IOWA STATE UNIVERSITY

CASR

FAA Center for Aviation Systems Reliability

CASR FPI – Engineering Studies: FPI Process and Specifications

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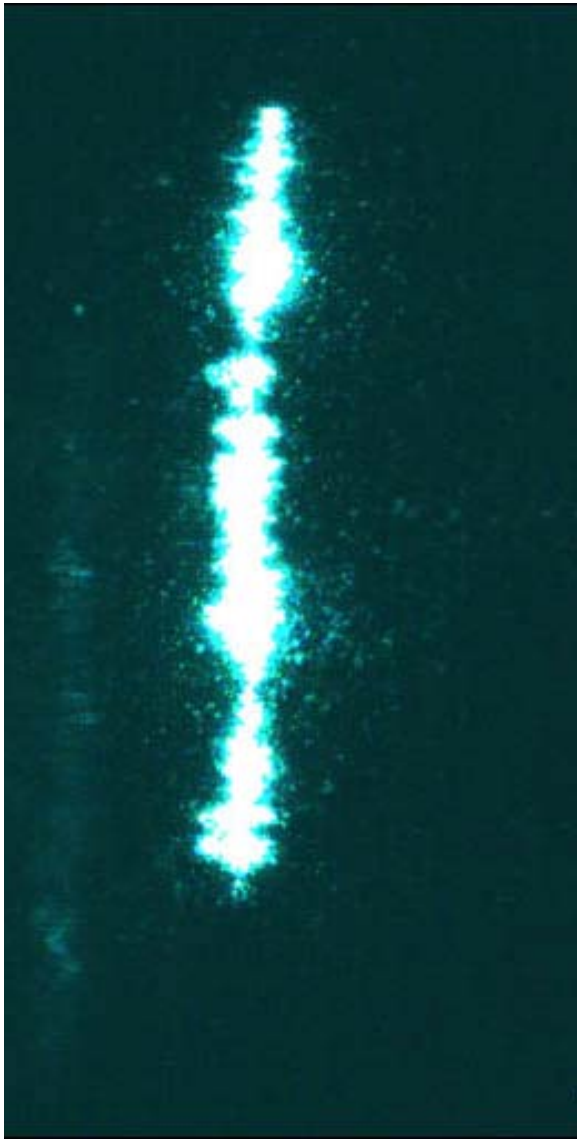
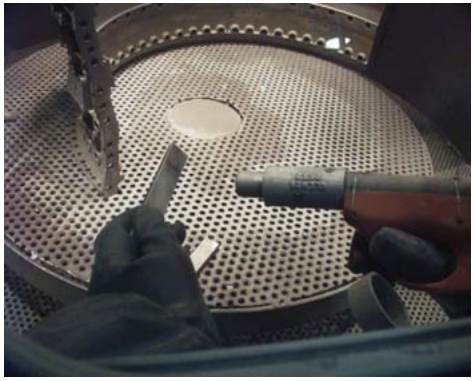
Fluorescent Penetrant Inspection

- Detects surface breaking defects
- Requires clean, dry surface
- Requires proper processing
- Both fluorescent and nonfluorescent techniques are available, most aviation applications involve the use of fluorescent penetrants in a bulk process
- Liquid penetrant is applied to the precleaned surface of a part to be inspected. The liquid penetrant is drawn into defects by capillary action.
- Excess penetrant is gently removed from the surface, taking care not to remove penetrant from any defects. The crack remains full of penetrant.
- A thin layer of developer is applied to the part surface.
- The developer acts as a blotter to draw penetrant out of the flaw. The developer also helps to provide contrast so the colored penetrant can be viewed more easily. The part is then inspected for signs of penetrant, indicating the presence of a defect.



Preparation for Penetrant Inspection

- Process begins with a clean, dry part to which the penetrant is applied.



