



# Requirements for Automated NDT Equipment

Global Common

SD-1043

ISSUED  
REVISED

December 1, 2017  
October 14, 2019

© 2019 Nexteer Automotive

All rights reserved.

### Table of Contents

1. Scope.....	3
2. Reference Specifications.....	3
3. General Requirements.....	3
4. Machine Error-Proofing .....	4
5. Machine Masters .....	5
6. Machine Runoff, Qualification and Acceptance.....	7

## 1. Scope

This document is a general specification defining requirements and guidelines for the design, construction and qualification of automated factory floor NDT equipment and instrumentation purchased by Nexteer for detecting and containing components with local and/or general flaws characterized in-advance by part or application-specific Manufacturing Equipment Purchase Specs (referred to hereafter as t-specs). This specification provides general rules and guidelines for NDT equipment; whereas the t-specs define requirements and information pertaining to:

- specific components and part families to be tested
- equipment cycle time and changeover
- program schedules
- equipment installation locations
- machine layout, footprint and factory floor space requirements
- material handling
- specific error-proofing
- other project requirements.

## 2. Reference Specifications

The following specifications universally apply to manufacturing equipment purchased by Nexteer; however, additional regulations and requirements may be applicable depending on the final equipment destination:

- A TP99-NNN document (T-spec.) will be issued to detail the specific equipment requirements.
- All requirements and standards referenced in Nexteer's new equipment standards (SD-000 "Nexteer Automotive Machinery and Equipment Specifications" and SD-007 "Approved Components List") apply unless specifically altered within the T-Spec. These documents are available at <https://nexteerdatabase.com/> under "Vendor Documents."

## 3. General Requirements

### 3.1 Flaw Detection:

NDT instruments and monitoring equipment must be selected and functionally demonstrated to consistently and reliably detect flaws in accordance with the critical flaw size, shape and orientation characteristics specified within the T-spec. Prior to designing the machine, the supplier shall write and submit an Application Report to the responsible Nexteer Engineer; confirming the capability of the instrumentation to properly detect the specified flaws; and defining the part and instrumentation motions required to automate the inspection process.

### 3.2 Machine Automation and Part Handling:

The machine must be designed and constructed to:

- load, stage, process and discharge a sufficient buffer of parts to enable the machine to run without operator intervention for no less than 3 consecutive minutes.
- divert failed parts to reject chutes by pick and place units or other positive machine motions (walking beam, escapements, etc.) with instrumented part disposal verification.
- handle parts without scratching or marking part surfaces (ref. SD-001, Section 8.5).
- protect bar code labels from damage due to contact with machine components, conveyance equipment, or other parts.

## 4. Machine Error-Proofing

- 4.1 The machine must be configured and controlled to prevent loading and transferring of incorrect or improperly oriented parts. This can be done using bar code scanning or sensors (photo eyes, proximity sensors, etc.) with the appropriate machine controls.
- 4.2 Bar code scan functions must be properly back-checked to:
- 4.2.1 Interrupt the machine cycle if multiple sequential unsuccessful part scans occur.
- 4.2.2 Reject a part and generate a warning fault after more than three unsuccessful bar code read attempts.
- 4.2.3 Parts which fail barcode scanning must be immediately indexed to a scrap container or removed from the machine by the operator. **These parts may be reintroduced to the machine for reinspection if the barcode scanning issue is resolved.**
- 4.3 The machine must track workpieces through all stations and write part status information (part serial number and test results information) to a datafile as-soon as all test functions are complete. **Inspection results for each check must be displayed on an HMI screen with, at minimum, "pass" (highlighted in green) or "fail" (highlighted in red), with the inspection(s) and probe channels identified. This information shall be formatted and stored per the traceability requirements provided by the responsible Nexteer Manufacturing Engineers.**
- 4.4 The workpiece must be scanned and tracked through the machine for traceability purposes. The PLC or cell controller must immediately store part test information with the part serial number based on machine sequence logic immediately upon the completion of the final test sequence for each part (cycle); not triggered by part detection or sensor feedback from machine stations after the final part inspection position.
- 4.5 Part and probe motions (rotational and linear) must be evaluated via servo feedback during each machine cycle to verify rotational velocities and probe traverse rates – this is to detect lost motion or slippage between parts and spindles, etc. Rotational motions may be verified by counting proximity sensor pulses or other means of detection involving direct contact or interaction with the part.
- 4.6 Probes and NDT instrumentation must be evaluated during test cycles to verify proper high and low signals. This information shall be used to detect mal-functioning probes, stop the machine, and communicate probe malfunction faults on the machine HMI.

#### 4.7 Where ultrasonic bubbler sensors are used:

- 4.7.1 Gates and thresholds must be established and utilized to verify the presence of couplant between the transducers and acrylic probe bodies, and between probe bodies and test parts.
- 4.7.2 Lock boxes are recommended around couplant flow control valves to restrict adjustment access by unauthorized personnel.

