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CASR

FAA Center for Aviation Systems Reliability

# CASR FPI – Engineering Studies: Key Conclusions


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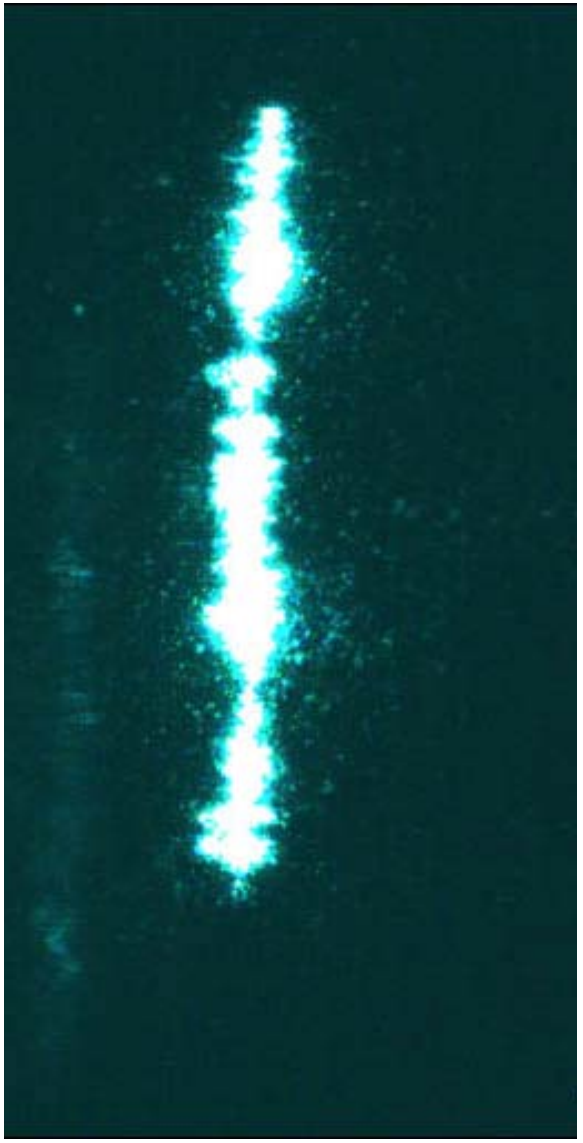
**http://www.cnde.iastate.edu/faa-casr/fpi/index.html**

# Fluorescent Penetrant Inspection

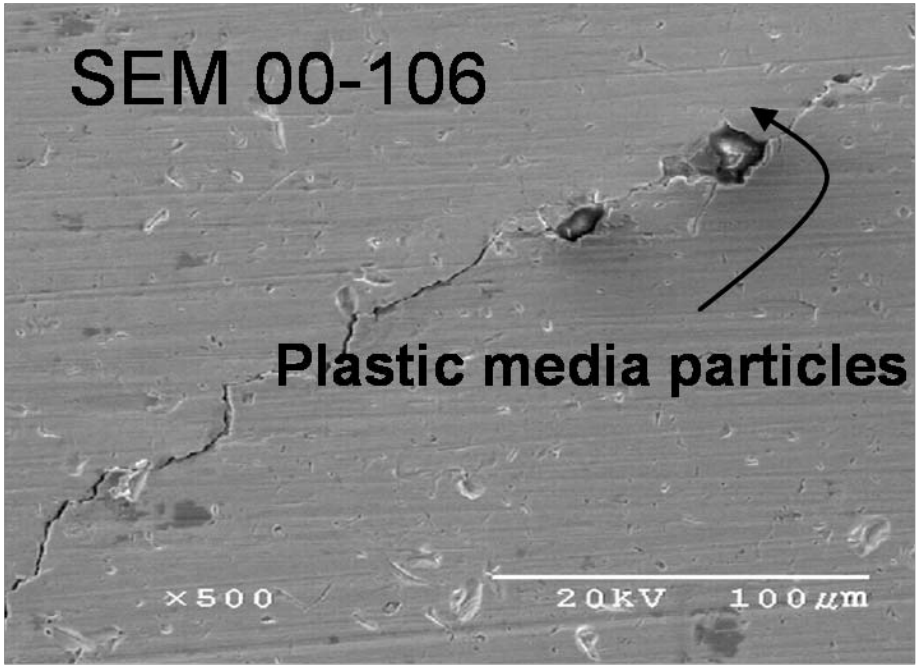
- Detects surface breaking defects
- Requires clean, dry surface
- Requires proper processing
- Both fluorescent and nonfluorescent techniques are available, most aviation applications involve the use of fluorescent penetrants in a bulk process
- Liquid penetrant is applied to the precleaned surface 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.



