Fuel Tank Internal Wiring Installation Quality

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Purpose of Presentation

- Show results of in-tank wiring inspections on new transport aircraft
- Overview of the tank inspection process
- Convey “lesson learned”

Background

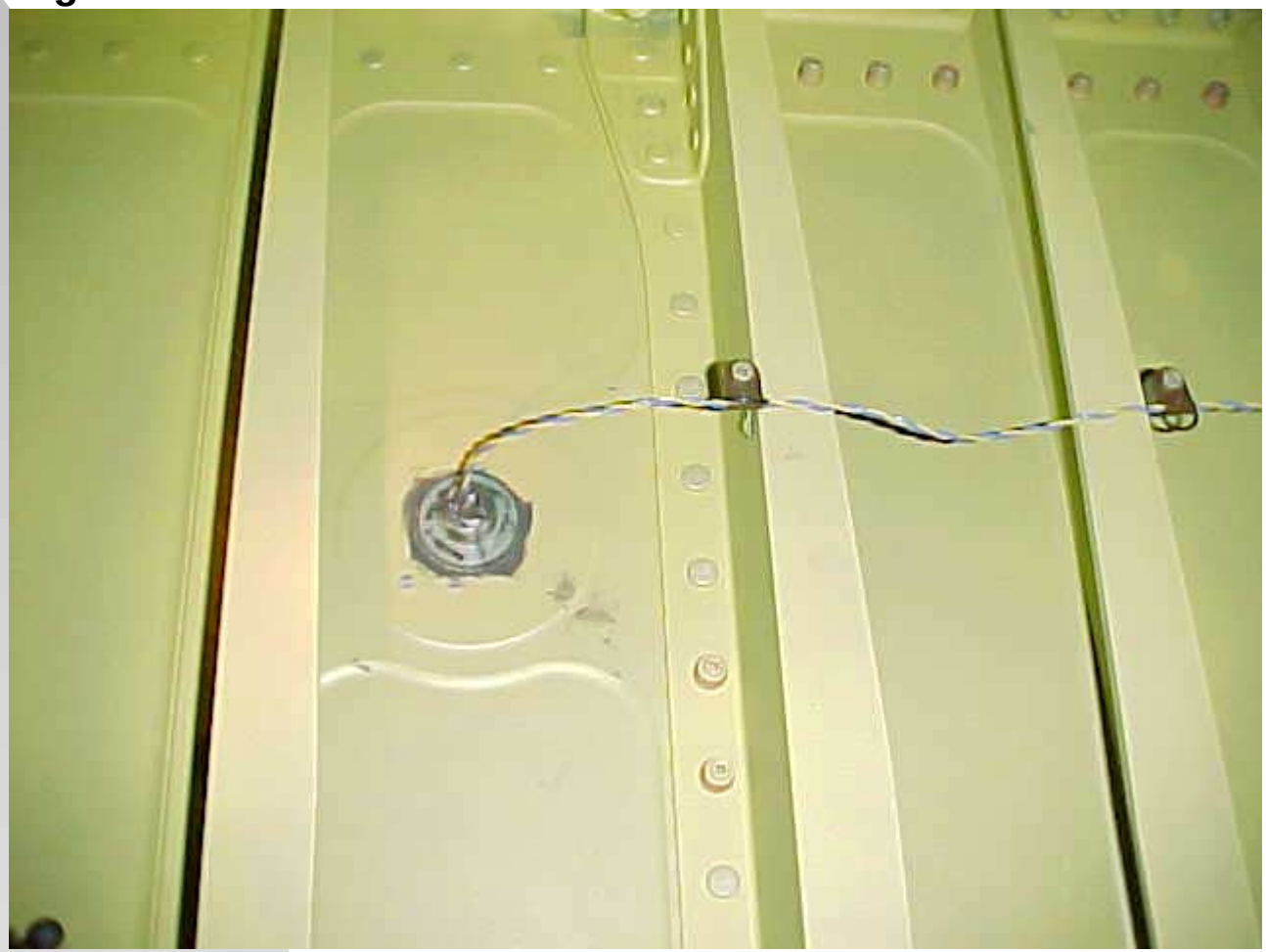
- In 1998, the Seattle ACO Propulsion Branch (ANM-140S) requested tank inspections on a transport airplane for compliance substantiation and continued airworthiness
- Significant problems found, resulted in a CMR and an AD
- Ever since, ANM-140S has periodically performed in-tank wire inspections on different airplanes
- Examples of in-tank wiring are shown herein
- Limited discussion on other areas to inspect is provided

