Perform Air International Inc.
NDT Manual
Section: IX - MPI
Fluorescent Magnetic Particle Inspection

Revision	Revision Date	Revision Change
N/I	02/08/2010	Initial Release/Re-release
1	09/04/2012	Repagination of Procedure. Revision to header, 1.0, 2.0, 3.0, 4.0, 5.1 thru 5.3, 5.5, 5.5.1.1 thru 5.5.1.2, 5.5.2.1 thru 5.5.4, 5.5.4.2, 5.5.5.4, 5.5.7 thru 5.5.10, 5.6.1 thru 5.7, 5.9 thru 5.10, 5.10.2 thru 5.13.1, 5.18 and 6.0 thru 6.7. Addition of 5.5.6.
2	05/31/2018	Removed 6.7
3	07/31/2019	Revised 2.0, 6.2
4	10/16/2020	Revised 3.0
5	*11/20/2024*	*Revised 3.5, 5.1, 5.5, 5.5.1.1, 5.5.2.1, 5.5.3.1, 5.5.4.2, 5.5.5.4, 5.5.6, 5.5.7.1, 5.7, 6.3, 6.4, 6.5*

1.0 Purpose:

To provide information relating to Fluorescent Magnetic Particle Inspection process at Perform Air International Inc.

2.0 Scope:

This procedure provides the instructions for performing fluorescent magnetic particle inspection in accordance with ASTM E 1444/E1444M as revised, on in-service metal components at Perform Air International Inc.

3.0 Responsibility:

3.1 It is the responsibility of Company Level III Inspectors to maintain this procedure.

3.2 It is the responsibility of Company Level III Inspectors to ensure that all NDT inspectors are properly trained.

3.3 It is the responsibility of the Training Manager to maintain employee training records as per the Records Retention Table.

3.4 It is the responsibility of Company Level I, II and III Inspectors to conduct NDT inspections at Perform Air International Inc. as stated on the SL.02 Roster of Inspection Personnel.

3.5 It is the responsibility of the *Executive V.P. of Operations* to oversee the program for the maintenance function.

4.0 Definitions: None at this time

5.0 Procedure:

5.1 NDT Qualification and Certification: Personnel performing Fluorescent Magnetic Particle Inspection shall be qualified and certified in accordance with ATA-105 and NDT Certification Record *(Form 55.16).*

5.2 Equipment and Materials: - The following equipment is in use at Perform Air International Inc:

Uresco Ardrox Model 4105, 3 phase, FWDC with 5 turn 12" coil and hose particle applicator
Magnaflux Magnaglo 14A fluorescent particles
Magnaflux Carrier II
Magnaflux 100 Watt Black Light
Spectroline DSE-100X UV and Visible Light Meter
Gould Bass DLM 1000 UV and Visible Light Meter
MX Industrial Model DM1416 Demagnetizer
Ardrox Model MD-220 Hall Effect Gaussmeter
AS5282 Ketos Ring
RB Annis Model 25 Field Indicator
Centrifuge Tube and Stand
Selection of Central Conductors
Small Parts Adaptor
Magnaflux ZB100-F Black Light

5.3 Materials Certification and Equipment Calibration: Materials shall be certified and equipment calibrated in accordance with Table I requirements.

Material/Equipment	Certification	Calibration Frequency
Magnetic Particles	Initial	N/A
Carrier Fluid	Initial	N/A
AS 5282 Ketos Ring	Initial	N/A
Black/White Light meter	N/A	Six months
Field Indicator	N/A	Six months
Hall Effect Gaussmeter	N/A	Six months

Magnetic Particle Materials and Equipment Calibration
Table I

5.4 Restrictions: Inspectors shall not wear eyeglasses with light sensitive (photochromatic) lenses or permanently darkened glasses while processing parts or performing inspection.

5.4.1 Parallel current induced magnetization shall not be used for magnetic particle examination. This method of magnetization occurs when a ferromagnetic part is placed alongside and parallel to a current-carrying conductor. A magnetic field will be induced in the part that is more transverse than circular.

