MATERIAL SPECIFICATION

Part No: 26109031 **Rev/Chg Level:** 002A

Specification Name: SPEC, REQ FOR HT PARTS

Production Release

SAFETY AND/OR GOVERNMENT REGULATED PART ☐YES ☒NO					
DESIGNATED CHARACTERISTICS REF: NEXTEER GLOBAL PROCEDURE G1331			**DC SYMBOL**	**QCL TYPE**	**QCI TYPE**
0	**LAST NO USED**	**SAFETY/COMPLIANCE**		**CL1/CL2**	**QS-100V QS-DR**
0	**TOTAL ON DRAWING**	**FIT/FUNCTION**		**CL4/CL5**	**CI-100V CI-DR**
DC NO	**TYPE**	**DESCRIPTION**	**RATIONALE**	**ZONE**	**SH**

Substances of Concern and Recycled Content per Nexteer Automotive 23000000

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

1. SCOPE:

1.1. The purpose of this specification is to provide the expectations and requirements for heat treated components for Nexteer Automotive. This specification is applicable to all heat treat processes being conducted on the intended component(s) at any point in the value stream. Heat treat processes governed by this standard include all of those referenced in AIAG CQI-9. Heat treaters are expected to conform to the Quality System Requirement provided in the Nexteer Automotive Global Supply Management Supplier Requirements. It assumes that quality planning, a quality manual, and continuous improvement programs are established.

1.2. Exceptions to this specification, and alternative plans for control of heat treating processes may be used provided they afford adequate protection of a process currently proven to be stable and capable, are documented in a control plan, and have the written concurrence of the affected Nexteer Automotive receiving plant metallurgist or materials engineer.

1.3. The heat treater shall have the latest revision Nexteer Automotive engineering drawing with any associated purchase specifications listing the engineering and manufacturing requirements (e.g., incoming material, case depth, surface hardness, core hardness, hardenability, sizes, sampling, etc.) of Nexteer Automotive parts to be processed. The heat treater may have supplemental internal written specifications to further describe their unique process characteristics to achieve Nexteer Automotive's functional requirements. Any exceptions to the requirements in this specification will be stated on either the engineering drawing or the purchase specification.

2. REFERENCED STANDARDS AND DOCUMENTS:

2.1. This section provides the methods to be used for material testing. The requirement for what tests needing to be performed shall be defined through sections 7.15 through 7.18, AIAG CQI-9, engineering drawing and/or the purchase specification.

2.2. Nexteer Automotive Central Materials Laboratory Procedure SDM-322.

2.3. SAE J423 Methods of Measuring Case Depth.

2.4. ASTM E112 Standard Test Methods for Determining Average Grain Size

2.5. AIAG CQI-9 Special Process: Heat Treat System Assessment

2.6 ASTM E18 Standard Test Methods for Rockwell Hardness for Rockwell Hardness of Metallic Materials

2.7 ASTM E384 Standard Test Method for Knoop and Vickers Hardness of Materials

2.8 ASTM E140 Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop hardness, and Scleroscope Hardness

2.9 ASTM E3 Standard Guide for Preparation of Metallographic Specimens

2.10 ASTM E407 Standard Practice for Microetching Metals and Alloys

2.11 ASTM E1077 Standard Test Methods for Estimating the Depth of Decarburization of Steel Specimens

3. ENVIRONMENTAL/SAFETY REQUIREMENTS:

3.1. All materials supplied to this specification must comply with the requirements of Nexteer Automotive 23000000, Substances of Concern and Recycled Content.

3.2. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this specification to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

4. GENERAL MATERIAL CONFORMANCE REQUIREMENTS:

4.1. The heat treater shall establish a written process specification for each unique part. The process specification shall completely describe the process to assure that the parts meet the requirements of the engineering drawing. All parts must be heat treated to the defined process and specification. All heat treat process parameters shall be consistent with good metallurgical practices defined in industry standards, and manuals (including heat treat equipment manufacturers). The process specification shall include at least the following:

4.1.1. The principal operating parameters, such as:

4.1.1.1. Temperature

4.1.1.2. Cycle time

4.1.1.3. Carbon potential

4.1.1.4. Energy input

4.1.2. Target values, and upper/lower control limits

4.1.3. Part and/or furnace loading conditions

4.1.4. In process and final product evaluation

4.1.5. Sampling frequencies

4.1.6. Test location on the parts

4.2. A written control plan is required for parts covered by this specification. It shall include both in process checks, and finish product evaluations against the engineering drawing specifications.

4.3. No rework of Nexteer Automotive parts is permitted without prior approval of the Nexteer Automotive receiving plant metallurgist. When Nexteer Automotive approval is granted, procedures for rework, both processing and inspection are required.

4.4. The heat treater shall provide an equipment layout and work flow diagram for Nexteer Automotive's review. The equipment layout shall include type and manufacturer of furnaces, and test equipment (i.e., hardness testers).

4.5. The usage of dedicated equipment (i.e., consistent atmosphere for a furnace, consistent temperature settings for a tempering furnace, induction coils to machines for induction operations, etc.) for Nexteer Automotive parts is strongly recommended. For heat treaters that utilize the same equipment for multiple processes and which require changeovers the receiving Nexteer Automotive plant metallurgist must review and approve the heat treater’s changeover procedures (which must include verification) prior to start of production. This process must be documented in the heat treater's process control plan.

