples shall be checked quarterly for equipment operating below 760C (1400F) and changed every two years at a minimum. Type R and S thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed bi-annually every two years at a minimum. Protection Tubes shall be visually checked at same frequency as thermocouples.	Yes	Yes	Yes

PROCESS TABLE C - Aluminum Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

*Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Solution Treating and Aging Furnaces	Continuous Solution Treating and Aging Furnaces	Annealing Furnace
C2.4	3.4	<p>Temperature Uniformity Survey (TUS): refer to AMS 2750D for procedures. TUS frequency shall be quarterly and after major rebuild.</p> <p>Temperature uniformity tolerance for solution treating and aging furnaces shall be +/- 6 C (or +/- 10 F). Temperature uniformity tolerance for annealing furnaces shall be +/- 14 C (or +/- 25 F).</p> <p>Minimum and maximum temperature ranges shall be tested per AMS 2750D. Exception: if the operating range of the Qualified Work Zone is equal to or less than 85 C (153 F) then only one temperature is required to be tested. The temperature shall be within the operating range of the Qualified Work Zone.</p> <p>Frequency reductions per AMS 2750D are not allowed.</p>	Yes	Yes - In Qualified Work Zone	Yes
C2.5	3.5	Recorded temperature(s) shall be controlled within +/- 6C (or +/- 10F) of the set point as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above).	Yes	Yes - In Qualified Work Zone	—
C2.6	3.5	Recorded temperature(s) shall be controlled within +/- 8C (or +/- 15F) of the set point as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above).	—	—	Yes
C2.7	3.2	Infrared pyrometers shall be calibrated to a black body furnace annually.			

PROCESS TABLE C - Aluminum Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

*Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.
— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Solution Treating and Aging Furnaces	Continuous Solution Treating and Aging Furnaces	Annealing Furnace
3.0 PROCESS MONITOR FREQUENCIES					
C3.1	1.4 2.14	Monitor primary temperature control instrument(s).	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each lot or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.
C3.2	1.4 2.12	Quench Media Process Parameters - Heat treater shall specify temperature range based on product form and material. Temperature shall be monitored as noted. - Quench Level - Agitation	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement. Daily - Daily visual check is required. - Monitor each load in the absence of an alarm system.	Each lot or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement. Daily - Daily visual check is required. - Monitor every 2 hours in the absence of an alarm system.	— — —
C3.3	1.4 2.14	Monitor process cycle time	Each batch	Twice/shift & after any change in the indexing speed.	Each batch
C3.4	1.4 2.7	Monitor load size or fixturing as applicable.	Each batch	Twice/shift & after any change in loading rate.	Each batch
C3.5	1.4 2.12	Quench Delay Time - Quench delay time shall be based on the time that the load exits the furnace to the time the load is at the bottom of the quench tank.	Each batch	Each load	—
4.0 IN-PROCESS/FINAL TEST FREQUENCIES					
C4.1	1.4 2.15	Hardness or tensile testing (post aging)	Each batch	Every 4 hours	Each batch or every 4 hours for continuous furnaces.
5.0 QUENCHANT AND SOLUTION TEST FREQUENCIES					
C5.1	2.12 3.14	Polymer Quench Media - Concentration - Suspended solids - Quenchability Check; e.g., cooling curve, viscosity, or titration.	Daily Every six months Every six months	Daily Every six months Every six months	— — —
C5.2	2.12 3.14	Water Quench Media - Suspended solids	Every six months	Every six months	—
C5.3	2.11	Washers - Concentration of cleaner - Temperature of solution (required if temperature is specified to be above ambient temperature).	Daily Each shift	Daily Each shift	Daily Each shift

PROCESS TABLE D - Induction Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Per Coil
1.0		PROCESS AND TEST EQUIPMENT REQUIREMENTS	
D1.1	---	Per customer requirement	
D1.2	2.16	All hardness test equipment (for each scale used) shall be calibrated semi-annually minimum, and verified daily minimum per the applicable ASTM standard.	----
D1.3	2.16	Files shall be verified daily (or prior to use) with provers per SAE J864.	----
D1.4	3.2	Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified each shift (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum.	----

