# Special Process: Heat Treat System Assessment

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| **Facility Name:** | **Metex Heat Treating Ltd.** |
| **Address:** | **225 Wilikinson Road, Brampton, ON L6T 4M2** |

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|---|---|
| **Phone Number:** | **905-453-9700** |
| **Fax Number:** | **905-453-8707** |
| **Number of Heat Treat Employees at this Facility: 45** | |
| **Internal (Captive) Heat Treater** | **No** |
| **Commercial Heat Treater (Y/N):** | **Yes** |
| **Date of Assessment:** | **January 9, 2013** |
| **Date of Previous Assessment:** | **January 12, 2012** |

| **Type(s) of Thermal Processing at this Facility:** | |
|---|---|
| **Process Table A - Ferrous** | |
| **Carburizing** | **Yes** |
| **Carbonitriding** | **Yes** |
| **Carbon Restoration** | **Yes** |
| **Neutral Hardening (Quench and Temper)** | **Yes** |
| **Austempering / Martempering** | **No** |
| **Tempering** | **Yes** |
| **Precipitation Hardening / Aging** | **No** |
| **Process Table B - Ferrous** | |
| **Nitriding (Gas)** | **No** |
| **Ferritic-Nitrocarburizing (Gas or Salt)** | **No** |
| **Process Table C - Aluminum** | |
| **Aluminum Heat Treatment** | **No** |
| **Process Table D - Ferrous** | |
| **Induction Heat Treating** | **Yes** |
| **Process Table E** | |
| **Annealing** | **Yes** |
| **Normalizing** | **Yes** |
| **Stress-Relieving** | **Yes** |
| **Process Table F** | |
| **Low Pressure Carburizing** | **No** |
| **Process Table G** | |
| **Sinter Hardening** | **No** |
| **Process Table G** | |
| **Ion Nitriding** | **No** |

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| **Current Quality Certification(s):** | **ISO/TS 16949:2009 and ISO/IEC 10725** |
| **Date of Re-assessment (if necessary):** | **Not available at this time** |

**Personnel Contacted:**

| **Name:** | **Title:** | **Phone:** | **Email:** |
|---|---|---|---|
| **Surjit Bawa** | **President** | **(905) 453-9700 ext. 302** | **surjit@metexht.com** |
| **Rajiv Rishi** | **Plant Manager** | **(905) 453-9700 ext. 304** | **rajiv.rishi@metexht.com** |
| **Gursharan Parmar** | **Quality Assurance Manager** | **(905) 453-9700 ext. 306** | **gursharan@metexht.com** |

**Auditors/Assessors:**

| **Name:** | **Company:** | **Phone:** | **Email:** |
|---|---|---|---|
| **Gursharan Parmar** | **Metex - Q.A. Manager** | **(905) 453-9700 ext. 306** | **gursharan@metexht.com** |
| **Rajiv Rishi** | **Metex - Plant Manager** | **(905) 453-9700 ext. 304** | **rajiv.rishi@metexht.com** |
| **Vraj Shah** | **Metex - Quality Engineer** | **(905) 453-9700 ext. 313** | **vraj.shah@metexht.com** |

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| **Number of "Not Satisfactory" Findings:** |
| **0** |
| **Number of "Needs Immediate Action" Findings:** |
| **0** |
| **Number of "Fail" Findings in the Job Audit(s):** |
| **0** |

# Special Process: Heat Treat System Assessment

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| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| **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. | Job descriptions are available for all the staff at Metex. Metex, currently employs five Metallurgical Engineers, most of whom have an average of 15+ years experience. Production workers and furnace operators have an average of 15+ year experience. | | **Yes** | | |
| 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. | Metex performs APQP whenever it is required. A generic APQP is done on similar parts. Metex regularly provides input on heat treat specifications and material selection. Documentation is either via email or quotations. Cross-functional teams and customer input are used during the APQP process. | | **Yes** | | |
| 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. | PFMEA's are created either for specific parts, a part family or for a generic process, as applicable. They are developed by a cross-functional team and address the process flow along with necessary parameters. Special characteristics are identified as required by customers and Metex. Annual Review is performed and all are up to date. | | **Yes** | | |

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| 1.4 | Are heat treat process control plans up to date and reflecting current processing? | The organization shall incorporate the use of a documented Control Plan procedure and ensure the Control Plans are updated to reflect current controls.<br>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.<br>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. 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. | PPAP's are complete with control plans which document part specific or generic processes. PPAP's are based on full load batch. Cross-functional teams, including production operators and customer's input are used during the development of Control Plans. | | **Yes** | | |

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| 1.5 | Are all heat treat related and referenced specifications current and available? For example: Industry and customer specific specifications such as SAE, AIAG, ASTM, ISO, EN, JIS, General Motors, Ford, and Chrysler. | 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, ISO, EN, JIS, General Motors, Ford, and Chrysler. 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. | In-house *Industry Standards and Specification Matrix* tracks all required specifications. Matrix is reviewed minimum every 12 months. Metex is registered with Techstreet.com to receive notification updates. The information is transmitted to the responsible personnel, including the shop floor through process sheet changes within a two week time frame. Job is done by Quality Assurance Manager or its designate. | | **Yes** | | |
| 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.<br>All active processes should have a written process specification.<br>These process specifications may take the form of work instructions, job card, computer-based recipes, or other similar documents. | Process recipes, detailing all the relevant steps, are stored in a computer database. Recipes are linked to various customer's PN's. PN's cannot be processed without a process sheet which automatically attaches the recipe. | | **Yes** | | |

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| 1.7 | Has a valid process 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 process 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 process 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. | Capability studies are done for validation of every process. Metex has examples of capability studies for equipments re-located from customer plant to our plant. Capability studies are performed with the aid of our Quality Software Program. | | **Yes** | | |
| 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.<br>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. | Computer-aided trending charts are used for data collection and analysis over time. Charts are reviewed regularly for both furnace controls and final product. | | **Yes** | | |

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| 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.<br>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. | The furnace monitoring system is being reviewed every 24 hours. The computerized data monitoring is documented. Documented procedure is available for review. | | **Yes** | | |
| 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. | Metex conducts internal audits to comply with its own and customers requirements using AIAG HTSA. Several customers have also co-audited with Metex at various times. | | **Yes** | | |
| 1.11 | Is the OEM customer notified when parts are reprocessed? | The OEM shall be notified when parts are reprocessed in the heat treat operation. It is preferred that the notification be on a case-by-case basis. However, it is understood that some reprocessing (such as but not limited to re-tempering operations) may be pre-approved during the APQP or PPAP phase. To be pre-approved for reprocessing, the heat treater shall meet the following requirements:<br>• The heat treater shall submit for approval by the OEM customer the reprocessing procedure and this procedure shall be referenced in the heat treater's FMEA and process control plan<br>• The procedure shall describe product characteristics for which reprocessing is permissible as well as those characteristics for which reprocessing is not permissible.<br>• Any reprocessing activity shall require a new processing control sheet issued by qualified technical personnel denoting the necessary heat treat process modifications.<br>• Records shall clearly indicate when and how any material has been reprocessed.<br>• The Quality Manager or a designee shall authorize the release or reprocessed product. | Pre-approved reprocessing by OEM is included in the APQP documents during the PPAP phase. However, the OEM is notified when parts need to undergo reprocessing, and an approval is needed. | | **Yes** | | |

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| 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. | PR 7.2 - Corrective and Preventative Actions process is used. This process covers hold logs, 8D's or PPSR's, and continuous improvement projects. | | **Yes** | | |
| 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. | Continuous improvement projects are always onging. Statuses are updated as the projects progress. Operating Management System Policy & Quality Manual highlights this (Section 8.5) | | **Yes** | | |
| 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 quarantine material. | PR 7.0 - Control of non-conforming material. Quarantine cage is locked. Only QM has access to the cage. | | **Yes** | | |
| 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. | Furnace operation procedure and other intructions are available for operators at each furnace. | | **Yes** | | |
| 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. | Employees are trained as per the training schedule. Post training quizzes have been developed to measure the effectivness of training. | | **Yes** | | |

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| 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. | There is a responsibility matrix for key functions, including items from the heat treat process table and is available at any time. | | **Yes** | | |
| 1.18 | Is there a preventive maintenance program for all heat treat equipment? Is maintenance data being utilized to form a predictive maintenance program? | The organization shall have a documented preventive maintenance program for all heat treat process equipment. 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.<br><br>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.<br><br>Maintenance data shall be collected and analyzed as part of a predictive maintenance program. | Preventatitve maintenance program is in use. Metex has recently upgraded to a computerized work order tracking system. Maintenance Procedure Refer to PR#13.1 | | **Yes** | | |

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| 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. | Spare parts list with lead times are developed and available all the time. | | **Yes** | | |
| 1.20 | Is material from different steel mill heats or metals which may preclude achieving the specified metallurgical properties prevented from being processed together? | Different steel mill heats or metals which require different heat treat parameters, such as but not limited to, austentizing, quenching, or tempering times and/or temperatures shall be processed separately in order to achieve specified metallurgical properties. | Metex maintains lot integrity per customer PO. The lots run separately from one another. Lot #'s are entered onto Process Sheets and a traceability is maintained throughout entire process. | | **Yes** | | |

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| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| **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? | 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.<br>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. | Metex has written procedure for receiving instructions, process sheets & shipping I.D. | | **Yes** | | |
| 2.2 | Is product clearly identified and staged throughout the heat treat process? | 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. | Metex has various tags in use stating the current production condition or any further action to be taken. Areas for shipping / receiving, hold and for further processes are identified. | | **Yes** | | |
| 2.3 | Is lot traceability and integrity maintained throughout all processes? | Out-going lot(s) shall be traceable to the incoming lot(s).<br>The discipline of precisely identifying lots and linking all pertinent information to them enhances the ability to do root cause analysis and continual improvement. | Lot traceability is maintained through the job numbering system. Each job number is unique and is traced back to the Customer PO/Paperwork using the ERP system. | | **Yes** | | |

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| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| 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. | Designated Quarantine / hold areas with reject / hold logs. ERP system does not create shipping documents till quality has approved. | | **Yes** | | |
| 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. | Trap points visual displays are posted at the furnace. Individual trap points are marked on furnaces; they are monitored and logged daily. | | **Yes** | | |
| 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. | Operator are instructed to inspect all the containers after emptying and before re-using. Walk checks ar frequently done by management and supervisory staff. The operators sign-off on process sheets. | | **Yes** | | |
| 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. | Furnace loading specifications are written in heat treat recipes, which are managed through a computer database. Each customer PN has a recipe linked to it. | | **Yes** | | |

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| 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, austentizing, quenching, tempering. | Emergency procedures, work instructions, reaction plans available in all furnace/equipment/work stations manuals. Training records per training logs. | | **Yes** | | |
| 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 overloaded containers can also increase the risk of part damage. | Metex has designated areas for receiving / shipping; receiving areas are different from shipping areas. Parts go back in the same containers as they come in.unless customer wants them in a different container. | | **Yes** | | |
| 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. | Furnace operators and other workers are addressed regarding plant cleanliness and housekeeping during daily production meeting. | | **Yes** | | |

