



Goodrich Aerostructures
Alabama Service Center (USA)

Damage and Repair Techniques for Bonded Nacelle Structures

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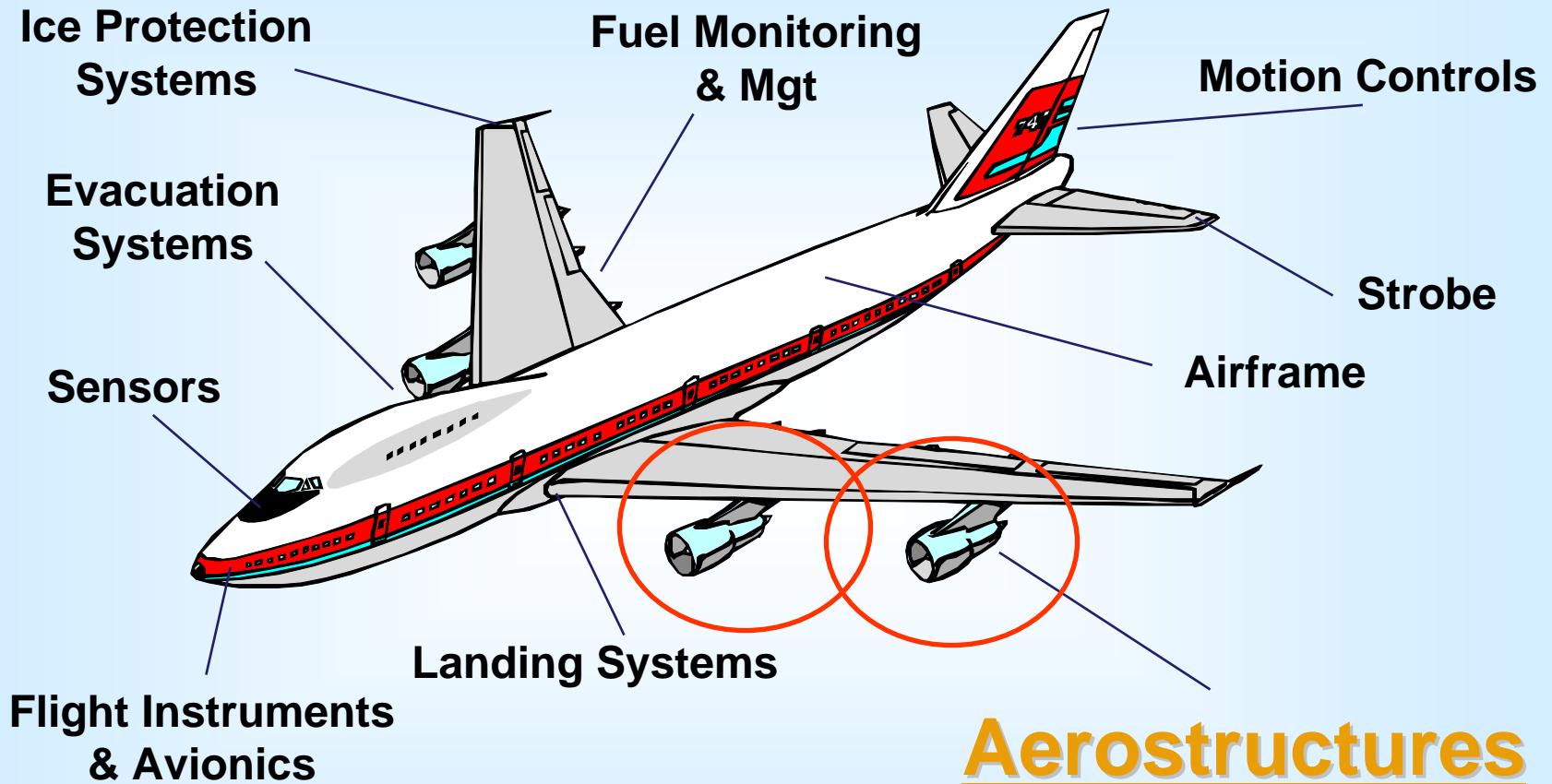
Agenda

- ◆ **Introduction**

- ◆ **Nacelle Component Repair Considerations**
 - **Inlet**
 - Drainage
 - Acoustic
 - **Inlet and Fan Cowl**
 - Lighting Strike Protection
 - **Inlet, Fan Cowl, and Thrust Reverser**
 - Corrosion Issues
 - Heat Damage

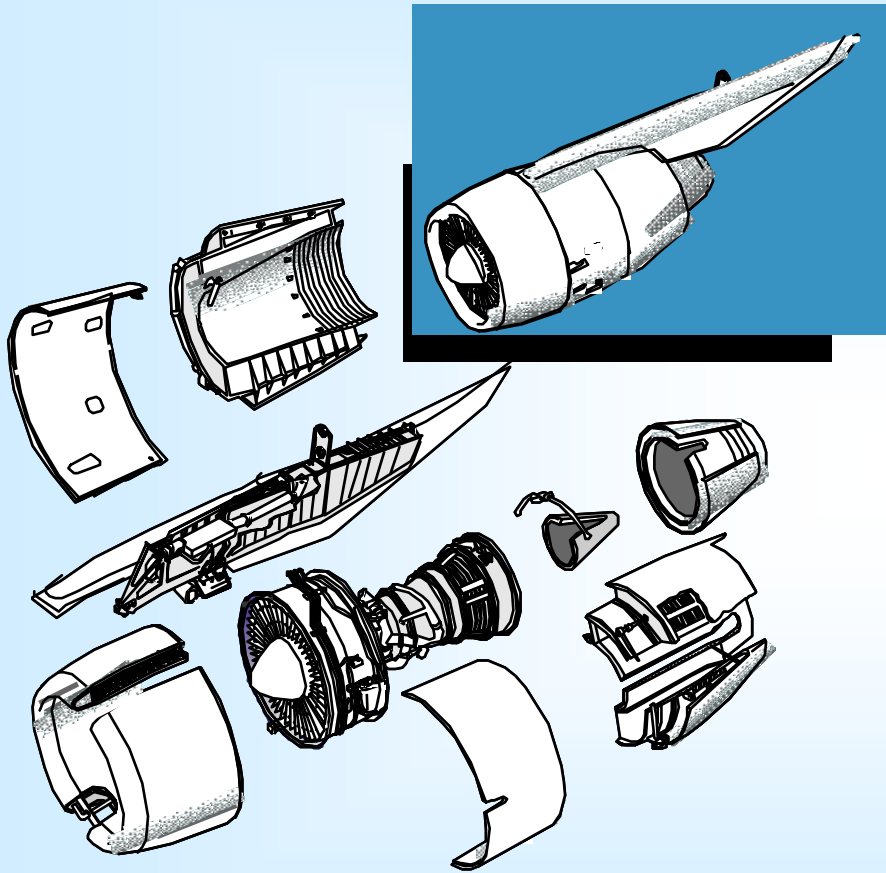
- ◆ **Summary**

Goodrich Corporation



Maintenance, Repair, & Overhaul Services

Introduction



- ◆ Goodrich has over 65 years of experience in aviation industry.
- ◆ We operate Maintenance Repair facilities world wide.
- ◆ The Alabama Service Center is a Part 145 FAA repair station. (EASA and TCCA approved)