4.6. An operations manual including emergency, start-up, shutdown, and general operating procedures should be readily available to the production supervisors and operators. It should also include process sheets, inspection sheets, control plans, troubleshooting guide, alerts, and other pertinent information needed by operating, inspection, and maintenance personnel.

4.7. The heat treater must demonstrate that the equipment used for the heat treatment process is within upper and lower control limits, and that the process produces parts which comply with the engineering drawing specifications.

4.8. Parts must be clean, free of rust, burrs, and chips, and free from detrimental amounts of drawing, forming and/or rust preventative oils and lubricants prior to heat treatment. Parts must be clean or cleaned after heat treat to provide adequate corrosion protection per the engineering drawing or purchase specification.

4.9. Good housekeeping must be exercised at all times. All parts found on the floors must be scrapped. All parts that have been found as a result of maintenance on heat treat equipment and/or housekeeping must be scrapped (i.e. parts left in quench tanks, stuck in conveyors, washers, etc.).

5. GENERAL TEST METHOD REQUIREMENTS:

5.1. All test methods used (i.e. ASTM E18, SAE J423, etc…) shall be documented in the heat treater's control plan and approved by the Nexteer Automotive receiving plant metallurgist or product materials engineer.

5.1.1 All Rockwell hardness testing performed shall be done per ASTM E18. If microhardness is necessary, ASTM E384 shall apply. All hardness conversions needed shall be converted and reported per ASTM E140.

5.1.2 All metallographic samples prepared shall be per ASTM E3.

5.1.3 All metallographic samples undergoing microetching shall be performed per ASTM E407.

5.1.4 All grain size evaluations conducted shall be per ASTM E112.

5.1.5 All Retained Austenite Ratings (RAR) evaluated shall be per the RAR Chart of SDM-322.

5.1.6 All case depth (including total and effective) determined shall be per SAE J423. When determining case depth by measuring from the surface (edge) of a sample to a direct hardness indentation, the depth is to be read to the center point (half of the diameter) of the indent. See Figure 1.

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

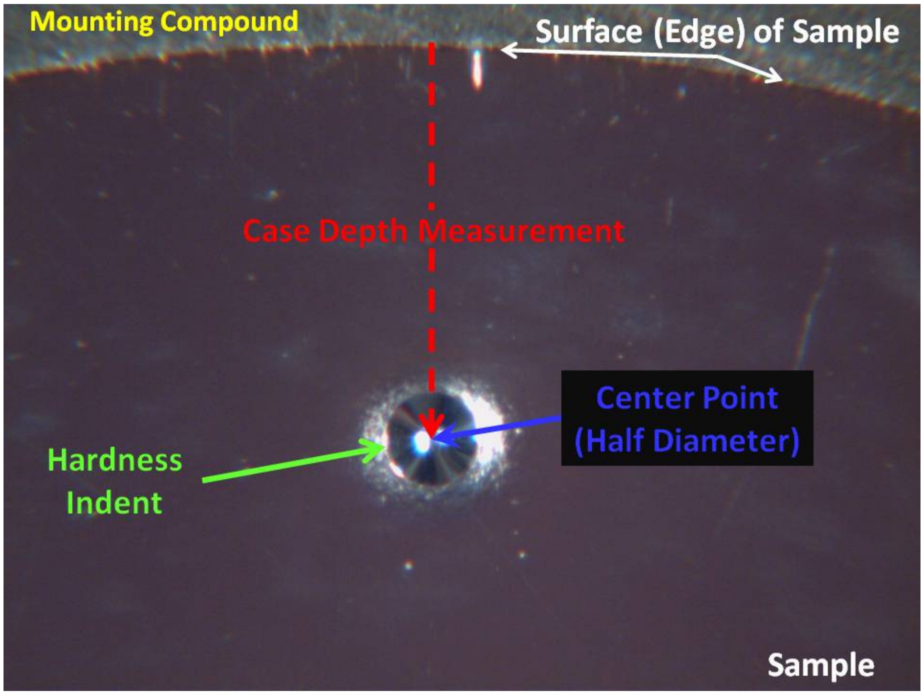

Figure 1: *Photograph example of measuring case depth to the center point of a direct hardness indentation.*

5.1.7 All decarburization evaluations performed shall be per ASTM E1077.

5.1.8 All Intergranular oxidation (IGO) measurements performed shall be on non-etched metallographically prepared samples. The IGO depth shall be measured from a surface defined by the engineering drawing or purchase specification. Figure 2 provides an example photograph illustrating how to measure the depth of IGO.

5.1.9 All non-martensitic transformation product (NMTP) measurements performed shall be on a metallographically prepared sample that has been etched based on ASTM E407 with the specifics stated below. The depth of NMTP shall be measured from a surface defined by the engineering drawing or purchase specification. Figure 3 provides a photograph of an example microstructure illustrating how to measure the depth of NMTP.