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| 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. | All continuous furnaces have pre-wash & post-wash logs that are monitored and maintained. Washers are dunk and sprayed regularly. Wash Temperature is controlled. Nozzles are maintained. All Quench tanks have oil filtration system installed. Parts in continuous furnace are washed before they go in the furnace. | | **Yes** | | |
| 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.<br><br>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. | Computerized and two hour logs and all record maintained as per 3.0 & 5.0. Alarms and daily check of oil level. Daily visual check is done for oil agitation. Quench delay recording of every load; if there is a quench delay (time to quench is exceeded) the load will not physical go into quench (IQ furnace #60) | | **Yes** | | |
| 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. | Rust prevention solutions are in place. The logs in place and are maintained as per 5.0. | | **Yes** | | |

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| 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. | Computerized and two hour logs maintained / reviewed at frequencies as per 3.0. Generators are also on 2 hour log. | | **Yes** | | |
| 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. | Metex exceeds standard requirements for in-process and final test frequencies. | | **Yes** | | |
| 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. | An outside contractor is hired to calibrate equipments every six months. Further, the equipment is verified in every shift by QA. | | **Yes** | | |

## Special Process: Heat Treat System Assessment

| Question Number | Question | Requirements and Guidance | Objective Evidence | Assessment N/A | Satisfactory | Not Satisfactory | Needs Immediate Action |
|---|---|---|---|---|---|---|---|
| **Section 3 - Equipment** | | | | | | | |
| 3.1 | Do furnaces, generators, and quench systems have proper process control equipment? | The heat-treat equipment including 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, etc. as listed in the applicable Process Tables, Section 1.0. | All furnaces, generators and quench systems have temperature indicating instruments. The readings of all furnaces are recorded continously on computer. Metex has two hour logs for every equipment. | | **Yes** | | |
| 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. | Calibration and certification is done every three months by an outside contractor and records are maintained as per section 1.0 & 2.0. | | **Yes** | | |
| 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. | They are checked monthly, as per 2.0. | | **Yes** | | |
| 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. Certain furnace designs, e.g., rotary retorts & some continuous pusher furnaces preclude direct temperature profiles. Alternate test methods per Section 3.4.5 are acceptable for furnaces where temperature uniformity studies are not possible. TUS studies are not required for Ion Nitriding. Refer to Process Table H Item # H2.4 for specific requirements. | Performed per schedules on process tables. | | **Yes** | | |
| 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 value and the set point temperature shall be within the limits defined in the applicable Process Tables, Section 2.0. For Ion nitriding refer to Process Table H Item # H2.5 for specific requirements. | The variation is within defined limits as per 2.0. | | **Yes** | | |

## Special Process: Heat Treat System Assessment

| | | | | Assessment | | | |
|---|---|---|---|---|---|---|---|
| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| 3.6 | Are the process & equipment alarm checks being tested for proper function? | The heat treater shall have a list of heat treat process and equipment alarms that, if not properly working, may have a high probablity of producing non-conforming product. These alarms shall be checked quarterly at a minimum or after any repair or rebuild.<br><br>Other alarms, including but not limited to safety-related, shall be checked per heat treater's requirment.<br><br>These alarm checks shall be documented. | The alarms are tested, checked and logged quarterly. | | **Yes** | | |
| 3.7 | Are generators and furnace atmospheres continuously monitored, automatically controlled, and documented?<br>NOTE: This requirement is specific to Process Tables A, B, E, F, and G; Sections 1.0 and 3.0. | Generator and furnace atmosphere carbon potential/dew point shall be continuously monitored, automatically controlled, and documented. Recorded carbon potential shall be controlled within +/- 0.05 of the set point. Recorded dew point shall be controlled within acceptable limits specified in the control plan or internal procedures.<br><br>NOTE: For rotary retort and shaker furnaces that preclude in situ control and monitoring, the method described in Section 3.4.5 "Property Surveys" shall be used.<br><br>If generators are not used, the flow rates of the supplied atmosphere gases shall be monitored and controlled.<br><br>The automatic and continuous atmosphere control system shall consist of sensors such as oxygen probes or on-line Infrared (IR) gas analysis. The heat treater shall also have a back-up method of checking the carbon potential/dew point. Examples are dew point, electrical wire resistance, gas analysis, shim stock, carbon bar, etc. See Process Tables, Sect. 3.0 for verification frequencies of primary and back up method. | There is a sign off log every 2 hours. Computerized data monitoring and logs are maintained within specified controls as per sections 1.0 & 3.0. We do not do processes B, F and G i.e. not applicable to Metex. | | **Yes** | | |

## Special Process: Heat Treat System Assessment

| | | | | Assessment | | | |
|---|---|---|---|---|---|---|---|
| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| 3.8 | A back up verification of the atmosphere is required. When the back-up verification check of the atmosphere does not 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?<br><br>NOTE: This requirement is specific to Process Tables A, B, E, F, and G; Sections 1.0 and 3.0. | When the back-up verification check of the atmosphere does not 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.<br>The heat treater shall make appropriate technical adjustments 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:<br>• Carbon bar, slug, or surface carbon of part<br>• Shim stock<br>• 3-gas analyzer<br>• Dew point<br>• Hot wire resistance | A corelation is established with shim and carbon sensor.If any discrepancy arisies, then a graph is plotted for different carbon potentials in the furnace; or it is resolved by fixing the discrepant source. | | **Yes** | | |
| 3.9 | Are all ammonia lines equipped with a fail-safe method to prevent ammonia leaks into the furnace? | One of these fail-safe methods shall be used to prevent ammonia to leak into the furnace:<br>• A quick disconnect or physical separation of the lines<br>• Three-valve ammonia "fail-safe" vent system is permitted. See the definition “Three Valve Fail-Safe Vent” and diagram in the glossary.<br>• 1 manual and 2 electrical magnetic valves in series<br><br>The heat treater shall show evidence that ammonia lines were disconnected for non-ammonia bearing atmosphere processes. | There is a quick disconnect method applied to prevent ammonia leakage into the furnace. | | **Yes** | | |

## Special Process: Heat Treat System Assessment

| | | | | Assessment | | | |
|---|---|---|---|---|---|---|---|
| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| 3.10 | Is there a miniumum of 3 hour purge of the furnace atmosphere when switching from an ammonia bearing atmosphere to a non-ammonia bearing? | Ammonia pick-up can be undesirable in parts and heat treat processes not specifying/requiring ammonia as an addition.<br><br>The heat treater shall perform a minimum 3 hours purge prior to processing product not requiring ammonia as an addition. Reduction of 3 hours purge requires conclusive test data of the atmosphere to show no significant amount of residual ammonia is present in the furnace atmosphere.<br><br>Log book, data logger, or other records shall document the actual purge 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. | Burn out time is maintained and logged.<br>A 3 hour purge is maintained. | | **Yes** | | |
| 3.11 | Do all atmosphere furnaces and generators have flow scopes or flow meters for all gases? | 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. | All furnaces and gas generators have flow scopes and are serviced regularly. | | **Yes** | | |
| 3.12 | Is there a rigorous fail-safe at the front of the furnace to prevent non-uniform loading of parts?<br><br>In absence of a rigorous fail-safe, are all continuous belt furnaces equipped with sight glass inspection ports and infrared temperature pyrometers at discharge end of the hardening furnace? | In absence of a rigorous fail-safe at the front of the furnace to prevent non-uniform loading of parts (this includes the combustion system maintenance/adjustments to ensure proper efficiencies and physical limitation for part loading), then the heat treater shall have an infrared temperature pyrometer at the exit end.<br><br>The infrared temperature pyrometers are required at the exit end of continuous belt furnaces to monitor for under temperature parts. The temperature alarm shall be within 28°C (50°F) of the furnace set point temperature. Results shall be strip charted or continuously data logged. Infrared temperature pyrometers shall be calibrated annually at a minimum and certified. All sight glasses shall be cleaned per the preventive maintenance schedule. | To prevent non-uniform loading of parts there is a leveling bar after the hopper to limit the height of the parts.<br>Infrared sensors in drop zone and sight glass ports on continuous lines; Results of IR sensors are data logged. | | **Yes** | | |

## Special Process: Heat Treat System Assessment

| | | | | Assessment | | | |
|---|---|---|---|---|---|---|---|
| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| 3.13 | Is salt chemistry in the austenitizing salt bath monitored?<br><br>Note: This is applicable to salt bath heat treating processes listed in Process Tables A & B. | The heat treater shall check the salt chemistry in the austentizing salt bath, or part decarburization, daily. Refer to the applicable Process Tables, Section 3.0, for frequency of checks. | N/A | | **N/A** | | |
| 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. This does not include Process Table G & H.<br>• The quench media characteristic tolerances shall be specified by the quench medium supplier or the heat treater.<br>• Analysis shall be reviewed for conformance by the heat treater. This review shall be documented. | Analysis of quench media & cooling curves is done every quarter by oil and polymer supplier. Reports are reviewed and filed, if okay. | | **Yes** | | |

## Special Process: Heat Treat System Assessment

| | | | | Assessment | | | |
|---|---|---|---|---|---|---|---|
| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| **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. | Positioning is controlled by tooling and fixturing. | | **Yes** | | |
| 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.<br>• 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).<br>• An energy monitor or equivalent is acceptable if approved by the authorized customer representative. | A monitor showing Power Level, Plate Voltage and Current, Grid Current is in place as required. | | **Yes** | | |
| 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.<br>• Spare coils for each part shall be available on-site.<br>• Coils shall conform to the approved original design.<br>• Engineering change approval from the customer is required whenever the coil design is changed. | There is a coil master list that lists spare coils adn original drawings/designs. | | **Yes** | | |
| 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. | The quench system is controlled by tooling and fixturing. Parts are automatically ejected from tooling into quench medium. | | **Yes** | | |
| 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. | Induction lead hand verifies new set-ups and checks part for conformity. Results are recorded. | | **Yes** | | |
| 3.20 | Is there a procedure that addresses maintenance of the inductor and quench spray nozzle(s) (for example, quench ring, quench shower)? | Procedure shall include regular inspection and cleaning of the inductor and quench spray nozzle(s). | Induction lead hand verifies the inductor and quench spray nozzles regularly. It is also a part of scheduled maintenance. There is a procedure in place. | | **Yes** | | |

## Special Process: Heat Treat System Assessment

| | | | | Assessment | | | |
|---|---|---|---|---|---|---|---|
| **Question Number** | **Question** | **Requirements and Guidance** | **Objective Evidence** | **N/A** | **Satisfactory** | **Not Satisfactory** | **Needs Immediate Action** |
| 3.21 | Is there a procedure to purge the air pockets from the quench lines? | After downtime of the induction heating system, air pockets may form in the quench lines. These air pockets will cause interrupted quenching at start-up. The Heat treater shall establish the time limit (of the downtime) when this procedure is to be followed. [Example: The quench lines shall be purged after induction heating system is down greater than 4 hours.] Factors such as quench line diameter, length, geometry, etc. shall be considered. | Procedure for purging air pockets is established and induction lead hand maintains it. | | **Yes** | | |