# Key Conclusions

Cleaning:

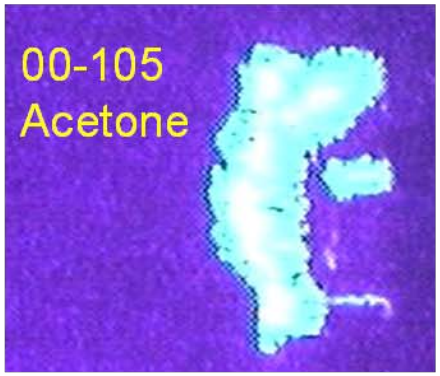
- Selection of cleaning method should be stringent enough to remove soil of concern without detrimental effect on the component or on FPI performance
- Four-step process shown to be most effective for Ni
- Hot water rinse (>150F, 15 minutes) recommended for Ti
- Mechanical cleaning can lead to metal smear and entrapment of cleaning media if recommended practices aren't adhered to
- Use of wet-glass bead is not recommended prior to FPI

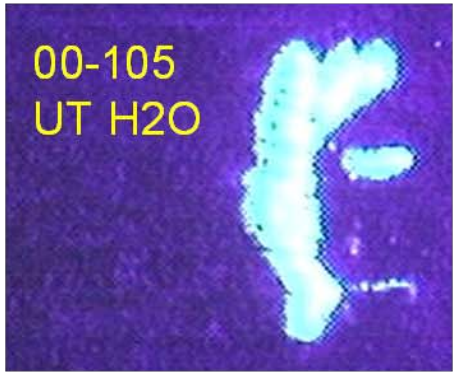


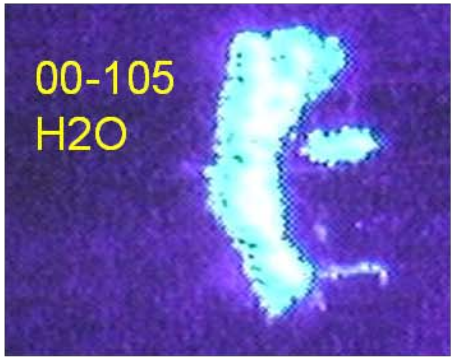
# Key Conclusions

Drying

- Water is a contaminant which degrades penetrant process, i.e., drying is an important step in preparation for FPI
- No statistically significant differences found between flash dry and oven dry methods