Etching Specifics:
5.1.9.1 Utilize a 2% Nital etchant
5.1.9.2 Etch the sample for 10-15 seconds
5.1.9.3 Rinse the sample in running tap water
5.1.9.4 Rinse the sample in hot water to aid / accelerate drying
5.1.9.5 Dry the sample with forced air

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

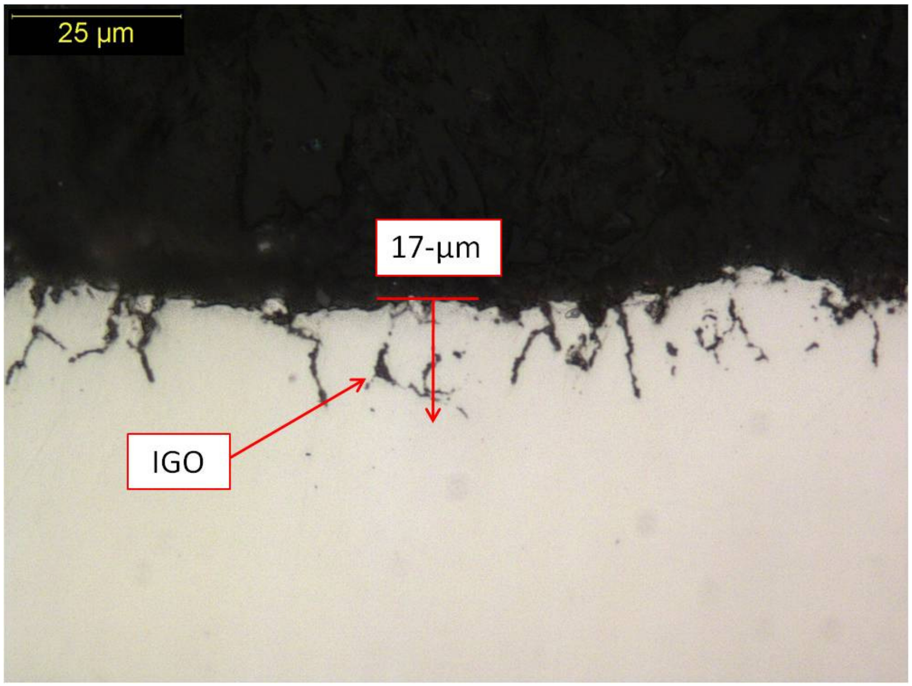

Figure 2: *Example of a metallographically prepared sample with the IGO depth measured (1000X Original)*

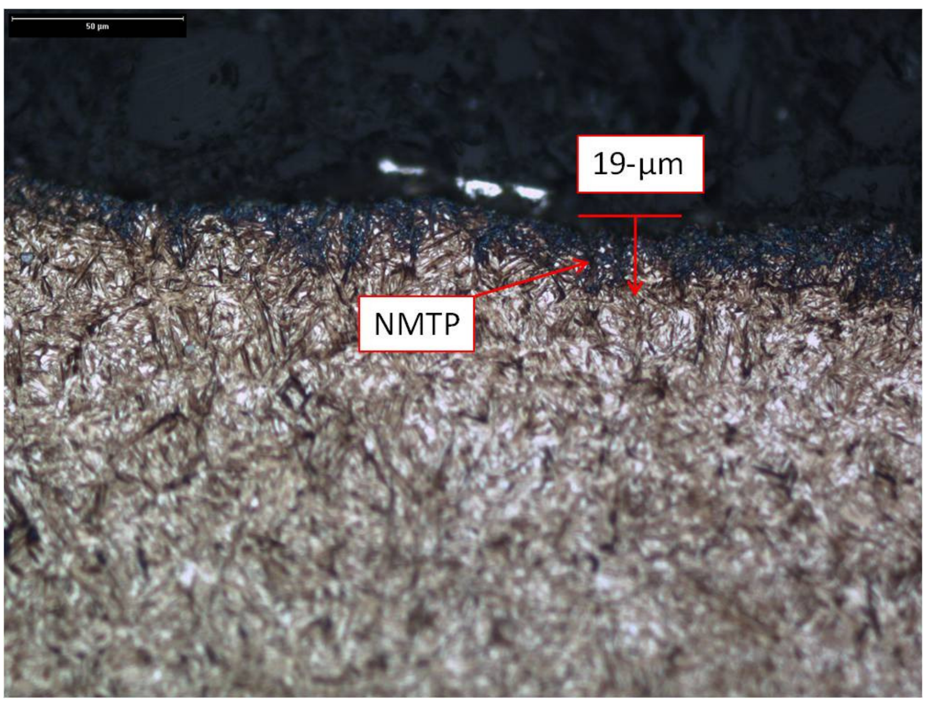

Figure 3: *Example of a metallographically prepared sample that has been etched per the specifics of 5.1.9 with the NMTP depth measured (500X Original)*

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

6. PROCESS CONSTRAINTS FOR FERROUS COMPONENTS REQUIRING HARDENING (e.g. NEUTRAL HARDENING, CARBONITRIDING, CARBURIZING, AND CONDUCTION/INDUCTION HARDENING):

6.1. AUSTENITIZING TEMPERATURE:

6.1.1. For carbonitriding: The maximum temperature shall not exceed 870°C.

6.1.2. For atmosphere carburizing: The maximum recommended temperature is 925°C.

6.1.3. For low pressure carburizing: The maximum recommended temperature is 1035°C.

6.1.4. For induction hardening: The maximum recommended temperature is 1200°C.

Note: If it is necessary to exceed the recommended temperatures for carburizing and induction hardening due to unique process characteristics or product performance requirements, it is required to obtain prior approval from the Nexteer Automotive receiving plant metallurgist or product materials engineers.