5.5 Process Controls: - Process control checks are not required when the line is not in use. When in use, the line shall have process control checks performed at the

frequency specified in Table II. Process Control Form MPI *(Form 55.13)* is utilized to document compliance with the process controls noted herein. Enter the starting date on the log for each week. The completed log shall be kept for audit purposes for 7 years as per Records Retention Table (Att.52.07). Perform Air International Inc. works on a one shift per day schedule.

Process Control	Maximum Time Between Verification
Black Light Intensity	Every Shift
Visible Light Intensity	Weekly
Ambient Visible Light Intensity	Weekly
Wet Particle Concentration	Every Shift
Wet Particle Contamination	Weekly
System Performance Verification	Daily
Ammeter Accuracy	6 Months
Timer Control	6 Months
Quick Break Check	6 Months

Process Controls
Table II

5.5.1 Black Light Intensity: - All black lights shall be checked at the interval specified in Table II and after bulb replacement for output using an UV meter. Allow the black light to warm-up for 5 minutes prior to verification of intensity. Measure the black light intensity at a distance of 15". The lamp shall measure the minimum value of 1000 uW/cm^2. Black lights failing this requirement shall have their bulbs replaced.

5.5.1.1 When the check is acceptable, enter value of the black light intensity in uW/cm^2 within the appropriate block of the Process Control Form MPI *(Form 55.13).* Enter the initials or stamp of the inspector performing the process control check.

5.5.1.2 On a periodic basis the black light filter shall be checked for cleanliness and integrity. The filter shall be cleaned or replaced as required to obtain required intensity.

5.5.2 Visible Light Intensity Check: The visible light intensity at the inspection surface shall be determined using a calibrated white light meter. Visible light intensity shall exceed 100 foot-candles at the inspection surface. If the check is not acceptable, correct the root cause, e.g., change bulb, to increase the visible light intensity.

5.5.2.1 When the check is acceptable, enter the value of the visible light intensity in foot-candles within the appropriate block of the

Process Control Form MPI *(Form 55.13)*. Enter the initials or stamp of the inspector performing the process control check

5.5.3 Ambient Visible Light Intensity Check: The ambient visible light intensity in the darkened inspection area shall be determined using a calibrated white light meter. The black light shall be on during the measurement of ambient visible light intensity. Avoid measuring black light intensity when performing ambient visible light measurements. Ambient visible light intensity shall not exceed 2 foot-candles at the inspection surface. If the check is not acceptable, correct the root cause, e.g., booth curtain condition, to reduce the ambient visible light intensity.

5.5.3.1 When the checks are acceptable, enter an "A" within the appropriate block of the Process Control Form MPI *(Form 55.13).* The value of the ambient white light need not be recorded. Enter the initials or stamp of the inspector performing the process control check.

5.5.4 Wet Particle Concentration Check: Agitate the particle suspension a minimum of thirty minutes to ensure uniform distribution of particles throughout the bath. Periodically, the sump screen shall be checked for particulates and contamination. The sump screen shall be kept clean to facilitate proper bath flow. A brush may be used to wipe any particles from the sides of the tank or any crevice that might entrap particles within the tank.

5.5.4.1 The wet particle concentration shall be checked after the suspension has been circulated for a minimum of thirty minutes. Place a 100-ml sample of the agitated suspension in a pear-shaped centrifuge tube graduated to 1 mL in 0.05-mL increments. Demagnetize the sample (without the stand) and allow the tube to stand undisturbed for at least 60 minutes. The particle concentration shall be within the range of 0.1 to 0.4 mL.

5.5.4.2 If the results were unacceptable, add particles or bath medium as necessary, and repeat the test. If the settled particles appear to be loose agglomerates rather than a solid layer, take a second sample. If the second sample appears agglomerated, replace the entire suspension. The centrifuge should be emptied at the conclusion of the process control. When the check is acceptable, enter an "A" within the appropriate block of the Process Control Form MPI *(Form 55.13).* Enter the initials or stamp of the inspector performing the process control check.

5.5.5 Wet Particle Contamination Check: Upon mixing of the initial suspension, a sample shall be taken and set aside for use during the contamination check. This original "set aside" sample shall be stored in a darkened area.