Importance of In-Tank Wire Installation Quality

- Good in-tank wire installation quality is one means to help preclude ignition sources
- Good wire installations mean less FQIS problems, leading to less tank entries, leading to reduced risk of tank contamination or component damage
- Less in-tank FQIS wire problems also means happy operators

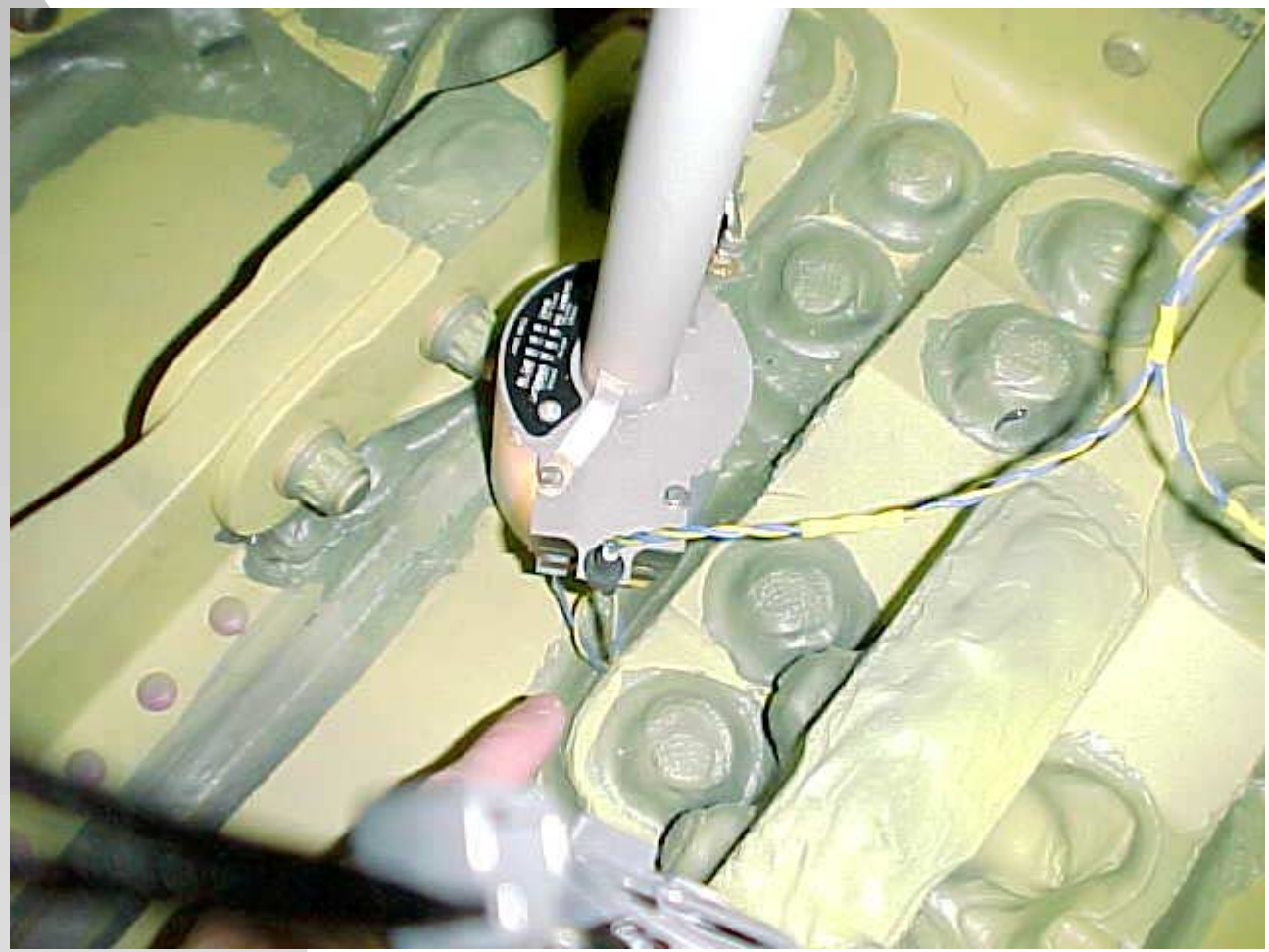
Center Wing Tank (CWT)

