LIQUID PENETRANT EXAMINATION OF NON-POROUS MATERIALS

1. STATUS

This Quality Note contains the process to establish the minimum requirements for performing liquid penetrant examinations of nonporous materials. The liquid penetrant examination method is used for the detection of discontinuities, such as cracks, lack of fusion, laps, cold shuts, and porosity, that are open or connected to the surface.

2. APPLIABILITY

All Suppliers utilizing Liquid Penetrant Testing for Non-Destructive Testing (NDT) for deliverable hardware.

3. REFERENCE

Note: The following documents form a part of this instruction to the extent specified herein:

3.1 ASTM Standards:

D 95  Test Method for Water in Petroleum Products and Bituminous Materials by Distillation

E 543  Standard Practice for Agencies Performing Nondestructive Testing

E 1135  Test Method for Comparing the Brightness of Fluorescent Penetrants

E 1316  Terminology for Nondestructive Examinations

E 1417  Standard Practice for Liquid Penetrant Examination

3.2 Society for Automotive Engineers (SAE) – AMS Documents:

AMS 2175  Castings, Classification and Inspection of

AMS 2644  Inspection Material, Penetrant

QPL-AMS-2644  Qualified Products List, Inspection Material, Penetrant

3.3 ANSI/ISO/AIA Standards:

ANSI/NCSL Z540-1  General Requirement for Calibration Laboratories and Measuring Test Equipment

ISO 10012-1  Quality Assurance Requirements for Measuring Test Equipment
3.4 Order of Precedence: In the event of conflict between the text of this standard and the referenced documents cited, the text of this standard takes precedence.

4. Definitions:

Note: The terminology relating to liquid penetrant examinations that appears in ASTM E 1316 shall apply to the terms used in this procedure.

4.1 Aerospace: - any component that will be installed on a system that flies.

4.2 Component: - the part(s) or element(s) of a system described, assembled, or processed to the extent specified by the drawing.

4.3 Final Penetrant Examination: - the final examination performed for the acceptance of the item. Any change to the item's surface such as machining, grinding, welding, heat treatment, or etching by subsequent manufacturing operation, may render the previous examination invalid, requiring reexamination of all affected surfaces.

4.4 In-process: - that which occurs during manufacturing before a component is in its final form.

4.5 In-service: - refers to components that are in use or storage for their intended function.

4.6 Reprocess: - repeat, after cleaning, the application and appropriate processing of penetrant, emulsifier (as required), and developer (as required).

4.7 Supplier: - the organization contracted to supply the material, parts, or assembly.

4.8 Linear indication: - penetrant indication with at least a three to one length to width ratio.

4.9 Rounded indication: - penetrant indication whose length to width ratio is less than three-to-one.

5 Responsibilities - Suppliers are to either use this procedure as their NDT guideline or generate their own that meets or exceeds the requirements of this document.

6 Procedure - Liquid Penetrant Inspection

6.1 Classification:

6.1.1 Penetrant examination processes and materials are classified in accordance with the material classification contained in AMS 2644. Penetrant systems covered by this practice shall be of the following types, methods, and sensitivity levels:

6.1.1.1 Type:
Type I: Fluorescent dye.
Type II: Visible dye.

6.1.1.2 Method:
Method A: Water washable.
Method B: Post-emulsifiable, lipophilic.
Method C: Solvent-removable.
Method D: Post-emulsifiable, hydrophilic.

Sensitivity: (These levels apply to Type I penetrant systems only. Type II penetrant systems have only a single sensitivity and it is not represented by any of the levels listed as follows):

Sensitivity Level 1/2: Very low.
Sensitivity Level 1: Low.
Sensitivity Level 2: Medium.
Sensitivity Level 3: High.
Sensitivity Level 4: Ultrahigh.

6.1.1.3 Developers shall be of the following forms:
Form a: Dry powder.
Form b: Water-soluble.
Form c: Water-suspendable.
Form d: Non-aqueous for Type I fluorescent penetrant.
Form e: Non-aqueous for Type II visible dye.
Form f: Specific application.

6.1.1.4 Solvent removers shall be of the following classes:
Class 1: Halogenated.
Class 2: Non-halogenated.
Class 3: Specific application.

6.2 General Requirements:

6.2.1 Acceptance Requirements: The acceptance requirements, applicable to a component or group of components, are provided on the drawing or applicable standards or specifications. Methods for classifying metal castings are provided in AMS 2175.

6.2.2 Personnel Qualification: Personnel performing examinations to this procedure shall be qualified and certified in accordance with NAS 410.
6.2.2.1 Personnel making accept/reject decisions shall be certified Level 2 or 3 in the liquid penetrant inspection method.

6.2.3 NDT Facility Accreditation: Supplier NDT facilities shall be NADCAP accredited or evaluated in accordance with ASTM E 543.

6.2.4 Qualified Materials: Only the materials listed on QPL-AMS 2644 (reference AMS 2644) shall be utilized for penetrant examination.

