

**MANUFACTURING EQUIPMENT  
PURCHASE SPECIFICATION  
NEXTTEER AUTOMOTIVE**

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**TITLE:** General Specification for Induction Heating Equipment      **NUMBER:** SD-1003

**ISSUED BY:** Mark Andrus

**DATE:** 31JAN07

**APPROVED BY:**

*Michael A. Keet* 9/18/17

**REVISION:** D

**DATE:** 15SE17

**SHEET:** 1 of 12

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**I. SCOPE**

- A. The intent of this specification is to provide a greater degree of standardization to facilitate maintenance, retooling, and to provide for trouble-free operation. It is not intended to inhibit design or progress of the "Induction Heating or Machine Tool Industry".

**II. MACHINE DESIGN AND BUILD REQUIREMENTS**

- A. Finished locating surfaces shall be accessible to check levelness of each section of the equipment, without removing machine components and/or fixtures, after the machine is installed and ready for operation. All tooling, inductor coils, and fixtures shall be dimensioned and located from this surface.
- B. Splined connections rather than pinned connections shall be used for rotating transfer bars.
- C. The machine shall have a mist collection system to minimize the exposure of mist outside the guarding of the machine. The maximum allowable exposure is 10 mg/m<sup>3</sup>. The responsible Nexteer engineer must approve of the type and brand of mist collector being submitted.
- D. Cooling of power supplies shall be de-ionized or distilled water. Cooling with quench water or tower water is not permitted.
- E. Access shall be provided for servicing all mechanical, hydraulic, lubrication, coolant, pneumatic and electrical components, induction coils, capacitors and transformers. Machine shall be designed to minimize requirements for side access.
- F. Machine shall limit access requirements for operation and machine setup to the front of the machine. Machine shall be designed to minimize frontal width.
- G. Whenever possible, the entire machine must be mounted and supported on a common base with a jack-screw system and all mounting hardware required to level the machine. The jack screws shall be ¾" diameter U.N.F. pitch thread. A 1-1/16" hole for tie-down bolts must be provided on 5" centers to the jack-screws. In all cases, these must be accessible. The tie-down bolt holes must

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be located such that a drill requiring 28" of height and 5" from the center line of the drill can be used to drill the hold-down bolt holes into the floor.

- H. "Locate at assembly" methods of hole or component location shall not be used except in special approved cases such as alignment of motor shafts or workstations.
- I. Adjustments of machine elements, which are not required periodically to maintain process limits shall be analyzed for their necessity and eliminated if possible. Where it is desirable or necessary to provide ability to adjust location of components for set-up purposes, thickness blocks shall be removed and re-installed if this is practical. Slotted holes shall be used only as a last resort.
- J. All drive components and cylinder motions shall be designed to stall the cylinder or slip a clutch rather than damage the machine components.
- K. The operator load/unload door shall be designed in such a way that the actuator cylinder and guide assembly are not exposed to the quench water.
- L. The machine shall contain an automatic Trabon lubrication system to lubricate any moving parts.
- M. The machine shall contain an automatic door. When the (whisker) cycle start switch is activated, the door shall automatically close, and when the cycle is complete, the door shall automatically open. This door must contain a safety device to prevent the operator from getting injured by the door. (Preferably a Tolomatic magnetic coupler)
- N. The part rotation shall be selectable through the part program 0-400 r.p.m.
- O. The upper centers of the machine shall be activated by air cylinders and utilize live centers to aid in part rotation.
- P. All drive tooling for holding and rotating the part are to be designed and constructed by the machine builder. The responsible Nexteer process engineer must approve the tooling designs.
- Q. The tooling shall be designed to be quick change with replaceable inserts at wear locations.
- R. The vendor must build the machine with as many standard commercially available components as possible, and follow SD-007 preferred component list.

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- S. Recommended spare parts list (itemized) for the machine with OEM's name and part number must be provided.
- T. Machine shall contain a lockable reject container that will hold a quantity of parts as specified by the Nexteer Process Engineer in charge. The container shall incorporate sensing capability to provide feedback to the machine logic as specified by the Nexteer Process Engineer in charge.
- U. Machine quench system shall cool the part to less than 50°C for operator handling.
- V. All machine faults and manual mode functions shall be demonstrated by the machine builder and recorded on a verification sheet.