PROCESS TABLE D - Induction Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Per Coil
2.0		PYROMETRY	
D2.1	3.2	Infrared pyrometers shall be calibrated to a black body furnace annually.	----
3.0		PROCESS MONITORING FREQUENCIES	
All process parameters shall be checked the beginning of every shift, tool change, or any equipment repair. In absence of process parameter alarms, also check process parameters at end of shift or lot (whichever is the greater frequency).			
D3.1	1.4 2.12	Quench Media Process Parameters	
		- Temperature	Alarm system for high and low temperature is required.
		- Quench Level	Daily
		- Quench Pressure and Flow	- Quench pressure and flow may be checked at manifold. Quench flow shall be checked visually at each coil. - In the absence of an alarm system, monitor every 2 hours or after any change.
D3.2	1.4 2.14	Monitor cycle time	Check cycle time at start up and after any process change.
D3.3	1.4 2.14 3.16	Monitor: 1) Volts or Amps, and 2) Kilowatts Use of an energy monitor or signature monitor satisfies 1) and 2).	- This requirement applies to each power supply (not per coil). - In the absence of an alarm system, monitor every 2 hours or after any change.

PROCESS TABLE D - Induction Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Per Coil
4.0		IN-PROCESS/FINAL TEST FREQUENCIES	Production Setup or Coil Change - Per Coil (1st Piece Inspection)
D4.4	1.4 2.15	Induction pattern length	1 part at start-up, end of production run, and every 4 hours minimum, and 1 part pre and 1 part post tool change, equipment repair, station alarm (shutdown, malfunction, etc.)
D4.5	1.4 2.15	Total or Effective Case depth	1 part at start-up, end of production run, and 1 part per 8 hours minimum, and 1 part pre and 1 part post tool change, equipment repair, station alarm (shutdown, malfunction, etc.)
D4.6	1.4 2.15	Surface hardness	1 part at start-up, end of production run, and every 4 hours minimum, and 1 part pre and 1 part post tool change, equipment repair, station alarm (shutdown, malfunction, etc.)
D4.7	1.4 2.15	Core hardness (when specified)	1 part at start-up, end of production run, and every 4 hours minimum, and 1 part pre and 1 part post tool change, equipment repair, station alarm (shutdown, malfunction, etc.)
D4.8	1.4 2.15	Microstructure	1 part at start-up, and 1 part pre and 1 part post tool change, equipment repair, station alarm (shutdown, malfunction, etc.)

PROCESS TABLE D - Induction Heat Treating

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Per Coil
5.0		QUENCHANT AND SOLUTION TEST FREQUENCIES	
		Quench Media Controls If Applicable	
D5.1	2.12 3.14	Polymer Quench Media	
		- Concentration	Once per day
		- Quenchability Check; e.g., cooling curve, viscosity, or titration	Monthly
D5.2	2.12 3.14	Water Quench Media	
		- Suspended solids	Quarterly
D5.3	2.12 3.14	Brine or Caustic Quench Media	
		- Concentration and/or Specific Gravity	Monthly
		- Suspended solids	Quarterly
D5.4	2.13	Rust Preventive - Soluble Oil	
		- Concentration	2x / week
D5.5	2.11	Washers	
		- Concentration of cleaner	Daily
		- Temperature of solution (required if temperature is specified to be above ambient temperature).	Each shift

PROCESS TABLE E - Annealing / Normalizing / Stress-Relieving

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

** Does not apply to furnaces operating below 760C (1400F).

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
1.0		PROCESS AND TEST EQUIPMENT REQUIREMENTS			
E1.1	3.1 3.7	All furnaces, generators and quench systems (where applicable) shall have temperature indicating instruments.	Yes	Yes	Yes
E1.2	3.1 3.7	Continuous strip charts and/or data loggers are required for temperature and carbon monitoring unit, e.g., dew point, oxygen probe, IR gas analyzer, etc.	Yes	Yes	Yes
E1.3	3.2	Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum.	Yes	Yes	----
E1.4	3.2	Dew pointers, 3-gas analyzers, spectrometers, and carbon IR combustion analyzers (shim stock analysis), used to verify carbon potential in furnaces, shall be calibrated annually at a minimum. This is applicable when used in controlling carbon-bearing atmospheres.	----	----	----
E1.5	3.2	Verification of calibration of spectrometers, and carbon IR combustion analyzers, shall be checked daily or prior to use. This is applicable when used in controlling carbon-bearing atmospheres.	----	----	----
E1.6	3.2	Verification of calibration of 3-gas analyzers with zero gas and span gas shall be performed weekly at a minimum. This is applicable when used in controlling carbon-bearing atmospheres.	----	----	----
E1.7	3.2	Oxygen probe controllers shall be calibrated quarterly at a minimum. This is applicable when used in controlling carbon-bearing atmospheres.	Yes	Yes	Yes
E1.8	2.16	All hardness test equipment (for each scale used) shall be calibrated semi-annually minimum, and verified daily minimum per the applicable ASTM standard.	----	----	----

