

| | | | |
|---|---|------------------------|---------------------------|
| ISPEC-MPIWI | Title: Magnetic Particle Inspection Work Instruction | | |
| | No: | Rev 1 | Page 1 of 5 |
| Trinity Forge & Machine Mansfield, Texas | Written by: Jun Peng 12/20/2016 | Responsible Department | |
| | Last change by: | Date | Quality Assurance |
| | Approved by: Tim Ellis | Effective date: | 1/6/17 |
| Proprietary Document | This proprietary document is the exclusive property of Trinity Forge & Machine. It may not be copied or used for any purposes other than those for which it was loaned. | | Uncontrolled when printed |

Due to format differences, the total number of sheets of your representation may not agree with the number of sheets specified. To ensure you have the complete document, the last sheet has been clearly identified as being the last sheet.

1. Scope:

- 1.1 This specification details the requirements for the fluorescent magnetic particle inspection (MPI) by the wet continuous and residual methods in accordance with ASTM E1444.

2. Application:

- 2.1 This procedure is applicable to the MPI examination of products manufactured by Trinity Forge & Machine, Mansfield, Texas facility in any state of processing.
- 2.2 Final MPI shall be conducted on as-forged, heat treated and finished machined components. No in-process examinations shall be considered a final acceptance test where a final examination is required.

3. Applicable Specifications:

| | |
|----------------------|--|
| ASTM E1444 | Standard Practice For Magnetic Particle Examination |
| MIL-STD-1949 | Inspection, Magnetic Particle (Obsolete replaced by ASTM E1444) |
| AMS 2640 | Magnetic Particle Inspection |
| Trinity ISPEC-MPICM | Calibration and Maintenance Procedure for MPI Equipment |
| MIL-STD-105 | Sampling Procedures and Tables For Inspection (Obsolete, Superseded by ANSI ASQC-Z1.4) |
| ANSI ASQC-Z1.4 | Sampling Procedures & Tables for Inspection by Attributes. |
| NAS-410 (ASNT-TC-1A) | Certification & Qualification of Nondestructive Test Personnel |
| Trinity ISPEC-NDTTR | Qualification and Certification of NDT Personnel |

4. Equipment:

- 4.1 Magnaflux: Type ARQ-545 Horizontal Wet Bench 5 Turn Coil 12 inch diameter coil 4500 amps FWDC magnetizing current
- 4.2 Magnaflux: Type H-10 Horizontal Wet Bench 5 Turn Coil 12 inch diameter coil 5000 amps FWDC magnetizing current
- 4.3 Demagnetizer: Magnaflux type SB-1416(AC)
- 4.4 Light meters: Magnaflux type UV-A meter (UV light only) or equivalent, Spectroline ACCU-MAX XRP-3000 (white and UV light) or equivalent (Readout Unit: XR-1000)
- 4.5 Shunt Ammeter: Magnaflux type 10090 or equivalent
- 4.6 Hall Effect Meter: Gould-Bass Type MD-220 or equivalent
- 4.7 Ketos Ring Magnaflux - 94616
- 4.8 Field Strength Indicator - Model 25 ± 10 (2) or equivalent
- 4.9 Blacklights: Magnaflux type ZB-100 and Type ZB-1; Spectroline Type SB-100P, SB-PX and BIB-150P
- 4.10 Blacklight Filters: Smooth Glass PN 519227 or equivalent
- 4.11 Central Conductors: Copper or Brass, hollow or solid not to exceed 2" diameter.
- 4.12 Flat Coil Magnaflux PN 611700 or equivalent
- 4.13 Yokes: Parker type 8300(1), NDT type ES-X (6) Magnaflux type Y-7
- 4.14 Sprayer: Graco Nova type 390 or equivalent

5. Quality Provisions:

- 5.1 MPI shall be performed on a sample basis in accordance with the requirements on the router. When specified, MPI can be performed on machined parts, raw material or forgings.
- 5.2 A minimum of three (3) minute shall be allowed to provide for eye adaptation in the darkened inspection area prior to beginning any MPI examinations.

| | | | |
|---|---|------------------------|---------------------------|
| ISPEC-MPIWI | Title: Magnetic Particle Inspection Work Instruction | | |
| | No: | Rev 1 | Page 2 of 5 |
| Trinity Forge & Machine Mansfield, Texas | Written by: Jun Peng 12/20/2016 | Responsible Department | |
| | Last change by: | Date | Quality Assurance |
| | Approved by: Tim Ellis | Effective date: 1/6/17 | |
| Proprietary Document | This proprietary document is the exclusive property of Trinity Forge & Machine. It may not be copied or used for any purposes other than those for which it was loaned. | | Uncontrolled when printed |