Penetrant Application and Dwell

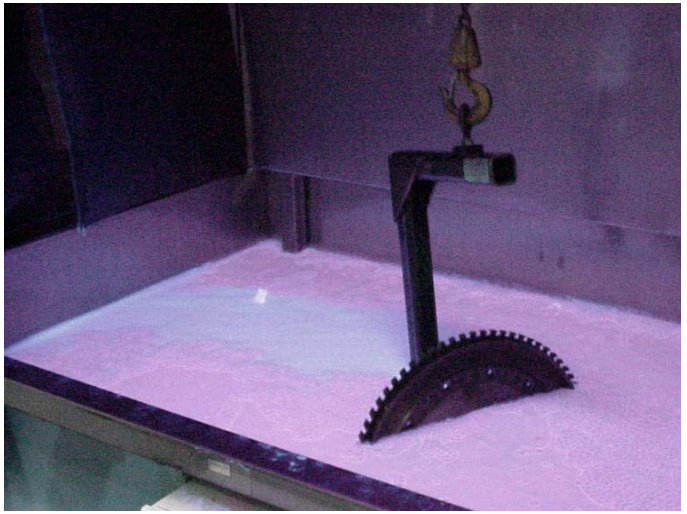
- Aerospace applications utilize the fluorescent penetrant method, typically in a dip tank.
- Liquid penetrant is applied to the precleaned surface of a part to be inspected.
- Penetrant is drawn into defects by capillary action.

Pre-rinse

After the specified dwell time, excess penetrant is removed typically using a spray pre-rinse of acceptable temperature and pressure.

Emulsification

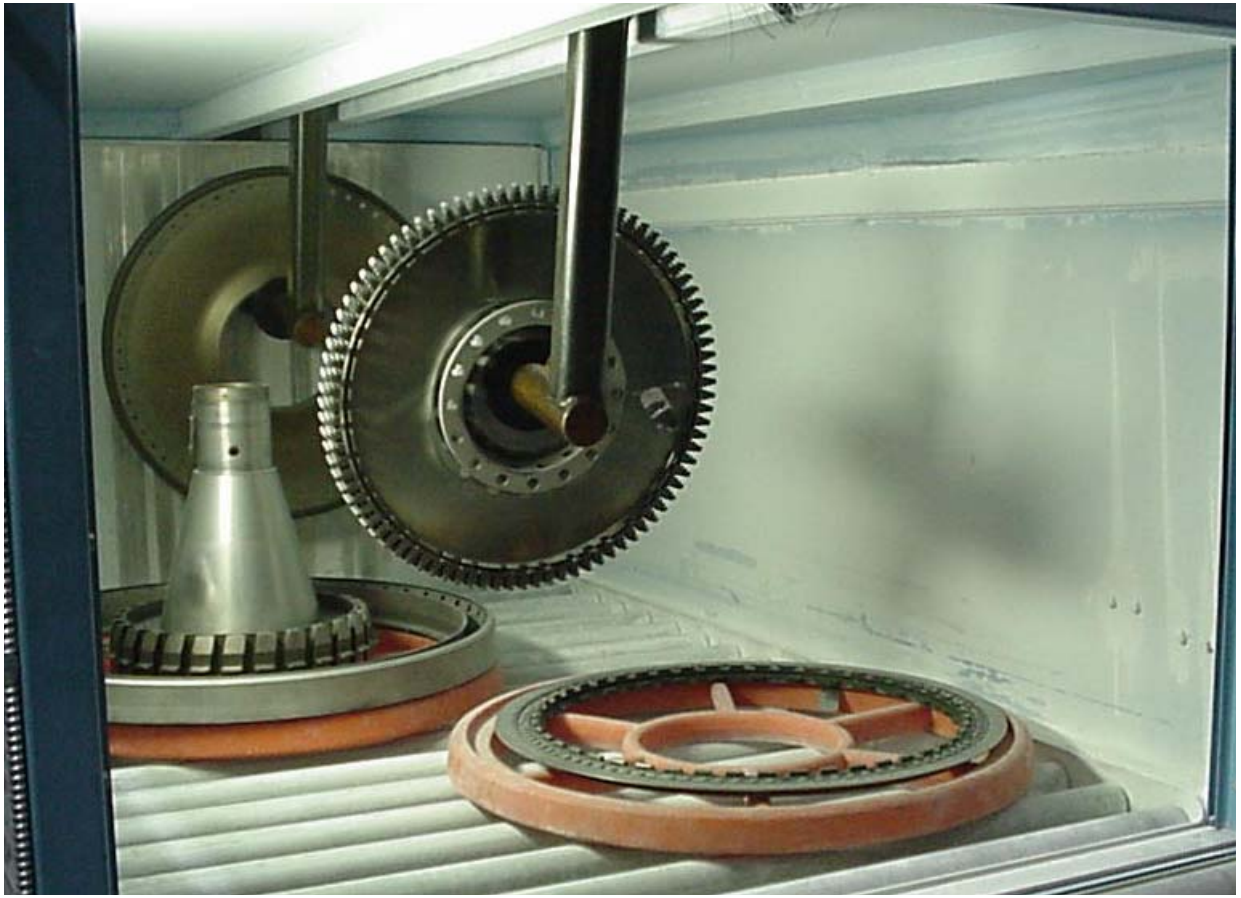
- If the post-emulsifiable process is being used, the part is then dipped in the emulsification bath to make the oil-based penetrant removable by water wash