6.2.5 Equipment and Facilities: Processing equipment used in the penetrant examination process shall be constructed and arranged to permit a uniform and controlled operation. The equipment shall meet all applicable national and local safety requirements as well as the requirements specified herein.

6.2.5.1 Viewing Areas: Areas where components are reviewed shall be kept clean at all times. For visible dye examination, Type II, the lighting system shall provide at least 100 foot-candles (1076 lux) of visible light when measured at the examination surface. For fluorescent dye examination, Type I, the ambient visible light background shall not exceed 2 foot-candles (21.5 lux) at the examination surface. The black lights shall provide a minimum of 1000 μW/cm² at the examination surface. Black lights shall meet the requirements of paragraph 6.3.8.4.1.

6.2.5.1.1 Where lamps are physically too large to directly illuminate the examination surface, special lighting, such as UV pencil lights, or UV light guides, or remote visual inspection equipment shall be used. When using a borescope, the image viewed must have sufficient resolution to effectively evaluate the indication. Light intensity shall be measured at the expected working distance and shall meet the requirements of 6.3.8.5.1 as appropriate.
6.2.5.2 Drying Oven: When components are oven dried, the dryer must be a forced-air recirculating type. In automated systems, where components are dried by radiant heat and forced air, the travel speed of the system shall be such as to preclude over-drying of the components. The forced air does not have to be recirculating but must preclude contamination of the components. The temperature shall be controlled with a calibrated device capable of maintaining the oven temperature at ±15°F of the temperature for which it is set. The oven shall not exceed 160°F. The temperature indicator shall be accurate to ±10°F of the actual oven temperature.

6.2.6 Written Procedures: When liquid penetrant examination procedures are similar for many components, a master written procedure may be utilized that covers the details common to a variety of components. As a minimum, the following information is required in either individual procedures, or a master procedure, or a combination thereof:

6.2.6.1 Details of the pre-cleaning and etching process, including the materials used and specification for controlling the process, the drying parameters and the processing times. If these operations are performed by other than examination personnel, details concerning the operations may be specified in other documents but must be referenced in the procedure(s).

6.2.6.2 Classification of the penetrant examination materials required in accordance with Section 3 and AMS-2644.

6.2.6.3 Complete processing parameters for the penetrant examination materials including concentrations, application methods, dwell times, drying times, temperatures, and controls to prevent excessive drying of penetrant or overheating of component, as appropriate.

6.2.6.4 Complete examination/evaluation requirements including light intensities (both examination and ambient), the accept/reject criteria and the method and location of marking.

6.2.6.5 Identification of the components or areas within a component to be examined in accordance with the procedure.

6.2.6.6 Complete post-cleaning procedures. If post-cleaning is performed by other than examination personnel, details concerning this operation may be specified in other documents, but must be referenced in the procedure.
6.2.7 **Examination Sequence:** Final penetrant examinations shall be performed after completion of all operations that could cause surface-connected discontinuities or operations that could expose discontinuities not previously open to the surface. Such operations include, but are not limited to, grinding, welding, straightening, machining, and heat treating.

6.2.7.1 **Surface Treatment:** Final penetrant examinations may be performed prior to treatments that can smear the surface but not by themselves cause surface discontinuities. Such treatments include, but are not limited to, vapor blasting, deburring, sanding, buffing, sandblasting, lapping, or peening. Performance of final penetrant examination after such surface treatments requires that etching be included in the pre-cleaning operation, unless otherwise agreed on between the Raytheon Level 3 and the NDT facility.

6.2.7.2 **Surface Coatings:** All coatings and other surface conditions, such as, paint, plating, corrosion, etc. shall be removed from the area to be examined prior to penetrant examination. The penetrant examination shall precede any surface finish, such as anodize, except for in-service components that may be examined without removing the anodize.

6.2.8 **Material and Process Limitations:** Not all penetrant sensitivity levels, materials, and process methods are applicable to all examination requirements. The sensitivity level shall be adequate for the intended purpose of the examination. The following selections are mandatory or forbidden as indicated, unless there is an approval for deviation given by the Raytheon Level 3:

6.2.8.1 Forms a and b (dry powder and water-soluble) developers shall not be used with Type II (visible dye) penetrant systems. This is not intended to prohibit the use of a Form f developer that has been qualified with a particular Type II system in accordance with AMS-2644.

6.2.8.2 Type II penetrant examinations shall not be used for final acceptance examination of aerospace products.

6.2.8.3 Type II penetrant examinations shall not be used prior to Type I penetrant examinations of the same surface. This is not intended to eliminate the use of in-process Type II inspections where subsequent fabrication/forming operations remove the surfaces inspected.
6.2.9 Records: The results of all penetrant examinations shall be recorded. All recorded results shall be identified, filed, and made available to the Raytheon organization upon request. Records shall provide for traceability to the specific component or lot inspected. As a minimum, the records shall include: a reference to the specific procedures used; location, classification, and disposition of relevant indications; the inspector’s inspection stamp, electronic ID, or signature; and the date of examination. Records shall be kept as specified in Q note TC section 6.0 or as otherwise specified in the purchase order or contract.