Goodrich Aerostructures

**From Alabama - - to Scotland - - to Singapore,
our service network spans the globe.**

5



Our network of service centers enables us to provide maintenance, repair and overhaul services where – and when – our customers need them.

Alabama Service Center

6

◆ Current Staff -17 Engineers

- 5 Master of Science Degree
- 6 Bachelor of Science Degree
- 2 Associate Degree
- 3 Airframe & Powerplant

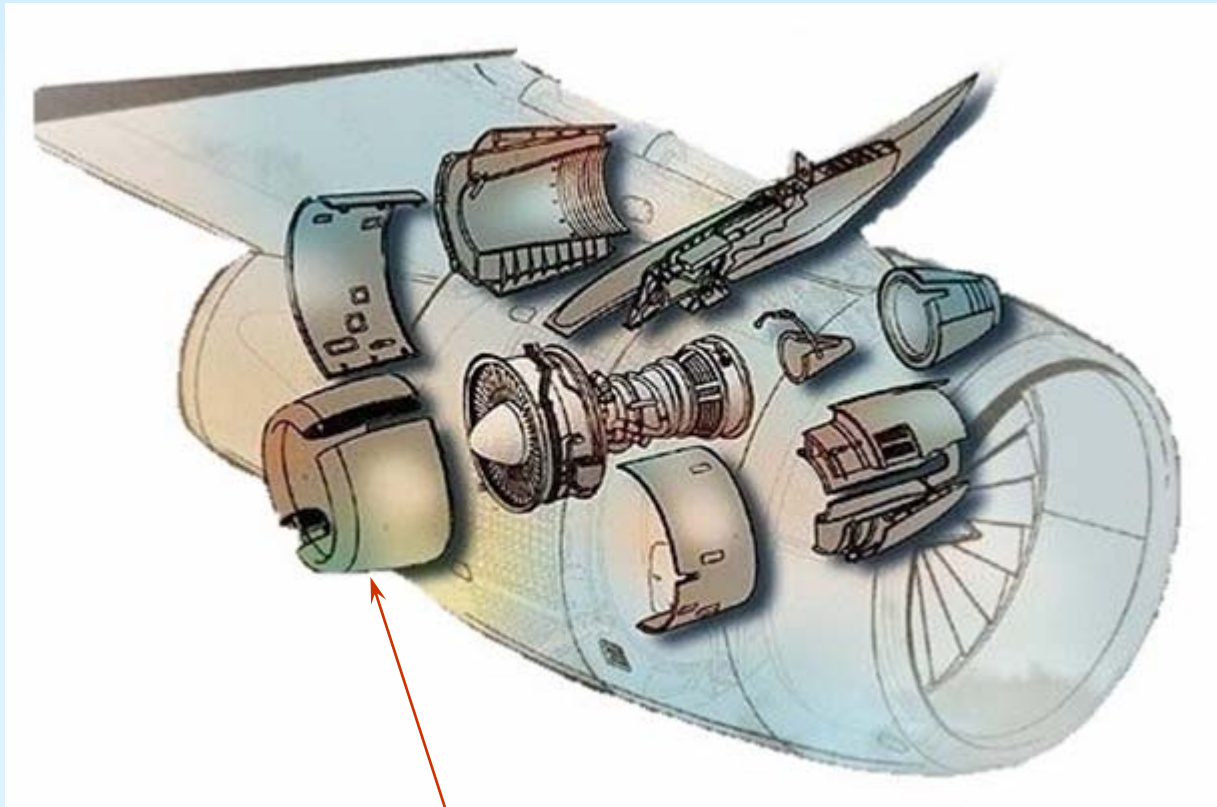
◆ Years experience

- 2 Engineers 30+
- 5 Engineers 20+
- 3 Engineers 10+
- 5 Engineers MRB Board Member (former)
 - Boeing, McDonnell Douglas, Lockheed, Northrop, LTV, Learjet, Rolls Royce, Pratt Whitney, DCMC
- 1 Engineer 6+ Structures DER



- ◆ 200,000 Square Feet MRO Facility

Inlet Cowl

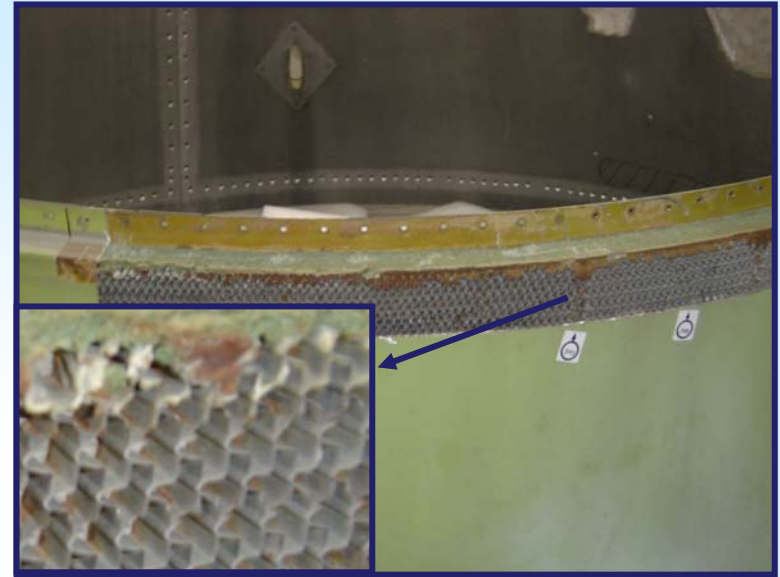


— Inlet Cowl (aka Nose Cowl)

