The Teamwork Of Jet Engine Cleaning & Fluorescent Penetrant Inspection (FPI)

By Jeff Stevens

Editor's Note: *At the 1998 Aerospace/Airline Plating and Metal Finishing Forum in San Antonio, TX, Jeff Stevens received the Garland Award for best paper presented at the conference. Reprinted here is an outline of his presentation, in bulleted format, with accompanying graphics.*

This presentation provides a "hands-on" maintenance engineer's perspective on the basic steps to success in jet engine cleaning, part stripping and inspection. Subjects covered include:

- **The purpose of chemical and abrasive blasting (precautions and key points to remember).**
- **How clean is "clean"?**
- **What are the causes for dirty parts at inspection time?**
- **The use of silicated cleaners.**
- **"Flash" drying.**
- **Common fluorescent penetrant inspection (FPI) problems.**
- **Solutions to cleaning and FPI problems.**

Cleaning procedures and test results will be presented for the effects of water and plastic blast on cracks, oven-dried parts, wet and dry parts, "flash" drying and crack detection results.

It's About Crack Detection!

The basic steps to success are:

- Clean
- Strip
- Inspect

Purpose of Chemical & Abrasive Blasting

- Prepares parts for inspection

Test Parts
Materials & Crack Size

Test Piece	Length	Crack Size	Materal	Nomenclature
#1	.170"	Very Tight Fatigue Crack	(Ni Alloy)	HPC 6th Vari-Vane
#2	.220"	Very Tight Fatigue Crack	(Ni Alloy)	HPC 5th Vari-Vane
#3	.050"	Very Tight Fatigue Crack	(Ni Alloy)	HPC 5th Vari-Vane
#6	.200"	Very Tight Fatigue Crack	(Ni Alloy)	HPC 5th Vari-Vane
#4	.047"	Tight Fatigue Crack	(Ti Alloy)	HPC 9th Blade
#5	.195"	Tight Fatigue Crack	(Ti Alloy)	HPC 8th Blade
#X17	.018/.020/.045"	Cracks in Hard Face	(Ni Alloy)	HPT 3rd Blade
#C18	.045"	Crack in Hard Face	(Ni Alloy)	HPT 3rd Blade
#C10	.050"	Dross	(Ni Alloy)	HPT 1st Blade
#7	.200"	Wide Open Crack From FOD	(Ti Alloy)	HPC 7th Blade
A & B	2.00"	0-50 micron Crack Panels	Cr Plate on Brass Panel	

–Cleans service contaminants, grease, oil, carbon, oxidation, heat scale (hardened deposits)
–Strips paints, antigallants, RTV and sealants
- Use only cleaning (SPOPs) in Engine Manual that are specified for the part
- Use approved cleaning materials and SPOPs specified to provide necessary cleanliness for inspection
- Dry parts prior to inspection

–Hot water (flash air dry)
–Hot circulating air or vacuum oven
- Parts only need to be sufficiently clean so that the correct inspection method is possible
- Stains on nickel-cadmium-plated parts do not need to be removed for FPI
- Strip paints/varnishes on Al and Mg covers/cases, only if fluorescence is excessive

Why Do I Have Dirty Parts At Inspection?

- Inadequate cleaning equipment/solution agitation
- Incorrect process/SPOPs
- Improper solution temperature, concentration or dwell time
- Ineffective rinsing
- Lack of solution maintenance
- Inadequate training of personnel and loss of experience

How Clean Is Clean?

- Parts are rejected at FPI when:

–They are considered insufficiently clean and the reason is obvious, or when it becomes a matter of opinion
–Inspectors unnecessarily want parts to look like new
–Parts not fully clean as a result of improper cleaning method(s)

- Parts are not clean enough when:

–Soil, grease or oil rubs off on your finger

–Penetrant beads up or separates on part surface
–Water beads up or "breaks" on part in FPI wash cycle
–Light smut or dust causes excessive background fluorescence
–Background from soil or coating interferes with FPI
• Light surface dust is permissible
• It's normal to see some background fluorescence on:
–Castings
–Mating surface contact areas, such as splines, bolt head/spacer contact area
–Manufactured or refurbished areas, including plasma, diffused coatings, chromium plate, edges of nickel plate
–Oxidation and stained areas
• What about discoloration in galled areas on fan blades and disk/hub slots?
–Area is sufficiently clean for FPI if background fluorescence is not excessive
–Pressure face surface galling should not be removed by abrasive blasting prior to FPI
–Crack indications on titanium can be masked by unapproved dry glass bead or other blasting

What About Silicated Cleaners?