### **III. INDUCTION COILS**

#### **A. Coil Development**

1. The machine builder is responsible for the design, construction, and development of all induction coils. Samples of heat treat patterns shall be submitted for approval before the machines are completed. Nexteer Automotive will share designs of the series bus, the quick change bus, the quench ring, and induction coil design to keep common tooling at the receiving plant.
2. The induction coil designs must be approved by the responsible Nexteer Process Engineer. \*NOTE: This approval does not relieve the machine builder's responsibility of designing a machine that will produce a statistically qualified heat treat process.
3. The induction coils must be quick change and replaceable in 5 minutes or less while maintaining the coil position to the part.
4. Single-shot coils for 3-10khz induction hardening shall be made of .5 inch machined copper construction or equivalent and utilize steel laminations as field intensifiers.
5. Single-shot radio frequency coils for induction hardening shall utilize an integral quench and use Ferrotron as an intensifier.
6. The centerline of the induction coils from the output transformer face shall be 400 mm minimum. This will allow sufficient room for cooling water hose, quench lines, and access to the induction coil mounting bolts, etc.

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**B. Coil Construction Materials**

1. Copper

- a. Bar stock shall be SAE-CA10100.
- b. Tubing stock shall be SAE-CA10200.

2. Coil Connectors

- a. Flags shall be Nexteer TL#213997, to fit Jackson Products output transformer.
- b. Non-magnetic, stainless steel type inserts shall be installed in all threaded holes.

3. Insulation and Protection

- a. Shall be Teflon sheet, Micarta G-10 or G-11.

**C. Coil Liners and Rails for Forge Heating Coils**

- 1. Ceramic refractory tubes shall be used for coil liners, with minimum 1.2" thickness.
- 2. Because ceramic may conduct electricity at elevated temperatures, the liners shall be wrapped with refractory cloth of at least two (2) wraps of .01 thickness or equivalent.
- 3. Rails to support the stock being heated shall be Inconel 601 (or equivalent) to reduce creeping and wear-resistance problems at high temperatures.

**D. General Design and Construction Practices**

- 1. Where more than one coil is used to make a set, all coils shall be interchangeable - i.e., no right-hand/left-hand combinations are allowed.
- 2. Induction coils shall be spaced away from machine supports:
  - 0 to 4"                      Non-metallic
  - 4 to 12"                    Non-magnetic stainless steel
  - 12" and up                Normal structural materials
- 3. Coils shall be designed for continuous power duty cycle. Coils shall not be cooled by the quench media.

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4. Inductors are to be electrically sound, water tight, and tested to 100 p.s.i. They are to be of continuous silver soldered construction. No Silfloss is allowed.
5. Mitered joints shall not be completely through square tubing - i.e., cut a notch, then bend so only three sides require brazing, leaving one side with solid copper.
6. Remove all burrs and sharp edges to minimize magnetic corona effect - it may be necessary to chamfer edges, especially for radio frequency coils.

#### **IV. POWER SUPPLY**

- A. The power supply heat station combination shall be equipped with an energy monitor that displays on the H.M.I. and has upper and lower set points for kilowatt-seconds.
- B. All OEM component part numbers and manufacturer's names shall be noted in the spare parts list for the power supplies.
- C. All high voltage lines inside the power supply must be covered with Plexiglas shielding for safety.
- D. There shall be one common lockable disconnect for the whole machine that is rated at a minimum of 65,000 amp interrupting capacity.
- E. The preferred power supplies to be used are I.G.B.T. The power supplies shall operate at no more than 80% to the total power output available to produce a part with nominal case depth.

#### **V. HEAT STATION**

- A. The output transformer shall be tappable for different ratios to maximize the tuning range for the machine to run different kinds of parts and coils for future heat treating applications.
- B. The quantity and sizing of tuning capacitors shall be as such to maximize the tuning range for induction hardening various types of parts and coils for future heat treating applications.
- C. The output transformer shall be mounted on an x-y base for alignment and shall have a method of indicating transformer position (i.e. scale or rule).

#### **VI. DEIONIZED COOLING WATER AND QUENCH SYSTEMS**

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A. Deionized cooling water and quench system shall be subject to the requirements in SD-1006.