Typical Damage

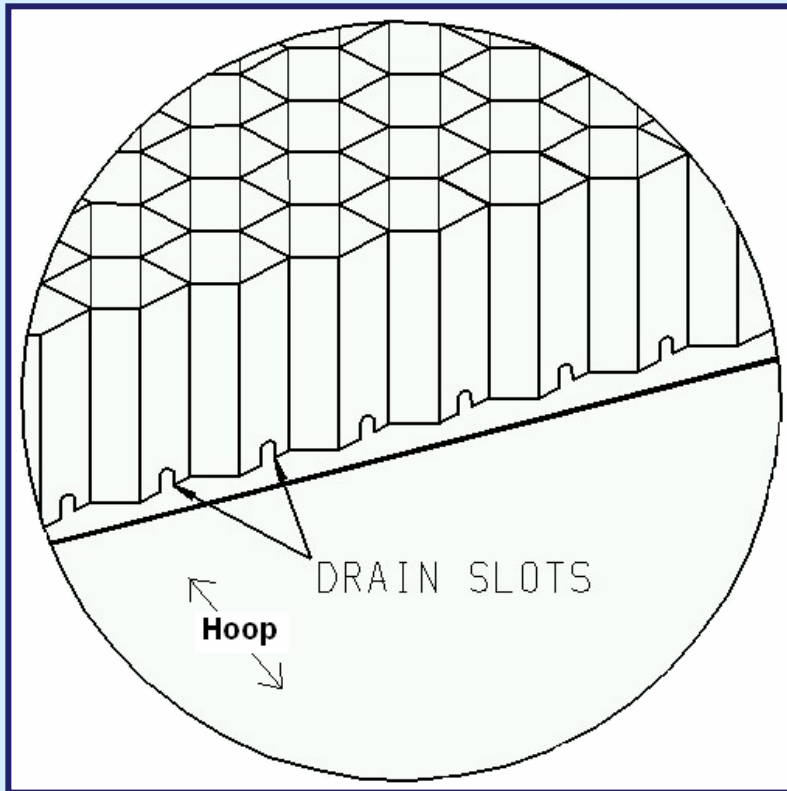


- ◆ Inner Barrel (Metal bond)
 - Punctures
 - F.O.D.



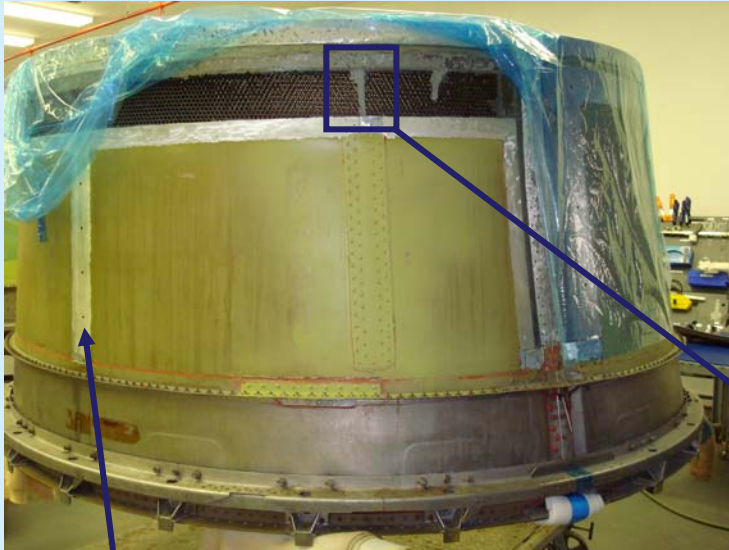
- ◆ Inner Barrel (Metal bond)
 - Corrosion

Drainage



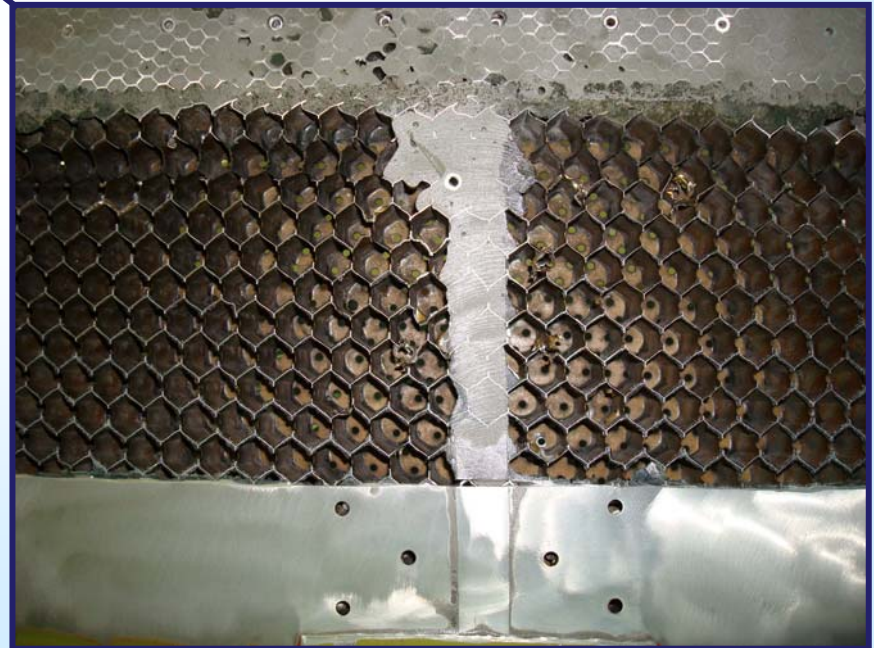
- ◆ Slotted core on 6 O'clock panel
- ◆ Conventional, sectional replacement of this core would destroy the panel's ability to drain

Drainage

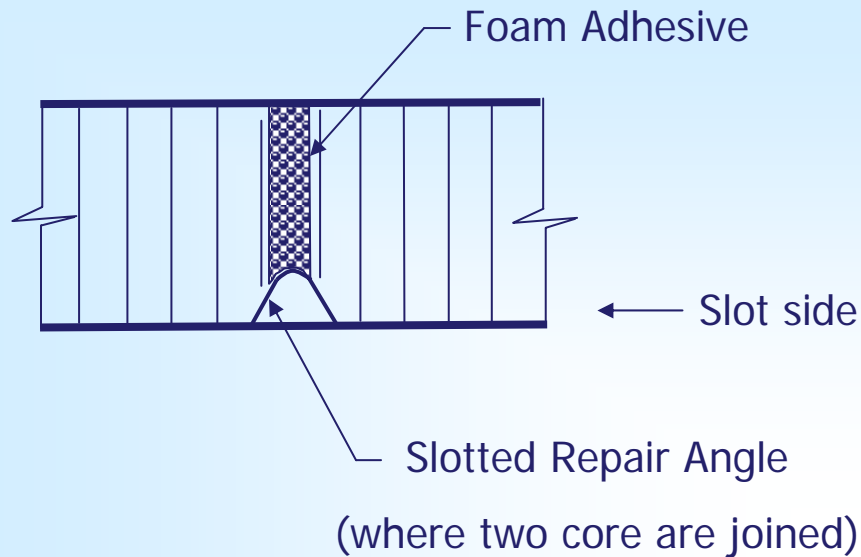


Drain holes

- ◆ Local potted repair
 - blocking drainage path



Drainage



- ◆ Full Core Replacement
 - Slotted Core
- ◆ Partial Core Replacement
 - Slotted Core
 - Additional Consideration
- ◆ Drainage Check