6.3 Specific Requirements:

Surface Preparation: All surfaces to be examined shall be clean, dry, and free of soils, oil, grease, paint and other coatings (except as allowed by paragraph 6.2.7.2), corrosion products, scale, smeared metal, welding flux, chemical residues, or any other material that could prevent the penetrant from entering discontinuities, suppress dye performance, or produce unacceptable background. Cleaning methods, including etching, selected for a particular component shall be consistent with the contaminants to be removed and shall not be detrimental to the component or its intended function.

6.3.1.1 Solvent cleaning that includes vapor degreasing, solvent soak, ultrasonic cleaning, or aqueous-based cleaning solutions shall be used for the removal of oils, greases, waxes, and as the final cleaning step prior to penetrant examination, unless etching is required.

6.3.1.2 Chemical cleaning shall be used for the removal of paints, varnishes, scale, carbon, or other contaminants that are not removable by solvent cleaning methods.

6.3.1.3 Mechanical cleaning shall be used for the removal of soils and other contaminants that cannot be removed by solvent or chemical cleaning methods.

6.3.1.4 Grit blasting, without etching, may be an acceptable cleaning method if it can be demonstrated that a sufficiently fine abrasive (150 grit or finer) will not cause peening and can be removed by a detergent or alkaline cleaner.
6.3.1.5 Etching. shall be performed when evidence exists that previous cleaning, surface treatments, or service usage has produced a surface condition that degrades the effectiveness of penetrant examination. The etching processes shall be developed and controlled to prevent damage to the component under test. Etching is not required for those features such as close tolerance holes, close tolerance surfaces, faying surfaces, etc., where the function of the component or assembly would be degraded. Etching is not required for intermediate examination when the surface(s) are not retained in the final component configuration or when the final penetrant examination is preceded by etching.

6.3.2 Penetrant Application: The entire surface of the component to be examined shall be covered with penetrant. Large components may be examined in sections. Penetrant shall be applied by spraying, dipping, brushing, or other methods to provide coverage as required. The component, penetrant, and ambient temperatures shall all be in the range from 40 to 125°F.

6.3.2.1 Penetrant Dwell Time: The dwell time shall be a minimum of 10 minutes. For temperatures between 40 and 50°F, the dwell time shall be a minimum of 20 minutes. Rotate or otherwise move components, if required, during the dwell time to prevent pooling of the penetrant. For dwell times greater than 2 hours, the penetrant shall be reapplied as required to prevent drying. The component shall be immersed in the penetrant, if that is the application method, for no longer than half the total dwell time.

6.3.3 Penetrant Removal:
6.3.3.1 Method A Process: Water-washable penetrants shall be removed with a manual or automated water spray, a manual wipe, or an air agitated immersion wash. **Manual Spray:** Water pressure adequate to remove the penetrant shall be used but shall not exceed 40 psi. Water temperature shall be between 50 to 100°F. When hydro-air nozzles are used, the air pressure shall not exceed 25 psi. A coarse spray shall be used with a minimum distance of 12 inches, whenever possible, between the spray nozzle and the component. Washing shall be conducted under the appropriate illumination. Caution shall be exercised to ensure that over-washing does not occur. If over-washing does occur, the component(s) shall be thoroughly dried and reprocessed. After rinsing, drain water from the component and utilize repositioning, suction, blotting with clean absorbent materials, or filtered shop air at less than 25 psi, to prevent pooling in cavities, recesses, and pockets.

**Note:** Over-removal of the surface penetrant shall require that the component be cleaned and reprocessed. A good indicator of over-wash or over-removal of the surface penetrant is evidenced by the total lack of residue that may occur on all or a specific area of the component.

6.3.3.1.1 Automated Spray: For automated spray systems, the wash parameters shall meet the requirements specified in paragraph 6.3.3.1.1. Water temperature shall be maintained between 50 to 100°F.

6.3.3.1.2 Manual Wipe: Excess penetrant shall be removed using a clean, dry, lint-free cloth or absorbent toweling. The remainder of the surface penetrant shall then be removed with a water-dampened cloth or towel. The surface shall not be flushed with water and the cloth or towel shall not be saturated with water. The component shall be examined under the appropriate illumination to ensure adequate removal of the surface penetrant. The surface shall be dried by blotting with a clean, dry towel or cloth, or by evaporation.

6.3.3.1.3 Immersion: Immersion wash may be utilized if the water is air agitated and good circulation is maintained throughout the wash operation. Water temperature shall be maintained between 50 and 100°F.
6.3.3.2 Method B Process: Lipophilic post-emulsifiable penetrant shall be removed by air agitated water immersion, water spray, or hydro-air spray rinse after application of an emulsifier and an appropriate emulsifier dwell time. Water pressure and temperature and air pressure shall meet the requirements specified in paragraph 6.3.3.1.1.