# Section 4 - Job Audit

**Job Identity:** Jan 7/2013
**Customer:** PREMIER FASTNER INC.
**Shop Order Number:** 145527
**Part Number:** P.O. No.: Sub 9862
**Part Description:** HT9978267
**Material:** C10B21
**Heat Treat Requirements:** NEUTRAL HARDENING, HRC 27-36, Class 9.8(J1199)

| 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<br>1.3<br>1.4<br>1.17 | As per Heat Treat Systems Assessment (HTSA) | Process Sheets are created seperately for each order | Recipe entered into Database by authorized staff; Generic PPAPs for process; Actual job card (Process Sheet) | Pass |
| 4.2 | Does the heat treat facility have the customer specifications for the part? | 1.5 | As per HTSA | Yes: Provided on Customer Drawing | Refer drawing | Pass |
| 4.3 | Is a shop traveler created to meet customer requirements? | 1.6<br>2.1 | Customer requirements | Job # 145527 | Yes, Process Sheet | Pass |
| 4.4 | Is material identification (part numbers, lot numbers, heat numbers, contract numbers, etc.) maintained throughout the heat treat process? | 2.2<br>2.3<br>2.4 | As per HSTA and customer requirements | Customer tags, Customer P.O, Bin #, Quantity & Lot #, all tie into Unique Job card (Process sheet) | Yes, Process Sheet (Job Card): # 145527 | Pass |
| 4.5 | Is there documented evidence of Receiving Inspection? | 2.1 | Internal Requirement | Yes- visual inspection of incoming load for any damage/weights/also checking each bin for traveller. If traveller is missing, a temporary I.D. is made and customer is informed | Filing of Customer Paperwork | Pass |
| 4.6 | Are the Loading / Racking requirements identified? | 1.6<br>2.7<br>2.9 | Internal Requirement | Recipe database to contain loading requirements as per PN, per furnace | Process sheet specified furnace loading for continuous belt line furnace #21 | Pass |

# Section 4 - Job Audit

**Job Identity:** Jan 7/2013
**Customer:** PREMIER FASTNER INC.
**Shop Order Number:** 145527
**Part Number:** P.O. No.: Sub 9862
**Part Description:** HT9978267
**Material:** C10B21
**Heat Treat Requirements:** NEUTRAL HARDENING, HRC 27-36, Class 9.8(J1199)

| 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 |
|---|---|---|---|---|---|---|
| 4.7 | 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<br>1.6<br>2.1<br>2.14<br>2.15 | As per HSTA | Recipes for parts are contained in the recipe database which is linked to the part number; each part number has a recipe number for processing | All set-up process parameters were checked | Pass |

# Section 4 - Job Audit

**Job Identity:** Jan 7/2013
**Customer:** PREMIER FASTNER INC.
**Shop Order Number:** 145527
**Part Number:** P.O. No.: Sub 9862
**Part Description:** HT9978267
**Material:** C10B21
**Heat Treat Requirements:** NEUTRAL HARDENING, HRC 27-36, Class 9.8(J1199)

| 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 | As per Customer Requirements | As noted on the process sheet | Job # 145527 | Pass |
| 4.8.1 | Requirement: (1) | | Surface Hardness | Surface Hardness as Quenched by Operator | | |
| | Test Method: | | | Rockwell hardness tester | HRN - 30N scale used | Pass |
| | Test frequency or quantity: | | | 5 pcs | 5 pcs | Pass |
| | Selection of samples: | | | Random | Random Selection | Pass |
| | Specification: | | | HR30N 48-56 | HR30N 48-56 | Pass |
| 4.8.2 | Requirement: (2) | | Core Hardness | Core Hardness as Quenched by Operator | | |
| | Test Method: | | | Rockwell hardness tester | HRC scale used | Pass |
| | Test frequency or quantity: | | | 10 pcs | 10 pcs | Pass |
| | Selection of samples: | | | Random | Random Selection | Pass |
| | Specification: | | | HRC 27-36 | HRC 27-36 | Pass |
| 4.8.3 | Requirement: (3) | | Surface Hardness | Surface Hardness after Temper by Quality | | |
| | Test Method: | | | Rockwell hardness tester | HRN - 30N scale used | Pass |
| | Test frequency or quantity: | | | 5 pcs | 5 pcs | Pass |
| | Selection of samples: | | | Random | Random Selection | Pass |
| | Specification: | | | HR30N 48-56 | Certified | Pass |
| 4.8.4 | Requirement: (4) | | Core Hardness | Core Hardness after Temper by Quality | | |
| | Test Method: | | | Rockwell hardness tester | HRC scale used | Pass |
| | Test frequency or quantity: | | | 10 pcs | 10 pcs | Pass |
| | Selection of samples: | | | Random | Random Selection | Pass |
| | Specification: | | | HRC 27-36 | Certified | Pass |

## Section 4 - Job Audit

**Job Identity:** Jan 7/2013
**Customer:** PREMIER FASTNER INC.
**Shop Order Number:** 145527
**Part Number:** P.O. No.: Sub 9862
**Part Description:** HT9978267
**Material:** C10B21
**Heat Treat Requirements:** NEUTRAL HARDENING, HRC 27-36, Class 9.8(J1199)

| 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<br>2.2<br>2.3<br>2.14 | Customer and Internal Requirement | Sign off on Process Sheet and Log Sheets | Refer Job # 145527 | Pass |
| 4.10 | Were all inspection steps, as documented in the control plan performed? | 1.2<br>1.4 | Customer and Internal Requirement Per HTSA | Process Sheet and Log Sheets signed off | Yes, performed according to generic control plan | Pass |
| 4.11 | Were steps/operations performed that were not documented in the control plan? | 1.2<br>1.4<br>1.6 | Customer and Internal Requirement Per HTSA | Process Sheet and Control Plan were followed | Reviewed against generic Control Plan | Pass |
| 4.12 | If additional steps were performed, were they authorized? | 1.2<br>1.4<br>1.6<br>1.11<br>1.17 | Not Applicable | Not Applicable | Not Applicable | N/A |
| 4.13 | Does the governing specification allow reprocessing or rework? | 1.11 | Customer Requirement | Re-work requires customer approval | Case by Case Basis | Pass |
| 4.14 | If the order was certified, did the certification accurately reflect the process performed? | 2.14<br>2.15 | Customer Requirement | Job Certification completed | C of C in general references surface and core hardness; lot information, process & furnace information | Pass |

# Section 4 - Job Audit

**Job Identity:** Jan 7/2013
**Customer:** PREMIER FASTNER INC.
**Shop Order Number:** 145527
**Part Number:** P.O. No.: Sub 9862
**Part Description:** HT9978267
**Material:** C10B21
**Heat Treat Requirements:** NEUTRAL HARDENING, HRC 27-36, Class 9.8(J1199)

| 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 |
|---|---|---|---|---|---|---|
| 4.15 | Was the certification signed by an authorized individual? | 1.17 | Customer and Internal Requirement Per HTSA | Certificate of Compliance | Only Authorized staff can log in to certification database and generate C of C; not actually signed but name of inspector printed | Pass |
| 4.16 | Are the parts and containers free of inappropriate objects or contamination? | 2.6<br>2.11 | Customer and Internal Requirement Per HTSA | Visual Check, Part of Quality Systems | Foreign Material not found/bins were free of inappropriate objects and contamination | Pass |

# Section 4 - Job Audit

**Job Identity:** Jan 7/2013
**Customer:** PREMIER FASTNER INC.
**Shop Order Number:** 145527
**Part Number:** P.O. No.: Sub 9862
**Part Description:** HT9978267
**Material:** C10B21
**Heat Treat Requirements:** NEUTRAL HARDENING, HRC 27-36, Class 9.8(J1199)

| 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 | Customer Requirements | As per P.O | P.O references Bin Numbers | Pass |
| 4.18 | Are parts packaged to minimize mixed parts (for example, parts packed over height of container)? | 2.9 | Customer Requirements | As per P.O | P.O references Bin Numbers | Pass |
| **Shipping Requirements** | | | | | | |
| 4.19 | Were the parts properly identified? | 2.3<br>2.9 | Customer and Internal Requirements | Traveller Tags filled by Metex - Yes properly identified | Travellers were filled out by Metex for heat treat operation | Pass |
| 4.20 | Were the containers properly labeled? | 2.3<br>2.9 | Customer Requirements | Shipping Papers | Yes, it is properly labelled | Pass |

## Section 4 - Job Audit

**Job Identity:** Jan 7/2013
**Customer:** ALFA INTERNATIONAL ENTERPRISE
**Shop Order Number:** 145508
**Part Number:** 307032
**Part Description:** Cam Trans PRK PWL ACTU (FORD)
**Material:** C5120H
**Heat Treat Requirements:** Effective Case @ HV 610: 0.6 - 1.0 mm; Surface HRC 58 min; Core HRC 23 min

| 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<br>1.3<br>1.4<br>1.17 | As per Heat Treat Systems Assessment (HTSA) | Process Sheets are created seperately for each order | PPAP documentation training; Recipe entered into Database by authorized staff; Generic PPAPs for process; actual job card | Pass |
| 4.2 | Does the heat treat facility have the customer specifications for the part? | 1.5 | As per HTSA | Yes: Provided on Customer Drawing | Refer the drawing | Pass |
| 4.3 | Is a shop traveler created to meet customer requirements? | 1.6<br>2.1 | Customer requirements | Job # 145508 | Yes, temperatures,carbon potential desgined to yield results required by customer | Pass |
| 4.4 | Is material identification (part numbers, lot numbers, heat numbers, contract numbers, etc.) maintained throughout the heat treat process? | 2.2<br>2.3<br>2.4 | As per HSTA and customer requirements | Customer tags, Customer P.O, Bin #, Quantity & Lot #, all tie into Unique Job card (Process sheet) | Process Sheet (Job Card) # 145508 | Pass |
| 4.5 | Is there documented evidence of Receiving Inspection? | 2.1 | Internal Requirements | Yes- visual inspection of incoming load for any damage/weights/also checking each bin for traveller. If traveller is missing, a temporary I.D. is made and customer is informed | Filing of Customer Paperwork | Pass |
| 4.6 | Are the Loading / Racking requirements identified? | 1.6<br>2.7<br>2.9 | Internal Requirements | Recipe database to contain loading requirements as per PN, per furnace | Process sheet specified furnace loading for batch furnace #63 | Pass |