#### 4.8 Where eddy current devices are used: probe signals must be evaluated each cycle to verify proper sensor function (see 4.6, above).

- 4.9 The machine controls must address cycle stop and E-stop conditions to ensure that parts are properly purged from the machine prior to resumed operation if any interlocked gates, guards, doors, etc. are breached.
- 4.10 Machine controls must force/require part mastering at changeover/setup, startup, and frequency of no more than every 4 hours of operation. Failure to master or master sequence failures shall prevent the machine from running in automatic mode until the machine is properly mastered.
- 4.11 The machine shall be manufactured with interlocked part nests for each master part model to be run. Provisions for 3 additional sets of masters and associated sensors and controls shall be incorporated into the design of the machine.
- 4.12 Reject chutes, mechanisms, etc. are to be fail-safe when possible. Active transfers with back-checked sensors must be utilized to assure that failed parts get rejected to the appropriate lock boxes or scrap chutes. Back-checked photo eyes, proximity sensors or limit switches are required to verify the correct disposition of accepted and rejected parts.

### 5. Machine Masters

- 5.1 Part defect masters must be designed and constructed for verification of instrument function throughout the inspection area where multiple probe and part motions are required.
- 5.2 Mastering algorithms must be written to verify that the machine can detect flaws throughout all inspected part areas.
- 5.3 Machine masters shall be labeled with 2-D, laser-etched, 20 Character barcodes per the following format: {8-digit part number}{6-digit Julian date code}{00NN}{99}, where "00NN" represents the detail number of the master and "99" is Nexteer's traceability designation for a part master. **This requirement may be waived for resonance inspection methods (modal acoustic or PCRI).**
- 5.4 Instrumented nests or holders are required for master part storage after the machine mastering sequence. The machine controls shall verify the presence of all part masters before allowing the machine to enter automatic mode.
- 5.5 Master parts shall be documented on Nexteer gage drawing format. Gage detail numbers shall be assigned for each master part. Manufactured flaws (where used) are to be dimensionally defined for each inspected part model on Nexteer drawing format.
- 5.6 Master part samples **for non-resonance (modal acoustic or PCRI) evaluation** must be painted red and labelled in non-test areas by etching or engraving to display gage/detail number and fabrication date.

- 5.7 Where possible, master parts are to be error-proofed vs. building into finished assemblies by obscuring critical interface surfaces with welding, adhesive, feature mutilation or feature removal, etc.; these modifications shall not interfere with the machine & instrument mastering process.
- 5.8 Master parts for non-resonance or PCRI testing are to be painted red in selected non-test areas and labeled by etching or engraving to display gage number, detail number and fabrication date.
- 5.9 Master parts are to be inspected and dimensionally certified with documentation prior to machine qualification. Inspection data are to be provided to the Nexteer Engineer prior to machine acceptance.
- 5.10 Where parts are scanned using eddy current probes for crack detection, master part defects are to be configured as-follows:
- 5.10.1 Where the probe is traversing a rotating part OD: EDM'd flaws are to be:
- oriented 45° to the part axis
  - 6.35 mm (0.25" long
  - 0.25 mm (0.010") max wide
  - 0.50mm (0.020") deep (notch depths are to be constant over the entire 6.35 mm length).
- 5.10.2 Where the probe follows a rotating surface in a specific location without sweeping, the manufactured flaw is to be oriented perpendicular to the motion of the surface at the evaluation point, and 4-6mm in length. The depth and width of these flaws are to be .50mm and .25mm max, respectively.
- 5.10.3 Where external splines are being tested for cracks in the tooth root areas, manufactured defects shall be located in the central root area of one tooth space and plunged to a depth of 0.5 mm with a maximum width of 0.25mm and a length of 5 mm.
- 5.10.4 If the surface quality or texture of the Nexteer parts is too coarse to detect manufactured flaws conforming to the recommendations stated herein, deeper flaws may be considered with the approval of Nexteer's responsible Engineer.
- 5.11 When ultrasonic inspection is required to detect crack-like flaws:
- The manufactured flaw length is to be 6.35mm
  - The flaw is to be oriented according to t-spec instructions.
  - The flaw depth is to be 0.2 mm, or the least detectable depth as determined by application studies and agreed upon by the responsible Nexteer Engineer.
- 5.11.1 A documented study will be required to evaluate parts with 0.2 mm, to 2.0mm deep flaws manufactured in increments of 0.2 mm (10 samples total. These flaws can be machined either by wire or electrode EDM'ing.
- 5.11.2 The final machine master will have manufactured flaws consistent with the minimum repeatable detectable flaw depth determined by the application study, with approval from Nexteer's responsible Engineer and the appropriate Plant Metallurgist.