6.3.3.2.1 Lipophilic emulsifiers shall be applied by immersion or flowing. Lipophilic emulsifiers shall not be applied by spray or brush and shall not be agitated while on the surface of the component. The maximum dwell times shall be 3 minutes for Type I systems and 30 seconds for Type II systems, or as recommended by the manufacturer. Actual dwell times shall be the minimum necessary to produce an acceptable background on the component.

6.3.3.2.2 Rinsing: After the appropriate emulsifier dwell time, emulsification shall be stopped by immersion or water spray. For spray removal of the penetrant/emulsifier mixture, the parameters of paragraph 6.3.3.1.1 shall apply. Dwell time in an agitated immersion rinse shall be the minimum required to remove the emulsified penetrant. Examine the components under the appropriate illumination after rinsing. Clean and reprocess those components with excessive background. After rinsing, drain water from the component and utilize repositioning, suction, blotting with clean absorbent materials, or filtered shop air at less than 25 psi, to prevent pooling. Caution shall be exercised to ensure that the air nozzle is held at a sufficient distance from the component to ensure that the developing indication is not smeared by the air blast. If over-emulsification is observed, the component shall be cleaned and reprocessed.
6.3.3.3 Method C Process: Solvent-removable penetrants are removed by first wiping the excess penetrant with a clean, lint-free, dry cloth or absorbent toweling. The remainder of the surface penetrant is then removed with a solvent-dampened lint-free cloth or towel. The surface of the component shall not be flushed with solvent, and the cloth or towel shall not be saturated with solvent. The component and cloth or toweling shall be observed under the appropriate illumination to ensure adequate removal of the surface penetrant. Over-removal of the surface penetrant shall require the component to be cleaned and reprocessed. The surface shall be dried by blotting with a lint-free, dry cloth or towel, or by evaporation. Method C can also be used for water-washable penetrants using water or solvent for removal of the excess penetrant.

6.3.3.4 Method D Process: Hydrophilic post emulsifiable penetrant shall be removed with a water pre-rinse, application of the hydrophilic emulsifier and then a post-rinse.

6.3.3.4.1 Rinse: The water pre-rinse shall be applied for the minimum amount of time required to achieve removal of the bulk surface penetrant. The rinse parameters specified in paragraph 6.3.3.1.1 shall apply.

6.3.3.4.2 Emulsifier Application: Hydrophilic emulsifier shall be applied by immersion, flowing, foaming, or spray. For immersion applications, the concentration in percent volume shall be no higher than that specified by the penetrant system supplier and shall not exceed that for which the system was qualified. For immersion applications, the emulsifier or component may be mildly agitated. Dwell time shall be the minimum required for adequate surface penetrant removal, but shall not exceed 2 minutes. For spray applications, the concentration shall not exceed 5 %.
6.3.3.4.3 Post Rinse: After the application and dwell of the hydrophilic emulsifier, the component being examined shall be rinsed with water. The spray rinse parameters of paragraph 6.3.3.1.1 shall apply. Evidence of over-removal shall require the component to be cleaned and reprocessed. Excessive background may be removed by additional (touchup) application of the hydrophilic emulsifier provided its maximum allowable dwell time is not exceeded. Additional rinsing of the touch-up area will be required after application and dwell of the hydrophilic emulsifier. If careful touch-up application of the hydrophilic emulsifier does not produce an acceptable background, the component shall be cleaned and reprocessed. Manual systems shall require the use of the appropriate illumination to ensure adequate penetrant removal.

6.3.4 Drying: The components shall be dried prior to application of the dry developer, non-aqueous developer, or examination without developer. The components should be drained of excess water but not dried before the application of aqueous soluble or suspendable developers. The components shall be dried after the application of aqueous developers.

6.3.4.1 Drying Parameters: Components shall be air dried at room temperature or in a drying oven. Oven temperatures shall not exceed that specified in paragraph 6.2.5.2. Drying time shall only be that necessary to adequately dry the component. Components shall be removed from the oven immediately after drying. Components shall not be placed in the oven with pooled water or pooled aqueous solutions or suspensions.

6.3.5 Developing: Developers shall be utilized for penetrant examination, unless otherwise specified. Type I penetrants that are qualified to AMS-2644 may be used without developer under either one of the following conditions: manufacturing examination of aluminum and magnesium castings classified by AMS-2175, as Class 3 or 4, or with the expressed approval by the Raytheon Level 3. Minimum and maximum penetrant bleed-out times without developer shall be 10 minutes and 2 hours, respectively. When developer is used, components that are not inspected before the maximum bleed-out time shall be cleaned and reprocessed. When developer is not used, components that are not inspected before the maximum bleed-out time shall be reprocessed.
6.3.5.1 **Dry Developers:** The components shall be dry before the developer is applied. The developer shall be applied in such a manner as to contact all surfaces to be inspected. Excess dry developer may be removed after the development time by light tapping or light air blow-off not exceeding 5 psi. Minimum and maximum developer dwell times shall be 10 minutes and 4 hours, respectively. Dry developers shall not be used with Type II (visible dye) penetrants.