| | | | | | | |
|---|---|---|---|---|---|---|
| 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<br>1.6<br>2.1<br>2.14<br>2.15 | As per HSTA | Recipes for parts are contained in the recipe database which is linked to the part number; each part number has a recipe number for processing | All set-up process parameters were checked | Pass |
| 4.8 | What are the product inspection requirements? | 2.15 | As per Customer Requirements | As noted on the process sheet | Job # 145508 | Pass |
| 4.8.1 | Requirement: (1) | | Core Hardness | Core Hardness: HRC 23 min | | |
| | Test Method: | | | Core Hardness HRC | HRC scale used | Pass |
| | Test frequency or quantity: | | | 10 parts | 10 parts checked | Pass |
| | Selection of samples: | | | Random selection | Randomly Selected | Pass |
| | Specification: | | | HRC 24-28 | Certified | Pass |
| 4.8.2 | Requirement: (2) | | Surface Hardness | Surface Hardness: HRC 58 min | | |
| | Test Method: | | | Rockwell hardness tester | HRC scale used | Pass |
| | Test frequency or quantity: | | | 5 pcs | 5 pcs | Pass |
| | Selection of samples: | | | Random | Random Selection | Pass |
| | Specification: | | | HRC 58-61 | Certified | Pass |
| 4.8.3 | Requirement: (3) | | Effective Case Depth | Effective Case Depth @ HV 610: 0.6 - 1.0 mm | | |
| | Test Method: | | | Micro-Hardness Tester | Micro-Harness Tester | Pass |
| | Test frequency or quantity: | | | 1 Part | 1 Part Checked | Pass |
| | Selection of samples: | | | Random selection | Randomly Selected | Pass |
| | Specification: | | | 0.6 - 1.0 mm | 0.8 | Pass |
| 4.8.4 | Requirement: (4) | | | | | |
| | Test Method: | | | | | |
| | Test frequency or quantity: | | | | | |
| | Selection of samples: | | | | | |
| | Specification: | | | | | |
| **Operator or Inspector Responsibilities** | | | | | | |
| 4.9 | Were appropriate process steps signed off? | 1.4<br>2.2<br>2.3<br>2.14 | Customer and Internal Requirement | Sign off on Process Sheet and Log Sheets | Refer Job # 145508 | Pass |
| 4.10 | Were all inspection steps, as documented in the control plan performed? | 1.2<br>1.4 | Customer and Internal Requirement Per HTSA | Process Sheet and Log Sheets signed off | Yes, performed according to generic control plan | Pass |
| 4.11 | Were steps/operations performed that were not documented in the control plan? | 1.2<br>1.4<br>1.6 | Customer and Internal Requirement Per HTSA | Process Sheet and Control Plan were followed | Reviewed against generic Control Plan | Pass |
| 4.12 | If additional steps were performed, were they authorized? | 1.2<br>1.4<br>1.6<br>1.11<br>1.17 | Not Applicable | Not Applicable | Not Applicable | N/A |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4.13 | Does the governing specification allow reprocessing or rework? | 1.11 | Customer Requirement | Re-work requires customer approval | Case by Case Basis | Pass |
| 4.14 | If the order was certified, did the certification accurately reflect the process performed? | 2.14<br>2.15 | Customer Requirement | Job Certification completed | C of C in general references surface and core hardness; lot information, process & furnace information | Pass |
| 4.15 | Was the certification signed by an authorized individual? | 1.17 | Customer and Internal Requirement Per HTSA | Certificate of Compliance | Only Authorized staff can log in to certification database and generate C of C; not actually signed but name of inspector printed | Pass |
| 4.16 | Are the parts and containers free of inappropriate objects or contamination? | 2.6<br>2.11 | Customer and Internal Requirement Per HTSA | Visual Check, Part of Quality Systems | Foreign Material not found/bins were free of inappropriate objects and contamination | Pass |
| **Packaging Requirements** | | | | | | |
| 4.17 | Are packaging requirements identified? | 2.9 | Customer Requirements | As per P.O | P.O references Bin Numbers | Pass |
| 4.18 | Are parts packaged to minimize mixed parts (for example, parts packed over height of container)? | 2.9 | Customer Requirements | As per P.O | P.O references Bin Numbers | Pass |
| **Shipping Requirements** | | | | | | |
| 4.19 | Were the parts properly identified? | 2.3<br>2.9 | Customer and Internal Requirements | Traveller Tags filled by Metex - Yes properly identified | Travellers were filled out by Metex for heat treat operation | Pass |
| 4.20 | Were the containers properly labeled? | 2.3<br>2.9 | Customer Requirements | Shipping Papers | Yes, it is properly labelled | Pass |

## Section 4 - Job Audit

**Job Identity:** Jan 7/ 2013
**Customer:** BRADFORD - A Division of Ventra Group Inc.
**Shop Order Number:** 145522
**Part Number:** 1410146103
**Part Description:** X61F SECTOR
**Material:** C 1018
**Heat Treat Requirements:** Carbonitriding & Temper: Case: 0.007 - 0.015; Surface HRB 80-84

| 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<br>1.3<br>1.4<br>1.17 | As per Heat Treat Systems Assessment (HTSA) | Process Sheets are created seperately for each order | Recipe entered into Database by authorized staff; Generic PPAPs for process; Actual job card (Process Sheet) | Pass |
| 4.2 | Does the heat treat facility have the customer specifications for the part? | 1.5 | As per HTSA | Yes: Provided on Customer Drawing | Refer drawing | Pass |
| 4.3 | Is a shop traveler created to meet customer requirements? | 1.6<br>2.1 | Customer requirements | Job # 145522 | Yes, Process Sheet | Pass |
| 4.4 | Is material identification (part numbers, lot numbers, heat numbers, contract numbers, etc.) maintained throughout the heat treat process? | 2.2<br>2.3<br>2.4 | As per HSTA and customer requirements | Customer tags, Customer P.O, Bin #, Quantity & Lot #, all tie into Unique Job card (Process sheet) | Reference: Process Sheet (Job Card): # 145522 | Pass |
| 4.5 | Is there documented evidence of Receiving Inspection? | 2.1 | Internal Requirement | Yes- visual inspection of incoming load for any damage/weights/also checking each bin for traveller. If traveller is missing, a temporary I.D. is made and customer is informed | Filing of Customer Paperwork | Pass |
| 4.6 | Are the Loading / Racking requirements identified? | 1.6<br>2.7<br>2.9 | Internal Requirement | Recipe database to contain loading requirements as per PN, per furnace | Process sheet specified furnace loading for continuous belt line furnace #31 | Pass |

| | | | | | | |
|---|---|---|---|---|---|---|
| 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<br>1.6<br>2.1<br>2.14<br>2.15 | As per HSTA | Recipes for parts are contained in the recipe database which is linked to the part number; each part number has a recipe number for processing | All set-up process parameters were checked | Pass |
| 4.8 | What are the product inspection requirements? | 2.15 | As per Customer Requirements | As noted on the process sheet | Job # 145522 | Pass |
| 4.8.1 | Requirement: (1) | | Core Hardness | Core Hardness: HRBw 80-84 max. | | |
| | Test Method: | | | Core Hardness HRBw | HRBw scale used | Pass |
| | Test frequency or quantity: | | | 10 parts | 10 parts checked | Pass |
| | Selection of samples: | | | Random selection | Randomly Selected | Pass |
| | Specification: | | | HRBw 95 max. | Certified | Pass |
| 4.8.2 | Requirement: (2) | | Total Case Depth | Total Case Depth 0.007-0.015 | | |
| | Test Method: | | | Visual Check, Brinell Scope | Brinell Scope | Pass |
| | Test frequency or quantity: | | | 1 part | I part Checked | Pass |
| | Selection of samples: | | | Random selection | Randomly Selected | Pass |
| | Specification: | | | 0.007-0.015 | 0.01 | Pass |
| 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: | | | | | |
| **Operator or Inspector Responsibilities** | | | | | | |
| 4.9 | Were appropriate process steps signed off? | 1.4<br>2.2<br>2.3<br>2.14 | Customer and Internal Requirement | Sign off on Process Sheet and Log Sheets | Refer Job # 145522 | Pass |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4.10 | Were all inspection steps, as documented in the control plan performed? | 1.2<br>1.4 | Customer and Internal Requirement Per HTSA | Process Sheet and Log Sheets signed off | Yes, performed according to generic control plan | Pass |
| 4.11 | Were steps/operations performed that were not documented in the control plan? | 1.2<br>1.4<br>1.6 | Customer and Internal Requirement Per HTSA | Process Sheet and Control Plan were followed | Reviewed against generic Control Plan | Pass |
| 4.12 | If additional steps were performed, were they authorized? | 1.2<br>1.4<br>1.6<br>1.11 | Not Applicable | Not Applicable | Not Applicable | N/A |
| 4.13 | Does the governing specification allow reprocessing or rework? | 1.11 | Customer Requirement | Re-work requires customer approval | Case by Case Basis | Pass |
| 4.14 | If the order was certified, did the certification accurately reflect the process performed? | 2.14<br>2.15 | Customer Requirement | Job Certification completed | C of C in general references surface and core hardness; lot information, process & furnace information | Pass |
| 4.15 | Was the certification signed by an authorized individual? | 1.17 | Customer and Internal Requirement Per HTSA | Certificate of Compliance | Only Authorized staff can log in to certification database and generate C of C; not actually signed but name of inspector printed | Pass |
| 4.16 | Are the parts and containers free of inappropriate objects or contamination? | 2.6<br>2.11 | Customer and Internal Requirement Per HTSA | Visual Check, Part of Quality Systems | Foreign Material not found/bins were free of inappropriate objects and contamination | Pass |
| **Packaging Requirements** | | | | | | |
| 4.17 | Are packaging requirements identified? | 2.9 | Customer Requirements | As per P.O | P.O references Bin Numbers | Pass |
| 4.18 | Are parts packaged to minimize mixed parts (for example, parts packed over height of container)? | 2.9 | Customer Requirements | As per P.O | P.O references Bin Numbers | Pass |
| **Shipping Requirements** | | | | | | |
| 4.19 | Were the parts properly identified? | 2.3<br>2.9 | Customer and Internal Requirements | Traveller Tags filled by Metex - Yes properly identified | Travellers were filled out by Metex for heat treat operation | Pass |
| 4.20 | Were the containers properly labeled? | 2.3<br>2.9 | Customer Requirements | Shipping Papers | Yes, they are properly labelled | Pass |

## PROCESS TABLE A - Carburizing / Carbonitriding / Carbon Restoration / 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #'**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | |
|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | **OK / NOK / NA** |
| A1.1 | 3.1<br>3.7 | All furnaces, generators and quench systems shall have temperature indicating instruments. | OK |
| A1.2 | 3.1<br>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. | OK |
| A1.3 | 1.18 | A program for furnace and generator burnout is required (applies to carbon bearing atmospheres). | OK |
| A1.4 | 3.2 | Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum. | OK |
| 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. | OK |
| A1.6 | 3.2 | Verification of calibration of spectrometers, and carbon IR combustion analyzers, shall be checked daily or prior to use. | OK |
| A1.7 | 3.2 | Verification of calibration of 3-gas analyzers with zero gas and span gas shall be performed weekly at a minimum. | OK |
| A1.8 | 3.2 | Oxygen probe controllers shall be calibrated quarterly (single-point or multi-point calibration) or semi-annual (multi-point calibration only; single-point calibration not allowed). | OK |
| A1.9 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved standard. | OK |
| A1.10 | 2.16 | Files for testing hardness shall be verified per the Customer requirement. | NA |
| A1.11 | 3.2 | Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified prior to use (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum. | OK |
| **2.0** | | **PYROMETRY** | **OK / NOK / NA** |
| A2.1 | 3.2<br>3.3 | Thermocouples and calibration of thermocouples shall conform to Section 3.1 | OK |
| A2.2 | 3.2<br>3.3 | Pyrometry Instrumentation and Calibration of instrumentation shall conform to Section 3.2 | OK |
| A2.3 | 3.2<br>3.3 | CQI-9 requires a System Accuracy Test (SAT) check of the control thermocouple in the Qualified Work Zone per Section 3.3 | OK |
| A2.4 | 3.4 | TUS shall be performed annually and after major rebuild per Section 3.4<br><br>Temperature uniformity tolerance for hardening furnaces shall be +/- 15°C (or +/- 25°F). Temperature uniformity tolerance for tempering furnaces shall be +/- 10°C (or +/- 20°F). | OK |
| A2.5 | 3.5 | Recorded temperature(s) for austentizing processes shall be controlled within +/- 10°C (or +/- 15°F) 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).<br><br>**For Continuous Furnaces, this requirement applies to the Qualified Work Zone.** | OK |
| A2.6 | 3.5 | Recorded temperature(s) for tempering and precipitation hardening processes shall be controlled within +/- 5°C (or +/- 10°F) 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). | OK |
| A2.7 | 3.2 | Infrared pyrometers shall be calibrated annually using proper calibration methods or an approved manufacturer's procedure. | OK |