- 5.3 Eye glasses with light sensitive (Photochromic) lenses shall not be worn by inspectors while performing inspection, nor shall they wear permanently darkened lenses.
- 5.4 Inspection personnel shall be qualified and certified in the magnetic particle inspection method in accordance with Trinity ISPEC-NDTTR. Personnel making accept/reject decisions on finished components shall be certified Level II (minimum).
- 5.5 Continuous inspection shall not be performed for more than 2 hours without a 15 minute break.
- 5.6 Ambient white light shall be kept to a level where it does not interfere with inspection. A maximum of 2 foot candles is allowed.
- 5.7 A white light with a minimum intensity of 100 foot-candles (measured at the inspection surface) shall also be provided for evaluating indications revealed.
- 5.8 For each part that inspected a technique sheets shall be made up in accordance with all requirements of this specification.
- 5.8.1 Technique Sheets - Magnetic particle inspection shall be carried out in accordance with technique sheets listing particular details which pertain to the component under examination. A certified Level II or Level III shall develop the technique sheet, which shall be approved by an NDT Level III in the MT method.
- 5.8.1.1 When NDT Level III approval is not readily available; the Level II inspector shall affix a "proceed at risk" stamp to the shop router just prior to the stocking operation. The inspected lot shall be held and not stocked until the technique sheet is approved. Once approved a Level II inspector or QA supervisor can initial or sign the router to release the lot for stocking.
- 5.8.2 The elements of the MT technique sheets generated as a result of this document shall contain the following minimum information:
- Trinity Part Number
 - Alloy
 - Sample size (applied AQL or, 100%)
 - NDT inspector's name & certification level
 - Date Filled Out
 - Central Conductor shots, each magnetization shot has to be listed separately, as actual amperage used, and if specified by customer, Hall Effect meter reading.
 - Head shot, central conductor shot, and coil shots listed separately, as actual amperage used and Hall Effect meter reading (if applicable) or, flaw shim (QOI) and pie gage acceptability.
 - Pulse duration, as specified per ASTM E1444
 - Magnetization Method Used (Continuous/Residual)
 - Pre- & post-cleaning methods
 - Pictures and sketch showing part(s) relation to applied magnetic fields
 - Level III approval & date
- 5.9 All equipment calibrations/verifications shall be completed prior to the beginning of MPI examinations for final product acceptance. Refer to Trinity ISPEC-MPICM – Calibration & Maintenance Procedures for MPI Equipment.
- 5.10 Prior to beginning any examination, the inspection solution (carrier and particles) shall be circulated a minimum of 30 minutes.
- 5.11 Magnetizing current pulse duration shall be 0.5 seconds (min) to 1.0 seconds (max).

6. Procedure:

6.1 General Requirements:

- 6.1.1 Preparation for examination; Parts to be inspected shall be free of grease, oil, rust, scale, paint, or other substances which will interfere with the inspection process. The parts shall be demagnetized before

| | | | |
|---|---|-----------------|---------------------------|
| ISPEC-MPIWI | Title: Magnetic Particle Inspection Work Instruction | | |
| | No: | Rev 1 | Page 3 of 5 |
| Trinity Forge & Machine Mansfield, Texas | Written by: Jun Peng 12/20/2016 | | Responsible Department |
| | Last change by: | Date | Quality Assurance |
| | Approved by: Tim Ellis | Effective date: | 1/6/17 |
| Proprietary Document | This proprietary document is the exclusive property of Trinity Forge & Machine. It may not be copied or used for any purposes other than those for which it was loaned. | | Uncontrolled when printed |

inspection if prior operations have produced a residual magnetic field which will interfere with the inspection.

- 6.1.1.1 Magnetic particle examination is performed after all operations which might cause or reveal discontinuities. Such operations include, but are not limited to, forging, heat treating, electroplating, machining, grinding, straightening, and proof loading. The sequence of examination shall follow the requirements in current revision of section ASTM E1444 (for example, Section 5.4 in ASTM E1444-2016).
- 6.1.2 Parts must be inspected by the wet continuous method using fluorescent particles; on areas or features not readily inspected by the continuous method, the residual method may be employed. The following applies to the usage of the residual method:
 - 6.1.2.1 The full-wave rectified alternating current (FWDC) must be utilized when the residual method is used.
 - 6.1.2.2 Inspection shall take place within 5 minutes from application of the magnetizing force when the residual method is used.
 - 6.1.2.3 A dwell time between application of medium and actual inspection shall be allowed to permit drainage of excess medium which may mask defects. Special attention shall be given to fillet radii and internal corners where defects may be masked by accumulation of magnetic particles
- 6.1.3 To ensure the detection of discontinuities in any direction, each part must be magnetized in at least two directions at approximate right angles to each other. This may consist of circular magnetization in two or more directions, or both circular and, longitudinal magnetization, or of longitudinal magnetization in two or more directions.