6.3.5.2 **Nonaqueous Developers:** The components shall be dry before application of the developer. Nonaqueous developer shall be applied by spraying. For Type I penetrants, the developer shall be applied as a uniform thin coating over the entire surface to be inspected. For Type II penetrants, the developer shall be applied over the entire surface to form a uniform, white coating to provide suitable color contrast for the penetrant indications. The uniformity and thickness of the developer coating is important for both types of penetrant systems. If the developer coating thickness is too heavy for Type I systems such that the metallic surface is completely masked, the component shall be cleaned and reprocessed. Unless otherwise specified, the minimum and maximum development times for nonaqueous developers are 10 minutes and 1 hour respectively. For nonaqueous suspendable developer, the developer container shall be frequently agitated during application.

6.3.5.3 **Aqueous Developer:** Aqueous soluble developers shall not be used with Type II penetrants or Type I, Method A penetrants. Aqueous suspendable developers can be used with both Type I and Type II penetrants. Aqueous developers may be applied to the component after rinsing. Developers shall be applied by spray, flowing, or immersion. The applied developer shall not be allowed to puddle and shall completely cover all surfaces to be inspected. Components shall be air dried or oven dried to the requirements of 6.2.5.2. Minimum and maximum development times, after the component is dry, are 10 minutes and 2 hours. Aqueous suspendable developers must be either constantly agitated to keep the particles from settling out of suspension or they must be thoroughly agitated prior to use to ensure that the particles are in suspension.
6.3.6  **Inspection:** The inspection area shall meet the requirements of paragraph 6.3.8.4.5. Components shall be inspected before the maximum developing time, and monitored periodically during the developing time. Components not inspected before the maximum developing time shall be cleaned and reprocessed.

6.3.6.1 **Type I Processes:** The inspector’s vision shall be dark adapted for a minimum of 1 minute prior to examining components. Inspectors shall not wear photochromic or permanently darkened lenses while processing or reviewing components under black light. The black lights shall meet the requirements of paragraphs 6.3.8.4.1 or 6.3.8.4.2, as appropriate. All areas of fluorescence shall be interpreted. Components with no indications or only non-relevant indications shall be accepted. Components with relevant indications shall be evaluated with respect to the applicable acceptance criteria. Components with excessive background fluorescence shall be cleaned and reprocessed.

6.3.6.2 **Type II Processes:** All indications shall be interpreted. Components with no indications or only non-relevant indications shall be accepted. Components with relevant indications shall be evaluated with respect to the applicable acceptance criteria. Components with excessive background shall be cleaned and reprocessed.

6.3.6.3 **Evaluation:** All indications found during inspection shall be evaluated in accordance with applicable acceptance criteria (see paragraph 6.2.1).

6.3.6.3.1 **Indication Verification:** Indications shall be evaluated by wiping the indication with a solvent-dampened swab or brush, allowing the area to dry, and redeveloping. Redevelopment time shall be as long as the original development time, except non-aqueous redevelopment time shall be 3 minutes minimum. If no indication reappears, the original indication is considered false. This procedure may be performed twice for any given original indication.
6.3.6.3.2 Discontinuity Removal: Discontinuity(ies) may be removed using an approved procedure such as sanding, either powered or manual, or grinding, to determine the depth and extent of the discontinuity(ies). After the mechanical operation, the area shall be cleaned, etched (if permitted), and reexamined. The process used for reexamination shall be at least as sensitive as the original process.

6.3.6.4 Sizing: If the acceptance criteria is written in terms of indication sizes, the indication size shall be measured. If the acceptance criteria is written in terms of discontinuity or flaw sizes, the discontinuity shall be measured.

6.3.6.4.1 Indication Sizing: When sizing indications for judgment against the appropriate acceptance criteria, the penetrant indication (whether visible or fluorescent) shall be carefully evaluated under appropriate lighting, after the required development or redevelopment time as applicable. Measure the indication size at its largest dimension with a measuring device and the appropriate light that meets the requirements of 6.2.5.1.

6.3.6.4.2 Discontinuity Sizing: When sizing discontinuities for judgment against the appropriate acceptance criteria, the area may be carefully wiped with a solvent-dampened cotton swab or brush, ensuring rapid evaporation so that the area for examination is not flooded with solvent. Immediately measure the discontinuity using a measuring device and the appropriate light that meets the requirements of 6.2.5.1.