Post Rinse

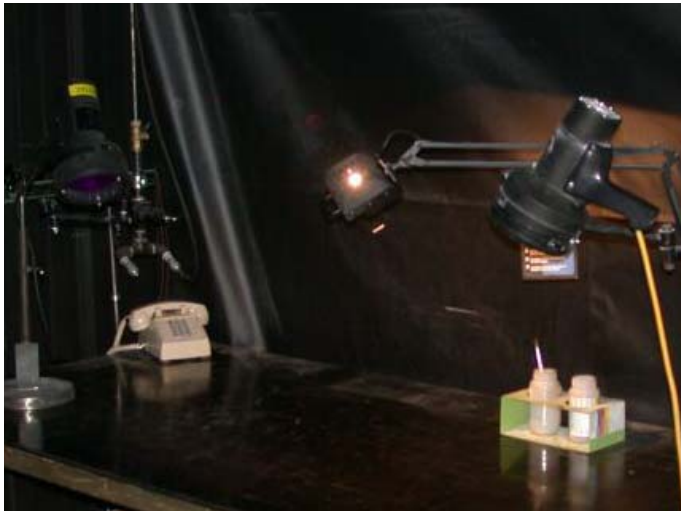
The emulsification step is followed by a post-rinse step.

Developer Application and Dwell



After a drying step, developer is applied, typically using either a spray application or developer chamber as shown here.

Inspection



- Upon completion of adequate developer dwell time, component is inspected under blacklight in a darkened room or booth

Process Specifications

- AMS 2647 – FPI Aircraft and Engine Component Maintenance

SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2647C

Issued 1985-04
Revised 2008-10-20

Superseding AMS 2647B

Fluorescent Penetrant Inspection
Aircraft and Engine Component Maintenance (R)

RATIONALE

Fluorescent Penetrant Inspection (FPI) is a widely used inspection method for the detection of cracks and other imperfections in aircraft and engine components. This specification is focused on the requirements associated with maintenance and overhaul inspection of aviation components which come with added complexities because of component geometries, inservice use effects, and field conditions, i.e., service coatings, lubricants, soot, oxides, etc., which can adversely affect the FPI process. Modifications have been made to the previous revision to reflect the results of research studies focused on determination of optimal process parameters for FPI. In addition, three appendices were added which were not part of previous versions.

1. SCOPE

1.1 Purpose

This specification details requirements and procedures for the detection of defects in aircraft and engine components during maintenance and overhaul operations.

1.1.1 This specification contains three appendices which provide additional guidance designed to supplement the information contained in the main body of the document. Because the guidance contained in the appendices is either subjective in nature or may have alternative acceptable approaches, it is not intended to be binding unless specifically invoked by the cognizant engineering organization (CEO), an original equipment manufacturer (OEM), or other contractual agreement. Personnel performing inspections to this specification should be familiar with the guidance and exercise good judgment if variance from this guidance is necessary. The following appendices are included:

1.1.1.1 Appendix A – Guidelines for Design, Procurement and/or Fabrication of Penetrant Systems

1.1.1.2 Appendix B – Guidelines for Assessment of Background Fluorescence

1.1.1.3 Appendix C –Processing and Inspection of Drum Rotors/Deep Well Spools and Other Complex Parts w/Limited Accessibility

1.2 Processing of parts and interpretation and evaluation of indications revealed by this inspection process shall be accomplished by qualified personnel having experience with fluorescent penetrant inspection. Qualification of personnel shall be in accordance with ATA 105, MIL-STD-410, NAS 410, EN 4179, or ASNT SNT-TC-1A.