6.2. TEMPERING:

6.2.1. All parts must be furnace tempered at 163 +/- 5°C for 1 hour minimum (with the parts at the specified tempering temperature) unless otherwise stated on the engineering drawing or purchase specification (ie., to a given hardness, an alternate temperature/time, or process). Tempering must occur within 2 hours of being removed from the quench with the exception of in-line processing which is 4 hours maximum.

6.2.2 Alternative tempering methods are not allowed unless prior agreement from Nexteer Product and Materials Engineering has been obtained.

6.2.2.1 When alternative tempering processes have been agreed upon, the methods of tempering shall be documented in the control plan, and agreed to by Nexteer Product and Materials Engineering.

6.2.2.2 When alternative tempering processes have been agreed upon, the tempered part must show a hardness decrease from the “as quenched” hardness equal to or greater than for furnace tempering as stated above.

6.2.2.3 It is expected that a tempering hardness decrease minimum be established for all hardened locations, and will be evaluated at the same frequency of those hardness requirements per AIAG CQI-9.

6.2.2.4 When induction tempering has been agreed upon, temperature of the part prior to the start of induction tempering should be measured using an infrared pyrometer. The maximum and minimum incoming part temperatures should be established and documented in the control plan.

6.2.2.5 When induction tempering has been agreed upon, part temperature during the induction tempering process should be measured using an infrared pyrometer. The maximum and minimum part temperatures allowed during the tempering cycle should be established and documented in the control plan.

6.2.2.6 All hardened areas must receive an effective temper including areas outside the required hardening pattern, also known as run-out zones.

6.2.3 Retempering Test (for referee purposes only). To determine if the parts have been sufficiently tempered, the hardness of the tempered parts shall be measured before and after retempering. Parts shall be retempered for 30 minutes at a part temperature of 10 °C less than the minimum production tempering temperature. The difference between before and after retempering shall not exceed 20 Vickers units. Measure the Vickers hardness by averaging three readings using HV0.5.

6.2.4. A maximum delay time between the quench and temper operations shall be specified and monitored in the control plan. The action shall be recorded in a logbook, data logger, or other record.

6.2.5. Under no circumstances are properly hardened parts to be unloaded from heat treat containers/fixturing without being tempered except for test samples to be evaluated and disposed of (mutilate prior to disposal) by heat treat inspection.

6.2.6. Parts must never be left in the as-quenched condition during a shutdown. Work must be scheduled so parts will be through all heat treat operations before the shutdown begins.

6.3. RESULTANT MICROSTRUCTURE:

6.3.1. The resultant microstructure after austenitizing, quenching, and tempering shall be predominantly tempered martensite. The heat treater shall adhere to the following Nexteer Automotive best practices:

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

The following conditions will not be accepted:

6.3.1.1. Network carbides (carbides that surround or nearly surround grain boundaries) See Figure 4.

6.3.1.2. Melting or incipient melting (intergranular oxidation due to overheating) See Figure 5.

6.3.2. The following conditions will require prior approval by the Nexteer Automotive receiving plant metallurgist or product materials engineer:

5.3.2.1. Apparent grain size of 2 and coarser.

5.3.2.2. Retained Austenite Rating of 4 and higher

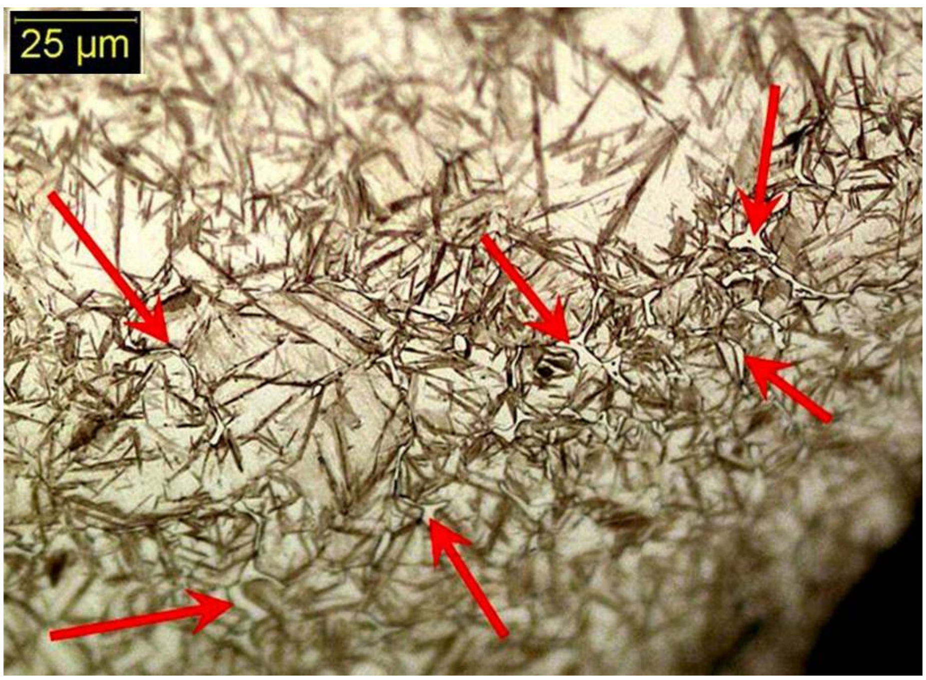

Figure 4: *Photomicrograph network carbides at near surface*
(1000X Original – 2% Nital)