B. There shall be a quench purging function which will purge all the quench fluid from the lines if the machine sits idle for more than 10 minutes. When the machine sits idle, a PLC timer shall start. When the timer reaches 10 minutes, the machine shall lose the "Ready for Cycle" bit and require the "Machine Home", or "Auto Initiate" function. When the machine is homed, or initiated, the quench valve shall open for 30 seconds to purge the cool quench and air bubbles from the quench lines. **The logic must be written to ensure that the normal heat cycle does not initiate before this quench purge is done. No overlap of purge cycle and normal machine cycle is allowed.**

## **VII. PROCESS AND EQUIPMENT MONITORS**

A. All induction machines shall have the following monitors.

1. Flowmeter with analog output to an analog input to PLC, (Kobold or Eletta preferred).
2. An energy monitor to observe the output power of the power supply to the parts. The energy monitor output will be displayed as a visual fault display and readout at operator station and shall be KW-S. The energy monitor value, as interpreted by the PLC, shall be accurate to  $\pm 1\%$  of the reading.

## **VIII. ELECTRICAL MACHINE CONTROLS**

- A. The machine shall be equipped with an H.M.I. (Human Machine Interface) for displaying all monitored parameters and for programming the part programs.
- B. The circuit designs shall incorporate a signal back-check feature. This feature will verify the transition of signals both on and off and inhibit any unwanted continuous motion or hazardous process (e.g. heat signals, etc.)
- C. For single-shot programs, the heat time shall be accurate to within 0.01 of a second, quench time and quench delay time shall be accurate to within 0.1 of a second.
- D. Contacts from process timers shall be hardwired to the control device in such a manner as to guarantee the use of specified accuracy regardless of the programmable device scan and I/O update time. Auxiliary contacts may need to be run to the programmable device inputs for additional machine sequence control and be back-checked with values entered in the H.M.I.

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- E. The H.M.I. shall provide access to upper and lower set-points on a separate process parameter screen for the following items:
  - a. Quench temperature
  - b. Cooling water temperature
  - c. Energy monitor kW seconds
  - d. Spindle speed (R.P.M.)
  - e. Tower water valve actuation temperature for quench water
  - f. Tower water valve actuation temperature for distilled water
- F. A means shall be provided to visually verify all data entry before it is transferred to the PLC working memory.
- G. The H.M.I. shall display the following in the run screen:
  - a. Part position and/or coil position
  - b. Quench temperature
  - c. Spindle rotation speed (R.P.M.)
  - d. Part program names
  - e. Kilowatt seconds
  - f. Distilled water temperature
- H. The machine system shall contain the following accuracy's
  - a. Spindle speed  $\pm 5$  R.P.M.
  - b. Table position (0.001) inch.
  - c. Quench flow  $\pm 1$  gallon/minute.
  - d. Quench temperature (000.0) Fahrenheit.
  - e. Power-supply cooling water temperature (000.0) Fahrenheit.
  - f. Energy monitor (0000.0) kilowatt seconds.
- I. Power supply meter values shall be displayed on the power supply and on the operator control panel or in the H.M.I. and include Kilowatts, Current, Voltage, Load Frequency, and Inverter Firing Frequency.

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- J. Part program storage in the H.M.I. shall be a minimum of twenty (20) programs. Vendor to quote how many heat settings are available per cycle.
- K. Machine shall have the capability to monitor and reject if necessary, any part that has exceeded a predetermined residence time within the hardener (1 hour typical). This requirement is intended to ensure the heat treated component reaches the temper process in less than 2 hours.
- L. The machine shall be designed to prevent loading of the wrong part or performing incorrect/incomplete heat treat process. Any part that is incorrectly loaded or heat treated, must cause the machine to enter a fault mode that can only be reset by automatic or manual discarding of the bad part into a reject container with sensor feedback. The Nexteer Process Engineer in charge must approve the error-proofing methods designed and built by the machine supplier.
- M. The machine shall be designed such that if the heating power is initiated and a fault occurs, the quench system will activate for 30 seconds. This requirement is an operator safety concern.

