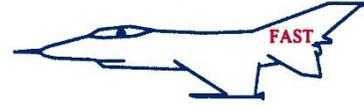


Using the FAST FOD Kit

Melanie A. Rejebian / George A. Morse

Failure Analysis Service Technology, Inc.

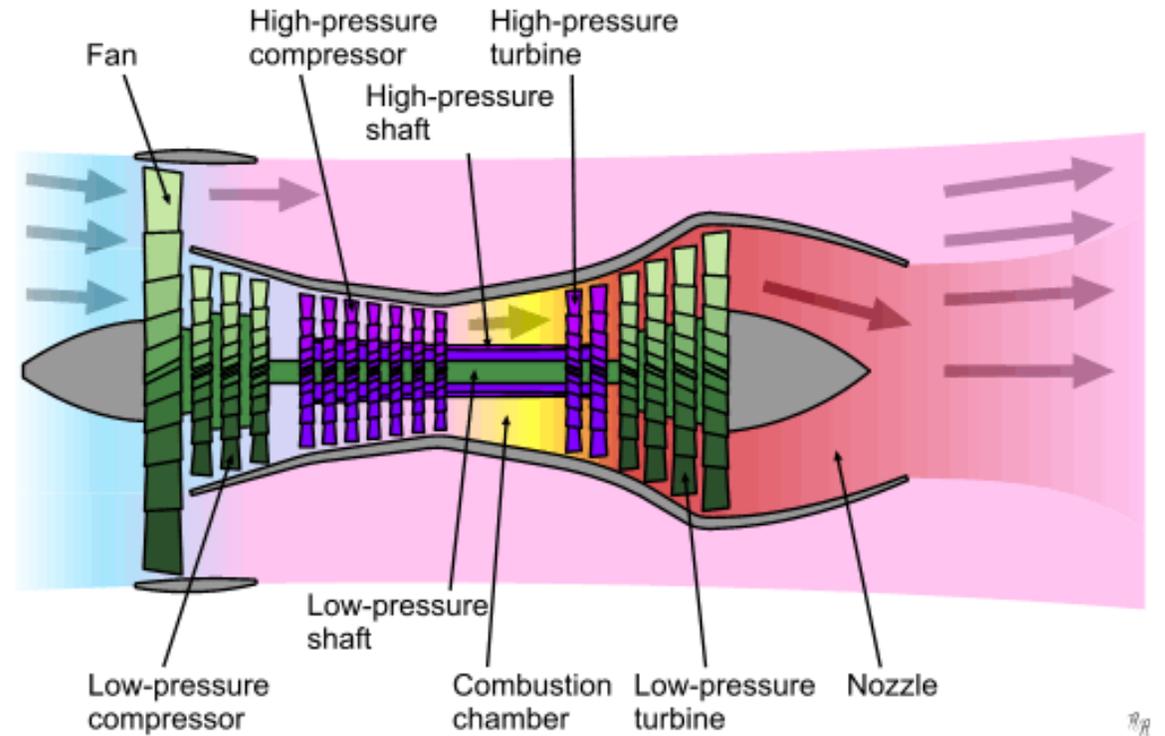
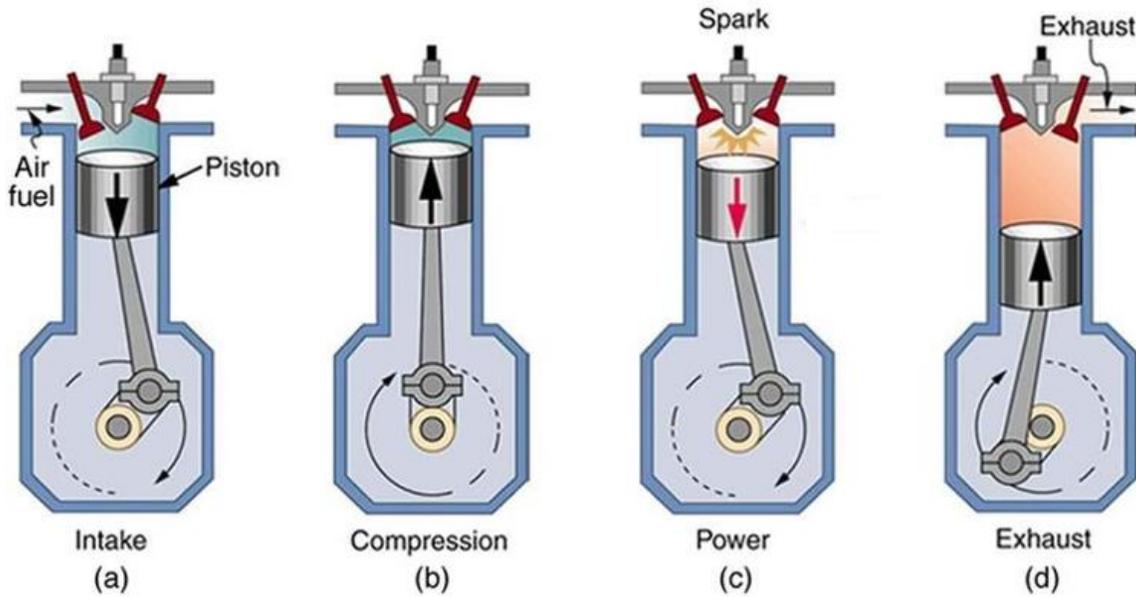
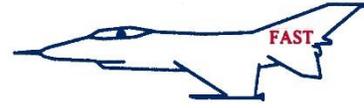
Overview



