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Efforts to Preclude a 'Dry Aircraft' Designation

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Abstract

A 'Dry Aircraft' designation is given when an aircraft has instrumentation mounted external to the aircraft which is susceptible to damage from moisture -- specifically strain gages and acoustic pressure transducers. When these components are mounted externally, they can be damaged by condensing water vapor from a flight regime that sees changes in altitude (pressure), temperature, and humidity. The components can also be damaged through the direct application of water whether it's from rain at 250 KCAS or maintainers washing the aircraft with brushes and harsh cleaning agents.

The Navy is investigating better moisture protection for strain gage installations through a 219 funded project. There is also a T&E S&T project which will ask the academic community to brainstorm new innovative ideas for performing strain and acoustical measurements that are not susceptible to moisture. The scope, approach, and status of these efforts will be discussed.

Outline

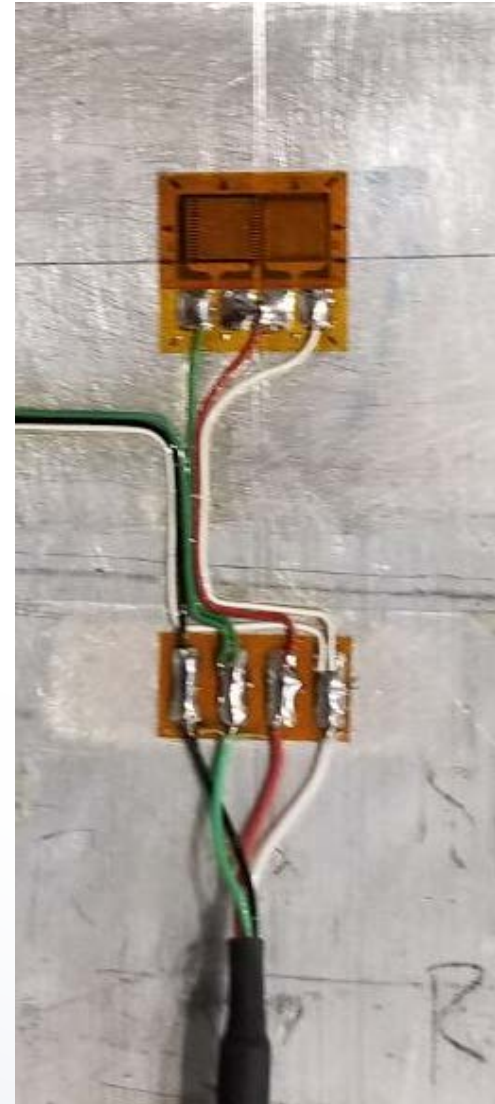
- Problem Statement
- 3 Part Approach
 - Better ways to protect Strain Gages from water
 - Other methods to acquire strain measurements
 - Create standard assessment of risk for Project Engineer to make go/nogo decision
- Strain Gage Protection Project
- S&T All Weather Measurements
 - Strain & Sound Pressure
- Water related Risk Assessment
- Conclusion

Problem Statement

- What is a 'Dry Aircraft' designation?
 - Assigned when external sensors susceptible to damage from moisture are installed
 - Strain gages and acoustic pressure transducers
- Externally mounted instrumentation damaged by
 - Condensing water vapor from changes in altitude (pressure), temperature, and humidity.
 - Direct application of water
 - Cloud cover
 - Rain (250 KCAS)
 - Maintainers washing aircraft (high pressure / cleaning agents)
- Instrumentation is designated 'Dry'
 - When risk is high or When risk cannot be assessed

Strain Gage Protection

- Current method of protecting gages
 - M-Coat A, 8802 / 870 Polysulfide
- Current Failure modes
 - Water penetrating sealant barrier
 - Water wicking down inside wire jacket
- Problems Caused
 - Corrosion
 - Can lead to circuit shorts
 - Gage glue bond failure
 - Unreliable data