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

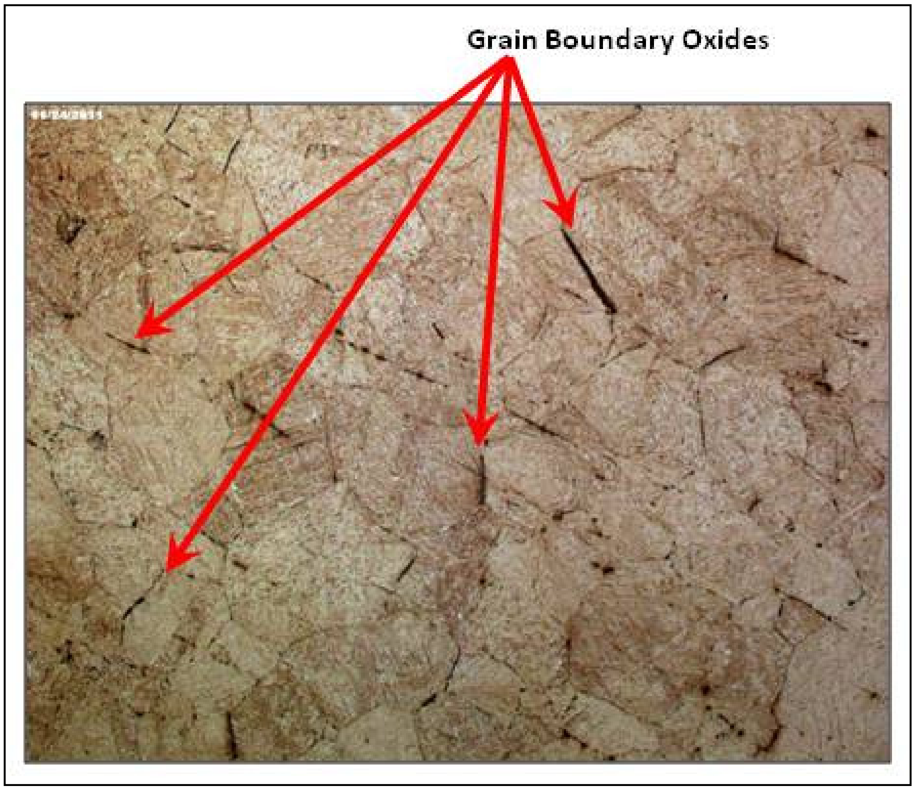

Figure 5: *Photomicrograph of near surface; large apparent grain size and oxide formation at the grain boundaries indicate incipient melting (100X Original – 2% Nital)*

6.4. QUENCH CRACKS

Parts that exhibit quench cracking are not permissible under any circumstances.

6.5 INDUCTION HARDENING PATTERNS

6.5.1 The induction hardening pattern must end on the same dimensional feature (ie., diameter, radius, or transition distance) as initial PPAP / validation samples unless otherwise specified on the Nexteer engineering drawing.

6.5.2 No through hardening is permitted unless prior approval is received from Nexteer Product and Materials Engineering. Through hardening for this purpose will be defined as an increase in part core hardness compared to the part core hardness in the respective location prior to induction hardening.

7. PROCESS MONITORING:

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

7.1. The process must be monitored and the data recorded. Process instructions (job instruction guides and heat treat process specifications), control plans, and/or process sheets must be located in the heat treat department, and available to the responsible operators, maintenance specialists, and/or other designated individuals.

7.2. INDICATED TEMPERATURE:

7.2.1. All temperature controlling and indicating instruments on furnaces, generators, induction units (includes energy monitors, kilowatt meters, timers, etc.), and quench systems shall be evaluated per AIAG CQI-9 for conformance to the set conditions of the process. On instruments with recording charts, the checker, at the time of the check, shall initial and date the face of the chart to verify the check or log.

7.2.2. Temperature uniformity in the designated zones must be checked per AIAG CQI-9 to insure furnace seal integrity and thermal homogeneity.

7.2.3. Recording of temperature data shall be per AIAG CQI-9 requirements.

7.2.4. Over Temperature (high) and Under Temperature (low), where applicable, process controls must be used. To be most effective, the over temperature limit should not be set more than approximately 25°C over the process set temperature. Auditing of alarms for proper functioning must be done on a routine basis.

7.3. STANDARDIZED TEMPERATURE CONTROLLER:
All instruments without built-in automatic self-compensation or constant voltage supply units must be manually checked and balanced against a standard per AIAG CQI-9. This manual standardization shall be recorded in a logbook, data logger or other record provided for that purpose.

7.4. TEMPERATURE MEASUREMENT DEVICES AND PROTECTION TUBES:
There shall be a schedule conforming to AIAG CQI-9 for checking temperature measurement devices and protection tubes on all heat treating furnaces, and it is to be documented in the process control plan.