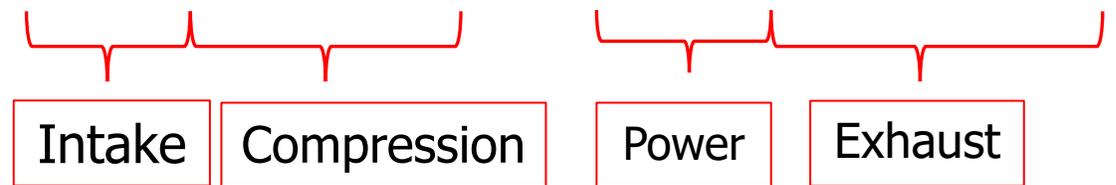
1. Theory
2. FAST Sample Procedure
3. Examples
4. Summary
5. Do Nots

Theory

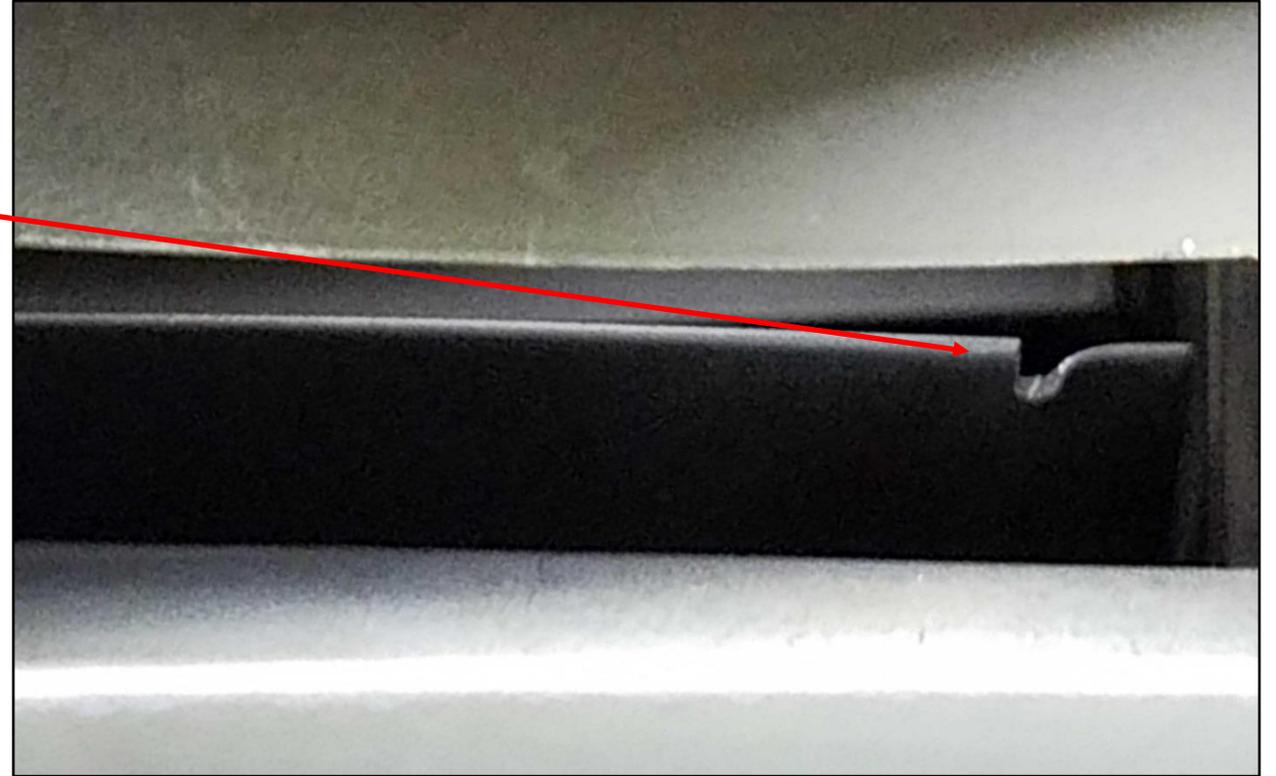
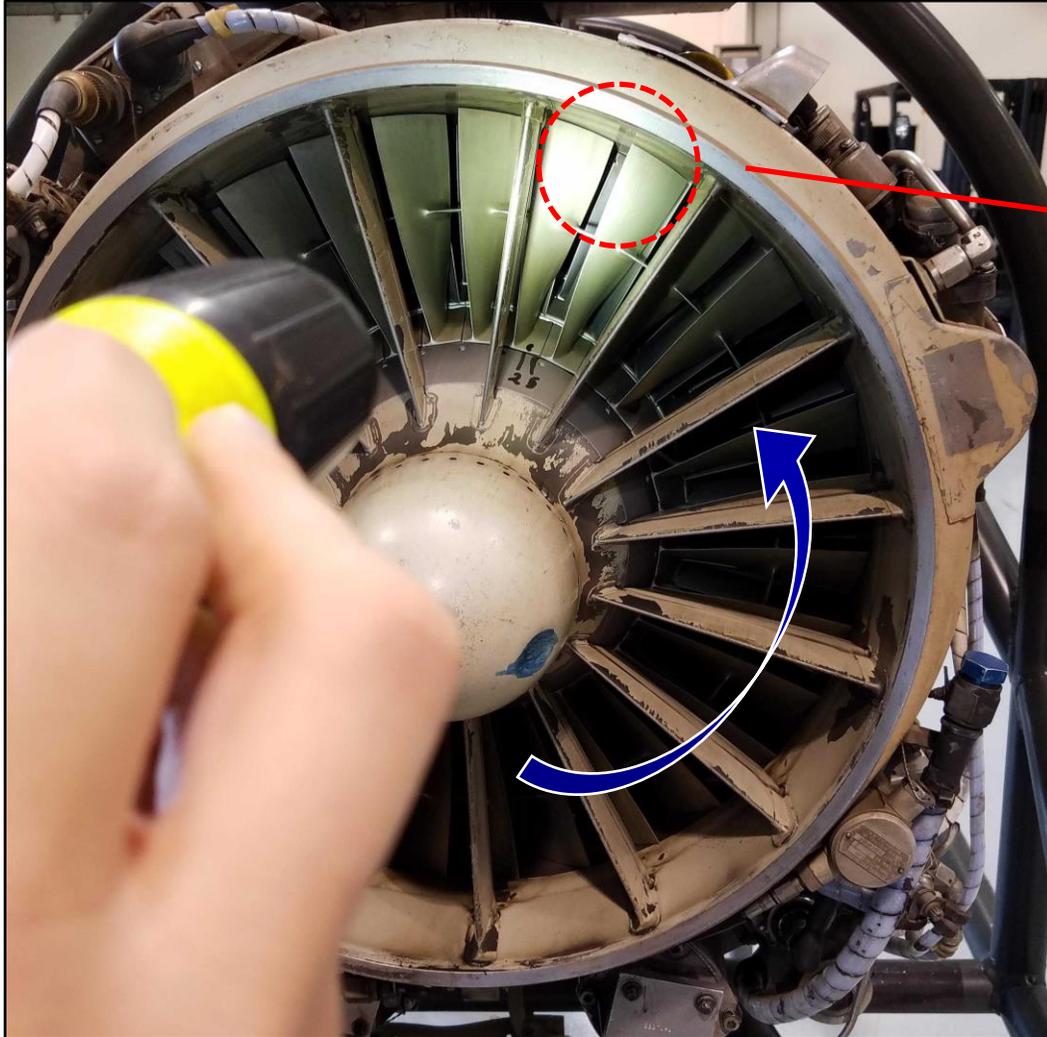
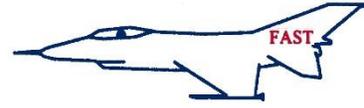
Engine Operation