## **IX. RUNOFF**

- A. A successful statistical runoff must occur on the machine builder's floor prior to shipment. An additional runoff will take place at the receiving plant after machine installation.
- B. Refer to the Induction Heating section of SD-002 section 2.2.2. for the runoff requirements.
- C. The statistical qualification shall consist of measuring the induction hardened case depth, core hardness, surface hardness, and microstructure according to the blueprint specifications. All machine parameters will be set to achieve the nominal print dimensions prior to the statistical runoff, as approved by the responsible Nexteer Process Engineer.
- D. All machine-monitored settings will be recorded throughout the run (i.e. kilowatt seconds, quench flow, quench pressure and quench temperature) and included in the operators manual.
- E. If the machine faults for any reason during the runoff, the runoff must be repeated unless authorized by the Nexteer Process Engineer in charge.

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- F. Vendor shall provide tempering services. Tempering capability to be approved by Nexteer Process Engineer in charge.
- G. All parts will be sequentially numbered and marked during the run.
- H. Runoff parts shall be magnafluxed inspected for cracks. Inspection to be quoted by the supplier.

## **X. SUPPLIER REQUIREMENTS**

- A. The vendor shall have on-site and utilize the services of a Metallurgical Laboratory during the coil development and before submitting any samples to Nexteer Automotive. The Metallurgical Laboratory shall contain the following Metallurgical equipment and resources, as a minimum.
  - 1. Metallurgist on staff.
  - 2. Hardness tester with Rockwell C and A and a microfiacial hardness tester with proof of certification within 12 months prior to runoff. Calibration blocks and any fixturing necessary to check the parts shall also be provided.
  - 3. Wet cutoff saw and belt sander for sectioning the parts and necessary fixturing to cut the parts. Sample preparation equipment for microstructure.
  - 4. Nitric Acid etchant to inspect the visual heat treat pattern.
  - 5. Brinell glass for measuring case depth capable of 20X.
  - 6. Calibrated optical microscope capable of 100X and 400X magnification for metallurgical evaluation.
  - 7. Calibrated Refractometer for measuring quenchant concentration.
  - 8. Vendor must provide proper disposal of quenchant and any other chemicals required.
  - 9. Vendor to supply the required quenchant for all development and runoff on vendor's floor. Quenchant to be verified by the Nexteer Process Engineer in charge.

## **XI. TRAINING**

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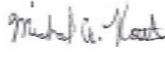
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- A. After installation of the machines at the Nexteer Receiving plant, the vendor shall provide onsite training for operators and maintenance personnel (all shifts) for the machine and power supply.
  - 1. Operator training to include, but not limited to, proper equipment setup, proper equipment operation, and preventative maintenance procedures.
  - 2. Maintenance training to include training for machine repair and electricians.
  - 3. Vendor must state the content and duration of the above training in the proposal.
  - 4. Nexteer Automotive shall have the right to duplicate any training materials.

## **XII. SHIPPING INSTRUCTIONS**

- A. Equipment shall be shrink wrapped and shipped on the air-ride truck and trailer to reduce damage to components.
- B. Equipment shall be properly protected with ethylene glycol anti-freeze to prevent damage, unless notified otherwise by responsible process engineer.
- C. Equipment that is shipped over water shall be contained in a water/moisture proof seaworthy container.

## **XIII. QUOTATION**

- A. Machine price to include all software needed to program and support the proposed control system licensed to Nexteer Automotive.
- B. Vendor must identify the location where the machine will be built and the level of experience at this location.
- C. Price for additional coils and busses.
- D. Price to supply the suggested spare parts package for machine at the quoted location.
- E. Price to supply the suggested spare parts package for power supplies. The power supply spare parts package for machine (itemized), with OEM's name and part number.
- F. Option to run an additional 1000 parts after runoff shall be included in the quote.

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- G. Concept drawing of the machine shall be included with the quotation.
- H. The machine shall be shipped per terms imposed by Nexteer Automotive Purchasing Department. Weight and dimensional estimates should be included in quotation.

**XIV. SPECIFICATION REVISION SHEET**

Page	Symbol	Revision	Date	Issued By
All	A	Specification completely rewritten	25 AUG 2006	Brian Kleinfeld
All	C	General touch ups	28 SEP 2012	David Novak
7	D	Add verbiage for quench purge function, add logic review for no heating during purge.	09Sep2017	Keith Daenzer

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