Perform Air International Inc.
NDT Manual
Section: IX - FPI
Fluorescent Penetrant Inspection Procedure

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, 5.2 thru 5.3, 5.4.1 thru 5.4.1.4.1, 5.4.1.6, 5.4.1.7.1, 5.4.1.8.2, 5.4.1.9, 5.4.1.9.3, 5.4.1.10.5, 5.4.1.10.6, 5.4.1.12.1, 5.4.1.13.4, 5.4.2 thru 5.4.2.1, 5.6, 5.8 thru 5.8.1, 5.12 and 6.0 thru 6.7. Addition of 5.4.1.9.2, 5.4.1.11.1 thru 5.4.1.11.2, and 5.4.8.2
2	11/30/2017	Revision to 5.4.1.13.2, 5.4.8.2 and 5.4.9
3	05/31/2018	Removed 6.7
4	07/31/2019	Revised 2.0, 6.2
5	10/16/2020	Revised 3.0
6	05/31/2022	Revised to follow current ASTM E1417/E1417M Standard. Removed fluorescent penetrant immersion tank and procedures.
7	11/20/2024	Revised 3.5, 5.1, 5.4.1, 5.4.1.1, 5.4.1.2, 5.4.1.3, 5.4.1.4.1, 5.4.1.5.2, 5.4.1.6.2, 5.4.1.6.3, 5.4.1.7.6, 5.4.1.8.1, 5.4.1.8.2, 5.4.1.9.1, 5.4.6.1, 6.4, and 6.5
8	12/23/2024	Revised 5.2 Materials Table I., to incorporate Sherwin D-106 Nonaqueous Developer (Form D).
9	*05/22/2025*	*Revised section 5.6*

1.0 Purpose:

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

2.0 Scope:

This procedure provides instructions for performing Fluorescent Penetrant Inspection at Perform Air International on in-service components. This procedure complies with the requirements of ASTM E1417/E1417M as revised.

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

5.0 Procedure:

5.1 NDT Qualification and Certification Personnel performing Liquid Penetrant Inspection at Perform Air International shall be qualified and certified in accordance with ATA-105 and NDT Certification Record (Form 55.16)

5.2 Materials: Only materials qualified to QPL-AMS-2644 are in use at Perform Air International. All material containers shall be identified with the material designation and batch number. The penetrant inspection materials in use at Perform Air International are noted in Table I. The manufacturer's material certifications for all materials shall be on file for review by auditors and customers.

Material	AMS 2644 Classification
Sherwin HM-604 Penetrant	Type I, Method A, Level 3
Sherwin D-90G Dry Developer	Form A
Magnaflux ZP-4B Dry Developer	Form A
Sherwin D-100 Non-Aqueous Wet Developer (Alt.)	Form D
Sherwin D-106 Non-Aqueous Developer	Form D
Ely Replica Transfer Coating (Alt.)	N/A
Magnaflux Zyglo SKC-S Cleaner/Remover (Alt.)	Type II
Magnaflux Zyglo ZL-27A Penetrant	Type I, Method B, Level 3
Magnaflux Zyglo ZE-4B Penetrant Emulsifier	Method B
Magnaflux Zyglo ZP-9F Non-Aqueous Developer (Alt.)	Type 1 Fluorescent
Magnaflux SKD-S2 Non-Aqueous Developer (Alt.)	Form D

Fluorescent Penetrant Inspection Materials
Table I

5.3 Equipment: Equipment utilized by Perform Air International is noted in Table II. Accessories utilized by Perform Air International are noted in Table III. All tanks shall be arranged or covered to prevent mixing of materials.

Equipment Description	Mfg./Size
Post Emulsifier Immersion Tank	16" x 23"
Penetrant Drain Station	33" x 35"
Penetrant Wash Sta. W/Backlight, wash hose W/TRICON Nozzle or equivalent	26" x 32"
Drain Station	27" x 32"
Tunnel Type Re-Circulating Hot Air Drier, 460V, 3 Phase.	34" x 72"
Rest Station	30.5 x 34"
Dry Developer Chamber	54" x 66"
Inspection Booth	3'0" x 8'0"