5.5.5.1 The wet particle contamination shall be checked in conjunction with the wet particle concentration test. Examine the graduated portion of the centrifuge tube under both black and white light for striations or bands different in color or appearance. Bands or striations may indicate contamination.

5.5.5.2 If the total volume of the contaminants, including bands or striations exceeds 30 percent of the volume of magnetic particles, the bath shall be adjusted or replaced.

5.5.5.3 Compare the centrifuge to the "set aside" sample to note degradation of the fluorescence of the particles. Notable degradation is an indication of contamination and/or dye separation and shall prompt bath replacement. A new "set aside" sample shall be taken for every bath replacement.

5.5.5.4 When the check is acceptable, enter an "A" within the appropriate block of the Process Control Form MPI *(Form 55.13).* Enter the initials or stamp of the inspector performing the process control check.

5.5.6 Water Break Test Check: A daily water break check is required to evaluate the surface wetting performance of water-based carriers. The water break check simply involves flooding a clean surface similar to those being inspected and observing the surface film. If a continuous film forms over the entire surface, sufficient wetting agent is present. If the film of suspension breaks (water break) exposing the surface of the component, insufficient wetting agent is present and the solution should be adjusted or replaced. This check is not recorded on the process control form MPI (*55.13*).

5.5.7 System Performance Verification Check: The overall performance of the fluorescent magnetic particle system shall be verified by using an AS5282 Ketos ring. The Ketos ring shall be circularly magnetized using a 1.0" diameter copper central conductor. Examine the ring within one minute after current application. The minimum number of holes indicated on the outer diameter of the ring at the specified amperages shall be as listed in Table III. The part shall be demagnetized, cleaned and stored in a container of Carrier II. Failure to achieve the required amount of hole

indications shall prompt an investigation of the system degradation, e.g., replacement of bath.

Amperages	Indicated Holes
500	3
1000	5
1500	6
2500	7
3500	9

System Performance Verification Check Chart
Table III

5.5.7.1 When the checks are acceptable, enter an "A" within the appropriate block of the Process Control Form MPI *(Form 55.13).* Enter the initials or stamp of the inspector performing the process control check.

5.5.8 Ammeter Accuracy Check: The bench unit ammeter accuracy shall be checked. A calibrated ammeter shall be connected in series with the output circuit. Comparative readings shall be taken at three output levels encompassing the usable range of the equipment. The equipment meter reading shall not deviate by more than +/- 10% of full scale, or 50 amps, whichever is greater, from the current value shown by the calibrated ammeter. This process control is performed by an outside calibration subcontract vendor.

5.5.9 Timer Control Check: The timer control shall be checked to an accuracy of +/- 10%. Pulse length shall be 0.5 second minimum and shall not exceed 0.75 seconds. This process control is performed by an outside calibration subcontract vendor.

5.5.10 Quick Break Check: The quick break feature of the horizontal unit shall be checked for functionality. This process control is performed by an outside calibration subcontract vendor.

5.6 Part Preparation: The surface of the part to be inspected shall be essentially clean and dry, being free of oil, scale, or other contaminants or conditions that may interfere with the efficiency of the inspection. Clean the part using the appropriate method for the contaminant prior to magnetic particle inspection.

5.6.1 All parts shall be checked for residual magnetization with a field indicator prior to inspection. Parts containing a magnetic field exceeding three gauss shall be demagnetized per 5.16 of this procedure.

5.6.2 Plugging or masking is necessary when specified by the Technical data.

5.6.3 Plating or coatings do not require removal prior to examination unless they are damaged, interfere with the inspection process, or are required to be removed by the applicable technical data.

5.7 Magnetic Particle Technique: All parts shall be inspected to a specific technique noting the P/N, dimensions of the part, illustration of the part, amperages, gauss readings, and any fixturing. Perform Air International Inc. part specific technique is noted on MPI Technique form (*55.14*). All techniques shall be approved by a Magnetic Particle Level 3.

5.8 Magnetic Field Direction and Technique: To ensure the detection of discontinuities in any direction, each part must be magnetized in at least two directions at right angles to each other. Depending on part geometry, this may consist of circular and longitudinal magnetism, circular magnetism in two or more directions, or longitudinal magnetization in two or more directions. Circular magnetization, when applied, shall always precede longitudinal magnetization to permit more effective demagnetization after the inspection is completed.