1. Jet engines operate on the same principles as car engines: 4 main stages. The fan acts as a compressor. **HOWEVER**, it is important to specify FAN from HPC during investigation.
2. FAN is driven by LPT, HPC is driven by HPT.
3. The most forward location of impact damage is important for investigation.
 - If damage was noted at HPC-7, but there was no forward damage, this tells investigators that the object very likely came from within the engine.

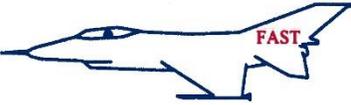


Engine Rotation



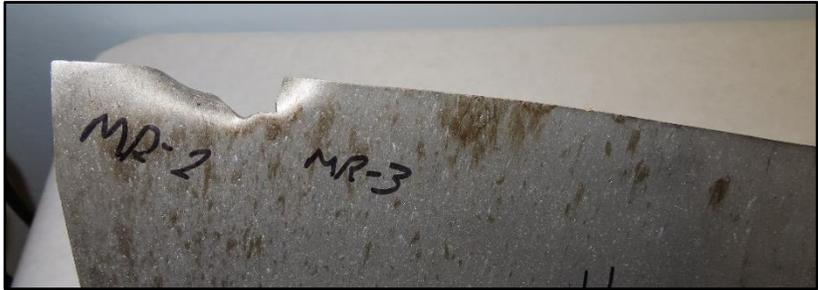
On the MAJORITY of engines, the engine rotation is counterclockwise resulting in blade deformation OPPOSITE engine rotation.

Impact Damage Geometry



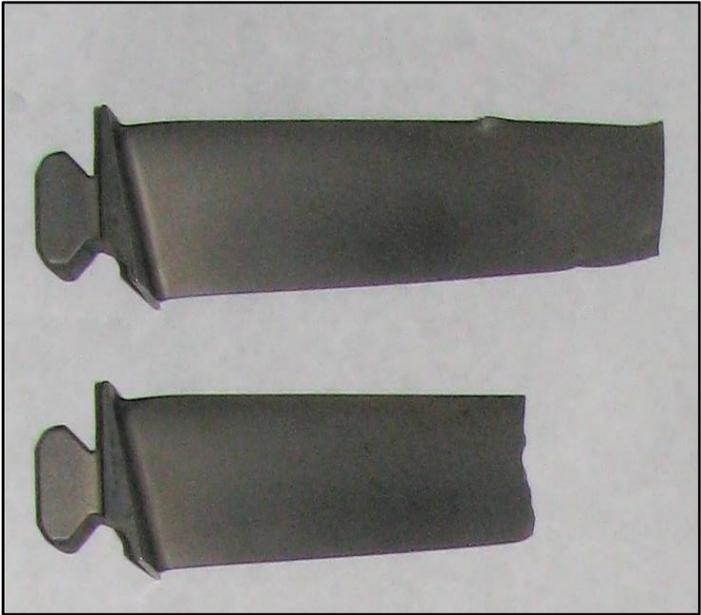
Circular

Look for regular (circular, angular, hexagonal) geometry.



Deformation

Smooth surface, evidence of soft object.

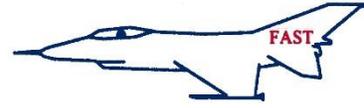


Blade Fracture

Airfoil missing, a possible indicator of fatigue.