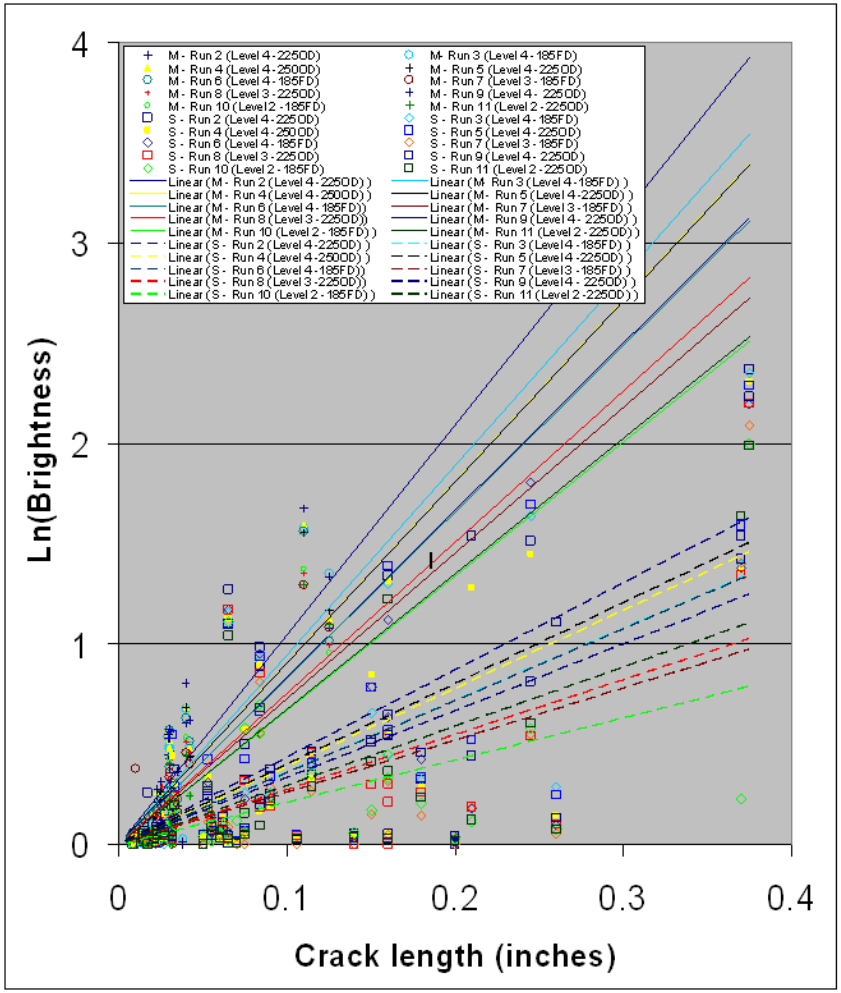
# Key Conclusions

Penetrant

- Increased penetrant dwell time can improve brightness performance, particularly for “tight cracks”
- Use of red dye prior to FPI led to detrimental effect on luminance of subsequent FPI processing
- Differences were found between penetrant method with Level 4 found to be more sensitive than Levels 3 or 2. Differences between levels 2 and 3 were not significant for the rinse times used in this study.

Emulsification

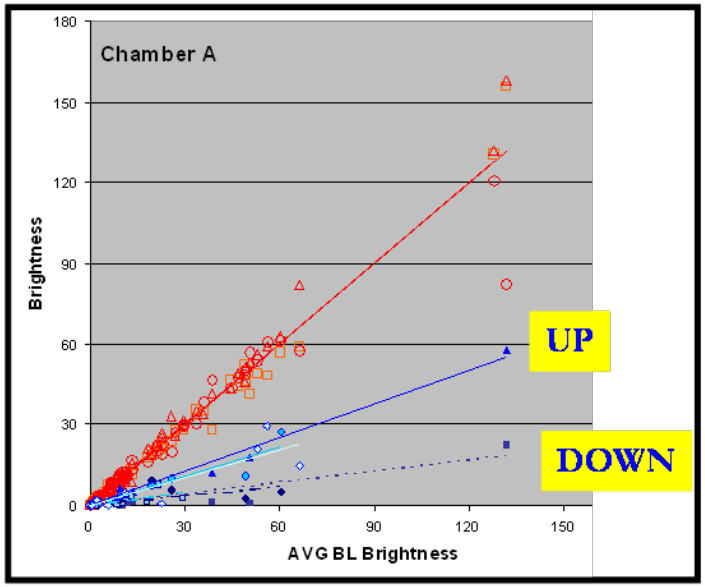
- Control of contact time was shown to be most critical factor



# Key Conclusions

Developer Application

- Variation within chambers evaluated in this study are representative, indicating widespread variation across the industry. Recommended measurements be made of operational chambers to ensure inspectors are aware of any deficient regions.
  - Known defect standards such as TAM panels, low-cycle fatigue cracks, twin crack panels, or parts with known cracks can be processed and placed at different locations and orientations in a systematic manner.
  - Comparison between defect response as a function of position should provide an indication of deficient regions.
- Allowing the inspectors to arbitrarily reduce powder volume within a dust storm cabinet, whether to avoid a mess in the inspection booth, or reduce powder usage, is not a good choice when seeking the most sensitive inspection possible.
- Obstacles impeding developer motion to the part surface, such as stacking of baskets, fixtures, rollers, and slings should be noted and avoided when feasible.
  - Additional developer should be applied to shielded areas using a dusting bulb, spray wand, or nonaqueous wet developer to ensure adequate and complete coverage of all surfaces.
- In most cases, crack location, i.e., top vs. bottom, is unknown prior to inspection. This may warrant processing of parts twice, inverting the part on the second run so that the other surface has the opportunity to be in the most sensitive “up position” during developer application. Alternatively, a secondary development method could be used to add supplemental developer to the lower surface and other critical areas of the component.
  - Research has shown that self-development of indications does not occur and use of developer is required to produce optimal indication luminance.



# Key Conclusions

Developer Application

- In most training programs, the inspector is taught to use a light coat of developer because of concerns with masking indications. While this can be an issue, it is important to ensure that adequate developer is applied. When using manual spray wands the inspector should make an effort to apply powder to all surfaces rather than holding the wand near a single location and expecting developer to reach all surfaces.
- Use of evacuation systems too early in the development process can reduce the developer contact with the surface and potentially lead to missing indications.
- In use of Form B and/or Form C developers, it is important to use the manufacturers recommended concentration.
  - In use of immersion systems, care should be taken to ensure pooling of the developer around geometrical features (in crevices and cavities), does not occur.
  - In spray applications, it is important that developer be applied to all surfaces.
- For electrostatic application of developer, a performance characterization study of the system prior to routine use and at periodic intervals is recommended. The time necessary to arrive at an optimal coating thickness for the typical part-to-gun distance should be established. Given that thickness variation (and resulting indication luminance variations) can occur with respect to the impinging direction of the spray, care should be taken to encircle the part with the spray gun when feasible.