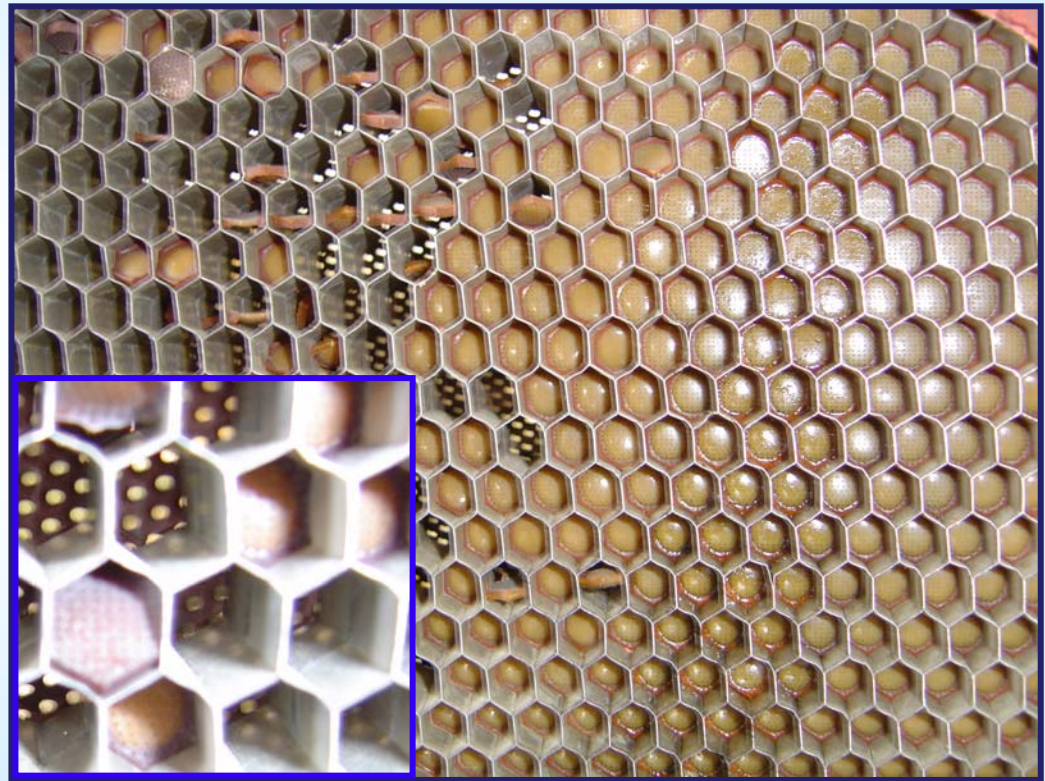
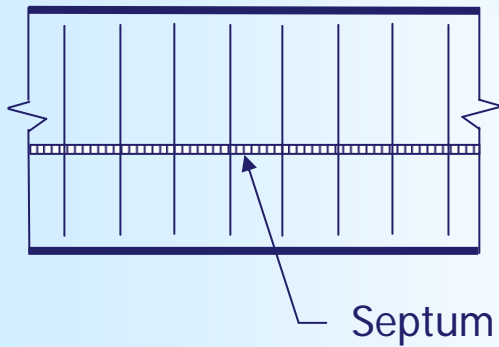


- ◆ Acoustic Requirements must be maintained
 - Noise Emission
 - FAA Regulation- Part 36 and part 21.93



- ◆ Key elements in acoustic panel
 - Honeycomb core
 - Cell Size/Depth
 - Conventional or septum
 - Perforated skin
 - Perforated hole size
 - Reticulation
 - Wire

◆ Septum Damage



◆ Inner Panel (Composite)