5.8.1 Direct magnetization is accomplished by passing current directly through the part under testing. Electrical contact is made to the part using the head and tail stocks. Precaution shall be taken to ensure that the electrical current is not flowing while contacts are being applied/removed and that excessive heating, as evidenced by discoloration, does not occur in the contact area. Proper maintenance of the head/tailstock copper pads, including the replacement of frayed/torn pads, will help prevent arcing. Wetting the pads with suspension prior to activating the current will help prevent arcing as well.

5.8.2 Indirect magnetization is accomplished by placing the part lengthwise in the coil or by inserting a central conductor through the part and clamping the central conductor between the headstock and tailstock.

5.9 Magnetization Current Determination: The applied magnetic field shall have sufficient strength to produce satisfactory indications, but it must not be so strong that it causes the masking of relevant indications by nonrelevant accumulations of magnetic particles. Current settings shall be preset prior to part magnetization, or with part in place, by proceeding from lower amperage to the desired value. When a lower amperage shot follows a higher amperage shot, the part shall be demagnetized between the two operations per 5.16 of this procedure.

5.9.1 For the direct or indirect techniques, amperage values shall be determined by using the Hall Effect Gaussmeter.

5.10 Hall Effect Gaussmeter Parameters: The plane of the probe shall be held as perpendicular to the part as possible when measurements are taken. The plane of the Hall Effect sensor shall be perpendicular to the magnetic field being measured and all measurements are to be taken while the current is being applied to the part.

5.10.1 On coil shots, the reading shall be taken away from ends and protrusions. This practice is meant to avoid a saturated reading caused by the flux leakage field created at the poles when a longitudinal field is induced into the part.

5.10.2 Minimum applied field strength of 30 gauss shall be present in all areas to be inspected. There is no maximum limit for a gauss measurement except the field must not be so strong that it causes the masking of relevant indications by nonrelevant accumulations of magnetic particles.

5.11 Indirect Circular Magnetization: A central conductor, either offset or centrally located, shall be used for circular magnetization. A central conductor of ferrous or non-ferrous metal, either solid or hollow, with as large a diameter as possible, shall be used for central conductor shots.

5.11.1 For the offset technique, the distance along the part interior circumference that is effectively magnetized shall be taken as approximately four times the diameter of the central conductor, as illustrated in Figure 1. Verify the field coverage with the Hall Effect Gaussmeter to assure a minimal field of 30 Gauss. The maximum current shall be limited by the masking of relevant indications by nonrelevant accumulations of magnetic particles. The entire circumference shall be inspected by rotating the part on the conductor, allowing for approximately a 10% magnetic field overlap.

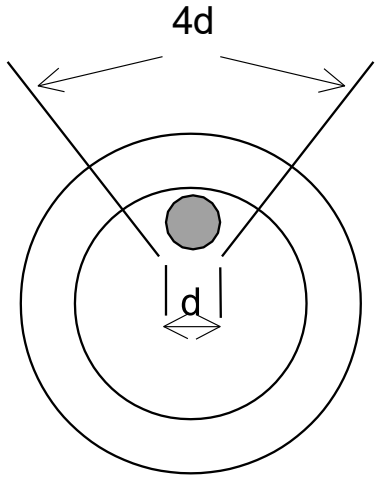

Figure 1

Figure 2 illustrates a central bar conductor shot on a multi-diameter part and the magnetizing current/magnetic field directions.