Fluorescent Penetrant Inspection Equipment
Table II

Description	Model and S/N	Calibration Frequency
UV & White Light Meter	Spectroline DSE-100X	Every 6 Months
UV & White Light Meter	Gould Bass DLM-1000	Every 6 Months
Drying Oven Temperature Controller and Drying Oven Temperature Indicator	Honeywell	Every 6 Months
Water Temperature Gage	N/A	Annual
Water Pressure Gage	N/A	Annual
Rinse Removal Air Gage	N/A	Annual
PSM-5 TAM Panel	Sherwin	N/A
4" Diameter Dry Developer Disk	N/A	N/A
Wash Booth Light	Magnaflux ZB-240	N/A
Inspection Booth Light	Gould-Badd CRL-2000	N/A
Timers	Various	N/A

Fluorescent Penetrant Inspection Accessories
Table III

5.4 Process Controls

5.4.1 Perform Air International Inc. works on a one shift per day schedule. When the line is not in use, process controls do not have to be performed. Enter "N/A" on the form when not in use. Daily process controls are to be performed at the start of the shift prior to any production inspection. Weekly process controls are to be performed at the beginning of the work week (typically Monday) prior to any production inspection. The quarterly process control is to be performed during the first week of the month it becomes due. Enter the weekly date on the top of the Penetrant Process Control Log (Form 55.15).

5.4.1.1 **Water Pressure Check**: This is conducted daily. Open the nozzle to the hose used in the liquid penetrant removal step. Check the water pressure while the water is spraying. Acceptable water pressure is ≤ 40 P.S.I. The pressure gage shall be calibrated annually. Non-compliant water pressure shall be adjusted to the proper settings prior to

performing penetrant examinations. This check is not recorded on the Penetrant Process Control Log (Form 55.15)

5.4.1.2 **Water Temperature Check**: This is conducted daily. Open the nozzle to the hose used in the liquid penetrant removal step. Check the water temperature while the water is spraying. Acceptable temperature is between 50° and 100° F., inclusive. The water temperature gage shall be calibrated annually. Non-compliant water temperature shall be adjusted to the proper settings prior to performing penetrant examinations. This check is not recorded on the Penetrant Process Control Log (Form 55.15)

5.4.1.3 **Inspection Area Cleanliness Check:** This is conducted daily: Clean the inspection area in the UV-A lamp booth at sufficient frequencies to ensure the area's cleanliness and absence of fluorescent contamination. Check the inspection area in the inspection booth under white light for cleanliness. Check the inspection booth with UV-A lamp for fluorescent contamination. If the area is unacceptable, clean it again or contact maintenance to clean the area. This check is not recorded on the Penetrant Process Control Log (Form 55.15)

5.4.1.4 **Dry Developer Condition Check:** This is conducted daily. Remove the lid off the pressure pot that holds the reservoir of dry developer; inspect the developer to ensure that it is fluffy and not caked. Caked dry developer is unsatisfactory and shall be replaced. If the pressure pot is less than half full, refill the pot with developer as necessary.

5.4.1.4.1 When the dry developer condition check is acceptable, record an "A" for acceptable in the Value block on the Penetrant Process Control Log (Form 55.15). Enter the inspector stamp to denote acceptance.

5.4.1.5 **Dry Developer Contamination Check:** This is conducted daily: Place the clean template (4-inch diameter circle) in the developer booth. Apply developer as one would during production inspection. Check under the UV-A lamp for any fluorescent contamination.

5.4.1.5.1 No more than 9 fluorescent specks of contamination shall be present on the template. Ten or more fluorescent specs observed under the UV-A lamp shall

be cause for rejection. Rejection of the developer shall require that the developer be discarded and the developer tank thoroughly cleaned to remove the fluorescent contaminant. Add new dry developer to the clean tank and repeat the test.

5.4.1.5.2 When the dry developer contamination check is acceptable, record an "A" for acceptable in the Value block on the Penetrant Process Control Log (Form 55.15). Enter the inspector stamp to denote acceptance.

5.4.1.6 UV-A lamp Intensity Check: This is conducted daily. Allow the inspection UV-A lamp to warm up for a minimum of 5 minutes. Place the ultraviolet light meter on the inspection surface. Ensure that the face of the UV-A lamp bulb is 15 inches from the sensor element of the ultraviolet light meter. Move the meter horizontally on the inspection surface to obtain the maximum UV-A lamp intensity.

5.4.1.6.1 The acceptable UV-A lamp intensity of the inspection light shall be greater than 1000 $\mu W/cm^2$ @ 15". If the minimum acceptable reading cannot be obtained, replace the UV-A lamp bulb and repeat the process.