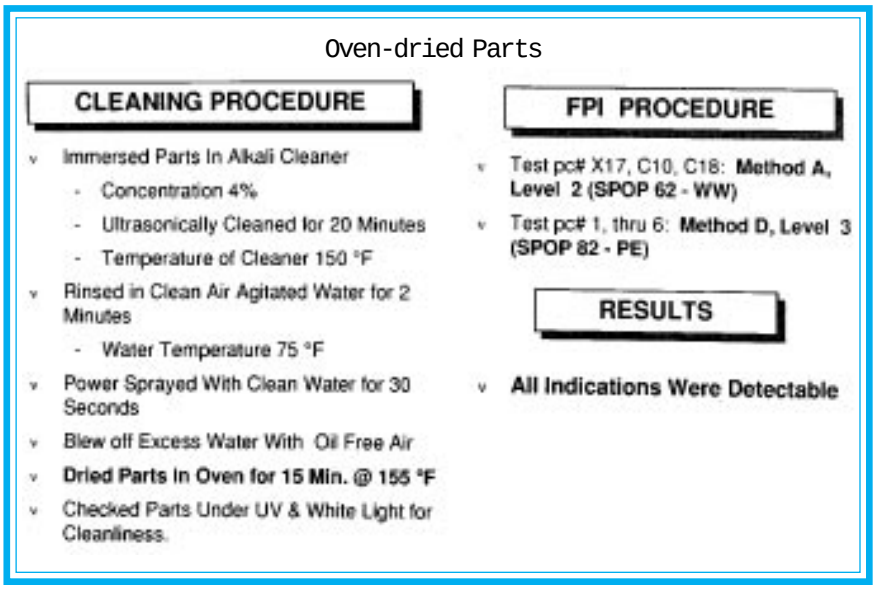
• Highly silicated cleaners and improper processing parameters can mask cracks prior to FPI
–Processing parameters can mask cracks prior to FPI
• SPOP 209 aqueous degreasing provides low and non-silicated solutions and parameters that do not mask FPI indications

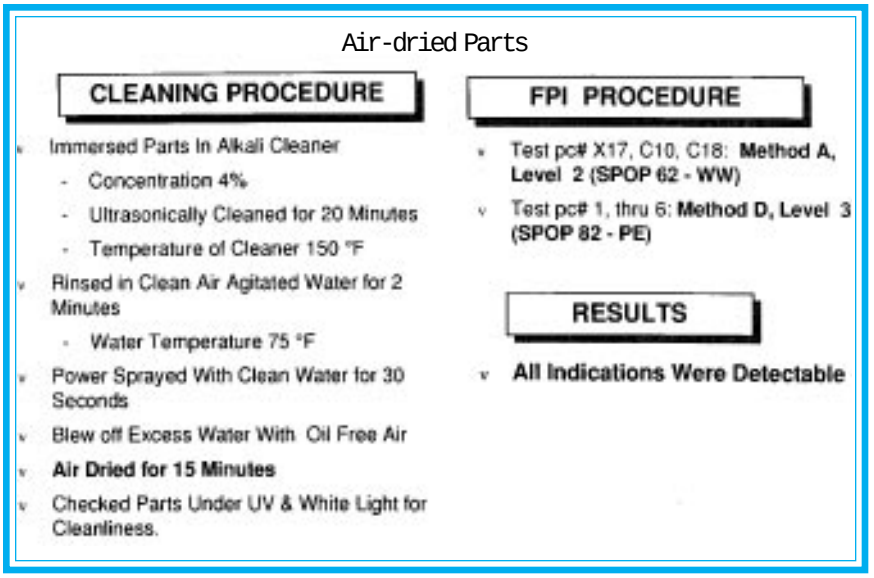
Precautions on Abrasive Blast Cleaning

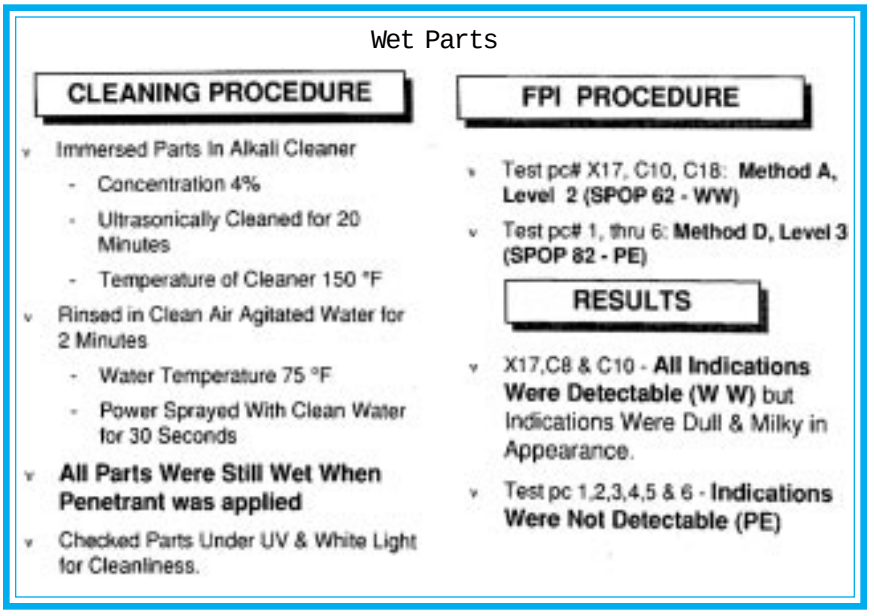
• Improper parameters can cause part surface smearing
–Media
–Pressure
–Angle
–Dwell
• Abrasive blasting should only be used to supplement chemical cleaning or stripping
• Do not mix media

What Is "Flash" Drying?