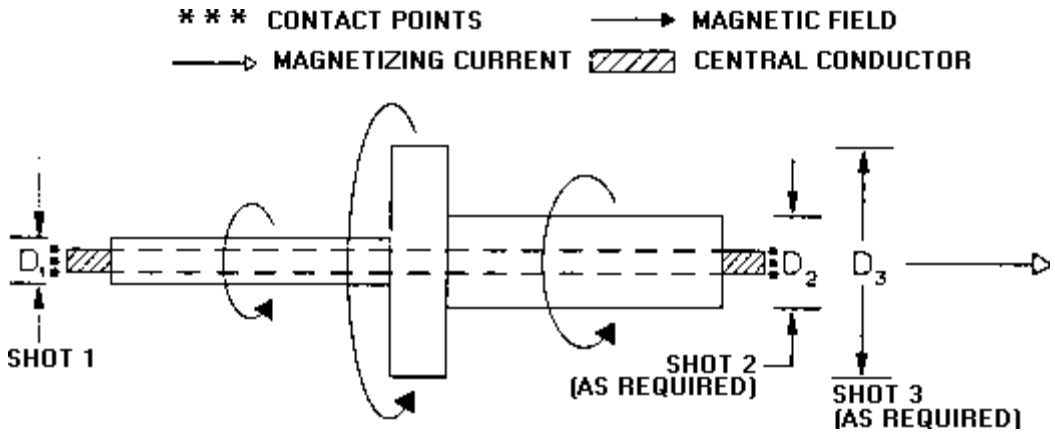

Figure 2

5.12 Direct Circular Magnetization: For direct circular magnetism, amperages shall be determined using the Hall Effect Gaussmeter. Figure 3 illustrates the proper probe positioning for the Hall Effect Gaussmeter for direct circular magnetization, and the resultant current/field direction.

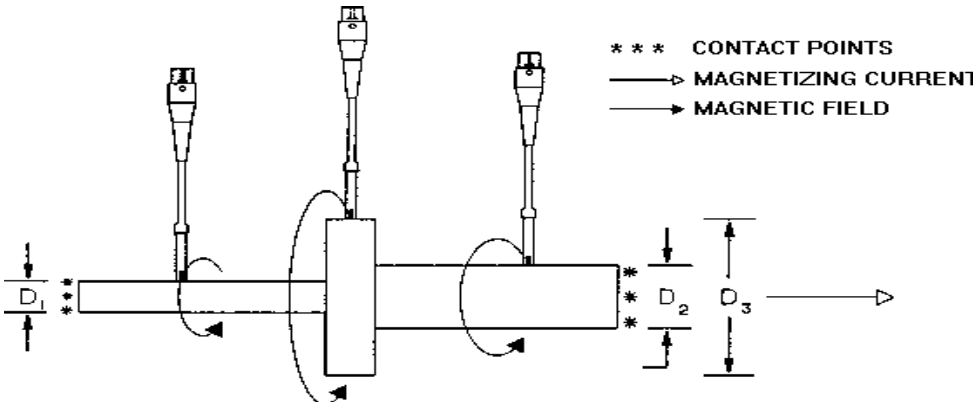

Figure 3

5.13 Coil Longitudinal Magnetization: For coil longitudinal magnetism, amperages shall be determined using the Hall Effect Gaussmeter. Longitudinal magnetization shall be induced by positioning the part in the coil with the long axis of the part parallel to the central axis of the coil. Figure 4 illustrates the proper probe positioning for the Hall Effect Gaussmeter for coil longitudinal magnetization, and the resultant current/field direction.