FAST Sample Procedure

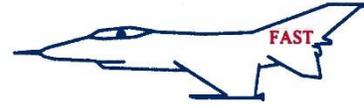
Necessary Steps



1. Photos of damage
2. Determine sample locations
3. Fill out the *Engine Sampling Form* **completely**
 - Write the label for the samples as you take the samples to ensure you do not forget or mislabel a sample.
4. Take samples

Damage Photography

Damage Photography



Damage Overview

- Aids in judging the scale of damage
- Small object materials are different than larger objects
- First view the on-site investigator has when observing the damage

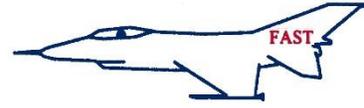
Close-ups

- Determines type of damage

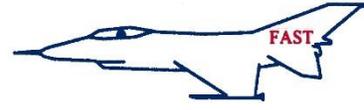
Include metrics when able

- Provides best scale and size estimation

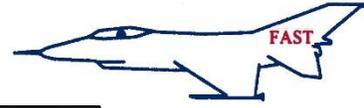
Damage Photography – The Big Picture



Damage Photography – Closer Examination

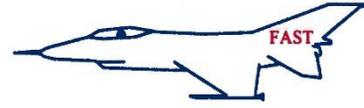


Damage Photography – Close-Up Photos

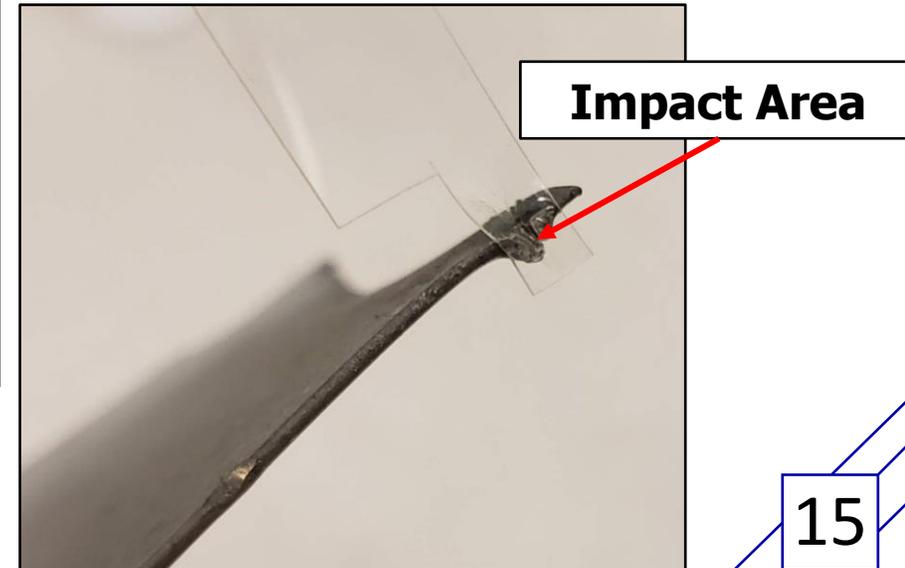
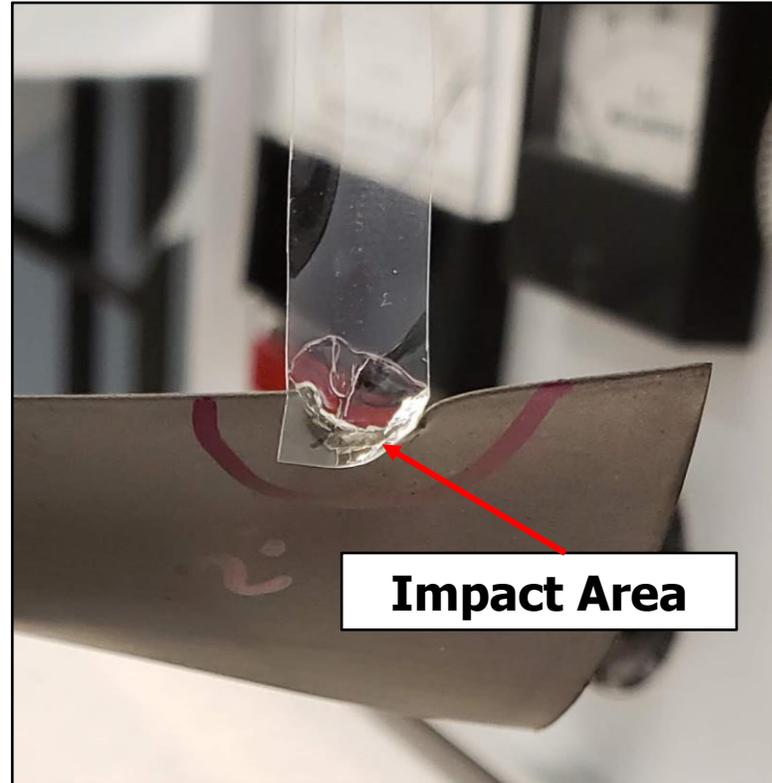


Determine FAST Sample Location

Sample Location



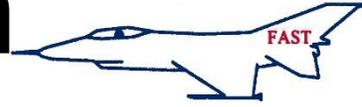
1. Most forward impact
2. Leading surface in blade rotation or the impact site
 - i. Fan/HPC - Concave surface
 - ii. HPT/LPT - Convex surface



Do NOT sample by folding the tape in half and placing over the damaged area

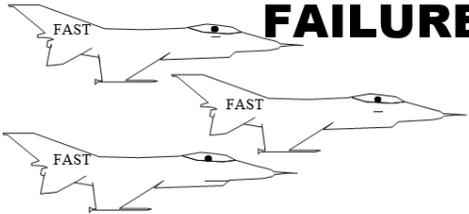
Completing the Engine Sampling Form

Completing the FAST Sampling Form



Customer Information Section

- 1. Fill out your information at the top of the ***Engine Sampling Form***.