• Immerse part fully or spray-wash part in hot water (150–200 °F)
• Allow part temperature to equalize with water temperature before removing







- Immediately remove residual water by part rotation, air blast or suction

Common FPI Problems

- Incorrect processing parameters
- Incorrect penetrant sensitivity
- Improperly cleaned parts
- Inspectors inadequately trained

Solutions to Cleaning/ FPI Problems

- Proper training does reduce turn time/rejection rates
- Departmental cooperation builds understanding of reasons for parts recycling
- Training needs include addressing:

–Engine part variations in configuration and complexity

–Variations in materials, coatings and engine run conditions

- Maintaining an experienced work force to minimize problems

What's the Bottom Line?

- Teamwork
- Common sense
- Proper and continuous training
- Experienced work force

PW Test Results on the Effects Of Water & Plastic Blast on Cracks

- Oven, air or "flash"-dried parts
- Wet parts and penetrants
- "Flash" drying and penetrants
- Wet vs. dry parts and penetrants
- Wet parts and very tight cracks
- Plastic blasting

About the Author

Jeff Stevens is a senior development engineer with Pratt & Whitney, 400 Main St., M/S 169-11, East Hartford, CT 06108, and is responsible for overhaul processes in the company's Commercial Standard Practices Manual. He specializes in chemical cleaning/stripping, abrasive blasting, fluorescent penetrant inspection, fluorescent magnetic particle inspection and plating processes. Working in this capacity for the past 15 years, he has responded to thousands of inquiries about these processes from commercial overhaul shops around the world, and often visits the facilities to review and troubleshoot problems.

Flash Drying

CLEANING PROCEDURE

- Immersed Parts In Alkali Cleaner
  - Concentration 20 - 30 %
  - Soaked for 5 Minutes
  - Temperature of Cleaner 155 °F
- Rinsed in Cold Immersion Tank for 2 Minutes
- Power Sprayed With Clean Water for 30 Seconds
- **Immersed In Hot Water For 5 Minutes**
  - **Water Temperature 178 °F**
- Blew off Excess Water With Oil Free Air
- Checked Parts Under UV & White Light for Cleanliness.

FPI PROCEDURE

- Test pc# X17, C10, C18: **Method A, Level 2 (SPOP 62 - WW)**
- Test pc# 1 thru 7*: **Method D, Level 3 (SPOP 82 - PE)**

* new test pc# 7 was added

RESULTS

- **All Indications Were Detectable**

Wet/Dry Parts

CLEANING PROCEDURE

- Immersed Parts* In Alkali Cleaner
  - Concentration 4%
  - Ultrasonically Cleaned for 20 Minutes
  - Temperature of Cleaner 150 °F
- Rinsed in Clean Air Agitated Water for 2 Minutes
  - Water Temperature 75 °F
- Power Sprayed With Clean Water for 30 Sec.
- Blew off Excess Water With Oil Free Air
- **Oven Dried Panel A for 15 Min. @ 155 °F**
- **Panel B and Test Pc# 7 Left Wet.**

*** Test pc# 7 and 0-50 micron Japanese cracked Chrome Panels A & B**

FPI PROCEDURE

- All test pc's: **Method D, Level 3 (SPOP 82 - PE)**

RESULTS

- **Cracks Were Detectable and Bright.** No Difference Between Dry **Panel "A"** and Wet **Panel "B".**
- Crack **Was Not Detectable** on Test Pc# 7 with **Wide Open Crack.**

Wet/Dry Parts

CLEANING PROCEDURE

- Immersed parts* in alkali cleaner
  - Concentration 4%
  - Ultrasonically cleaned for 20 min
  - Temp of cleaner 150 °F
- Rinsed in clean air-agitated water for 2 min
  - Water temperature 75 °F
- Power-sprayed with clean water for 30 sec
- Blew off excess water with oil-free air
- **Oven-dried Panel A for 15 min @ 155 °F**
- **Panel B & Test Pc#7 left wet.**
- Checked parts under UV & white light for cleanliness.

*** Test Pc#7 and 0-50 micron Japanese cracked chrome panels A & B**

FPI PROCEDURE

All test pc's: **Method A, Level 3 (SPOP 82 - WW)**

RESULTS

Cracks Were Detectable and Bright. No Difference Between Dry **Panel "A"** and Wet **Panel "B".**

Crack **Was Detectable** on Test PC# 7 with **Wide Open Crack.**