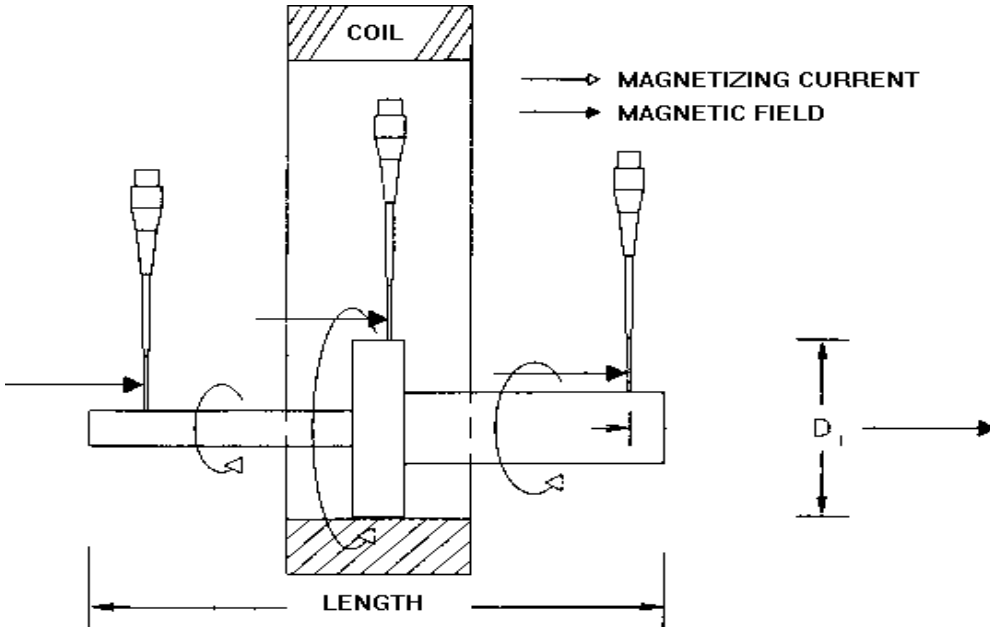

Figure 4

5.13.1 The effective field extends a distance on either side of the coil center approximately equal to the radius of the coil, i.e., 6" for Perform Air International Inc.'s 12" coil. The actual effective distance the field extends for long parts shall be confirmed via the Hall Effect Gaussmeter. For parts longer than this effective distance, the entire length shall be inspected by repositioning the part within the coil, allowing for approximately a 10% effective magnetic field overlap.

5.14 Inspection: The wet continuous method shall be used as the method of particle application.

5.14.1 Fluorescent particles suspended in a liquid vehicle at the required concentration shall be applied either by gently spraying or flowing the suspension over the area to be inspected. For the continuous method,

proper sequencing and timing of part magnetization and application of particle suspension are required to obtain the 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 duration of at least one-half second for each application, with a minimum of two shots being used.

5.14.2 The second shot should follow the first in rapid succession. It should come after the flow of suspension has been interrupted and before the part is examined for indications. Weakly held indications on highly finished parts are readily washed away, hence care must be exercised to prevent high-velocity flow over critical surfaces.

5.14.3 The minimum black light intensity at the inspection surface shall be 1000 uW/cm^2. The black light shall be positioned no greater than 15" from the part under examination.

5.14.4 Inspectors shall allow sufficient time for their eyes to adapt to the darkness in the inspection booth. This time shall be at least one minute.

5.15 Acceptance Criteria: The appropriate acceptance criterion is noted on the part specific technique.

5.16 Demagnetization: After completion of inspection, all accepted parts shall be demagnetized.

5.16.1 With the AC demagnetizing coil activated, hold the part approximately 12" in front of the coil and then move it slowly and steadily through the coil and at least 36" beyond the end of the coil. Repeat this process as necessary. Rotate and tumble parts of complex configuration while passing through the field of the coil.

5.16.2 After demagnetization, test parts with a field indicator at several locations including all significant changes in geometry and the ends of rods, bars and protrusions. Place the magnetometer as close as possible to the surface of the parts and orient the meter for maximum deflection from zero. Repeat the demagnetization if the maximum deflection at any place on the part exceeds +/- 3 Gauss.

5.17 Post Inspection Cleaning: Parts shall be cleaned and free of all magnetic particle residues after completion of inspection. Cleaning shall be done with a suitable solvent or by other means as necessary. Parts shall be inspected to ensure that the cleaning procedure has removed magnetic particle residues from coolant holes, crevices, passage ways, etc., since such residue could have an adverse

effect on the intended use of the part. Care shall be taken to remove all plugs, masking, or other processing aids that may affect the intended use of the part. Parts shall be protected from any possible corrosion or damage during the cleaning process and shall be treated to prevent the occurrence of corrosion after final inspection.

5.18 **Authorization:** Signatures will be annotated on Approval Letter from Authorized NDT Level III and List of Effective Pages/Table of Contents page.

6.0 Records:

6.1 ATA Specification 105
6.2 ASTM E 1444/E1444M
6.3 NDT Certification Record *(Form 55.16)*
6.4 Process Control Form MPI *(Form 55.13)*
6.5 MPI Technique *(Form 55.14)*
6.6 MPI In House NDT Testing Form (Form 55.09)