PROCESS TABLE E - Annealing / Normalizing / Stress-Relieving

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

** Does not apply to furnaces operating below 760C (1400F).

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
2.0		PYROMETRY			
E2.1	3.2 3.3	Thermocouples and calibration of thermocouples shall conform to AMS 2750D.	Yes	Yes	Yes
E2.2	3.2 3.3	Instrument Calibration per AMS 2750D shall be quarterly at a minimum. Frequency reductions per AMS 2750D are not allowed.	Yes	Yes	Yes
E2.3	3.2 3.3	CQI-9 requires a comparative check of the control temperature sensor (CTS) in the Qualified Work Zone to a (1) calibrated test temperature sensor (CTTS) or, (2) resident thermocouple (R-T/C). (1) The CTS shall be +/- 5C (or +/- 10F) of a CTTS at the operating temperature range; this checked shall be performed monthly. (2) The relationship between the CTS and R-T/C at the operating temperature range shall be within +/- 1C (or +/- 2F) of their relationship determined at the time of the most recent temperature uniformity survey; this checked shall be performed weekly. Any actions to correct a failing reading or validate a test result shall be documented. Additionally, Type K and N thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed annually at a minimum. Type K and N thermocouples shall be checked quarterly for equipment operating below 760C (1400F) and changed every two years at a minimum. Type R and S thermocouples shall be checked monthly for equipment operating at or above 760C (1400F) and changed bi-annually every two years at a minimum. Protection Tubes shall be visually checked at same frequency as thermocouples.	Yes	Yes	Yes

PROCESS TABLE E - Annealing / Normalizing / Stress-Relieving

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.

** Does not apply to furnaces operating below 760C (1400F).

— indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
E2.4	3.4	<p>Temperature Uniformity Survey (TUS): refer to AMS 2750D for procedures. TUS frequency shall be annual and after major rebuild.</p> <p>Temperature uniformity tolerance for hardening furnaces shall be +/- 14 C (or +/- 25 F). Temperature uniformity tolerance for tempering furnaces shall be +/- 11 C (or +/- 20 F).</p> <p>Minimum and maximum temperature ranges shall be tested per AMS 2750D. Exception: If the operating range of the Qualified Work Zone is equal to or less than 85 C (153 F) then only one temperature is required to be tested. The temperature shall be within the operating range of the Qualified Work Zone.</p> <p>Frequency reductions per AMS 2750D are not allowed.</p>	Yes	Yes - In Qualified Work Zone	—
E2.5	3.5	Recorded temperature(s) shall be controlled within +/- 9C (or +/- 15F) of the set point as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above).	Yes	Yes - In Qualified Work Zone	—

PROCESS TABLE E - Annealing / Normalizing / Stress-Relieving

All requirements given below are subordinate to customer specific requirements.

The customer may have additional requirements, e.g., inspection testing, greater frequencies, etc. When performing the job audit, the auditor shall verify heat treater is conforming to the customer's requirements.

* Continuous furnace frequencies are per lot (work order) or as specified, whichever is more frequent.
 ** Does not apply to furnaces operating below 760C (1400F).
 ---- indicate "not applicable".

Item #	Related HTSA Question #	Category/Process Steps	Batch Furnace	Continuous Furnace *	Generators
3.0					
PROCESS MONITOR FREQUENCIES					
E3.1	1.4 2.14	Monitor primary temperature control instrument(s).	Each batch or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each lot or continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Each Shift
E3.2	1.4 2.14 3.7	Monitor generator atmospheres	----	----	Continuous
E3.3	1.4 2.14 3.7	Monitor primary furnace atmosphere control(s)**.	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	Continuous recording with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement.	----
E3.4	1.4 2.14 3.7	Verify primary atmosphere control method by back-up method**.	Daily	Daily	Daily
E3.5	1.4 2.14 3.13	For salt baths: check salt chemistry (soluble oxides) in salt baths or decarburization on the parts.	Daily	Daily	----
E3.6	1.4 2.14	Monitor time in furnace, cycle time or belt speed.	Each batch	Twice/shift & after any change in the belt speed.	----
E3.7	1.4 2.7	Monitor load size or fixturing or loading rate as applicable.	Each batch	Twice/shift & after any change in loading rate.	----
4.0					
IN-PROCESS/FINAL TEST FREQUENCIES					
E4.1	1.4 2.15	Microstructure (when specified)	Daily per furnace	Daily per furnace	----
E4.2	1.4 2.15	Surface hardness (when specified)	Each batch	Every 2 hours minimum	----
E4.3	1.4 2.15	Core hardness (when specified)	Each batch	Every 4 hours	----
5.0					
SOLUTION TEST FREQUENCIES					
E5.1	2.13	Rust Preventive - Soluble Oil			
		- Concentration	2x / week	2x / week	----
E5.2	2.11	Washers			
		- Concentration of cleaner	Daily	Daily	----
		- Temperature of solution (required if temperature is specified to be above ambient temperature).	Each shift	Each shift	----