## 6. Machine Runoff, Qualification and Acceptance

This section defines the general MQ1 run-off requirements at the supplier prior to shipping approval. Qualification requirements defined in Manufacturing Equipment Purchase Specifications shall take precedent when directly in conflict with this section. Any interpretation issues or points of confusion shall be clarified by the Responsible Nexteer Engineer.

### 6.1 Runoff Readiness:

Prior to runoff (MQ1), the vendor must complete the checklists identified below and provide results to the Engineer in Charge for preliminary review. Upon acceptable review, the Engineer in Charge, along with other appropriate Nexteer personnel, will complete the following machine review:

- Machine Review and Runoff Checklist
- CSE-514 ~ Electrical Construction Checklist
- Safety Checklist (X-3260)
- Design in Ergonomics Checklist
- Error Proofing Checklist for NDT Machines (see Appendix "A")

6.2 Prior to machine qualification at the supplier's facility, the machine and instrumentation will be pre-qualified according to the t-spec and runoff plan prepared by the responsible Nexteer Engineer.

6.2.1 A prescribed quantity (per the t-spec) of known good parts and several parts with known defects and/or manufactured flaws will be used for the run. These parts will be randomly tested over a minimum 4-hour period. The machine must correctly accept and reject 100% of the parts. One or more sample part masters will be required for each part. A total run-time of 4 hours without part misidentifications or excessive downtime shall be required. Model changeovers and fixture set-up shall be demonstrated (if applicable). Additional MQ1 requirements may be defined in the t-spec.

6.3 Nexteer In-plant Machine Verification (MQ2): A repeat of the vendor's runoff (per 6.2) will occur on-site at Nexteer immediately following installation. Final acceptance of the system will occur after successful completion of an acceptance test run at the Nexteer facility. This run will be done at the standard production rate and must comply with all specifications. The service personnel who assist with the on-site installation at Nexteer must be present at the runoff.

6.4 The quotation must include as a separate line item 24 hours of on-site instrumentation training after the in-plant machine runoff for up to 4 Nexteer employees at the facility where the equipment is installed.

### APPENDIX A: Error Proofing Checklist for NDT Machines

Item	Ref Section	Description	Yes	No	N/A*
1	3.1	Has a documented instrumentation application study been submitted to Nexteer?			
2	3.2	Are moving / sliding part contact surfaces adequately hardened?			
3	3.2	Are the machine and its material handling designed to prevent part damage, including obscuring of barcode labels?			
4	4.12	Are parts removed from the machine by positive conveyance or pick / place devices?			
5	4.12	Are reject chutes instrumented to verify disposal of rejected parts?			
6	-	Does part quality status logically default to "Fail" before parts test "good?"			
7	-	Does the part traceability data format agree with Nexteer's documented traceability plan?			
8	4.1	Does the load station enforce introduction of the correct part model and orientation?			
9	4.2	Does the machine generate a fault and stop after 3 successive part barcode scan errors?			
10	4.2	If barcode read failure parts are indexed to the Operator, do controls exist to enforce proper part disposition?			
11	4.3	Does the machine display on the HMI and write to the traceability database inspection results for each sensor, channel and station?			
12	4.4	Does the machine store traceability data for each part immediately after the final part test is completed?			
13	4.5	Are part and probe motions tracked and verified throughout each test?			
14	4.7	Are UTS instruments back-checked each cycle to verify proper couplant conditions?			
15	4.7	Are the bubbler flow control valves locked out to prevent unauthorized adjustment?			
16	4.8	Are eddy probe signals back-checked each cycle to verify sensor functionality?			
17	4.9	Does the machine control logic require the proper removal of parts from the machine during cycle-stop / e-stop recovery such that all parts are properly tracked when machine function resumes?			
18	4.10	Do the machine controls require machine setup verification by part mastering after each changeover, shift change, or after ever 4 hours of production?			
19	4.11	Does the machine include instrumented master part nests for each model + 3 more?			

20	4.12	Are reject chutes fail-safe? Instrumented? Are parts dispositioned to scrap or production by positive machine motions vs. gravity conveyors, etc.?			
21	5.1	Are machine masters designed to enable verification of the entire surface?			
22	5.2	Do the machine mastering routines evaluate the entire range of machine motion?			
23	5.3, 5.6, 5.7	Are the machine masters labeled per Nexteer requirements?			
24	5.5	Are all part masters certified and documented?			
25	6.4	Does the quote / PO include instrumentation training following machine installation?			

\* N/A responses must be justified in writing and approved by the responsible Nexteer Engineer.

## RECORD OF REVISIONS

Revision No	Date	Section	Description
001	01DE17	All	Initial publication.
002	140C19	4, 6	Added highlighted verbiage to 4.3, added 6.4, added associated highlighted items to Appendix A Checklist. Updated document to match global common template.
003			
004			
005			
006			
007			
008			
009			
010			
011			
012			
013			
014			
015			
016			
017			
018			
019			
020			