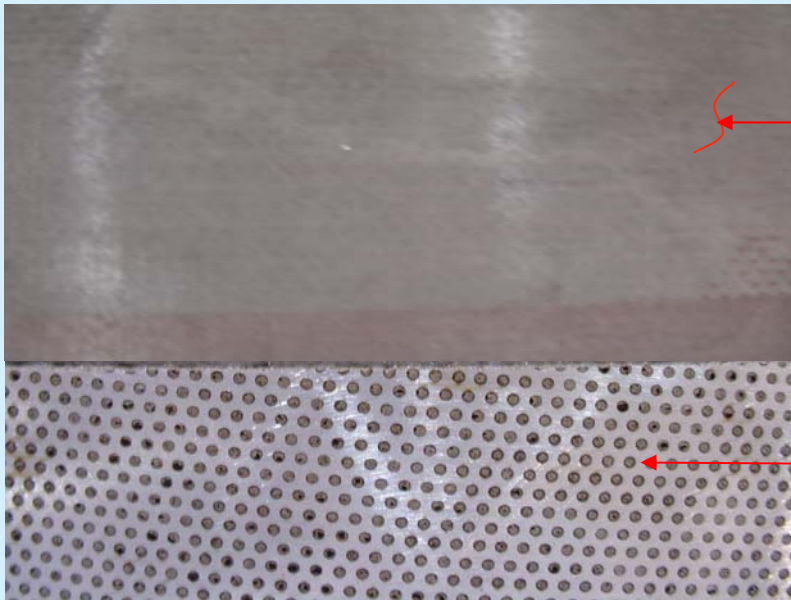
- Missing Wire
- Acoustic Blockage

◆ Results

- Significant Acoustic Loss
- Not Airworthy

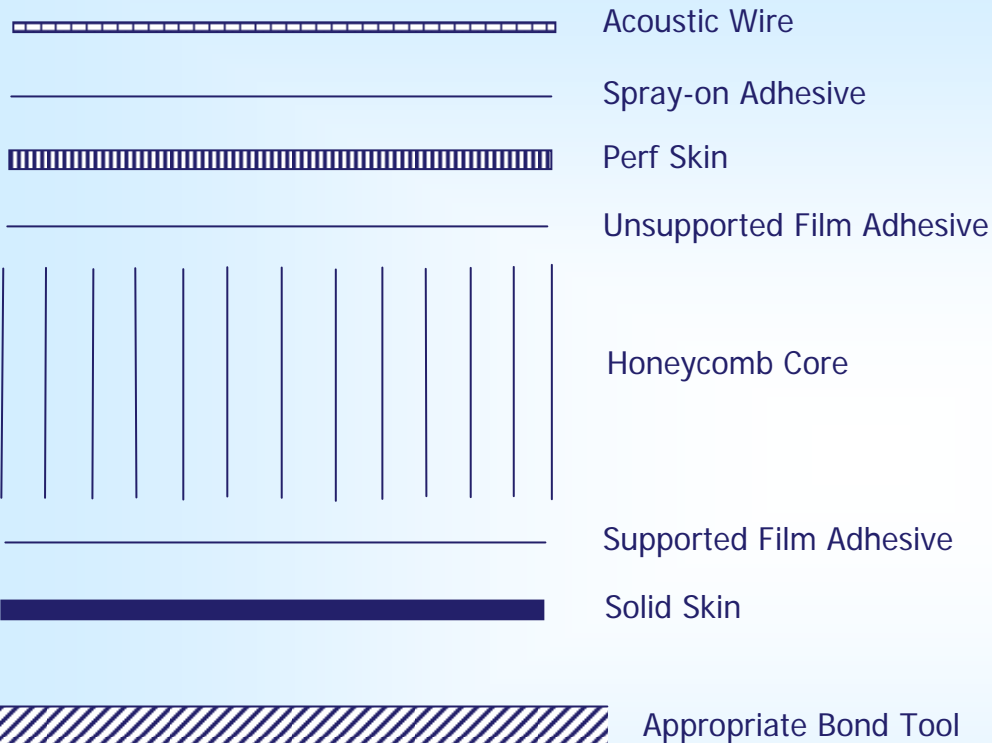


Acoustic



Wire bonded with
paste adhesive

Significant blockage in
perforated skin



◆ Acoustic Wire

- Rayl Value
- Weave
- Clean (Free of oil)

◆ Spray-on Adhesive

- Application Angle
- Thickness/Weight

◆ Inspection

- Raylometer

◆ Perf Skin

- POA
- Reticulation



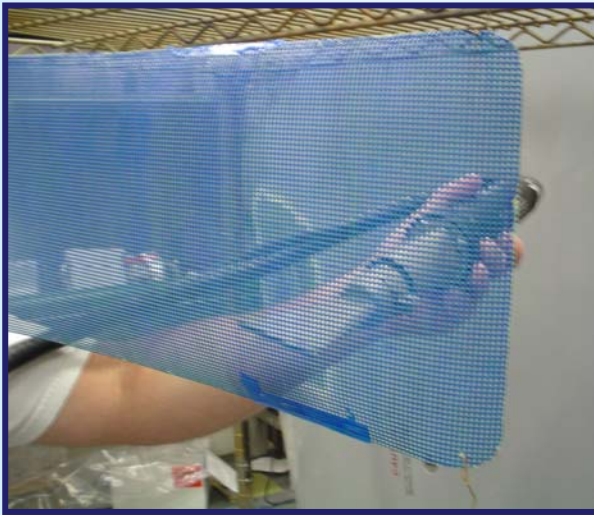
Perform verifilm inspection when working with formed parts.

Acoustic

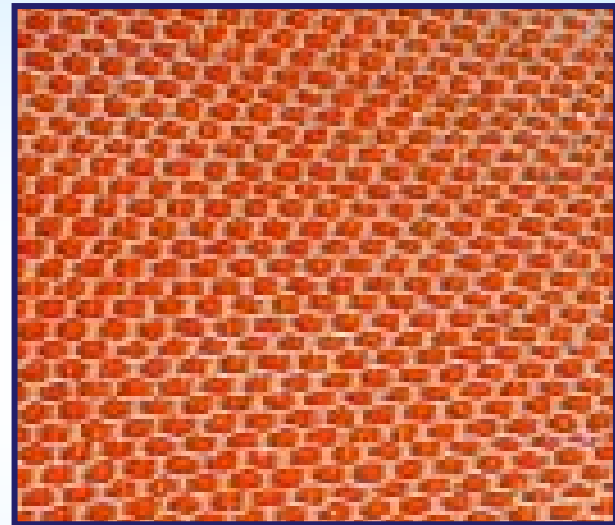
- ◆ Raylometer
 - Test and verify



- ◆ Maintain Original Reticulation Method



Reticulating perf skin



Reticulating core



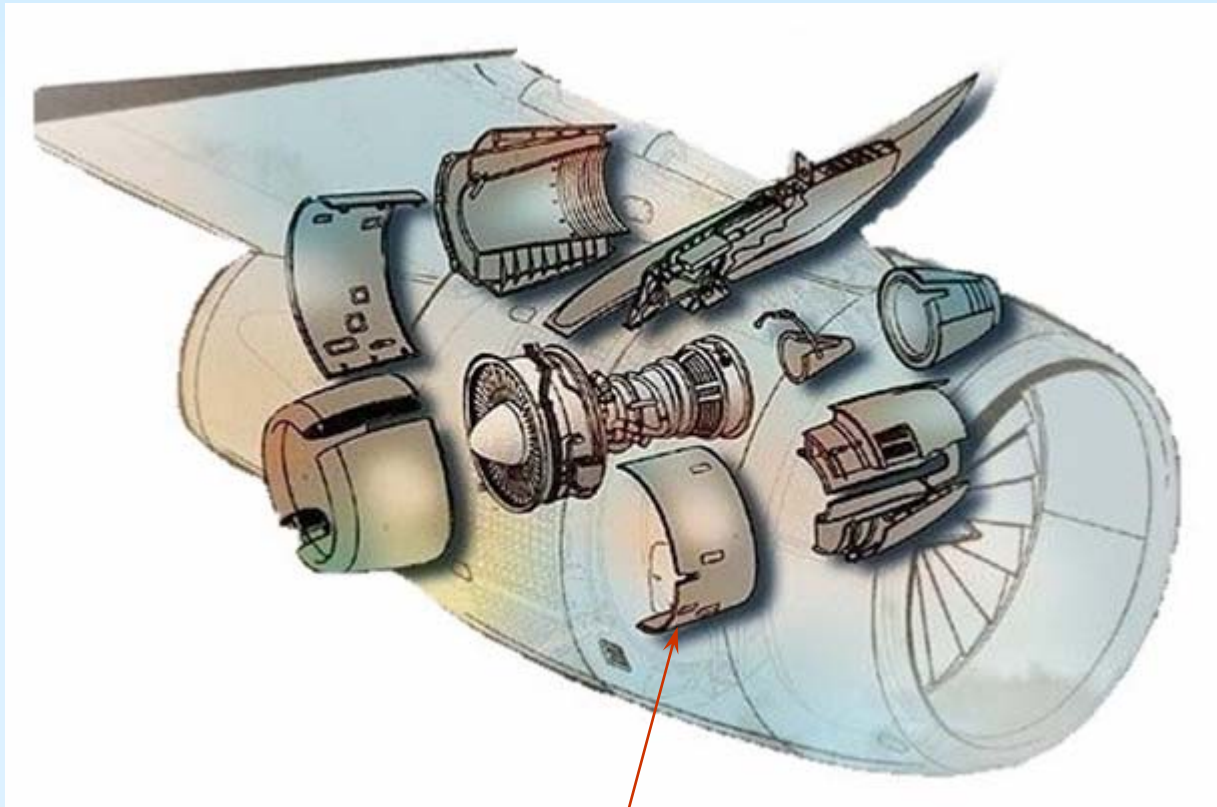
Do not brush-on paste adhesive.