6.3.7 Post-cleaning: All components shall be cleaned after examination to remove developer and other examination material residues if these are detrimental to subsequent operations or the components’ intended function.
6.3.8 Quality Control Provisions: The controls necessary to ensure that the penetrant system, materials and equipment provide an acceptable level of performance are provided as follows. The frequencies of the required checks in Table 1 are based upon a facility operating daily. For facilities operating less frequently, the frequency of daily and weekly checks and those required at the start of each shift may be reduced, but must be performed prior to processing components. Monthly and quarterly checks shall be performed at the same frequency as for full-time operations. The NDT facility may perform these process control operations or contract for their performance with an independent testing laboratory. Records of tests, except as noted in Table 1, shall be maintained and available for audit by the cognizant Raytheon organization or regulatory agencies. Retention of such records shall be as specified in Q note TC section 6.0. Penetrant materials that are provided ready-for-use and do not require mixing to a concentration, and are not recovered, or reused, or both, such as materials packaged in aerosol containers, closed drums or materials poured into containers for use and are not reused are not subject to the in-use penetrant requirements of 6.3.8.2.

6.3.8.1 Material Conformance (New): Prior to being placed into use, the conformance of penetrant materials to the requirements of AMS-2644 shall be verified, by a certified report from the supplier. Use of materials not conforming to AMS-2644 shall be approved by the Raytheon Level 3 prior to use, and shall be allowed only when materials conforming to AMS-2644 are inadequate for the particular application.

6.3.8.2 Material Checks (In-Use): The applicable tests specified in paragraphs 6.3.8.2.1 through 6.3.8.2.9 shall be conducted on in-use materials at the intervals specified in Table 1. Operators shall be alert to any changes in performance, color, odor, consistency, or appearance of all in-use penetrant materials and shall conduct the appropriate checks and tests if they have reason to believe the quality of the penetrant may have deteriorated. Penetrant examinations shall be conducted only after acceptable quality of materials has been established.
6.3.8.2.1 Penetrant Contamination: The in-use penetrant materials shall be viewed at the interval specified in Table 1 to determine if any of the following conditions are evident: precipitates, waxy deposits, white coloration, surface scum, or any other evidence of contamination or breakdown. When any of the above conditions are detected, the material shall be discarded or corrected as appropriate.

6.3.8.2.2 Penetrant Brightness: Brightness tests of in-use fluorescent penetrants shall be conducted at the interval specified in Table 1. Tests shall be in accordance with ASTM E 1135 with a representative sample of the unused penetrant serving as the reference. Brightness values less than 90% of the unused penetrant brightness are unsatisfactory and the in-use penetrants shall be discarded or otherwise corrected, as appropriate.

6.3.8.2.3 Water Content of Water-Based Water-Washable Penetrants: The water content of water-based Method A penetrants shall be checked at the interval specified in Table 1 with a calibrated refractometer. The water content shall be maintained according to the manufacturer’s recommendations.

6.3.8.2.4 Water Content of Non-Water-Based Water-Washable Penetrants: Water content of non-water-based Method A penetrants shall be checked at the interval specified in Table 1 in accordance with Test Method D 95 or Karl Fischer Method as described in ASTM E 1417, Annex A1. If the water content of the in-use penetrant exceeds 5%, the penetrant shall either be discarded or sufficient unused penetrant added to reduce the water content to below 5%.

6.3.8.2.5 Lipophilic Emulsifier Water Content: The water content of lipophilic emulsifiers shall be checked at the interval specified in Table 1, in accordance with ASTM D 95 or the Karl Fischer Method as described in ASTM E 1417, Annex A1. If the used emulsifier exceeds the water content of the original (un-used) emulsifier by more than 5%, the emulsifier shall be discarded or corrected, as appropriate.
6.3.8.2.6 Hydrophilic Emulsifier Concentration:
Concentration of the hydrophilic emulsifier solution shall be checked at the interval specified in Table 1, using a calibrated refractometer. A longer period may be used if a plan justifying this extension is prepared by the NDT facility and approved by the Raytheon Level 3. Refractometer values obtained shall be compared to actual values obtained from known concentrations of emulsifier solutions. For immersion applications, the concentration, as percent of volume, shall be no higher than that specified by the penetrant system supplier and shall not exceed that for which the system was qualified. For spray applications, the concentration shall not exceed 5%.

6.3.8.2.7 Dry Developer Condition: Recycled or reused dry developer shall be checked at the interval specified in Table 1, to check for fluorescence and to ensure it is fluffy and not caked. Caked dry developer is unsatisfactory and shall be replaced. To check for fluorescence, apply a thin layer of in-use developer to a flat test panel using the same method of application used for production parts, and observe under a black light. Dry developer exhibiting ten or more fluorescent specks in a 4-inch diameter circle is unsatisfactory and shall be replaced.

6.3.8.2.8 Aqueous Developer Contamination: Soluble and suspendable aqueous developers shall be checked at the interval specified in Table 1 for fluorescence and coverage. Immerse a clean aluminum panel, about 3 by 10 inches in the in-use developer, dry it, and observe it under a black light. Observed fluorescence or failure to uniformly wet the panel is unsatisfactory and the developer shall be discarded or otherwise corrected, as appropriate.