7.5. MONITOR OF THE FURNACE/GENERATOR OF CARBON BEARING ATMOSPHERE:

7.5.1. All carbon-bearing atmospheres for use in carburizing, carbonitriding, carbon correction, or neutral hardening furnaces must be controlled and monitored at the frequency stated in AIAG CQI-9 to assure conformance with the specified carbon potential. This shall be accomplished by one or more of the following methods:

7.5.1.1. CO_2 Content

7.5.1.2. Oxygen Partial Pressure

7.5.1.3. Electrical Resistance of an Iron Test Wire

7.5.1.4. Complete Gas Analysis

7.5.1.5. Carbon Potential

7.5.1.6. Dew Point

7.5.1.7. Shim stock, Leco carbon or weight analysis

7.5.1.8. Spectrographic surface carbon analysis

7.5.2. The accuracy of instruments must be verified at a frequency sufficient to demonstrate control. The date and time of the verification shall be logged in an appropriate record. Instrument calibration is to be performed per AIAG CQI-9.

7.5.3. A program of routine furnace/generator burn offs per AIAG CQI-9 must be employed and documented, especially when a unit is used for carburizing or carbonitriding.

7.5.4. Furnace conditions must be checked to assure positive internal furnace pressure, to determine the presence of air and gas leaks, and to verify the condition of radiant tubes relative to burn through and cracks.

7.6. ATMOSPHERE FLOW RATE:
All flow meters shall be set and held within specified ranges as required on the heat treat process specifications. They are to be monitored for proper flow (as per the specification), and the readings recorded.

7.7. ATMOSPHERE CHANGES:

7.7.1. When the process for which a furnace is being used is to be changed (for example: carburizing to neutral hardening) the correct furnace atmosphere required for the new process must be fully developed within the furnace, and confirmed by O_2 analyzer, gas analysis, CO_2, or resistance wire before production to the new process can be started.

7. 7.2. When changing over a furnace atmosphere from one utilizing ammonia (carbonitriding) to one in which no ammonia is to be used, the ammonia supply line shall be completely disconnected from the furnace, and the open ends capped, to avoid any possibility of shut-off valve leakage. An alternative method, utilizing a valve arrangement that will direct any ammonia from a leaking valve to the air, rather than to the furnace, may be employed. Where applicable, quick - disconnect couplings designed for use with ammonia may be utilized.

7.7.3. To assure the atmosphere is free from ammonia, there shall be an adequate purge period after using an ammonia atmosphere before a Nexteer Automotive order not specifying ammonia enrichment of the atmosphere may be processed. The furnace must be burned off for a minimum of 2 hours at 925°C.

7.7.4. Record all actions in a logbook, data logger or other record.

7.8. MONITOR OF AN AMMONIA ENRICHED ATMOSPHERE:
Ammonia enriched atmosphere furnaces, known as nitriding or ferritic nitrocarburizing, must be controlled and monitored through an analysis of percent dissociation on a regular basis to assure conformance with the specified dissociation rates. This requirement applies to processes where the furnace temperature is less than 760°C and ammonia is greater than 5% of the incoming gas. The date and time of the verification shall be logged in an appropriate record, along with any necessary corrective actions.

7.9. MONITOR OF SALT BATHS:
All salt bath equipment must be controlled and monitored on a regular basis including the temperature-control system, exhaust smoke from the combustion chamber of fuel-fired furnaces, and bath activity through a rapid performance test. The date and time of the verifications shall be logged in an appropriate record, along with any additions of fresh salt, water, and graphite cover material. For austenitizing salt baths the salt chemistry (soluble oxides) or decarburization on the parts shall be checked per AIAG CQI-9.

7.10. CONDITION OF QUENCH:

7.10.1. The quench system shall be checked per AIAG CQI-9 to assure that quenchant level, temperature, concentration, suspended solids, pressure, visual condition, agitation, flow rate, and pattern adhere to the process specification, and the checks recorded. Oil systems shall be checked to determine their suitability for continued service. Additionally when the quenchant is oil, check the oil for water content, viscosity, and amount of suspended solids formed from oxidation and contamination. Salt baths shall be checked for proper analysis (i.e., contaminants, melting point, etc.), and for any contaminants which may adversely affect bath performance per AIAG CQI-9. The results shall be recorded in a logbook, data logger or comparable record.

7.10.2. A high and low temperature limit is required on quench systems.

7.10.3. The time and temperature that parts are to remain in the quench media must be specified, monitored (each batch for batch furnaces or twice per shift and after any change for continuous furnaces) and recorded.

7.10.4. Any additions to the quench system must be recorded in a log book, data logger, or other record provided for that purpose.

7.11. LOADING RATE AND CYCLE TIME:

7.11.1. For furnace processes the loading rate/cycle time shall be specified and monitored per AIAG CQI-9 to assure thorough and uniform heating, correct time at temperature, uniform exposure to atmosphere gas, and uniform quenching of the load. Controlled methods of loading should be used to error proof these operations (i.e., heat treat trays/fixturing shall be sized accordingly). The loading rate/cycle time as well as the time and date of the check and the checkers initials shall be recorded in a logbook, data logger or other record provided for that purpose.

7.11.2. A method such as event recorders, which provide a record of furnace pushes or cycles, must be used according to AIAG CQI-9 to indicate problems with delays in pushes or quenching, thereby alerting responsible personnel to possibly defective loads.

7.11.3. On furnaces in which the load is not automatically quenched, there shall be a timer and a warning system to alert the operator that it is time to quench the load.