6.2 Operations:

All magnetic particle inspection operations shall be conducted in accordance with the latest revision of ASTM E1444 or ASTM A275.

6.3 Particle Application:

- 6.3.1 Continuous method - In the wet, continuous method, the magnetizing current shall be applied simultaneously with or immediately after diverting suspension from the part. Application of the magnetic particles (see Section 6.3.3 below) and the magnetization method shall be as prescribed in the paragraphs referenced herein.
- 6.3.2 Residual magnetization method - In the residual magnetization method, the magnetic particles are applied to the test part after the magnetizing force has been discontinued.
- 6.3.3 Wet magnetic particle application - Fluorescent particles suspended in a liquid vehicle at the required concentration shall be applied by a gentle flow of the suspension over the area to be inspected. Proper sequencing and timing of part magnetization and application of particle suspension are required to obtain proper formation and retention of indications. This generally requires that the stream of suspension be diverted from the part simultaneously with, or slightly before, energizing the magnetic circuit. The magnetizing current shall be applied for a minimum of a 1/2 second for each application with a minimum of two current shots being used. The second shot should follow the first in rapid succession. It should come after the flow of suspension has been interrupted, and should occur before the part is examined for indications. Care shall be exercised to prevent any damage to the part due to overheating or other causes. Weakly held indications on highly finished parts are readily washed away and hence, care must be exercised to prevent high-velocity flow over critical surfaces.

| | | | |
|---|---|-----------------|---------------------------|
| ISPEC-MPIWI | Title: Magnetic Particle Inspection Work Instruction | | |
| | No: | Rev 1 | Page 4 of 5 |
| Trinity Forge & Machine Mansfield, Texas | Written by: Jun Peng 12/20/2016 | | Responsible Department |
| | Last change by: | Date | Quality Assurance |
| | Approved by: Tim Ellis | Effective date: | 1/6/17 |
| Proprietary Document | This proprietary document is the exclusive property of Trinity Forge & Machine. It may not be copied or used for any purposes other than those for which it was loaned. | | Uncontrolled when printed |

6.4 Magnetization Methods:

6.4.1 Types of magnetizing current - The full-wave rectified alternating current (FWDC) magnetizing current shall be employed for magnetic particle inspection in accordance with this document. Full-wave rectified alternating current has the deepest possible penetration and must be used when inspecting for defects below the surface.

6.5 Surface Preparation:

6.5.1 Surface Cleanliness and Finish – The surface of the part to be examined shall be essentially smooth, clean, dry, and free of oil, scale, machining marks, or other contaminants or conditions that might interfere with the efficiency of examination.

6.5.2 Plugging and Masking – Plugging and masking is required when specified by the Cognizant Engineering Organization.

6.5.3 All areas on the part where electrical contact is made shall be sufficiently clean to prevent electrical arching.

6.6 Magnetic Field Strength:

The applied magnetic field shall have sufficient strength to produce satisfactory indications, but must not be so strong to cause masking of relevant indications by non-relevant accumulations of magnetic particles. Factors which determine the required field strength include the size, shape, and magnetic permeability of a part, the technique of magnetization, the method of particle application, and the type and location of defects sought. Adequate magnetic field strength may be determined by one or a combination of three methods:

Method 1: by testing parts having known or artificial defects of the type, size, and location specified in the acceptance requirements.

Method 2: by using a Hall-effect probe Gaussmeter capable of measuring the peak values of the tangential field.

Method 3: by use of the formulas given in ASTM E1444 Section X4 (See Note*)

- Note* - The current level formulas noted in method 3 shall serve as a rough guide. When employed, they shall be used in conjunction with another field strength monitoring method.

6.6.1 Should it become necessary to conduct an examination employing higher amperage shots preceding a shot of lower amperage; the component must be demagnetized prior to the lower amperage shot.

6.7 Demagnetization:

6.7.1 All parts and materials shall be demagnetized after completion of magnetic particle inspection.

6.7.2 When using an AC demagnetizing coil, put the part inside the coil and move it slowly away from the coil. Repeat this procedure as many times as necessary to remove residual magnetism.

6.7.3 When using the washroom Electromagnetic Demagnetizer, set parts on belt and operate device. Repeat procedure as many times as necessary to remove residual magnetism.

6.7.4 After demagnetization, test parts with a field indicator at several locations including all significant changes in geometry (i.e. flanges, tabs, etc.). Orient the meter for maximum deflection from zero. Repeat the demagnetization if the maximum deflection at any place on the part exceeds +/-2 Gauss.