5.4.1.6.2 For the Overhead UV-A lamp Intensity Check on the ZB-240 UV-A lamp, when not in use for Inspection of parts, Enter "N/A" in the Value block on the Penetrant Process Control Log (Form 55.15). Enter the inspector stamp to denote review accomplished.

5.4.1.6.3 For the UV-A lamp Intensity Check on the CRL-2000 (Handheld), Record the actual UV-A lamp reading and the date of UV-A lamp bulb replacement (if applicable) in the Value block on the Penetrant Process Control Log (Form 55.15). Enter the inspector stamp to denote acceptance.

5.4.1.7 System Performance Check: This is conducted daily: A TAM panel shall be processed for each sensitivity of penetrant in use. There shall be a "working" panel and a "master" panel for each penetrant in use. The TAM Panel shall be clean, dry and free of any contaminates before use.

5.4.1.7.1 Remove the panel from the storage container containing Acetone and dry for a minimum of 10 minutes to allow

for solvent evaporation. Panel may be placed in the drying oven at a temperature of no more than 150^0 F.

5.4.1.7.2 Before processing, observe the panel(s) under the UV-A lamp for evidence of residual fluorescent penetrant and under white light for visual damage, residues or contamination. If the panel exhibits fluorescence or contamination, it shall be cleaned in accordance with the specific TAM Panel cleaning requirements. If the panel is damaged it shall be replaced with a new panel and qualified as required per the initial calibration requirements.

5.4.1.7.3 Process the panels through the penetrant line using the same processing parameters used for the processing of production parts.

5.4.1.7.4 Compare the TAM Panel indications with the penetrant system standard (replica). The TAM Panel shall compare favorably to the replica.

5.4.1.7.5 If the panel fails the test, clean the panel thoroughly and run it again. Compare the results to the replica. If it fails again, run the master panel and compare the results to the corresponding TAM panel replica. If the master panel demonstrates acceptable results, then the suspect working panel shall be sent back to the manufacture for re-conditioning or discarded. Should both panels fail the Daily System Performance Test, the Quality Department shall conduct an investigation as to the Cause and Corrective Action that shall be taken. This may require replacement of the Penetrant materials and re-qualification of the process.

5.4.1.7.6 When the system performance is acceptable, enter the actual number of starbursts detected in the Value block on the Penetrant Process Control Log (Form 55.15) and the inspector stamp to denote acceptance.

5.4.1.7.7 As an alternative to the use of a TAM panel for the System Performance Test, the inspector may choose to run turbine blade #PAI-7 as the Known Defect Standard. Process the defective part through the penetrant line using the same processing parameters used for the processing of production parts. The crack

indication on the part must show in order to verify System Performance.

5.4.1.8 **UV-A lamp Integrity Check:** This is conducted weekly. UV-A lamp shall be checked for cleanliness and integrity and shall be cleaned, repaired or replaced as appropriate.

5.4.1.8.1 For the Overhead UV-A lamp Intensity Check on the ZB-240 UV-A lamp, when not in use for Inspection of parts, Enter "N/A" in the Value block on the Penetrant Process Control Log (Form 55.15). Enter the inspector stamp to denote review accomplished.

5.4.1.8.2 For the CRL-2000 UV-A lamp (Handheld), Enter an "A" in the Value block on the Penetrant Process Control Log (Form 55.15). Enter the inspector stamp to denote acceptance.

5.4.1.9 **Ambient Visible Light Check:** This is conducted every three months: With the inspection UV-A lamps on, place the sensor of the visible light meter on the surface normally used for inspection. The acceptable ambient light intensity is 2.0-foot candles or less.

5.4.1.9.1 Record the actual light intensity in the Value block on the Penetrant Process Control Log (Form 55.15). Enter the inspector stamp to denote acceptance.

5.4.1.10 **Qualification of Known Defect Standard Test Panels**. Upon receipt of the TAM panel from the supplier, the certification shall be filed and available for review.

5.4.1.10.1 Each panel shall be processed through the penetrant line per normal processing variables. The four largest starbursts shall be visible.

5.4.1.10.2 After successful processing, a replication of each new panel shall be made. Using clear packing tape, mask the washable side of the panel. Build the replication using Ely's Replica Transfer Coating. Spray a fine coat on the starburst side of the panel and allow the replica to dry. Build up successive coats of replica on the panel until it is opaque. This will take approximately 30 to 40 spray sequences.