6.3.8.2.9 Aqueous Developer Concentration: Soluble and suspendable aqueous developer concentration shall be checked with a calibrated hydrometer at the interval specified in Table 1. Concentration shall be in accordance with the developer supplier’s recommendation and shall be replaced or corrected accordingly.
6.3.8.3 System Performance: The penetrant system’s overall performance shall be checked at the interval specified in Table 1. The check shall be performed by processing a known defect standard through the system using in-use penetrant, emulsifier (if used), and developer, and the appropriate processing parameters. The resulting indications will then be compared to the indications obtained using unused penetrant, emulsifier (if used), and developer. This comparison may be made with records of previously obtained indications, or with a similar known defect standard processed with the unused materials. When the sensitivity or performance of the in-use materials falls below the performance of the unused materials, the in-use materials shall be checked in accordance with the appropriate sections in paragraphs 6.3.8.3.1 through 6.3.8.3.4, as appropriate, prior to conducting any further penetrant examinations. Unacceptable materials shall be discarded or otherwise corrected in accordance with the manufacturer’s instruction.

6.3.8.3.1 Known Defect Standards: The known defect standard shall be the TAM Panel (Pratt & Whitney #146040) or otherwise approved by the Raytheon Level 3. The user shall establish and document effective cleaning procedures based on the manufacturer’s instructions. The user shall ensure that cleaning of the standards between uses is adequate and that physical changes in the standard that make it unrepresentative of the indications found using the hold-out sample are detected.
6.3.8.3.2 Water-Washable (Method A) Penetrant Removability: The removability of water-washable (Method A) penetrants shall be tested when required in accordance with paragraph 6.4.8.3, using an AMS-2644 specified test panel. The test shall be performed using a sample of unused penetrant serving as the reference. Place a streak of the unused reference sample on one portion of the panel and a separate streak of the in-use penetrant on a separate area of the panel. Allow the panel to drain for five minutes and then wash the panel using the temperature, pressure, and wash times in use on the inspection line. Dry the panel, coat with developer, and examine under UV light. If the background of the in-use sample is visibly greater than that of the reference, then the in-use penetrant shall be discarded or otherwise corrected, as appropriate.

6.3.8.3.3 Emulsifier Removability: The removability of the in-use emulsifier shall be tested using an unused sample of the same brand of emulsifier serving as a reference when required in accordance with paragraph 6.3.8.3. The test shall be conducted using two test panels and processing parameters specified in AMS 2644. The in-use emulsifier shall be used with the unused penetrant on one panel and compared to the reference system of unused emulsifier with unused penetrant on a second panel. Allow both panels to drain for five minutes and then wash using the temperature, pressure and wash times used on the inspection line. Dry both panels, coat with developer, and examine under UV light. If the background is visibly greater than that of the reference system the emulsifier shall be discarded or otherwise corrected, as appropriate.
6.3.8.3.4 Comparative Penetrant Sensitivity: The comparative sensitivity of the in-use penetrant shall be checked using the procedures in 6.3.8.3 except that the check shall be performed by comparing the in-use penetrant to the reference unused penetrant by processing both with unused emulsifier, if applicable, and unused developer, when required in accordance with 6.3.8.3. If the comparative sensitivity of the in-use penetrant is noticeably less than the reference penetrant, the in-use penetrant is unsatisfactory for use.

Note: This test is not for determining the absolute sensitivity of the penetrant or for determining the sensitivity level of the penetrant neither of which can be performed using a starburst-type panel.

6.3.8.4 Equipment Checks: The following equipment checks shall be conducted at the intervals specified in Table 1 and recorded. Records shall be maintained and available for audit by the Raytheon Level 3. Retention of such records shall be as specified in Q note TC section 6.0. The calibration of equipment shall be traceable to the National Institute of Standards and Technology (NIST) or other recognized national standards, where applicable.

6.3.8.4.1 Black Lights: Portable, hand-held, permanently mounted or fixed black lights used to inspect components shall be checked for intensity at the interval specified in Table 1 or prior to use, and after bulb replacement. A longer period may be used if a plan justifying this extension is prepared by the NDT facility. The minimum acceptable intensity is 1000 μw/cm² at 15 inches from the front of the filter to the face of the sensor. Black lights shall be checked at the interval specified in Table 1 for cleanliness and integrity, and shall be cleaned, repaired, or replaced as appropriate.
6.3.8.4.2 Special UV Lighting: The light intensity of UV pencil lamps, UV light guides, borescopes, or remote UV inspection equipment shall be measured at the expected working distance and shall provide at least 1000 mW/cm² at the intended inspection surface, at the interval specified in Table 1, or prior to use. When using borescopes or remote video inspection equipment, the image or inspection area being viewed shall have sufficient resolution to effectively evaluate the area of inspection.