1.0 INTRODUCTION

Item	Value	Unit
1.1	1.0	1.0
1.2	1.0	1.0
1.3	1.0	1.0
1.4	1.0	1.0
1.5	1.0	1.0
1.6	1.0	1.0
1.7	1.0	1.0
1.8	1.0	1.0
1.9	1.0	1.0
1.10	1.0	1.0
1.11	1.0	1.0
1.12	1.0	1.0
1.13	1.0	1.0
1.14	1.0	1.0
1.15	1.0	1.0
1.16	1.0	1.0
1.17	1.0	1.0
1.18	1.0	1.0
1.19	1.0	1.0
1.20	1.0	1.0
1.21	1.0	1.0
1.22	1.0	1.0
1.23	1.0	1.0
1.24	1.0	1.0
1.25	1.0	1.0
1.26	1.0	1.0
1.27	1.0	1.0
1.28	1.0	1.0
1.29	1.0	1.0
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1.68	1.0	1.0
1.69	1.0	1.0
1.70	1.0	1.0
1.71	1.0	1.0
1.72	1.0	1.0
1.73	1.0	1.0
1.74	1.0	1.0
1.75	1.0	1.0
1.76	1.0	1.0
1.77	1.0	1.0
1.78	1.0	1.0
1.79	1.0	1.0
1.80	1.0	1.0
1.81	1.0	1.0
1.82	1.0	1.0
1.83	1.0	1.0
1.84	1.0	1.0
1.85	1.0	1.0
1.86	1.0	1.0
1.87	1.0	1.0
1.88	1.0	1.0
1.89	1.0	1.0
1.90	1.0	1.0
1.91	1.0	1.0
1.92	1.0	1.0
1.93	1.0	1.0
1.94	1.0	1.0
1.95	1.0	1.0
1.96	1.0	1.0
1.97	1.0	1.0
1.98	1.0	1.0
1.99	1.0	1.0
2.00	1.0	1.0

GLOSSARY

See also SAE J415 for additional definitions of heat treating terms

AIAG: Automotive Industry Action Group

AMS: Aerospace Material Specifications

ASTM: American Society for Testing and Materials

CTS: Control Temperature Sensor

CTTS: Calibrated Test Temperature Sensor

Capability: The total range of inherent variation in a stable process.

Control Plans: Written descriptions of the system for controlling processes for production of parts or bulk materials. Control Plans are written by organizations to address the important characteristics and engineering requirements of the product. Each part must have a Control Plan, but in many cases, "family" Control Plans can apply to a number of parts produced using a common process.

Critical Spare Parts List: A list of service parts critical for the operation of equipment. Extended delay in obtaining spare parts would result in unacceptable delays in the heat treat operation.

Cross-Functional Team: A team of employees that represent the different functions within an organization. The team will typically consist of an operator, line supervision, process engineer, metallurgist, and quality personnel.

Customer: The recipient of the organization's or supplier's product or service.

Customer Requirements: This term refers to the requirements or specifications from the original equipment manufacturer (typically the automobile company). These may be identified in the contract or purchase order, in engineering standards, part specifications, etc.

Dew Pointer: A meter especially suited for measuring the dew point of carbon-bearing atmospheres. Dew point is used to indirectly determine the carbon potential of the atmosphere.

Energy Monitor: An electronic monitor that measures and displays the actual energy delivered to the induction heating coil.

Furnace Monitoring Systems: A system that monitors the operation of the furnace.

Heat Treater: An organization that performs heat treating (see 1.2 Application) to production and/or service parts. The heat treating may be internal or "captive" to a manufacturing organization, or a separate commercial heat treating supplier.

HTSA: Heat Treat System Assessment

IR: Infrared

Nonconforming Product: Product that does not conform to the customer requirements.

Oxidizing Burn-Out: A process to remove any residual ammonia from the furnace. The process usually involves removing most of the carbon-bearing protective atmosphere and then introducing oxygen.

Oxygen Probe: An in-situ measuring probe that determines the partial pressure of oxygen in carbon-bearing atmospheres. This measurement provides an indirect measurement for the carbon potential of the atmosphere.