FAILURE ANALYSIS SERVICE TECHNOLOGY

2208 Melville Rd, Hangar E
Prescott, AZ 86301
(800) 657-5664 (928) 443-9900
E-mail: Melanie@fod.com

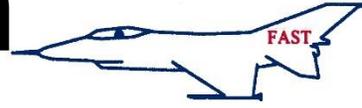
Engine Sampling Form

FAST Log Number _____
(Assigned by FAST Upon Receipt)

Customer _____ PO# _____
Address _____ Phone# _____
City, State ZIP _____
Contact Name _____ E-mail _____
Engine Sampled By _____

FAST uses this information to provide shipping/receiving updates, investigation progress, and to obtain payment information.

Completing the FAST Sampling Form



Background Information Section

2. Completely fill out the ***Background Information*** section.

- The *Background Information* section is the bottom of the first page and all the second page
- FAST requires the forensic evidence to match the physical damage/ observations, so FAST needs information about the engine history and how it was found

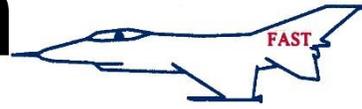
Background Information

Please fill out this form completely and with as much detail as possible and please E-mail or include digital photos (CD) of overall frontal damage of most forward location of damage and more detailed close-up photos. **VERY IMPORTANT! Investigation will not commence until digital photos are received.**

1. Describe circumstances of the event:
2. What is the most forward impact location? For example, "Stage 1 Fan."
3. Check applicable damage descriptions:
Blade tip curls: Broken blade/vane: Blade tip rib:
Half-moon shaped impacts: Blade damage with no obvious impact: LE Blade damage from tip to blade root:
Variable shaped nicks: Blade tears: Rub strip contact:
Blade dents: Cracked blade/vane:
4. Are the impact sizes and shapes consistent or variable? Describe.
5. If the blade tips are curled, which direction?
In the direction of engine rotation: Opposite direction of engine rotation: Not curled:
6. Are any blades fractured? Yes: No: If yes, what stage?
7. Are any vanes fractured? Yes: No: If yes, what stage?
8. Is the aircraft damaged anywhere other than the engine? For example, engine inlet duct, forward fuselage, wing leading edges, etc?
9. Where did the object exit?
10. Is there any visible foreign debris in the engine? If so, include it with your replicas. Describe where the debris was found.
11. Place the engine damage as you see it into one or more of the following categories:
Hard Object: Ice: Soft Object:
Bird Strike: Concrete/Stone: Fatigue:
12. Other comments.

Please submit any suspect components for comparative analysis.

Completing the FAST Sampling Form



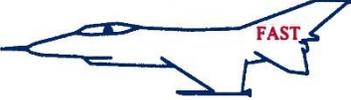
Sample Location & Description Section

3. Bring the ***Engine Sampling Form*** to the engine or damaged component.
 - This will help to ensure the samples are labeled correctly.

4. Complete the ***Sample Location/Description*** section as you take the samples.
 - After each sample is taken, label the ***Engine Sampling Form*** and petri dish before proceeding to the next sample.

 - See the next slide for good label naming conventions.

Sample Labels



Bring the *Engine Sampling Form* to sampling location

Label Convention

- "Location, Stage #, Blade #, Damage Location, Description"

- Ex: "HPC-8 Blade 5 LE Half-Moon"

Engine Sampling Form

FAST Log Number _____
(Assigned by FAST Upon Receipt)

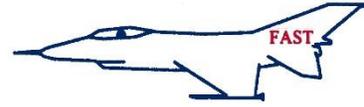
Customer _____ PO# _____
Address _____ Phone# _____
City, State ZIP _____
Contact Name _____ E-mail _____
Engine Sampled By _____