| 3.0 | | PROCESS MONITOR FREQUENCIES | Batch Furnace | Continuous Furnace | Atmosphere Generation | OK / NOK / NA |
|---|---|---|---|---|---|---|
| A3.1 | 1.4<br>2.14 | Monitor primary temperature control instrument(s). | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per limits in A2.5 and A2.6) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours). Alarm systems (if set per limits in A2.5 and A2.6) satisfy the sign-off requirement | Sign-off required for each shift for generators. | OK |
| A3.2 | 1.4<br>2.14<br>3.7 | Monitor atmosphere generation as applicable. | | | Generators shall be continuously monitored and alarmed. Other systems, such as nitrogen-methanol systems, may either be continuously monitored and alarmed, or sign-off every 2 hours. | OK |
| A3.3 | 1.4<br>2.14<br>3.7 | Monitor primary furnace atmosphere control(s) | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours). Alarm systems (if set per acceptable limits) satisfy the sign-off requirement | | OK |
| A3.4 | 1.4<br>2.14<br>3.7<br>3.8 | Verify primary furnace atmosphere control method by back-up method | Daily | Daily | | OK |
| A3.5 | 1.4<br>2.14<br>3.13 | For austentizing salt baths: Salt chemistry (soluble oxides) or decarburization on the parts shall be checked. | Daily | | | NA |
| A3.6 | 1.4<br>2.12 | **Quench Media Process Parameters** | | | | |
| | | Temperature | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours). Alarm systems (if set per acceptable limits) satisfy the sign-off requirement | | OK |
| | | Quench Level | Continuous monitor with alarm or daily verification. | | | OK |
| | | Agitation | Daily visual check, or monitor the agitation during the quenching operation with alarm systems set at acceptable limits. | | | OK |
| A3.7 | 1.4<br>2.14 | Monitor time in furnace, cycle time or belt speed. | Each batch | Twice/shift & after any change in the belt speed. | | OK |
| A3.8 | 1.4<br>2.7 | Monitor load size or fixturing or loading rate as applicable. | Each batch | Twice/shift & after any change in loading rate. | | OK |
| A3.9 | 1.4<br>2.12 | Quench Delay Time -<br>Quench delay time shall be based on the time that the furnace door starts to open to the time the load is at the bottom of the quench tank. | Each batch | Each basket for pusher-type continuous furnaces where the loaded basket is quenched.<br><br>Not applicable for belt, shaker, or pusher furnaces where parts free-fall into the quench. | | OK |
| A3.10 | 1.4<br>2.12 | Temper Delay Time -<br>The maximum delay time between quenching and tempering shall be specified on the control plan and monitored. | Each batch | Each load | | OK |
| **4.0** | | **IN-PROCESS/FINAL TEST FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | | **OK / NOK / NA** |
| A4.1 | 1.4<br>2.15 | Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available. | Each batch | Daily per furnace | | OK |

| | | | | | | |
|---|---|---|---|---|---|---|
| A4.2 | 1.4<br>2.15 | Surface hardness | Each batch | Every 2 hours | | OK |
| A4.3 | 1.4<br>2.15 | Core hardness (when specified) | Each batch | Every 4 hours | | OK |
| A4.4 | 1.4<br>2.15 | Case depth (when specified) | Each batch | Every 4 hours | | OK |
| **5.0** | | **QUENCHANT AND SOLUTION TEST FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | | **OK / NOK / NA** |
| A5.1 | 2.12<br>3.14 | **Polymer Quench Media** | | | | |
| | | Concentration | Daily | Daily | | OK |
| | | Cooling Curve Analysis | Semi-annually | Semi-annually | | OK |
| A5.2 | 2.12<br>3.14 | **Water Quench Media** | | | | |
| | | Suspended solids | Semi-annually | Semi-annually | | NA |
| A5.3 | 2.12<br>3.14 | **Salt Quench Media** | | | | |
| | | Analysis & Contaminants | Semi-annually | Semi-annually | | NA |
| A5.4 | 2.12<br>3.14 | **Brine or Caustic Quench Media** | | | | |
| | | Concentration and/or Specific Gravity. | Daily | Daily | | NA |
| | | Suspended solids | Semi-annually | Semi-annually | | NA |
| A5.5 | 2.12<br>3.14 | **Oil Quench Media** | | | | |
| | | Water content, suspended solids, viscosity, cooling curve, total acid, and flash point. | Semi-Annually | Semi-Annually | | OK |
| A5.6 | 2.13 | **Rust Preventive - Soluble Oil** | | | | |
| | | Concentration | 2x / week | 2x / week | | OK (CHECKED WHEN USED) |
| A5.7 | 2.11 | **Washers** | | | | |
| | | Concentration of cleaner | Daily | Daily | | NA |
| | | Temperature of solution (required if temperature is specified to be above ambient temperature). | Each shift | Each shift | | OK |

## 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #'**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | | |
|---|---|---|---|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | | | | | **OK / NOK / NA** |
| B1.1 | 3.1<br>3.7 | All furnaces, generators and quench systems shall have temperature indicating instruments. | | | | | NA |
| B1.2 | 3.1<br>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. For salt bath, only temperature is required to be recorded. | | | | | NA |
| B1.3 | 1.18 | A program for furnace and generator burnout is required. Not required for retort gas nitriding. | | | | | NA |
| B1.4 | 3.2 | Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum. | | | | | NA |
| B1.5 | 3.2 | Dew pointers and gas analyzers, used to verify proper atmosphere in furnaces, shall be calibrated annually at a minimum. | | | | | NA |
| B1.6 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved standard. | | | | | NA |
| B1.7 | 2.16 | Files for testing hardness shall be verified per the Customer requirement. | | | | | NA |
| B1.8 | 3.2 | Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified prior to use (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum. | | | | | NA |
| **2.0** | | **PYROMETRY** | | | | | **OK / NOK / NA** |
| B2.1 | 3.2<br>3.3 | Thermocouples and calibration of thermocouples shall conform to Section 3.1. | | | | | NA |
| B2.2 | 3.2<br>3.3 | Pyrometry Instrumentation and Calibration of instrumentation shall conform to Section 3.2 | | | | | NA |
| B2.3 | 3.2<br>3.3 | CQI-9 requires a System Accuracy Test (SAT) check of the control thermocouple in the Qualified Work Zone per Section 3.3 | | | | | NA |
| B2.4 | 3.4 | TUS shall be performed annually and after major rebuild per Section 3.4.<br><br>Temperature uniformity tolerance shall be +/- 10°C (15°F). | | | | | NA |
| B2.5 | 3.5 | Recorded temperature(s) shall be controlled within +/- 10°C (or +/- 15°F) 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).<br><br>**For Continuous Furnaces, this requirement applies to the Qualified Work Zone.** | | | | | NA |
| B2.6 | 3.2 | Infrared pyrometers shall be calibrated annually using proper calibration methods or an approved manufacturer's procedure. | | | | | NA |
| **3.0** | | **PROCESS MONITOR FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | **Generators** | **Salt Bath** | **OK / NOK / NA** |
| B3.1 | 1.4<br>2.14 | Monitor primary temperature control instrument(s). | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per limits in B2.5) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours). Alarm systems (if set per limits in B2.5) satisfy the sign-off requirement | Sign-off required for each shift for generators. | Every 2 hours & after any change | NA |
| B3.2 | 1.4<br>2.14<br>3.7 | Monitor generator atmospheres, if applicable. | | | Generators shall be continuously monitored and alarmed. Other systems, such as nitrogen-methanol systems, may either be continuously monitored and alarmed, or sign-off every 2 hours. | | NA |
| B3.3 | 1.4<br>2.14<br>3.7<br>3.8 | 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 | NA |

## 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #'**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | | |
|---|---|---|---|---|---|---|---|
| B3.4 | 1.4<br>3.7 | Dissociation of ammonia shall be checked in gas nitriding. | Each batch and every 4 hours minimum | Every 4 hours | Daily | N/A | NA |
| B3.5 | 1.4<br>3.7 | Gas ratios for ferritic nitrocarburizing shall be checked. | Each batch | Every 2 hours minimum | | | NA |
| B3.6 | 1.4<br>2.14<br>3.13 | Check salt chemistry (soluble oxides) in salt baths used for austenitizing, or decarburization on the parts. | | | | Daily | NA |
| B3.7 | 1.4<br>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. | NA |
| | | Quench Level | Continuous monitor with alarm or daily verification. | | | Daily | NA |
| | | Agitation | Daily visual check, or monitor the agitation during the quenching operation with alarm systems set at acceptable limits. | | | Daily | NA |
| B3.8 | 1.4<br>2.14 | Monitor time in furnace, cycle time or belt speed. | Each batch | Twice/shift & after any change in the belt speed. | | Each batch | NA |
| B3.9 | 1.4<br>2.7 | Monitor load size or fixturing or loading rate as applicable. | Each batch | Twice/shift & after any change in loading rate. | | Each batch | NA |
| B3.10 | 1.4<br>2.12 | Quench Delay Time if applicable -<br>Quench delay time shall be based on the time that the furnace door starts to open to the time the load is at the bottom of the quench tank. | Each batch | Each basket if applicable. | | Each batch | NA |
| 4.0 | | **IN-PROCESS/FINAL TEST FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | **Generators** | **Salt Bath** | **OK / NOK / NA** |
| B4.1 | 1.4<br>2.15 | Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available. | Each batch | Daily per furnace | | Daily per furnace | NA |
| B4.2 | 1.4<br>2.15 | Surface hardness | Each batch | Every 2 hours minimum | | Each batch | NA |
| B4.3 | 1.4<br>2.15 | Core hardness (when specified) | Each batch | Every 4 hours | | Each batch | NA |
| B4.4 | 1.4<br>2.15 | Case depth (when specified) | Each batch | Every 4 hours | | Each batch | NA |
| 5.0 | | **QUENCHANT AND SOLUTION TEST FREQUENCIES** | **Batch Furnace** | **Continuous Furnace*** | **Generators** | **Salt Bath** | **OK / NOK / NA** |
| | | **Quench Media Controls If Applicable** | | | | | |
| B5.1 | 2.12<br>3.14 | **Polymer Quench Media** | | | | | |
| | | Concentration | Daily | Daily | | | NA |
| | | Quenchability Check; e.g., cooling curve, viscosity, or titration. | Semi-annually | Semi-annually | | | NA |
| B5.2 | 2.12<br>3.14 | **Water Quench Media** | | | | | |
| | | Suspended solids | Semi-annually | Semi-annually | | | NA |
| B5.3 | 2.12<br>3.14 | **Salt Quench Media** | | | | | |
| | | Analysis & Contaminants | Semi-annually | Semi-annually | | Semi-annually | NA |
| B5.4 | 2.12<br>3.14 | **Brine or Caustic Quench Media** | | | | | |
| | | - Concentration and/or Specific Gravity | Daily | Daily | | | NA |
| | | - Suspended solids | Semi-annually | Semi-annually | | | NA |
| B5.5 | 2.12<br>3.14 | **Oil Quench Media** | | | | | |
| | | - Water content, suspended solids, viscosity, cooling curve, total acid, and flash point. | Semi-Annual | Semi-Annual | | | NA |
| B5.6 | 2.13 | **Rust Preventive - Soluble Oil** | | | | | |
| | | - Concentration | 2x / week | 2x / week | | 2x / week | NA |
| B5.7 | 2.11 | **Washers** | | | | | |
| | | - Concentration of cleaner | Daily | Daily | | Daily | NA |