7.11.4. On furnaces which have an integral quench system, there shall be a signal to alert the operator that a load or tray has been delayed between the furnace chamber and the quench media, and there must be a routine verification test to ensure timer and alarms are operational.

7.11.5. For induction operations there shall be a specified loading rate and/or heating time and/or energy input, quench time, and delay time, (between heating and quenching, if applicable) which are to be monitored along with energy monitoring per AIAG CQI-9. All parameters shall be checked and the results appropriately logged along with the time and date of the check and the checker's initials.

7.12. MATERIAL CONTROL:

7.12.1. All production material must be carefully identified and controlled to assure that all process steps are carried out in the correct sequence, that no operations are missed, and that similar parts or heat treated and non-heat treated parts are not mixed. Heat treat lot identification and traceability must be defined, recorded, and maintained for relationship to incoming material lots, unique process parameters, and finished product evaluation.

7.12.2. Material from different steel mill heats or metals which require different austenitizing, quenching, or tempering times and/or temperatures shall not be mixed or processed together to ensure that a given lot is processed as necessary to attain the specified metallurgical properties.

7.12.3. All containers used for transfer and/or transportation must be identified with part number and status (i.e., OK, REJECT, HOLD, etc. or as specified in plant procedures).

7.12.4. All non-heat treated parts and heat treated parts must be stored in separate areas.

7.12.5. Close control of containers which are used to hold both non-heat treated as well as heat treated stock is necessary to minimize the risk that a few parts may be left in the container thereby missing heat treat or being heat treated twice. Before filling containers, before or after heat treat, every container must be examined for loose or stray parts. Whenever possible, different size and/or color containers must be used for non-heat treated and heat-treated parts.

7.12.6. All conveyors and containers for heat-treated parts must be designed so that parts are not allowed to fall out or be held up from their normal flow.

7.13. REJECTED MATERIAL:
A procedure must be utilized to prevent shipment of rejected stock (or stock that is held for disposition). This may involve use of a locked crib for the quarantine of parts. Rejects and scrap must be monitored as to cause and quantity to assist in prioritizing corrective action(s). A written record must be provided as to stock disposition, through a logbook, showing stock movement with disposition noted.

7.14. HEAT TREAT PERSONNEL OBSERVATIONS AND COMMUNICATIONS JOB INSTRUCTIONS:
All personnel concerned with the handling of heat treated parts must be notified to be alert for parts that appear different than normal because of color, surface finish, cleanliness, or general appearance. Furnace operators must notify their supervisors and inspection of furnace malfunctions or abnormal conditions (i.e., temperature, time at temperature, atmosphere, quench condition, size of loads or unusual fixturing, etc.) when they occur. It is necessary to pass on important information to other shifts, such as special problems (i.e., jam-ups, and out of specification parts).

7.15. IN-PROCESS TESTS:
As used in this specification, in-process tests are tests and inspections performed on heat treated parts or test samples to evaluate the output of a heat treating process. The following in-process tests incorporated into this specification must be performed, and the data recorded. Inspection and test instruction sheets for these controls shall be located in the heat-treat department or laboratory as appropriate and available to the responsible individuals.

7.16. MICROSTRUCTURE:

7.16.1. Samples of heat-treated parts shall be examined metallographically under high magnification to assure that the microstructure conforms to engineering drawing and/or process, requirements. The minimum magnification shall be 100X.

7.17. HARDNESS:

7.17.1. Checks shall be performed on parts after heat-treating to assure conformance to engineering drawing or in-process specification requirements and the results logged. The heat treater shall maintain average and range or other statistical charts as appropriate for hardness to detect trends in the process, and to serve as a quality record. File, Rockwell, Brinell, etc. tests will be used as indicated on the engineering drawing. Alternate scales may be used upon approval by the receiving plant metallurgist and documented in the control plan. Accuracy of hardness testing machines must be checked at least daily by use of a standard block in the range of hardness values being produced, and the quality record noted to that effect. Hardness test equipment shall be cleaned at least annually and calibrated at least semi-annually.

7.17.2. When tempering is done immediately after the quenching operation, the testing may be done after tempering rather than after both quenching and tempering. Parts must be cooled to room temperature for checking.

7.18. CASE DEPTH:
Checks shall be made for proper case depth as specified by AIAG CQI-9 and the engineering drawing or in-process specification and the results logged. Case depth must be checked on production parts unless otherwise stated in the respective Nexteer Automotive engineering drawing or purchase specifications. Case depth records shall be maintained, an average-range or other statistical charts as appropriate to detect trends in the process and to serve as a quality record. Case depth shall be checked as total or effective case depth as required by the engineering drawing or purchase specification If total or effective case depth is not explicitly specified, then total case depth shall be used (SAE J423 shall be used if no method is stated). Induction heat treat patterns must be checked in a manner (both transverse and longitudinal cross sections) to ensure that the induction hardened case (including induction hardening runout / heat affected zones) conforms within the entire heat treated region specified on engineering drawings, purchase specifications, and/or process specifications.

7.19. NONDESTRUCTIVE TESTING (NDT):
NDT (i.e. eddy current testing) of finished heat treated parts from operations such as continuous carburizers or induction hardeners / annealers, is strongly recommended to readily increase the audit frequency of parts to determine if the correct heat treatment has been completed. NDT is not intended to replace the required checks for verification that the parts meet the individual engineering requirements. When required on Nexteer Automotive engineering drawings and/or purchase specifications, the frequency, methods of inspection, conformance to specification, and disposition of suspect parts shall be

included in the heat treater's process control plan, and approved by the Nexteer Automotive receiving plant metallurgist.