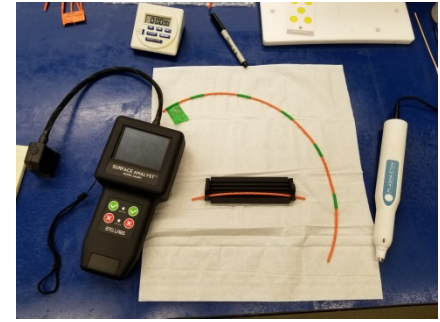
Gage Protection - Approach

- Use of Plasma Etch Wand
 - Etches polymer wire jacket and insulation
 - Promotes increased surface energy and adhesion
- Use of AMS3277-1826 Sealant
 - Polythioether vs Polysulfide
 - 7 days vs 14 days
 - Chemical cure
- Use of ETFE Wire
 - Higher baseline surface energy than PTFE

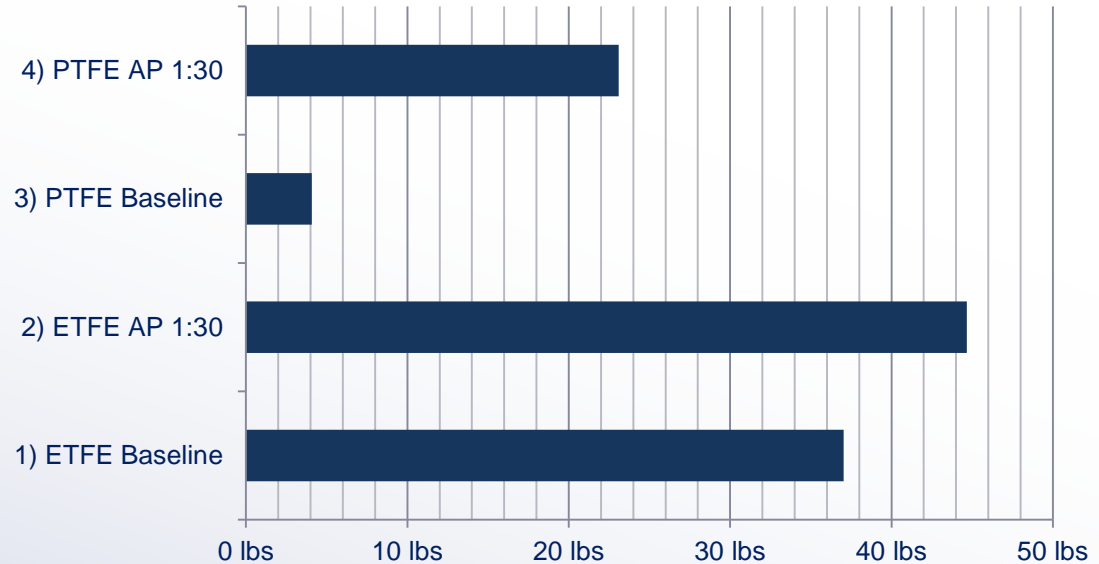


Gage Protection - Testing

- Contact Angle Testing-Dyne Pens, VCA Benchtop, and BTG Surface Analyst

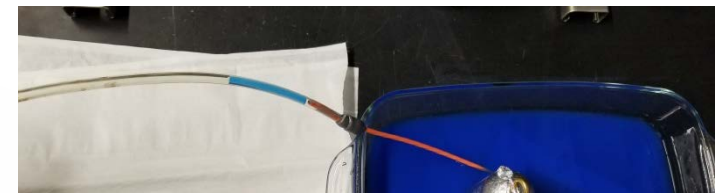
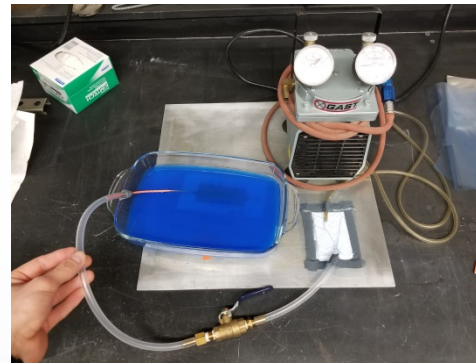


- ASTM D3032 Testing-Tests potting bond to wire jacket



Gage Protection - Testing

- Vacuum Testing
 - Simulate ~50k ft-13 psi delta
 - Initial Testing successful



- Future Testing
 - Use environmental chamber
 - Test Altitude, Temperature, Humidity
 - Use shaker table
 - Test flight vibration profiles