#	Sample Location/Description	FAST Technician Notes
1	HPC-8 Blade #5 LE Half-Moon	

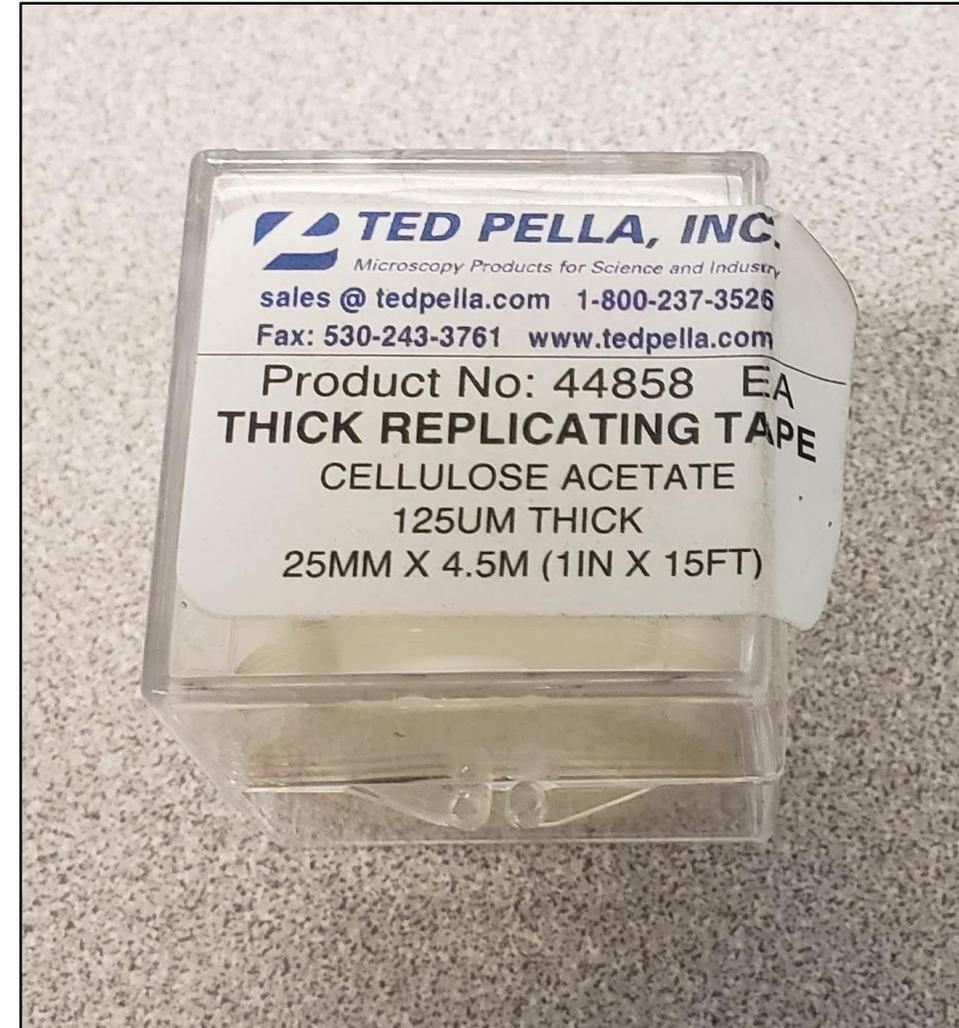
When writing on the labels that go on the petri dishes, ensure you write with a marker that will not smudge off the label. These samples become unidentifiable. (Do NOT use Dry Erase Expo Marker)

Taking FAST Samples

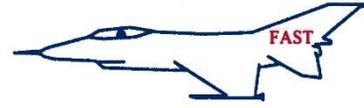
Taking Samples



- Cut an appropriate amount of tape to cover the damage, but not so much to leave excess, unused tape
 - Equal to or less than the length and width of a fingernail
- Orient the damaged component in order to work with gravity while sampling



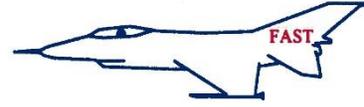
Taking Samples



- Fill syringe – Remove cap from bottle and pour a small amount of acetone into the cap
- Use the syringe to extract the acetone from the cap. Very little acetone is needed for sampling



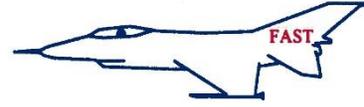
Taking Samples



Be prepared to perform steps 2-3 in quick succession

1. Orient the damaged component in such a way that it is easy to take a sample (work with gravity).
2. Using the forceps, gently grasp the previously cut piece of tape by one edge and place a single drop of acetone on one side of the tape. DO NOT get acetone on the forceps as this will possibly contaminate the sample.
 - If the forceps come in contact with acetone, they MUST be cleaned with isopropyl alcohol prior to sampling again.
3. Place the side with the drop of acetone on the damaged surface and lightly press with the dowel rod. DO NOT move the dowel rod once pressure is applied.
4. Continue applying pressure with the dowel rod for approximately 30 to 60 seconds. Allow the acetone to dry for another 60 to 120 seconds.
5. Once the acetone has dried, gently remove the tape and place in petri dish. Label each dish with the sample location and number that corresponds to the ***Engine Sampling Form***.

Miscellaneous Notes



Impact Area

- Damage may be large
- Isolate and sample the impact area – typically it is much smaller

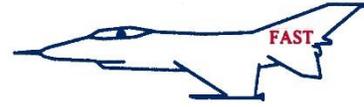
Number of Samples

- Multiple small samples are *always* preferable to one large sample

Control Samples

- Include a control sample, from an undamaged area adjacent to the actual damage, for each type of damaged blade/surface
 - Multiple controls from each stage are not needed. One control per stage is sufficient.

Miscellaneous Notes



Sample Location

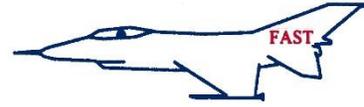
- Most forward location *always* – closest to the engine inlet
 - Engine materials change moving aft

- Forward location materials can transfer to aft stages
 - This complicates the investigation if the aft stages are sampled