Process Tables: Tables in the HTSA that list the required process controls for the heat treat processes covered. These tables contain minimum requirements.

Qualified Work Zone: The defined portion of a furnace volume where temperature variation conforms to the required uniformity tolerance.

Quenchability Check: A measure of the cooling dynamics of the quench media. A quenchemeter is the inspection machine that displays the cooling curve of the quench media.

Quench Delay: The time delay between the end of the heat treat cycle and the start of the quench operation. For furnace heat treating, this is period from the time the parts exit the furnace qualified work zone to the time the parts are at the bottom of the quench tank. For induction hardening systems, this is the time from the end of the heat cycle to the start of the quench flow (or when the parts enter a quench tank).

Quenching Medium: The medium used to quench parts after heat treating, e.g., oil, water, polymer, and salt.

R-T/C: Resident Thermocouple used for comparative check of the control temperature sensor (CTS).

Recipe: This term is typically used when a computer-based system sets and controls the process parameters, e.g., temperature, cycle time, carbon potential. The 'recipe' refers to the settings of the process parameters.

Reprocessing: Any process that is performed on nonconforming product so that it will meet the specified requirements.

Responsibility Matrix: A responsibility matrix defines the designated personnel for all key functions. This matrix includes the primary and secondary designees.

SAE International: Society of Automotive Engineers International

Shop Traveler: A document usually created in the receiving department for each batch or lot of parts received. The document defines the process routing of the parts.

Signature Monitor: An electronic monitor used to monitor induction heat treating systems. The monitor plots the energy unit, e.g., voltage or kilowatt, vs. time or distance.

Special Characteristics: are product characteristics or manufacturing process parameters which can affect safety or compliance with regulations, fit, function, performance or subsequent processing of product. Refer to customer-specific requirements.

Temperature Uniformity Survey: The measurement of the uniformity of temperature within the qualified work zone of a furnace. Description of the method to be used is in AMS 2750D.

Temper Delay: The time delay from when the parts exit the quench tank to the time when the parts are placed in the tempering furnace.

3 (Three) Gas Analyzer: An instrument that measures carbon monoxide, carbon dioxide, and methane in carbon-bearing atmospheres. This measurement provides an indirect measurement of the carbon potential of the atmosphere.

Three-Valve Fail-Safe Vent (for ammonia lines): An arrangement of three valves that prevents ammonia from inadvertently entering the furnace during carburizing or neutral hardening operations. The valves are arranged in such a way that, when the ammonia line to the furnace is shut off, any ammonia that might leak past the valve is vented to the atmosphere and thus prevented from entering the furnace. See the diagrams below.

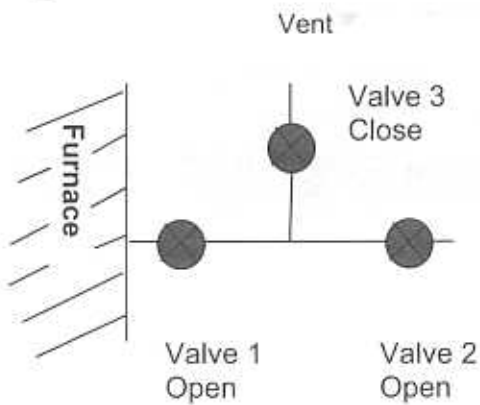


Figure 1 – Valves 1 and 2 are opened to allow ammonia flow into the furnace.

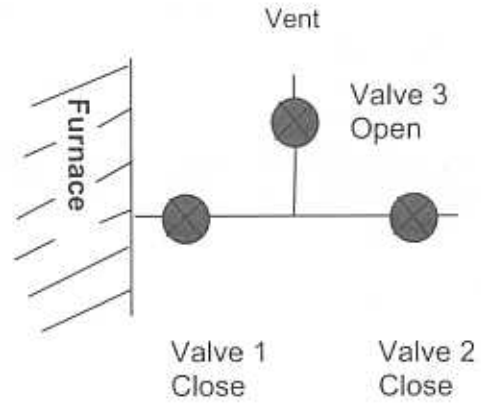


Figure 2 – Valves 1 and 2 are closed to prevent ammonia flow to furnace. If Valve 2 inadvertently leaks, ammonia is vented (Valve 3) to the atmosphere.

Trap Points: Areas in containers (baskets, fixtures, shipping boxes, etc.) or equipment that may inadvertently trap parts, allowing the potential for parts to be mixed between batches.

Work Instructions: Instructions that describe work conducted in one function in a company, e.g., setup, inspection, heat treat operation, process parameter tolerances, etc. The term “work instructions” is synonymous with the term “job instructions.”

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