## 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #'**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | | |
|---|---|---|---|---|---|---|---|
| | | - Temperature of solution (required if temperature is specified to be above ambient temperature). | Each shift | Each shift | | Each shift | NA |

# 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | |
|---|---|---|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | | | | **OK / NOK / NA** |
| C1.1 | 3.1 | All furnaces and quench systems shall have temperature indicating instruments. | | | | NA |
| C1.2 | 3.1 | Continuous strip charts and/or data loggers are required for temperature sensors. | | | | NA |
| C1.3 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved standard. | | | | NA |
| C1.4 | 3.2 | Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum. | | | | NA |
| C1.5 | 3.2 | Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified prior to use (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum. | | | | NA |
| **2.0** | | **PYROMETRY** | | | | **OK / NOK / NA** |
| C2.1 | 3.2<br>3.3 | Thermocouples and calibration of thermocouples shall conform to Section 3.1. | | | | NA |
| C2.2 | 3.2<br>3.3 | Pyrometry Instrumentation and Calibration of Instrumentation shall conform to Section 3.2. | | | | NA |
| C2.3 | 3.2<br>3.3 | CQI-9 requires a System Accuracy Test (SAT) check of the control thermocouple in the Qualified Work Zone per Section 3.3. | | | | NA |
| C2.4 | 3.4 | Temperature Uniformity Survey (TUS) TUS frequency shall be quarterly and after major rebuild per Section 3.4.<br><br>Temperature Uniformity tolerance for solution and aging furnaces shall be +/- 5°C (+/- 10°F).<br>Temperature Uniformity tolerance for annealing furnaces shall be +/- 15°C (+/- 25°F)<br><br>Minimum and maximum temperature ranges shall be defined. Exception: If the operating range of the Qualified Work Zone is equal to or less than 85°C (155°F) then only one temperature is required to be tested. The test temperature shall be within the operating range of the Qualified Work Zone.<br><br>**For Continuous Furnaces, this requirement applies to the Qualified Work Zone.** | | | | NA |
| C2.5 | 3.5 | **For Solution Treating and Aging:** Recorded temperature(s) shall be controlled within +/- 5C (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).<br><br>**For Continuous Furnaces, this requirement applies to the Qualified Work Zone** | | | | NA |
| C2.6 | 3.5 | **For Annealing Furnaces:** Recorded temperature(s) shall be controlled within +/- 10C (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).<br><br>**For Continuous Furnaces, this requirement applies to the Qualified Work Zone** | | | | NA |
| C2.7 | 3.2 | Infrared pyrometers shall be calibrated annually using proper calibration methods or an approved manufacturer's procedure. | | | | NA |
| **3.0** | | **PROCESS MONITOR FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | | **OK / NOK / NA** |
| C3.1 | 1.4<br>2.14 | Monitor primary temperature control instrument(s). | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per limits in C2.5 and C2.6) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours. Alarm systems (if set per limits in C2.5 and C2.6) satisfy the sign-off requirement | | NA |
| C3.2 | 1.4 | **Quench Media Process Parameters** | | | | NA |

## 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | |
|---|---|---|---|---|---|---|
| | 2.12 | Temperature | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours. Alarm systems (if set per acceptable limits) satisfy the sign-off requirement | | NA |
| | | Quench Level | Daily Verification | | | NA |
| | | Agitation | Daily visual check, or monitor the agitation during the quenching operation with alarm systems set at acceptable limits. | | | NA |
| C3.3 | 1.4<br>2.14 | Monitor process cycle time | Each batch | Twice/shift & after any change in the indexing or belt speed. | | NA |
| C3.4 | 1.4<br>2.7 | Monitor load size or featuring as applicable. | Each batch | Twice/shift & after any change in loading rate. | | NA |
| C3.5 | 1.4<br>2.12 | Quench Delay Time -<br>Quench delay time shall be based on the time that the furnace door starts to open to the time the load is at the bottom of the quench tank. | Each batch | Each basket for pusher type or roller hearth continuous furnaces. | | NA |
| 4.0 | | **IN-PROCESS/FINAL TEST FREQUENCIES** | | | | **NA** |
| C4.1 | 1.4<br>2.15 | Hardness or tensile testing (post aging). | Each batch | Every 4 hours | | NA |
| 5.0 | | **QUENCHANT AND SOLUTION TEST FREQUENCIES** | | | | **OK / NOK / NA** |
| C5.1 | 2.12<br>3.14 | **Polymer Quench Media** | | | | NA |
| | | Concentration | Daily | Daily | | NA |
| | | Cooling Curve Analysis | Semi-annually | Semi-annually | | NA |
| C5.2 | 2.12<br>3.14 | **Water Quench Media** | | | | NA |
| | | Suspended solids | Semi-annually | Semi-annually | | NA |
| C5.3 | 2.11 | **Washers** | | | | NA |
| | | Concentration of cleaner | Daily | Daily | | NA |
| | | Temperature of solution (required if temperature is specified to be above ambient temperature). | Each shift | Each shift | | NA |

# 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | |
|---|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | | **OK / NOK / NA** |
| D1.1 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved standard. | | OK |
| D1.2 | 2.16 | Files for testing hardness shall be verified per the Customer requirement. | | NA |
| D1.3 | 3.2 | Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified prior to use (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum. | | OK |
| **2.0** | | **PYROMETRY** | | |
| D2.1 | 3.2 | Infrared pyrometers shall be calibrated annually using proper calibration methods or an approved manufacturer's procedure. | | NA |
| **3.0** | | **PROCESS MONITORING FREQUENCIES** | | **OK / NOK / NA** |
| **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).** | | | | OK |
| D3.1 | 1.4<br>2.12 | | | |
| | | Quench Temperature | Alarm system for high and low temperature is required. | OK |
| | | Quench Level | Continuous monitor with alarm or daily verification. | OK - visual |
| | | Quench Pressure and Flow | Alarm system for quench pressure and flow rate for high and low limits is required.<br><br>In the absence of an alarm, the quench pressure and flow shall be checked at start-up and every 8 hours | OK |
| D3.2 | 1.4<br>2.14 | Monitor cycle time | Check cycle time at start up and after any process change. | OK |
| D3.3 | 1.4<br>2.14<br>3.16 | An energy monitor or signature monitor is required and shall be equipped with alarms set at acceptable limits. | This requirement applies to each power supply (not per coil). | NOK. The monitor is there, but it is not working. |

# 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | |
|---|---|---|---|---|
| D3.4 | 1.4<br>2.12 | Temper Delay Time -<br>The maximum delay time between quenching and tempering shall be specified on the control plan and monitored. | Each batch | OK |
| **4.0** | | **IN-PROCESS/FINAL TEST FREQUENCIES PER COIL** | | **OK / NOK / NA** |
| D4.1 | 1.4<br>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.) | OK |
| D4.2 | 1.4<br>2.15 | Total or Effective Case depth | 1 part at start-up, end of production run, change of and 1 part per 8 hours minimum, and 1 part pre and 1 part post tool change, equipment repair, station alarm (shutdown, malfunction, etc.) | OK |
| D4.3 | 1.4<br>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.) | OK |
| D4.4 | 1.4<br>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.) | OK |
| D4.5 | 1.4<br>2.15 | Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available. | 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.) | OK - as required |
| 5.0 | | **QUENCHANT AND SOLUTION TEST FREQUENCIES** | | |
| D5.1 | 2.12<br>3.14 | **Polymer Quench Media**<br>Concentration | <br>Daily | <br>OK |

# 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | |
|---|---|---|---|---|
| | | Cooling Curve Analysis | Every four months (complete replacement of the quench media and cleaning of the quench tank within four months satisfies this requirement). | OK. We change quenchant more often than every four months. |
| D5.2 | 2.12<br>3.14 | **Water Quench Media** | | |
| | | Suspended solids | Semi-annually (complete replacement of the quench media and cleaning of the quench tank within six months satisfies this requirement) | OK. We change quenchant more often than every six months. |
| D5.3 | 2.12<br>3.14 | **Brine or Caustic Quench Media** | | |
| | | Concentration and/or Specific Gravity | Daily | NA |
| | | Suspended solids | Semi-annually (complete replacement of the quench media and cleaning of the quench tank within six months satisfies this requirement) | NA |
| D5.4 | 2.13 | **Rust Preventive - Soluble Oil** | | |
| | | Concentration | 2x / week | OK (If Used) |
| D5.5 | 2.11 | **Washers** | | |
| | | Concentration of cleaner | Daily | NA |
| | | Temperature of solution (required if temperature is specified to be above ambient temperature). | Each shift | OK |

## 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | |
|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | **OK / NOK / NA** |
| E1.1 | 3.1<br>3.7 | All furnaces, generators and quench systems (where applicable) shall have temperature indicating instruments. | OK |
| E1.2 | 3.1<br>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. | OK |
| E1.3 | 3.2 | Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum. | OK |
| 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. | OK |
| 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. | OK |
| 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. | OK |
| E1.7 | 3.2 | Oxygen probe controllers shall be calibrated quarterly (single-point or multi-point calibration) or semi-annual (multi-point calibration only; single-point calibration not allowed). This is applicable when used in controlling carbon-bearing atmospheres. | OK |
| E1.8 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved standard. | OK |
| E1.9 | 3.2 | Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified prior to use (with distilled water) and calibrated annually (per manufacturer's requirements) at a minimum. | OK |

## 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | |
|---|---|---|---|
| **2.0** | | **PYROMETRY** | **OK / NOK / NA** |
| E2.1 | 3.2<br>3.3 | Thermocouples and calibration of thermocouples shall conform to Section 3.1. | OK |
| E2.2 | 3.2<br>3.3 | Pyrometry Instrumentation and Calibration shall conform to Section 3.2. | OK |
| E2.3 | 3.2<br>3.3 | CQI-9 requires a System Accuracy Test (SAT) check of the control thermocouple in the Qualified Work Zone per Section 3.3. | OK |
| E2.4 | 3.4 | TUS shall be performed annually and after major rebuild per Section 3.4.<br><br>Temperature uniformity tolerance for furnaces operating at austenitizing temperatures shall be +/- 15$^{o}$C (or +/- 25$^{o}$F). Temperature uniformity tolerance for tempering furnaces shall be +/- 10$^{o}$C (or +/- 20$^{o}$F). | OK |
| E2.5 | 3.5 | Recorded temperature(s) for austentizing processes shall be controlled within +/- 10$^{o}$C (or +/- 15$^{o}$F) 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).<br><br>For Continuous Furnaces, this requirement applies to the Qualified Work Zone. | OK |