All-Weather Measurements

- T&E S&T project for Advanced Instrumentation
 - All Weather Strain and All Weather Pressure Measurements
 - Enlisting Academia to look beyond the traditional methods
- We don't expect a silver bullet
 - Hopeful for niche area solutions
- Status
 - Held the initial meeting with T&E S&T folks
 - Waiting for funding due to the Govt's Continuing Resolutions
 - Budget has been signed, expect these to start moving

Risk Assessment

- Avoid 'Dry aircraft' designations
 - Convey 'Risk' to Test Team
 - Test Team can decide Fly / No-fly
- Instrumentation Engineer to determine risk
 - Likelihood of water/moisture damage
 - Consequence if damage occurs
- Flight Test Team generates fly/cancel decisions based on their understanding of:
 - Program Schedules
 - Test Point importance
 - Program risk if damage occurs

Dry Aircraft Risk Cube

Likelihood

- 1 – Waterproof
- 2 – Water-resistant
- 3 – Temporarily inoperable when wet/frozen
- 4 – May get wet, permanently damaged when frozen
- 5 – Permanently damaged when exposed to water

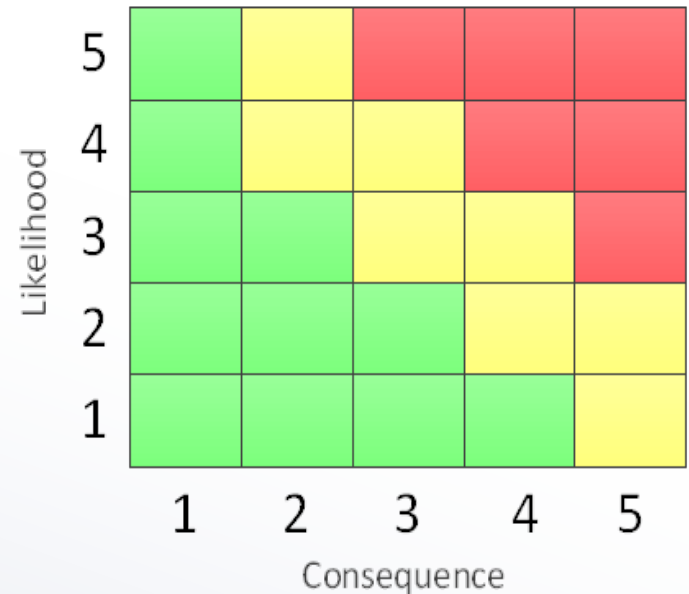
Consequence

- 1 – Loss of up to 2 days*
- 2 – Loss of 1 to 2 weeks*
- 3 – Loss of weeks to months**
- 4 – Loss of months to years**
- 5 – One-of-a-kind asset***

*parts on hand to repair and/or readily available

**long lead time to order or calibrate parts

***difficult or impossible to replace



Example Moisture Risk Eval

Likelihood

- 1 – Waterproof
- 2 – Water-resistant
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Likelihood	5			E		
	4	F	A,C		B	
	3		D			
	2					
	1					
		1	2	3	4	5
		Consequence				

- A. Tail Hook/Launch Bar Strain Gages
- B. Main Landing Gear Strain Gages
- C. Wing Microphones
- D. Nose Boom/Air Data System
- E. Nose Pallet DAU's
- F. Nose Landing Gear Pots

Risk Documentation Example

- **Launch Bar & Tail Hook Strain Gages:**
 - Launch Bar & Tail Hook strain gages are susceptible to moisture damage during ground & flight operations.
- **Risk Mitigation:**
 - Cover with plastic during aircraft washing,
 - Maintain calibrated spares,
 - Avoid leaving aircraft outside in the rain.
- **Impact if Damaged:**
 - May require removing sealant, drying out gages and resealing, to stripping, replacing and re-calibrating all gages.
 - Cost: \$500-\$5000 / Schedule: 1 – 5 days

Conclusion

- **Strain Gage Protection Project**
 - Looking favorable for better way to seal gages
 - Next step is to test using Environmental Chamber
 - Concurrent Alt, Temp, Humidity
- **T&E S&T Projects**
 - Just getting started
 - Looking for Range/Service POCs to help focus efforts
- **Risk Assessment**
 - Do NOT use a “Dry” designation
 - Use standard risk cube for the risk of water damage
 - Convey the Likelihood and Consequence of damage
 - **Let the Test Team make the call of fly/no-fly**

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