- ◆ Completed Repair
 - Full Acoustics Restored



Inlet Cowl Inner Barrel Panel (composite construction)

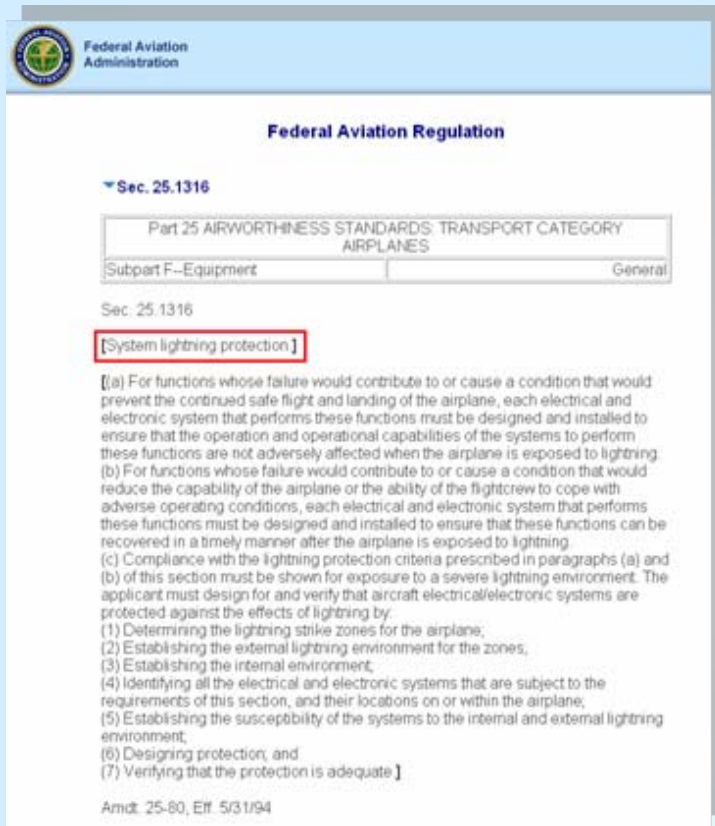
Fan Cowl



Fan Cowl

Lightening Strike Protection

22



The image is a screenshot of the Federal Aviation Administration's (FAA) website, specifically the Federal Aviation Regulation (FAR) page for Part 25.1316. The page header includes the FAA logo and the text "Federal Aviation Administration". Below the header, the title "Federal Aviation Regulation" is displayed. The regulation is identified as "Sec. 25.1316". A table below the title shows "Part 25 AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES" with "Subpart F--Equipment" and "General" listed. The text of the regulation is titled "Sec. 25.1316" and is enclosed in a red box. The text describes the requirements for lightning protection for aircraft systems. It includes a list of seven items: (1) Determining the lightning strike zones for the airplane; (2) Establishing the external lightning environment for the zones; (3) Establishing the internal environment; (4) Identifying all the electrical and electronic systems that are subject to the requirements of this section, and their locations on or within the airplane; (5) Establishing the susceptibility of the systems to the internal and external lightning environment; (6) Designing protection; and (7) Verifying that the protection is adequate. The regulation is amended by Amdt. 25-80, Eff. 5/31/94.

Federal Aviation Administration

Federal Aviation Regulation

▼ **Sec. 25.1316**

Part 25 AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES	
Subpart F--Equipment	General

Sec. 25.1316

[System lightning protection]

[(a) For functions whose failure would contribute to or cause a condition that would prevent the continued safe flight and landing of the airplane, each electrical and electronic system that performs these functions must be designed and installed to ensure that the operation and operational capabilities of the systems to perform these functions are not adversely affected when the airplane is exposed to lightning.

(b) For functions whose failure would contribute to or cause a condition that would reduce the capability of the airplane or the ability of the flightcrew to cope with adverse operating conditions, each electrical and electronic system that performs these functions must be designed and installed to ensure that these functions can be recovered in a timely manner after the airplane is exposed to lightning.

(c) Compliance with the lightning protection criteria prescribed in paragraphs (a) and (b) of this section must be shown for exposure to a severe lightning environment. The applicant must design for and verify that aircraft electrical/electronic systems are protected against the effects of lightning by:

- (1) Determining the lightning strike zones for the airplane;
- (2) Establishing the external lightning environment for the zones;
- (3) Establishing the internal environment;
- (4) Identifying all the electrical and electronic systems that are subject to the requirements of this section, and their locations on or within the airplane;
- (5) Establishing the susceptibility of the systems to the internal and external lightning environment;
- (6) Designing protection; and
- (7) Verifying that the protection is adequate]

Amdt. 25-80, Eff. 5/31/94

Increasing use of advanced composite structures.
Structure is TC with Lightning strike protection.
FAA Regulation - Part 25.1316.