Taking FAST Samples

Examples

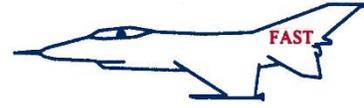
Taking Samples – Example Context



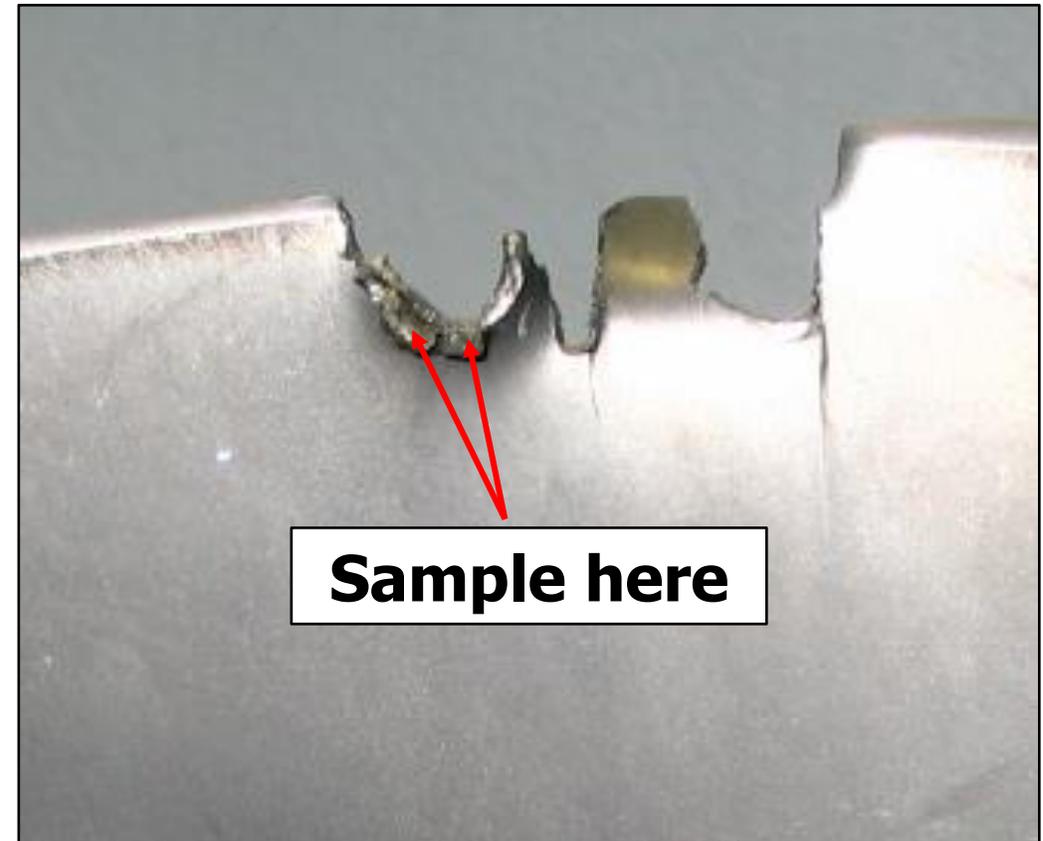
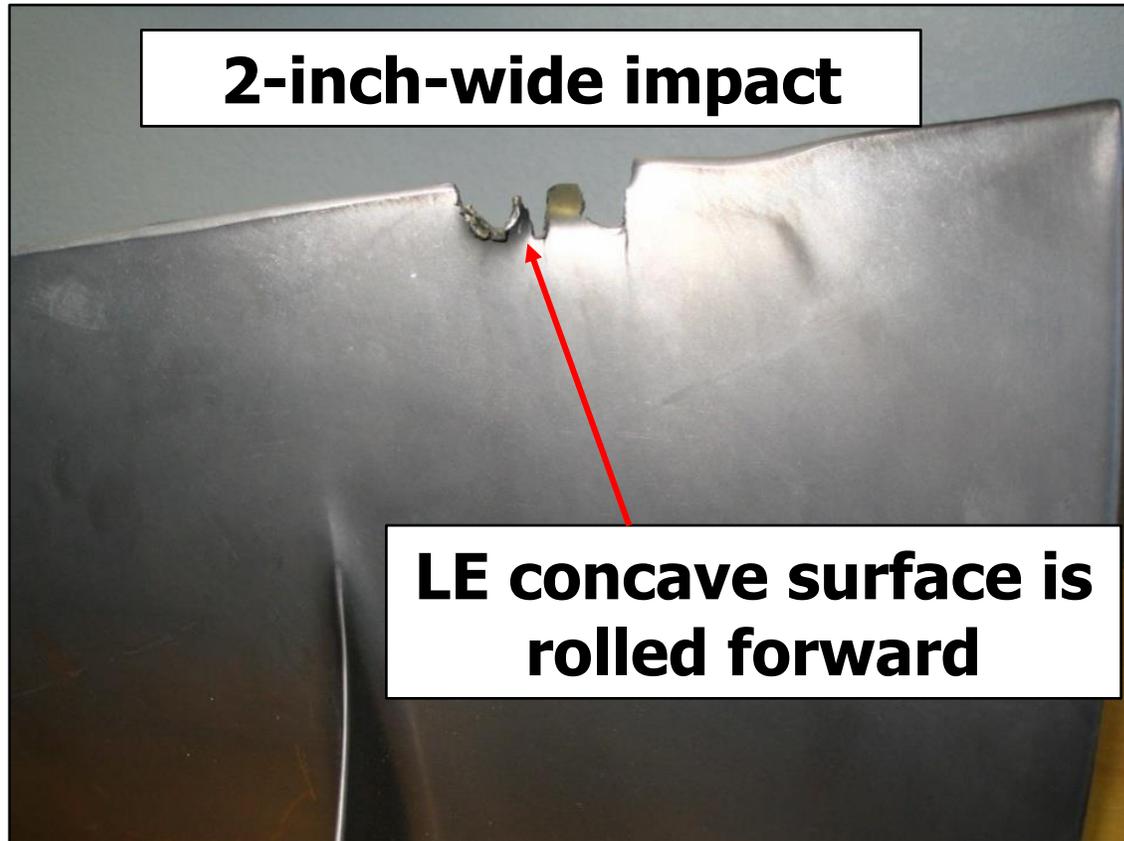
- This fan blade impact is over 2 inches wide
- The impact occurred to the leading edge (LE) concave (backside) surface
- Rotate the blade so the damage is horizontal (working with gravity)