# 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | |
|---|---|---|---|---|---|---|
| **3.0** | | **PROCESS MONITOR FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | **Generators** | **OK / NOK / NA** |
| E3.1 | 1.4<br>2.14 | Monitor primary temperature control instrument(s). | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per limits in E2.5) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours). Alarm systems (if set per limits in E2.5) satisfy the sign-off requirement. | Sign-off required for each shift for generators. | OK |
| E3.2 | 1.4<br>2.14<br>3.7 | Monitor generator atmospheres | | | Generators shall be continuously monitored and alarmed. Other systems, such as nitrogen-methanol systems, may either be continuously monitored and alarmed, or sign-off every 2 hours. | OK |
| E3.3 | 1.4<br>2.14<br>3.7 | Monitor primary furnace atmosphere control(s) | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours. Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | | OK |
| E3.4 | 1.4<br>2.14<br>3.7<br>3.8 | Verify primary atmosphere control method by back-up method. | Daily | Daily | | OK |
| E3.5 | 1.4<br>2.14<br>3.13 | For salt baths: check salt chemistry (soluble oxides) in salt baths or decarburization on the parts. | Daily | Daily | | NA |
| E3.6 | 1.4<br>2.14 | Monitor time in furnace, cycle time or belt speed. | Each batch | Twice/shift & after any change in the belt speed. | | OK |
| E3.7 | 1.4<br>2.7 | Monitor load size, fixturing or loading rate as applicable. | Each batch | Twice/shift & after any change in loading rate. | | OK |

## 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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | |
|---|---|---|---|---|---|---|
| **4.0** | | **IN-PROCESS/FINAL TEST FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | | **OK / NOK / NA** |
| E4.1 | 1.4<br>2.15 | Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available. | Each batch | Each production run or each shift at a minimum. | | OK - as required |
| E4.2 | 1.4<br>2.15 | Surface hardness (when specified) | Each batch | Every 4 hours | | OK |
| E4.3 | 1.4<br>2.15 | Core hardness (when specified) | Each batch | Every 4 hours | | OK - as required |
| **5.0** | | **SOLUTION TEST FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | | **OK / NOK / NA** |
| E5.1 | 2.13 | **Rust Preventive - Soluble Oil** | | | | |
| | | Concentration | 2x / week | 2x / week | | OK (if used) |
| E5.2 | 2.11 | **Washers** | | | | |
| | | Concentration of cleaner | Daily | Daily | | N/A |
| | | Temperature of solution (required if temperature is specified to be above ambient temperature). | Each shift | Each shift | | OK |

# PROCESS TABLE F - Low Pressure Carburizing

**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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | |
|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | **OK / NOK / NA** |
| F1.1 | 3.1<br>3.7 | All furnaces and liquid quench systems shall have temperature indicating instruments. | N/A |
| F1.2 | 3.1 | All gaseous quench systems shall have pressure indicators and fan operation indicators. | N/A |
| F1.3 | 3.1<br>3.7 | Recording instruments are required for temperature and, hydrocarbon flow and pressure. | N/A |
| F1.4 | 3.2 | Furnace weigh scales shall be verified quarterly and calibrated annually at a minimum. | N/A |
| F1.5 | 3.2 | Hydrogen sensors and carbon IR combustion analyzers used to verify carbon potential in furnaces, shall be calibrated annually at a minimum. | N/A |
| F1.6 | 3.2 | Verification of calibration of spectrometers and carbon IR combustion analyzers, shall be checked daily or prior to use. | N/A |
| F1.7 | 3.2 | Vacuum monitoring devices calibrated annually. | N/A |
| F1.8 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved | N/A |
| F1.9 | 2.16 | Files for testing hardness shall be verified per the Customer requirement. | N/A |
| F1.10 | 3.2 | Refractometers (typically used to check polymer quenchants and washer solutions) shall be verified prior to use (with distilled water) and certified annually per manufacturer's requirements at a minimum. | N/A |

## PROCESS TABLE F - Low Pressure Carburizing

**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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | |
|---|---|---|---|
| **2.0** | | **PYROMETRY** | **OK / NOK / NA** |
| F2.1 | 3.2<br>3.3 | Thermocouples and calibration of thermocouples shall conform to Section 3.1. | NA |
| F2.2 | 3.2<br>3.3 | Pyrometry Instrumentation and Calibration of instrumentation shall conform to Section 3.2. | NA |
| F2.3 | 3.2<br>3.3 | CQI-9 requires a System Accuracy Test (SAT) check of the control thermocouple in the Qualified Work Zone per Section 3.3. | NA |
| F2.4 | 3.4 | TUS shall be performed annually and after major rebuild per Section 3.4.<br><br>Temperature uniformity tolerance for hardening and tempering furnaces shall be +/- 10 C or +/- 20 F. | NA |
| F2.5 | 3.5 | Recorded temperature(s) for austentizing and tempering processes shall be controlled within +/- 5 C or +/- 10 F 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). | NA |

# PROCESS TABLE F - Low Pressure Carburizing

**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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | |
|---|---|---|---|---|
| **3.0** | | **PROCESS MONITOR FREQUENCIES** | | **OK / NOK / NA** |
| F3.1 | 1.4<br>2.14 | Monitor primary temperature control instrument(s). Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per limits in F2.5) satisfy the sign-off requirement. | | N/A |
| F3.2 | 1.4<br>2.14<br>3.7 | Monitor primary furnace atmosphere control(s) or hydrocarbon flows. Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | | N/A |
| F3.3 | 1.4<br>2.14 | Monitor pressure in the carburizing and gas quenching process. Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours (carburizing process). Continuous recording with sign-off each batch (quenching process). Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | | N/A |
| F3.4 | 1.4<br>2.14<br>3.7<br>3.8 | Verify primary atmosphere control method by back-up method by microstructural evaluation of parts or coupon, or carbon analysis of shim stock or carbon bar. Verification shall be daily. | | N/A |
| F3.5 | 1.2<br>2.7 | Prior to production (APQP), the surface area of the parts shall be calculated and documented for each load configuration. | | N/A |
| F3.6 | 1.4<br>2.12 | **Quench Media Process Parameters - Oil** | **FREQUENCY** | N/A |
| | | Temperature | Continuous recording with alarm system is required. | NA |
| | | Quench Level | Daily check or alarm system is required. | NA |
| | | Agitation | Daily check or alarm system is required.<br><br>Acceptable methods for checking agitation are using flow sensors, current sensors, or pressure differential sensors. | NA |
| F3.7 | 1.4<br>2.12 | **Quench Media Process Parameters - Gas** | | N/A |
| | | Pressure in the quench cell | Monitor each load. Alarm system is required | N/A |
| | | Fan speed or power | Monitor each load. Alarm system is required | N/A |
| | | Cooling water temperature and flow rate | Monitor each load. Alarm system is required | N/A |
| F3.8 | | Pressure monitors in cells shall be correlated. | Weekly | N/A |
| F3.9 | 1.4<br>2.12 | Temper Delay Time -<br>The maximum delay time between quenching and tempering shall be specified on the control plan and monitored. | Each batch | N/A |

# PROCESS TABLE F - Low Pressure Carburizing

**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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | |
|---|---|---|---|---|
| **4.0** | | **IN-PROCESS/FINAL TEST** | **FREQUENCY** | **OK / NOK / NA** |
| F4.1 | 1.4<br>2.15 | Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available. | Daily per furnace (may rotate cells) or any time one of the process parameters is out of specification. | N/A |
| F4.2 | 1.4<br>2.15 | Surface hardness | Each batch | N/A |
| F4.3 | 1.4<br>2.15 | Core hardness (when specified) | Daily per furnace (may rotate cells) or any time one of the process parameters is out of specification. | N/A |
| F4.4 | 1.4<br>2.15 | Case depth (when specified) | Daily per furnace (may rotate cells) or any time one of the process parameters is out of specification. | N/A |
| **5.0** | | **QUENCHANT AND SOLUTION TEST** | **FREQUENCY** | **OK / NOK / NA** |
| F5.1 | 2.12<br>3.14 | **Polymer Quench Solution** | | N/A |
| | | Concentration | Daily | N/A |
| | | Quenchability Check cooling curve. Check viscosity or titration. | Semi-annually | N/A |
| F5.2 | 2.12<br>3.14 | **Water Quenching** | | N/A |
| | | Suspended solids | Semi-annually | N/A |
| F5.3 | 2.12<br>3.14 | **Oil Quenching** | | N/A |
| | | Water content, suspended solids, viscosity, cooling curve, total acid, and flash point. | Semi-annually | N/A |
| F5.4 | 2.13 | **Rust Preventative Solution** | | N/A |
| | | Concentration shall be checked when the rust preventative is mixed in-house. | 2x / week | N/A |
| F5.5 | 2.11 | **Washers** | | N/A |
| | | Concentration of cleaner | Daily | N/A |
| | | Temperature of solution (required if temperature is specified to be above ambient temperature). | Each shift | N/A |