Lightening Strike Protection

23

- ◆ Indication of lightening strike damage
 - Local vaporization of the structure
 - Burn marks
 - Electro-mechanical deformation (metallic structure)

- ◆ Effects
 - EBU Systems
 - Degradation of structural material properties
 - Split open skin/structure
 - Explosive ignition of flammable vapors

Lightening Strike Protection

24

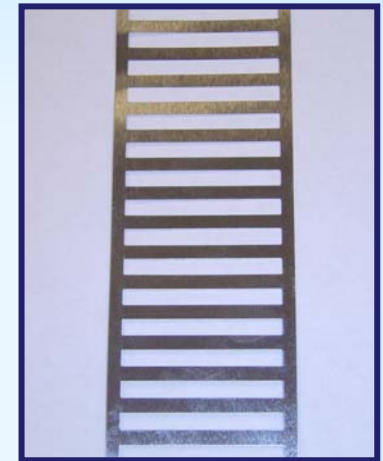
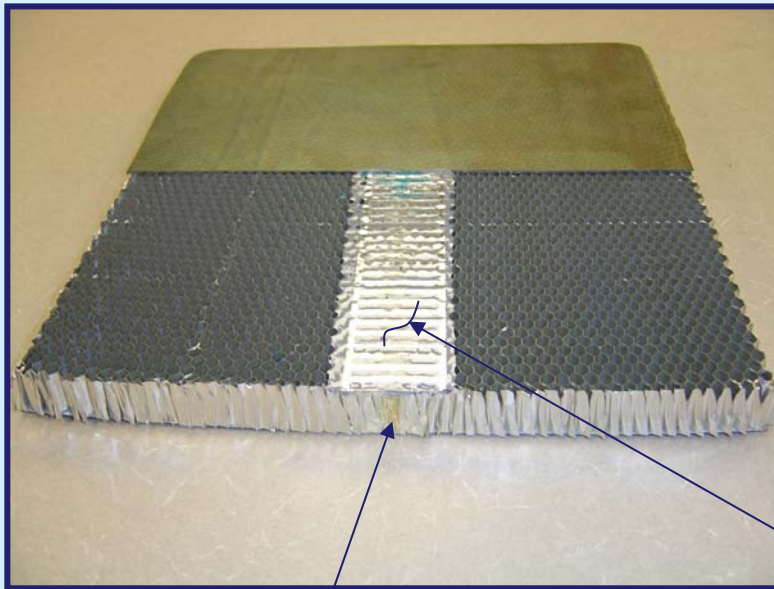
- ◆ Outer Laminate
 - Continuous Copper Mesh



Lightening Strike Protection

◆ Core

- Conductive Grid over core splices



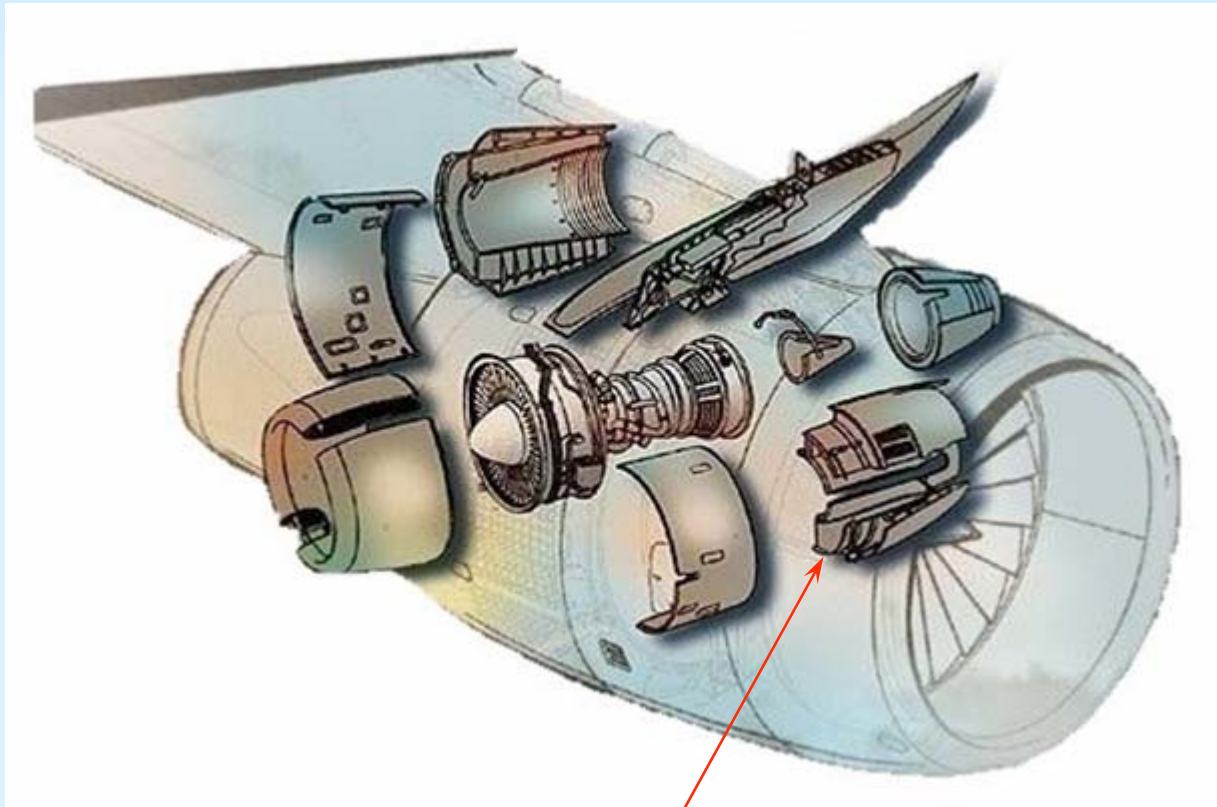
Foam Adhesive

Conductive Grid



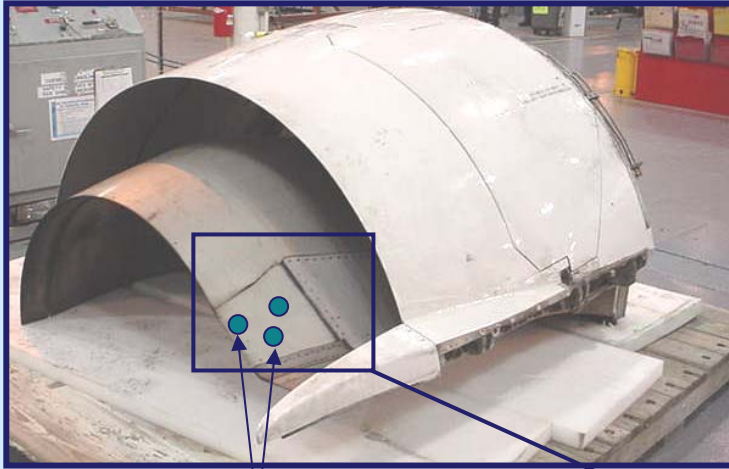
Discontinuities in the lightning current flow path such as adhesive joints must be bridged by a conductive path.