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- ASTM E1417 – Standard Practice for Liquid Penetrant Testing

Designation: E 1417 – 05ε1

Standard Practice for Liquid Penetrant Testing[1]

This standard is issued under the fixed designation E 1417; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial corrections were made in August 2005.

1. Scope

1.1 This practice establishes the minimum requirements for conducting liquid penetrant examination of nonporous metal, and nonmetal components.

1.2 The penetrant examination processes described in this practice are applicable to in-process, final, and maintenance (in-service) inspections. These processes are applicable for the detection of discontinuities, such as lack of fusion, corrosion, cracks, laps, cold shuts, and porosity, that are open or connected to the surface of the component under examination.

1.3 Caution must be exercised in the usage of elevated temperature with components manufactured from thermoplastic materials. Also, some cleaners, penetrants, and developers can have a deleterious effect on nonmetallic materials such as plastics. Prior to examination, tests should be conducted to ensure that none of the cleaning or inspection materials are harmful to the components to be examined.

1.4 The values stated in inch-pound units are regarded as standard. The SI units given in brackets are for information only.

1.5 All areas of this practice may be open to agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 The following documents form a part of this practice to the extent specified herein:

2.2 *ASTM Standards:* [2]
D 95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D 2512 Test Method for Compatibility of Materials with Liquid Oxygen (Impact Sensitivity Threshold and Pass-Fail Technique)
E 165 Test Method for Liquid Penetrant Examination
E 543 Practice for Evaluating Agencies that Perform Nondestructive Testing
E 1135 Test Method for Comparing the Brightness of Fluorescent Penetrants
E 1316 Terminology for Nondestructive Testing
2.3 *ASNT Standards:*[3]
ANSI/ASNT-CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel
SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing
2.4 *Military Standards:*[4, 5]
MIL-I-25135 Inspection Materials, Penetrant
QPL-25135 Qualified Products of, Inspection Materials, Penetrant
MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification
MIL-STD-792 Identification Marking Requirements for Special Purpose Components
MIL-STD-2175 Castings Classification and Inspection of
QPL-AMS-2644 Qualified Products List, Inspection Material, Penetrant
MIL-STD-45662 Calibration System Requirements
2.5 *ANSI/ISO/AIA Standards:*[6]

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.03 on Liquid Penetrant and Magnetic Particle Methods.
Current edition approved July 1, 2005. Published July 2005. Originally approved in 1991. Last previous edition approved in 1999 as E 1417 – 99.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.
[3] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518.
[4] Copies of specifications, standards, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.
[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[6] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

Key Process Requirements – Critical Aerospace Applications

- Cleaning methods should be efficient in removing the contaminants and/or service conditions without being chemically or mechanically detrimental to the part
- Parts shall be fully dry before application of penetrant using either oven dry or flash dry
- Penetrant dwell time should not be less than 20 minutes
- Typically Level 4 Postemulsifiable penetrant used for critical engine applications and Level 3 for many aircraft applications
- Water temperature, pressure and washing time controlled to prevent overwashing (not more than 90 sec in any area)
- Critical to control emulsification contact time, concentration particularly in complex shaped parts where pooling can occur

Key Process Requirements – Critical Aerospace Applications

- Control temperature and time during drying prior to developer application to prevent heat-induced fading
- Apply dry developer to a dry part so that all areas to be inspected are completely covered with a light coating of developer. In contrast to NAWD, application of excess dry developer and subsequent removal is preferred to application of a coating that is too light.
- Developer application to all surfaces to be inspected may require additional steps to ensure that the underside and/or the sides of parts receive adequate coverage. For cloud chamber configurations, this may be accomplished subsequent to the chamber application using a bulb or spray wand to provide assess to inadequately covered surfaces.
- Handling fixtures and containers may also block developer application.
- Supplemental developer application may be needed

Key Process Requirements – Critical Aerospace Applications

- Specification of white light contamination (not greater than 2 footcandles) and minimum black light intensity (1000 $\mu W/cm^2$)
- Ensure all required inspection surfaces are examined. Use a consistent and systematic search strategy in inspecting the component
- Before beginning inspection, the individual shall wait at least one minute to adapt to darkness vision. Dark adaptation times can vary among individuals and will also depend on the level of light the eyes were previously exposed to (i.e., shop lighting versus sunlight).
- Inspector should have access to relevant specification and reflected in training, task cards and other guidance