7.20. MISCELLANEOUS PROCEDURES:
In addition the above listed specific requirements, the heat treater shall have procedures or defined programs in place for the following:

7.20.1. Preventive Maintenance Program with details to include safety checks, recording equipment downtime, the reasons for the downtime, and corrective action taken being recorded.

7.20.2. Procedures for verification and calibration of in process monitoring equipment (i.e., thermocouples, flow meters, atmosphere controllers, etc.) and testing equipment (i.e., hardness testers, microscopes, etc.) in accordance to AIAG CQI-9. Procedures must include a recall system for in process or finished product if equipment is found out of calibration / verification or a check is missed. Procedures must include usage of calibration labels and/or tags.

7.20.3. Procedures for dealing with non-production parts, parts produced outside the normal operating procedures, and nonconforming material. The procedure must include documenting what action was taken if a deviation from the process specification or engineering specification is observed.

7.20.4. Procedures for training and recording training of all operators and inspection personnel.

7.20.5. Job instruction guides for all personnel.

7.20.6. Procedures for process monitoring and finished product data recording, record review, and retention.

8. MINIMUM FREQUENCIES FOR PROCESS MONITORS, LABORATORY CONTROLS, AND IN-PROCESS TESTS FOR FURNACE, SALT BATH AND INDUCTION PROCESSES:

8.1. The process monitor, method, and frequency shall be according to AIAG CQI-9 specifications and become part of the process control plan.

9. DEFINITIONS OF TERMS USED:

9.1. Unless otherwise stated the terms used are defined as found in the AIAG CQI-9. Additionally, the following terms are defined below:

9.1.1 Atmosphere Carburizing: Case-hardening process in which carbon is dissolved in the surface layers of a low-carbon steel part at austenitic temperatures, followed by quenching to form a martensitic microstructure.

9.1.2 Carbonitriding: Modified form of carburizing in which ammonia in addition to carbon is introduced into the furnace atmosphere to add nitrogen to the carburized case

9.1.3 Neutral Hardening: Heating to an austenitic temperature in a carbon neutral atmosphere (base metal carbon content +/- 0.05 %C) followed by quenching to form a predominantly martensitic microstructure

9.1.4 Austempering: Cooling from austenitic temperatures to a temperature below that of pearlite formation and above martensite formation in order to isothermally transform to a bainitic microstructure

9.1.5 Martempering: Process utilizing an interrupted quench from austenitic temperatures in order to homogenize the part at a temperature just above the start of the martensitic transformation; the result is a predominantly martensitic structure

9.1.6 Tempering: Process in which previously hardened steel is heated below austenitic temperatures and cooled at a suitable rate such that temper embrittlement, rehardening and excessive residual stresses are avoided

9.1.7 Nitriding: Case-hardening process where nitrogen is introduced into the surface of the part

9.1.8 Ferritic-Nitrocarburizing: Process in which both nitrogen and carbon are diffused into the surface of the part completely within the ferritic phase

9.1.9 Induction Heat Treating: Method of heating electrically conductive materials by application of a varying magnetic field whose force lines enter the part. Induction heat treating may include hardening, annealing or tempering.

9.1.10 Annealing: Treatment that consists of heating to and holding at austenitic temperatures followed by cooling at an appropriate rate (usually in a furnace) to produce a homogenous pearlite / ferrite microstructure

9.1.11 Spheroidize Annealing: Treatment that is used to generate a microstructure consisting of spheroidal carbides in a ferritic matrix by heating to austenitic temperatures and cooling at specific rates that vary with composition

9.1.11 Normalizing: Treatment that is used to generate a pearlite / ferrite microstructure by heating to and holding at a austenitic temperatures and then cooling in still or slightly agitated air

9.1.12 Stress-Relieving: Uniform heating of a part or portion of a part to a suitable temperature below the lower critical point for a specified period of time and cooled at an appropriate rate

9.1.13 Low Pressure Carburizing: Non-equilibrium boost diffusion type carburizing process in which the steel being treated heating to austenitic temperatures in a vacuum and quenched in either oil or gas

9.1.14 Quench Crack: Any crack which forms prior to tempering as a result of the thermal cycle of heating and rapidly cooling

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

Approved Supplier Page

MANUFACTURER	PRODUCT DESIGNATION	MATERIAL PART NO	TYPICAL PART NUMBERS QUALIFIED UNDER THIS SPECIFICATION

Nexteer Automotive
Production Release

Part No: 26109031 Rev/Chg Level: 002A

Specification Name: SPEC, REQ FOR HT PARTS

Revision History

SHT	DATE	REV	CHG	REVISION HISTORY	AUTH	DR	CK
---	29MY03	01	A	Engineering Release	040574	DCC	WHW
All	26MY15	002	A	Removed Frequency Charts, Added AIAG CQI-9 Specification, Added Definitions, Updated to Nexteer Automotive Specification	500061	NS	CB

DWG DATE:	REFERENCE:	FIRST USED:				
26MY15			APVD1	E. BRENNER	DR	D.C. COOK
			APVD2	T. LEFEVRE	CK	W. WATTS