Thrust Reverser (TR)



Thrust Reverser

Corrosion



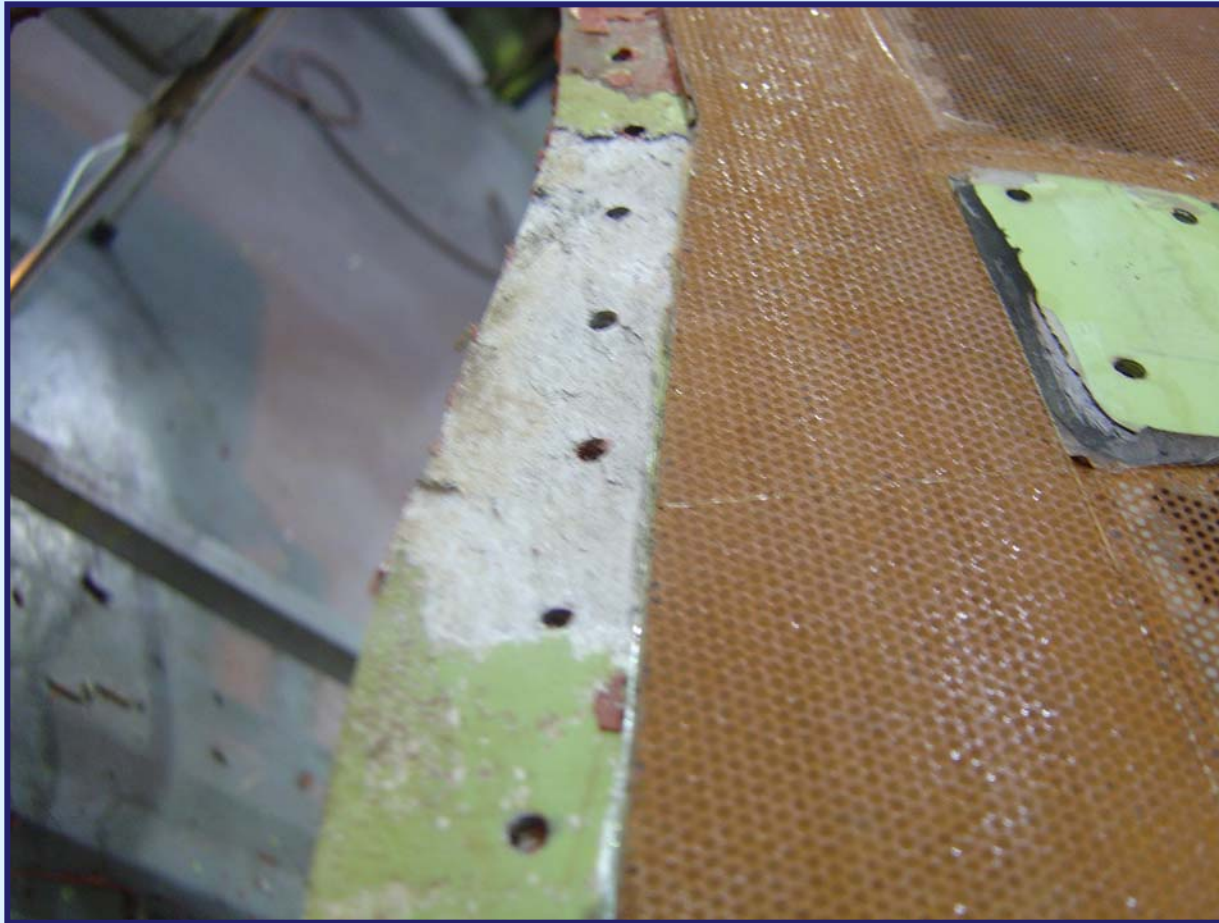
Multiple disbonds

◆ Injection- not a solution

Large areas of corrosion under skin.



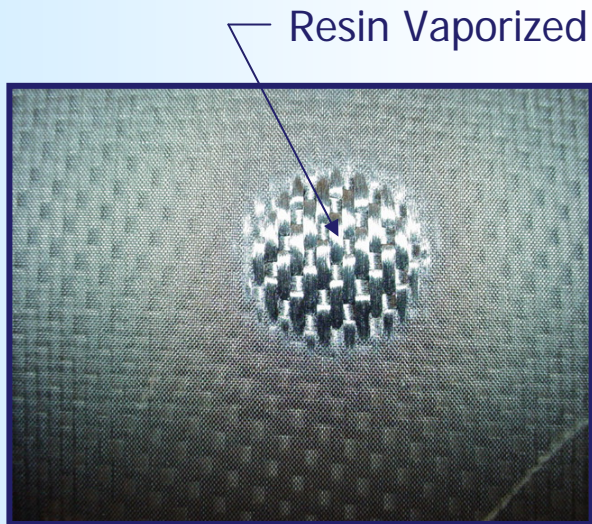
Corrosion



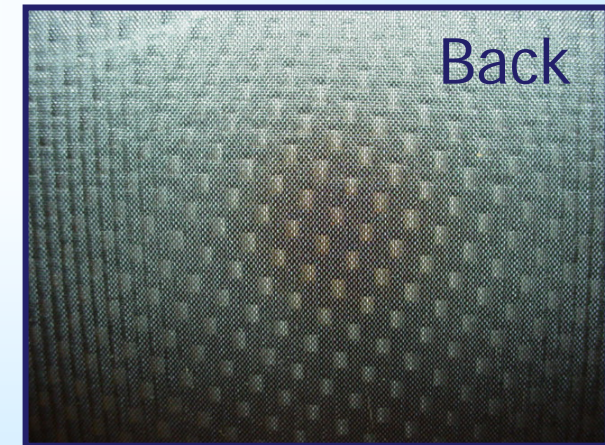
Heat Damage

◆ Indication of heat damage on composite structures

- Change in coloration
- Paint flaking
- No local stiffness
- Disbonds/Delamination



More severe



Minor burn mark on opposite side

Heat Damage

30



- ◆ Fixed Duct, Thrust Reverser



Heat Damage

31

- ◆ Technicians repairing damaged area in the *clean room*.



- ◆ Nacelle Repair Considerations
 - Drainage
 - Acoustics
 - Lightning Strike Protection
 - Corrosion
 - Heat Damage

- ◆ Questions?