5.4.1.10.3 Taking a razor blade, score the coating along the edge of the tape. Peel the tape back off the panel at an angle away from the replica and remove the tape completely, taking care not to tear the adjacent replica. Place a swath of clear packing tape over the entire replica. Press down evenly on the tape so that the tape adheres to the top of the replica. Carefully peel back the replica from one corner, taking care not to tear the replica. The replica may not peel back smoothly without the help of a razor blade separating the replica from the panel. Peel back and remove the combination of the tape and the replica completely from the panel.

5.4.1.10.4 Tape the replica to a sheet of glass that is inset into a picture frame. Label the picture frame with the penetrant/developer material and associated batch number.

5.4.2 Part Preparation: All surfaces to be penetrant inspected shall be clean, dry, and free of soils, grease, oil, paint and other coatings. This includes corrosion products, scale, smeared metal, welding flux, chemical residues or any other contaminants which could prevent the penetrant from:

1) entering discontinuities
2) create an unacceptable background
3) reduce the effectiveness of the penetrant inspection.

5.4.2.1 Perform Air International Inc. does not perform pre-penetrant acid etch. If pre-penetrant etch is required, per Engineering Drawing or Purchase Order, a customer approved source shall be utilized.

5.4.3 Inspection Sequence: Unless otherwise specified, final penetrant inspection shall be performed after operations that could produce, expose, or enlarge defects; e.g., welding, machining, grinding, straightening, heat treating, thermal cycle, spin testing, etching, or proof/pressure testing.

5.4.3.1 Final penetrant inspection shall be performed prior to operations and surface treatments which could hide surface defects; e.g., peening, coatings, plating, anodizing, or painting.

5.4.4 Inspection Coverage: Penetrant inspection shall be performed on all parts of each lot, except when sampling is permitted. All inspectable surfaces of each part shall be inspected, i.e., 100% coverage, unless specified otherwise by the customer.

5.4.5 Eye Glass Restrictions: While processing or inspecting parts, inspectors shall not wear eyeglasses with light sensitive (photochromic) lenses or permanently darkened lenses.

5.4.6 Penetrant Application: Penetrant shall be applied by brushing (Method B), or spraying (Method A). Spray is preferred for hollow parts, complex assemblies, or components which tend to bleed out during interpretation.

5.4.6.1 During dwell, rotate or turn the parts, as applicable, to prevent pooling. Verify adequate coverage by examining each part under black or white light. The temperature of the part(s) and all penetrant materials shall be between 40 and 125^0 F.

5.4.7 Penetrant Dwell Times: For temperatures between 50 to 125^0 F, the penetrant dwell times shall be a minimum of ten minutes. For temperatures between 40 to 50^0 F, the penetrant dwell times shall be a minimum of twenty minutes. For dwell times greater than two hours, the penetrant shall be reapplied. If the dwell time exceeds two hours without penetrant re-application, clean and reprocess the part. The minimum and maximum penetrant dwell time shall be measured with the aid of a timer.

5.4.8 Penetrant Removal: Surface penetrant shall be removed by using a coarse water spray from a Tri-Con nozzle, or equivalent, with a maximum operating pressure of 40 psi. The nozzle shall be held at an acute angle to the part and a minimum of 12" from the part when possible. Rinse water temperature shall be between 50 to 100^0 F. Penetrant removal shall be performed with the aid of a UV-A lamp to ensure adequate removal without over washing. Use the minimum time necessary to remove the excess penetrant.

5.4.8.1 If evidence of over-washing occurs, the component shall be dried and reprocessed. After rinsing, drain water from the component and use repositioning, suction, or filtered shop air at on more than 25 psi to prevent accumulation of water in cavities.

5.4.8.2 When conducting Method B penetrant removal process, flow the emulsifier onto the part and place on draining tray. Allow a maximum dwell time of 90 seconds and begin rinsing part. For dwell times more than 90 seconds, clean and reprocess the part.

5.4.9 Drying of Parts: Parts shall be dried in a forced hot air circulating oven only long enough to completely dry the component. Components shall be

removed immediately after drying. Parts are to be rotated if there is any evidence of pooling. Check parts every 5 to 10 minutes to assure that the part is not over-dried (burning hot to the touch). If over-drying is suspected, the components shall be cleaned and reprocessed. Oven temperature shall not exceed 160^0 F.