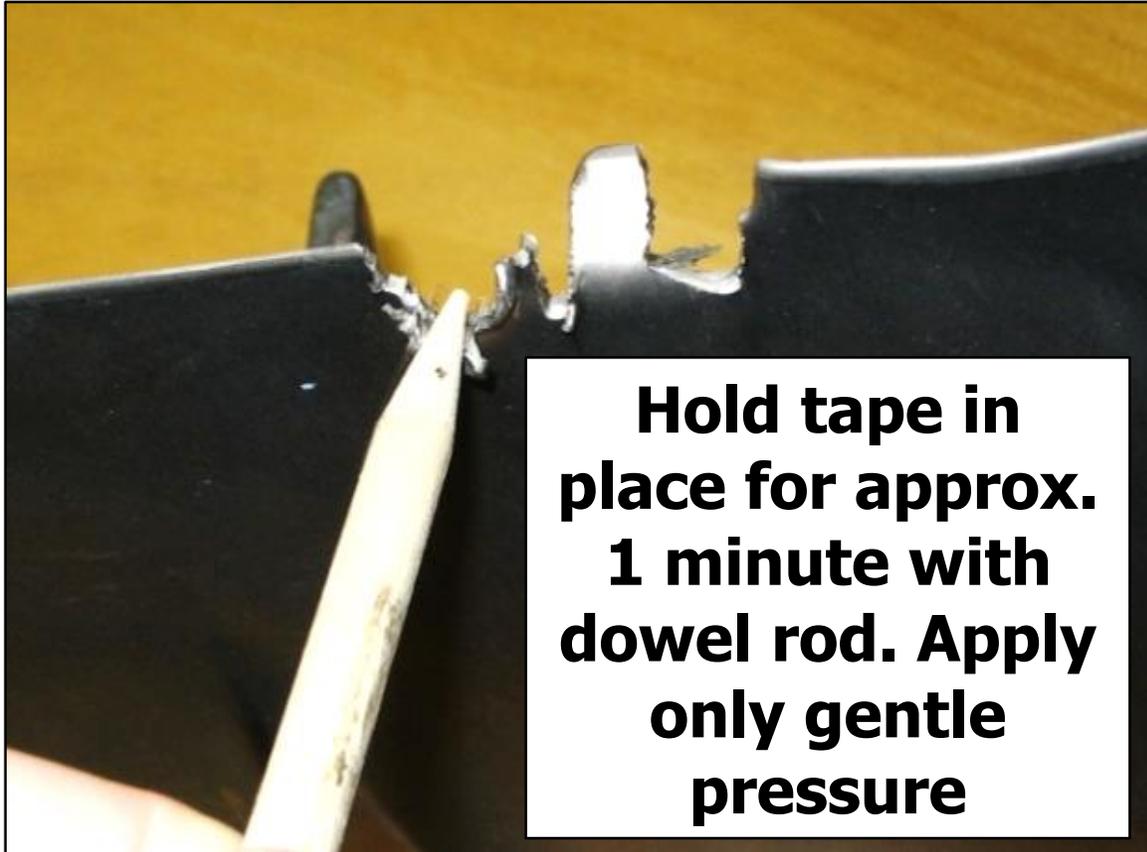
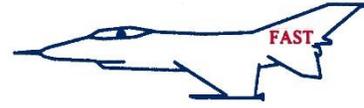
Taking Samples – Example



Do *NOT* try to sample all of a large impact with a single FAST sample, take several smaller samples

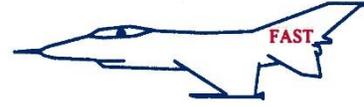


Taking Samples – Example



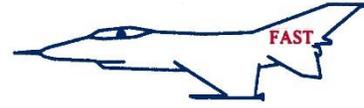
Summary

Summary - Photography



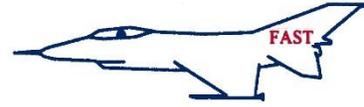
- Take multiple photos
- Include overview (big picture) AND close-up images
- Ensure photos are in focus
- Ensure damage is clearly visible
- Avoid borescope photos exclusively

Summary - Sampling



- Take multiple samples from forward locations
- Split large damaged areas into multiple small samples
- Isolate and sample the impact site only
- Tape size should be approximately equal to, or less than, a fingernail in length and width

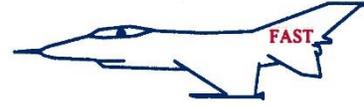
Summary - Sampling



- Work with gravity to ease the sampling process
- Apply small drop of acetone to tape
- Apply minimal pressure to the tape with the dowel rod. Do not rub or grind the tape in the sample location
- Allow the adhesive effect generated by the acetone on the tape to remove the debris from the impact site

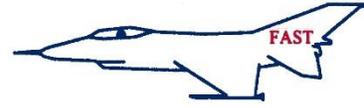
Do Nots

FAST Samples Do Nots



- Do not press too hard on the sample
- Do not rub the tape on the blade
- Do not fold the tape over each side of the blade – Do apply tape to the damaged area directly
- Do not use too much tape – the smaller the better

FAST Samples Do Nots



- Do not sample the whole damaged area at once – take multiple samples within the damaged area
- Do not remove the sample too quickly – acetone must dry completely – about 2 – 3 minutes
- Do not apply too much acetone – one drop is usually sufficient
- Do not get acetone on the forceps used to hold the tape – the forceps will stick to the tape and possibly contaminate the sample

Questions?

Contact: Melanie Rejebian – Melanie@fod.com

FAST is willing to consult on best sampling locations and practice before samples are taken. Email details to Melanie.

Thank you for purchasing the FAST FOD Kit and contributing to FOD safety, awareness, and mitigation.