# PROCESS TABLE G - Sinter Hardening

**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.**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | |
|---|---|---|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | | | | **OK / NOK / NA** |
| G1.1 | 3.1<br>3.7 | All furnaces, generators and quench systems shall have temperature indicating instruments. | | | | NA |
| G1.2 | 3.1<br>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. | | | | NA |
| G1.3 | 3.1 | Atmosphere flow meters/indicators are required. | | | | NA |
| G1.4 | 1.18 | A program for furnace and generator burnout is required (applies to carbon bearing atmospheres). | | | | NA |
| G1.5 | 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 (applies to carbon bearing atmospheres). | | | | NA |
| G1.6 | 3.2 | Verification of calibration of spectrometers, and carbon IR combustion analyzers, shall be checked daily or prior to use (applies to carbon bearing atmospheres). | | | | NA |
| G1.7 | 3.2 | Verification of calibration of 3-gas analyzers with zero gas and span gas shall be performed weekly at a minimum (applies to carbon bearing atmospheres). | | | | NA |
| G1.8 | 3.2 | Oxygen probe controllers shall be calibrated quarterly (single-point or multi-point calibration) or semi-annual (multi-point calibration only; single-point calibration not allowed). This applies to carbon bearing atmospheres. | | | | NA |
| G1.9 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved standard. | | | | NA |
| **2.0** | | **PYROMETRY** | | | | **OK / NOK / NA** |
| G2.1 | 3.2<br>3.3 | Thermocouples and calibration of thermocouples shall conform to Section 3.1. | | | | NA |
| G2.2 | 3.2<br>3.3 | Pyrometry Instrumentation and Calibration of instrumentation shall conform to Section 3.2. | | | | NA |
| G2.3 | 3.2<br>3.3 | CQI-9 requires a System Accuracy Test (SAT) check of the control thermocouple in the Qualified Work Zone per Section 3.3. | | | | NA |
| G2.4 | 3.4 | TUS shall be performed annually and after major rebuild per Section 3.4.<br><br>Temperature uniformity tolerance for hardening furnaces shall be +/- 15ºC (or +/- 25ºF). Temperature uniformity tolerance for tempering furnaces shall be +/- 10ºC (or +/- 20ºF). | | | | NA |
| G2.5 | 3.5 | Recorded temperature(s) for sintering processes shall be controlled within +/- 10ºC (or +/- 15ºF) of the set point for processes operating less than 1000ºC (1830ºF) and +/- 20ºC (+/- 35ºF) for processes operating greater than 1000ºC (1830ºF) as evidenced by continuous recording pyrometers. Furnace temperature shall be controlled with soak times starting at the lower tolerance limit (as defined above).<br><br>**For Continuous Furnaces, this requirement applies to the Qualified Work Zone.** | | | | NA |
| **3.0** | | **PROCESS MONITOR FREQUENCIES** | **Batch Furnace** | **Continuous Furnace** | **Atmosphere Generation** | **OK / NOK / NA** |
| G3.1 | 1.4<br>2.14 | Monitor primary temperature control instrument(s). | Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours. Alarm systems (if set per limits in G2.5) satisfy the sign-off requirement. | Continuous recording with sign-off every 2 hours or each lot for processes under 2 hours). Alarm systems (if set per limits in G2.5) satisfy the sign-off requirement | One of the three options is required.<br><br>(1) Record temperature 2x per shift or after any change.<br><br>(2) Continuously record temperature and sign-off 2x per shift or after any change.<br><br>(3) Alarm system on temperature controller. | NA |
| G3.2 | | Monitor generator atmospheres. | | | One of the three options is required.<br><br>(1) Record value(s) representing atmosphere 2x per shift.<br><br>(2) Continuously record value(s) representing atmosphere and sign-off 2x per shift.<br><br>(3) Alarm system on atmosphere controller. | NA |

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

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | |
|---|---|---|---|---|---|---|
| G3.3 | 1.4<br>2.14<br>3.7 | Monitor primary furnace atmosphere control(s) **Flow rates**. | Batch processes are in vacuum furnaces:<br><br>Monitor pressure in the carburizing and gas quenching process. Continuous recording with sign-off every 2 hours or each batch for processes under 2 hours (carburizing process). Continuous recording with sign-off each batch (quenching process).<br><br>Alarm systems (if set per acceptable limits) satisfy the sign-off requirement. | One of the three options is required.<br><br>(1) Record value(s) representing atmosphere 2x per shift or after any change.<br><br>(2) Continuously record value(s) representing atmosphere and sign-off 2x per shift or after any change.<br><br>(3) Alarm system on atmosphere controller or flow meter. | | NA |
| G3.4 | 1.4<br>2.14<br>3.7<br>3.8 | Verify primary atmosphere control method by back-up method**. FOR ENDOTHERMIC ATMOSPHERE ONLY. | Daily | Daily | | NA |
| G3.6 | 1.4<br>2.12 | **Quench Media Process Parameters - Oil** | | | | NA |
| | | Temperature of water exchange system for quench chamber (does not apply to convection systems) | One of the three options is required.<br><br>(1) Record temperature per batch or 2x per shift whichever is more frequent.<br><br>(2) Continuously record temperature and sign-off per batch or 2x per shift whichever is more frequent.<br><br>(3) Alarm system on temperature controller. | One of the three options is required.<br><br>(1) Record temperature 2x per shift or after any change.<br><br>(2) Continuously record temperature and sign-off 2x per shift or after any change.<br><br>(3) Alarm system on temperature controller. | | NA |
| | | Agitation (Fan/Blower Speed) | Alarm system is required to ensure proper operation of the fans.<br><br>If fan speed is variable, then verify fan speed **Every 8hrs or after any change.** | Alarm system is required to ensure proper operation of the fans.<br><br>If fan speed is variable, then verify fan speed **Every 8hrs or after any change.** | | NA |
| G3.7 | 1.4<br>2.12 | **Quench Media Process Parameters - Gas** | | | | NA |
| | | Pressure in quench vestible | Monitor each load. Alarm system is required | | | NA |
| | | Fan speed or power | Monitor each load. Alarm system is required | | | NA |
| | | Cooling water temperature and flow rate | Monitor each load. Alarm system is required | | | NA |
| G3.8 | 1.4<br>2.14 | Monitor time in furnace, cycle time or belt speed. | Each batch | Twice/shift & after any change in the belt speed. | | NA |
| G3.9 | 1.4<br>2.7 | Monitor load size or fixturing or loading rate as applicable. | Each batch | Twice/shift & after any change in loading rate. | | NA |
| G3.10 | 1.4<br>2.12 | Quench Delay Time -<br>Quench delay time shall be based on the time that the furnace door starts to open to the time the load is at the bottom of the quench tank (oil) or the start of the gas pressure quenching (gas quench). | Each batch | Not applicable for belt furnaces. | | NA |
| **4.0** | | **IN-PROCESS/FINAL TEST FREQUENCIES** | | | | **OK / NOK / NA** |

## PROCESS TABLE G - Sinter Hardening

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

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | | | |
|---|---|---|---|---|---|---|
| G4.1 | 1.4<br>2.15 | Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available. | Per customer requirement as specified in control plan. | Per customer requirement as specified in control plan. | | NA |
| G4.2 | | Mechanical Testing (when specified) | Each Lot | Each Lot | | NA |
| G4.3 | 1.4<br>2.15 | Apparent hardness | Each batch | Every 4 hours | | NA |
| G4.4 | 1.4<br>2.15 | Core hardness (when specified) | Each batch | Every 4 hours | | NA |
| G4.5 | 1.4<br>2.15 | Microstructure | Each batch | 1st piece and last piece each lot | | NA |

# PROCESS TABLE H - Ion Nitriding

**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.**

**Please note that the corresponding gas nitriding is Table "B" and the Plasma Ion Nitriding is is Table "H"**

**OK - Complies to requirement**
**NOK - Does not comply to requirement (Explain noncompliance in 'Related HTSA Question #')**
**NA - Requirement not applicable**

| Item # | Related HTSA Question # | Category/Process Steps | | |
|---|---|---|---|---|
| **1.0** | | **PROCESS AND TEST EQUIPMENT REQUIREMENTS** | | **OK / NOK / NA** |
| H1.1 | 3.1<br>3.7 | All vessels shall have temperature, flow meters, vacuum gages, and gas flow indicating instruments. | | NA |
| H1.2 | 3.1<br>3.7 | Data loggers and/or Recording instruments are required for temperature, **pressure**, amps and volts. Amps and volts are referance only. Frequency is per customer and control plan | | NA |
| H1.3 | 1.18 | Vessel is to be free of contamination that may affect the process. | | NA |
| H1.4 | 3.2 | Vacuum gages are to be calibrated a minimum of annually. | | NA |
| H1.5 | 3.2 | Gas ratios controller / meters shall be calibrated / verified as recommended by the manufacturer. As an option gas composition may be analyzed using gas mixture analyzer semi- annually and calibrated as recommended by the manufacturer. | | NA |
| H1.6 | 2.16 | All hardness test equipment (for each scale used) shall be calibrated annually minimum, and verified daily or prior to use, per the applicable ASTM standard, ISO standard, JIS standard, or approved standard. | | NA |
| H1.7 | 2.16 | Files for testing hardness, if used, shall be verified per the Customer requirement. | | NA |
| **2.0** | | **PYROMETRY** | | **OK / NOK / NA** |
| H2.1 | 3.2<br>3.3 | Thermocouples and calibration of thermocouples shall conform to Section 3.1. | | NA |
| H2.2 | 3.2<br>3.3 | Pyrometry Instrumentation and Calibration of instrumentation shall conform to Section 3.2. | | NA |
| H2.3 | 3.2<br>3.3 | Protection Tubes for thermocouples in the vessels, if used, shall be visually checked for each batch. | | NA |
| H2.4 | 3.4 | Temperature Uniformity Survey (TUS) and Systems Accuracy Test (SAT) are not required.<br>In lieu of TUS & SAT, Temperature ranges shall established during preproduction testing usining multiple thermocouples representing the work zone and confirmed in the capability study and documented in the Control Plan for each part. | | NA |
| H2.5 | 3.5 | Temperature shall be controlled with thermocouples in the load for each batch placed as practical to represent the extremes of the load (max and min temperatures) as evidenced by recording. | | NA |
| H2.6 | 3.2 | Infrared pyrometers shall be calibrated annually using proper calibration methods or an approved manufacturer's procedure. | | NA |
| **3.0** | | **PROCESS MONITOR PARAMETERS** | **FREQUENCY** | **OK / NOK / NA** |
| H3.1 | 1.4<br>2.14 | Monitor temperature control instrument(s). | Each batch or recording per see H1.2 above with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement. Control plan to include the lose of a thermocouple during the run and alarm settings. Alarms are to be checked quarterly and alarms during the cycle are to be documented. | NA |
| H3.2 | 1.4<br>2.14<br>3.7 | Monitor vessel vacuum control(s). | Each batch or recording per see H1.2 above with sign-off every 2 hours. Alarm systems satisfy the sign-off requirement. Control plan to include the alarm setting. Alarms are to be checked quarterly and alarms during the cycle are to be documented. | NA |
| H3.3 | 1.4<br>2.11<br>2.12 | Pump down of 75 microns per hour or less and leak up of 90 microns per hour or less are required prior to initiating the cycle | Each Batch | NA |
| H3.5 | 1.4<br>2.14 | Monitor time in furnace, cycle time. | Each batch | NA |
| H3.6 | 1.4<br>2.7 | Monitor load size or fixturing as applicable. | Each batch | |
| 4.0 | | **IN-PROCESS/FINAL TESTS** | **FREQUENCY** | **OK / NOK / NA** |
| H4.1 | 1.4<br>2.15 | Microstructure characteristics including compound zone and etched zone shall be checked. Microstructure shall be checked at a minimum magnification of 100x and, 400x or above 400x. Microstructural visual references shall be available. | Each Batch | NA |
| H4.2 | 1.4<br>2.15 | Surface hardness | Each Batch | NA |
| H4.3 | 1.4<br>2.15 | Core hardness (when specified) | Each Batch | NA |
| H4.4 | 1.4<br>2.15 | Case depth (when specified) | Each Batch | NA |
| 5.0 | | **SOLUTION TESTS** | **FREQUENCY** | **OK / NOK / NA** |
| H5.1 | 2.13 | **Rust Preventive - Soluble Oil** | | |
| | | Concentration - **when not purchased as a mixed solution** | 2x / week or as appropriate for cleaning the parts or per customer and Control Plan | NA |
| H5.2 | 2.11 | **Washers** | | NA |
| | | Concentration of cleaner | Daily or as appropriate for cleaning the parts or per customer and Control Plan | NA |
| | | Temperature of solution (required if temperature is specified to be above ambient temperature). | Each shift or as appropriate for cleaning the parts or per customer and Control Plan | NA |