5.5 Dry Developer application and Dwell Times: Part surfaces shall be dry before the developer is applied. Developer shall be applied to all surfaces of the component.

5.5.1 Dry Developer Application. Dry developer shall be applied such that the part is lightly coated in a dust cloud chamber. Insert the component or parts basket in the chamber and activate the dust cloud. Adequate developer coverage shall be by evidenced by a thin coating of dust on the top, sides and bottom of the component surface.

5.5.2 The developer shall dwell for at least 10 minutes, but not longer than 4 hours. Excess dry developer is removed by tapping the part or by blowing off with filtered shop air at no more than 5 psi. If the 4-hour dwell passes without the parts being inspected, the parts shall be cleaned and reprocessed. Dry developer minimum and maximum dwell time shall be measured with the aid of a timer.

5.6 Nonaqueous Wet Developer Application and Dwell Times: If using method B process, Non-aqueous wet developer is used. Non-aqueous wet developer shall be applied in a thin, uniform coating by *spraying*. Optimum developer thickness is indicated by the visibility of the part surface. If the inherent metallic luster cannot be seen, the developer is applied too thick. If non-aqueous developer is inadvertently applied too thick, the part shall be cleaned and reprocessed.

5.6.1 The non-aqueous wet developer shall dwell for a minimum of 10 minutes, but not longer than 60 minutes. If the 60-minute dwell passes without the parts being inspected, the parts shall be cleaned and reprocessed. Non-aqueous wet developer minimum and maximum dwell times shall be measured with the aid of a timer.

5.7 Inspection: Inspections shall be performed in a darkened area with a maximum ambient white light intensity of 2-foot candles at the inspection surface. Upon entering darkened inspection area, personnel shall permit their eyes to adapt to the dark for a minimum of one minute prior to inspecting parts.

5.7.1 During inspection, the UV-A lamp shall be positioned within 15 inches (38 cm) from the surface of the component being inspected or otherwise controlled to meet minimum illumination requirements of 1000 $\mu W/cm^2$ at

the inspection surface. The UV-A lamp shall be directed such that reflection into the inspector's eyes is minimized.

5.8 **Evaluation:** All fluorescent indications shall be evaluated for relevancy. All relevant indications shall be evaluated to Section 5.10 criteria. Linear indications shall be defined as those with at least a three-to-one ratio of length-to-width. Components with relevant indications that exceed the allowable limits shall be rejected. Indications that are determined to be non-relevant shall be accepted. Indications that are determined to be false (mechanically held) shall be accepted unless they are excessive, e.g., incomplete penetrant removal, which shall prompt cleaning and reprocessing of the component.

5.8.1 **Swabbing Technique:** Relevant indications shall be evaluated and sized after lightly wiping the indication with a cotton-tipped swab, dampened with MEK or acetone. Do not permit solvent to flood the surface. The applicator may be touched to an absorbent material such as a paper towel to remove excess solvent. If the indication is accidentally flushed with solvent, the part shall be cleaned and reprocessed.

5.8.2 After the solvent evaporates from the surface, apply dry or non-aqueous wet developer. If an indication reappears, evaluate it immediately. If the indication does not immediately reappear, the inspector shall allow the minimum required dwell time before re-evaluation. If a relevant indication does not reappear, evaluate it after redevelopment. The re-development time shall be a minimum of 10 minutes for dry developer and 3 minutes for non-aqueous wet developer. If a relevant indication does not reappear, it is considered false. Indications may be wiped and re-developed no more than twice. Developer minimum and maximum dwell times shall be measured with the aid of a timer.

5.9 **Marking:** Rejectable indications shall be marked with a grease pencil or permanent marker.

5.10 **Acceptance Criteria:** The part is acceptable if no linear or crack like indications are found. All components with linear or crack like indications shall be rejected and have a red-tag applied.

5.11 **Post Cleaning:** All components that have visible traces of penetrant material shall be post cleaned using solvent or a water spray to remove residual penetrant or developer.

5.12 **Records:** Complete FPI In House NDT Testing Form (Form 55.06).

6.0 Records:

6.1 ATA Specification 105
6.2 ASTM 1417/E1417M - Inspection, Liquid Penetrant
6.3 QPL-AMS-2644-4 - Products Qualified Under SAE Aerospace Material Specification 2644
6.4 NDT Certification Record (Form 55.16)
6.5 Penetrant Process Control Log (Form 55.15)
6.6 FPI In House NDT Testing (Form 55.06)