6.3.8.4.3 Visible Lights: For Type II, visible dye penetrant examinations, the lighting systems shall be checked at the interval specified in Table 1 to ensure a minimum of 100 foot-candles (1076 lux) when measured at the examination surface.

6.3.8.4.4 Light Meters: Ultraviolet and visible light meters shall be calibrated at the interval specified in Table 1 in accordance with ANSI/NCSL Z540-1 or ISO 10012-1.

6.3.8.4.5 Inspection Area: The inspection area for stationary systems for Type I penetrants shall be checked at the interval specified in Table 1 and shall be clean and free from excessive fluorescent contamination and excessive visible light background. The ambient visible light background shall be checked at the interval specified in Table 1 or when any changes, or construction, or both, in the inspection area are made. Ambient visible light shall not exceed 2 foot-candles (21.5 lux) at the examination surface.

6.3.8.4.6 Water Wash Operating Pressures/Temperatures: Indicators and controls shall be checked at the intervals specified in Table 1 to ensure proper settings. Non-compliant water pressure and temperature settings shall be adjusted to the proper settings prior to performing penetrant examinations. Indicators and controls shall be calibrated at the intervals specified in Table 1 in accordance with ANSI/NCSL Z540-1 or ISO 10012-1.
6.3.8.4.7 Drying Oven Calibration: The temperature-controlling device and the temperature-indicating device, if separate from the controller, on the drying oven shall meet the requirements of paragraph 6.2.5.2 and shall be calibrated at the interval specified in Table 1 in accordance with ANSI/NCSL Z540-1 or ISO 10012-1.

6.3.8.4.8 Timers: Timing devices used to measure or monitor processing times, such as dwell times and eye adaptation times, need not be calibrated.

6.3.9 Marking of Examined Parts: Components that have been accepted using liquid penetrant examination shall be marked in accordance with the applicable drawing, purchase order, or contract. The marking may contain an identification symbol or supplier number of the facility and a unique number or symbol identifying the examiner. The symbol “P” shall be used to denote 100% examination. All components, in the lot sampled, accepted on sampling basis shall be marked with the symbol “P” enclosed by an ellipse.
### Table 1 Required Tests and Frequency

<table>
<thead>
<tr>
<th>Tests</th>
<th>Frequency</th>
<th>Paragraph</th>
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<tr>
<td>Penetrant Contamination&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Daily</td>
<td>6.3.8.2.1</td>
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<tr>
<td>Penetrant Brightness</td>
<td>Quarterly</td>
<td>6.3.8.2.2</td>
</tr>
<tr>
<td>Water Content: Water-Based Penetrant (Method A)</td>
<td>Weekly</td>
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</tr>
<tr>
<td>Water Content: Non-Water-Based Penetrant (Method A)</td>
<td>Monthly</td>
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<tr>
<td>Lipophilic Emulsifier Water Content&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Monthly</td>
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<tr>
<td>Hydrophilic Emulsifier Concentration&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Weekly</td>
<td>6.3.8.2.6</td>
</tr>
<tr>
<td>Dry Developer Condition&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Daily</td>
<td>6.3.8.2.7</td>
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<tr>
<td>Aqueous Developer Contamination: Soluble and Suspensible</td>
<td>Daily</td>
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</tr>
<tr>
<td>Aqueous Developer Concentration: Soluble and Suspensible</td>
<td>Weekly</td>
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<tr>
<td>Penetrant System Performance&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Daily</td>
<td>6.3.8.3</td>
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<tr>
<td>Water-Washable Penetrant Removability</td>
<td>As required per 6.3.8.3</td>
<td>6.3.8.3.2</td>
</tr>
<tr>
<td>Emulsifier Removability</td>
<td>As required per 6.3.8.3</td>
<td>6.3.8.3.3</td>
</tr>
<tr>
<td>Comparative Penetrant Sensitivity</td>
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<tr>
<td>Black Light Intensity&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Daily</td>
<td>6.3.8.4.1</td>
</tr>
<tr>
<td>Black Light Integrity</td>
<td>Weekly</td>
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<tr>
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<td>Daily</td>
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<tr>
<td>Visible Light Intensity</td>
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</tr>
<tr>
<td>Light Meter Calibration&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Semi-annually</td>
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</tr>
<tr>
<td>Inspection Area Cleanliness&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Daily</td>
<td>6.3.8.4.5</td>
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<tr>
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</tr>
<tr>
<td>Water Wash Pressure Check&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Start of each working shift</td>
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<tr>
<td>Water Pressure Gage Calibration&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Water Wash Temperature Check&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td>Water Temperature Gage Calibration&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Semi-annually</td>
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<tr>
<td>Drying Oven Calibration&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Quarterly</td>
<td>6.3.8.4.7</td>
</tr>
</tbody>
</table>

<sup>A</sup> Need not be recorded.

<sup>B</sup> The maximum time between verifications or checks may be extended when substantiated by technical data and approved by the Raytheon Level 3.

<sup>C</sup> Not required for Method C examinations.