

# **Liquid Penetrant Inspection and Human Factors**

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**Human Factors Good Practices in  
Fluorescent Penetrant Inspection  
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# Background

**National Transportation Safety Board (NTSB) report (N75B/AAR-98/01) concerning the failure of the inspection system to detect a crack in a JT8D engine hub.**

- **Inspection failure in engine maintenance can cause engine failure and take lives!**

# Human Factors Study

- Five site visits were made, four air carriers and one OEM repair station.
- Emphasis on Human Factors relating to the FPI process and critical rotating parts.
- Interaction was with inspection management, cleaners and inspectors.
- Provided out briefing at each facility.

# **Human Factors Study**

## **Appendix 1**

- **Task description and analysis of each process:**
  - **1.0 Cleaning**
  - **2.0 Load/Transport in FPI**
  - **3.0 Apply Penetrant**
  - **4.0 Water Wash**
  - **5.0 Dry Part**
  - **6.0 Apply Developer and Air Clean**
  - **7.0 Read Part**

# Human Factors Study

## Appendix 2

- Detailed Human Factors Good Practices for Each FPI Process:

Breaks down each of the seven processes into very specific **Good Practices** and detailed explanations as to **Why!**

# Process Control

- **Write measured values in process control logs, i.e. actual numbers versus a check mark.**
- **Allow good access room around inspection booths for inspectors and maintenance.**
- **Wash and/or discard gloves between processes.**
- **Reduce ambient white light levels where UV light is used.**
- **Maintain good communication between cleaning and FPI.**

# Cleaning

- Train cleaners in the critical nature of how their job relates to the total penetrant inspection process!!
- Train cleaners to recognize when a part is **inadequately** cleaned by providing good feedback from inspectors.
- Use clearly visible/audible timers for processes
- Design indicator dials to be easily read
- Ensure system for matching components and paperwork is simple and visible.
- Ensure parts handling systems are functional



# Loading

- Provide custom hangers for parts.
- Ensure parts are marked for which process.
- Ensure part and paperwork are easily matched.
- Design handling system and hangers to ensure that chemicals can reach all parts of component

# Applying Penetrant

- **Dip tanks need to be clearly labeled as to type of penetrant.**
- **Metal to metal contact should be eliminated using nonmetallic rollers.**
- **Timers need to be used and visible/audible**
- **Proper parts handling equipment is needed**

# Applying Penetrant

- **Make spray gun easier to maneuver (balanced)**
- **Label all process tanks**
- **Design drum-to-spray gun connections so each gun can only be used with correct penetrant.**
- **Assure that the emulsifier spray gun is properly labeled and positioned.**
- **Perform spraying under UV light**

# Washing

- Design wash booths so that component can be washed at shoulder height.
- Wash under UV light with minimal white light.
- Provide air line and suction line.

## **Reading**

- **Provide timer for dark adaptation time, 3 – 5 minutes minimal for adaptation.**
- **Ensure objects in booth are not fluorescent.**
- **Provide clean surface for inspecting, soft, easy to clean.**
- **Ensure lights etc. can't make metal to metal contact.**
- **Train inspectors in a consistent strategy of eye movement, search strategy and marking of locations to assure 100% inspection coverage.**

# TAM Panels

- **Often used as quality assurance tool.**
- **Each penetrant sensitivity level should have a separate panel.**
- **There should be guidance in place for the care, cleaning and use of TAM Panels.**
- **What is done if a TAM Panel fails a check?**

# Contaminated TAM Panels

- **Ask to have panels prepared for testing as they are normally, then:**
  - \* **View panels under black light looking for starbursts.**
  - \* **Look for blue fluoresces from oils or yellow-green glow from residual penetrant.**
  - \* **Apply developer and view under black light looking for starbursts.**
- **What happens if panels show contamination?**

# CONCLUSION

- TRAINING!! TRAINING!!  
TRAINING!!
- This includes EVERYBODY involved in the penetrant process!
- Simple method?
- Mistakes, positive and negative are costly.



# **NDI Check List**

**Prepared by: FAA Center for Aviation  
Systems Reliability**

**Iowa State University**

**Prepared for: Federal Aviation Administration  
Training Academy**

**Course # 22518**

**<http://www.faa.gov/avr/afs/300/afs300a.html>**

<http://HFskyway.faa.gov>



Federal Aviation  
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Flight Standards  
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## Human Factors Good Practices in Fluorescent Penetrant Inspection



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# **Audit and Surveillance**

# **Audit/Surveillance**

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# Documentation

- An organization should have a documented means of assuring that only “qualified” persons perform Nondestructive Inspections.

- ❁ Written records

- ❁ Computer records

# **Documentation**

**Sufficient documentation must be available and retained for each individual.**

## **Records shall include:**

- **Education**
- **Experience**
- **Vision examination**
- **Training documentation**

- **An organization performing Nondestructive Inspections should be audited to assure compliance with their accepted procedure for training, qualifying and certifying NDI personnel.**

# Five Elements for Evaluation

- **Documentation**
- **Organization**
- **Environment**
- **Calibration**
- **Training**



# **Documentation**

**Written procedures, processes, specifications and/or methods used by air operators or air agencies in the performance and control of NDI activities.**

**Is it CREDIBLE?**

# Organization

**Relationship of NDI organization to management.**

- **Who is in charge?**
- **Who is consulted if questions arise?**
- **Who purchases equipment?**

# **Environment**

**The general physical condition of the facility, e.g., housekeeping, storage, safety, consumable management, equipment.**

- Is size of NDI area sufficient?**
- Is parts handling equipment adequate?**
- Is metal to metal contact prevented?**

# Calibration

**Process by which an item is checked against a standard.**

- **Is there a procedure for calibrating inspection devices to certified standards?**
- **Are referenced standards properly labeled?**
- **Are calibration methods documented?**
- **Are setup verifications performed on all shifts?**

# Training

**Methods used and records maintained to train and retrain NDI personnel.**

- **What is the criteria for training and certification?**
- **Are training methods identified in the manual/written practice?**
- **Is OJT recorded?**
- **Is there a procedure for rectification/decertification?**

# Methods Covered by Check List

- **Visual**
- **Liquid Penetrant**
- **Magnetic Particle**
- **Eddy Current**
- **Ultrasound**
- **Radiography**

# Liquid Penetrant

- **Has adequate training been provided?**
- **Are gauges, thermometers, and timers adequate?**
- **Are test panels used to verify system?**
- **Are calibration requirements followed and documented?**
- **Have cleaning personnel been trained?**

## Liquid Penetrant (Cont.)

- Is proper light intensity determined on a regular basis?
- Is the correct penetrant sensitivity being used?
- Are precleaning and post cleaning procedures in place?
- Are tanks protected from contaminants?
- Is the examining area free of interfering debris and “stray” fluorescent materials?



# Specifications

- **Two most common references for penetrant inspection are:**
  - \* **SAE AMS 2647B**
  - \* **ASTM E 1417**
- **Neither one allows visible (red) dye penetrants for aviation inspections!**

# Cleaning and Drying

- **Is there standing water on parts waiting to be inspected?**
- **Is there dust and dirt on incoming parts?**
- **How does the inspector know the part is clean and dry enough to inspect?**
- **Are the cleaning personnel aware of how clean and dry parts need to be?**
- **Is there communication between inspectors and cleaners?**

# Conclusion

- **Is the operation “credible”?**
- **Are they trying to be in compliance and not sure how to follow limited guidance?**
- **If the organization is trying to be in compliance, counsel, work with, provide references.**