- FQIS wire contacting stiffener/ribs. Design change made to add standoffs
- Pass-Through Seal added (shown here) to preclude wire contact against sharp edges of hole



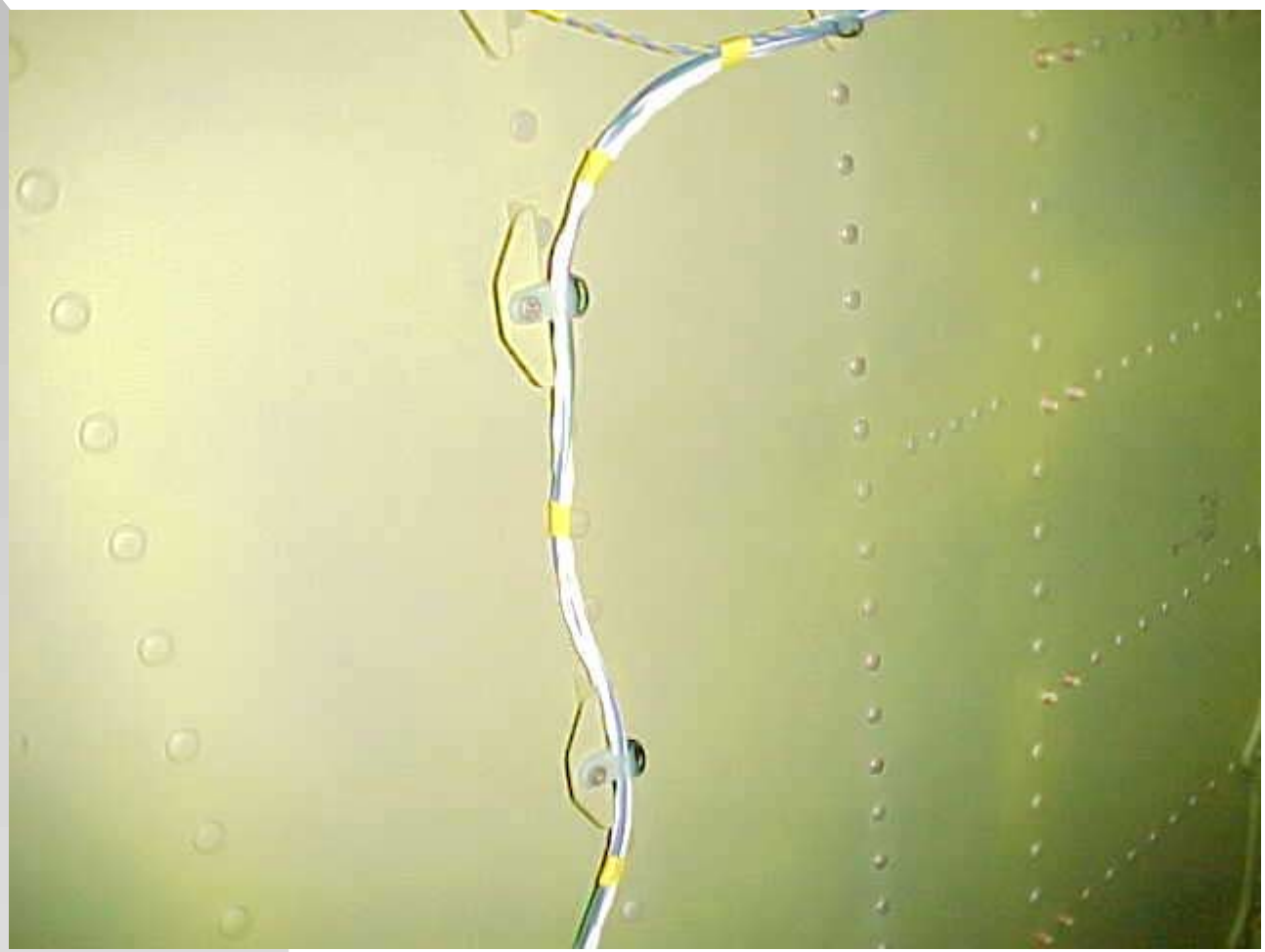
CWT

- Drip Loop Contacting Floor



CWT

- Anything Wrong Here?



CWT

- Closer look, different angle reveals problems with wire bundle contacting bracket edge.

Fuel Tank Inspections

- See anything wrong?

Fuel Tank Inspections

- Typical Corrective Actions
- Better orientation of p-clips, reduced wire slack and better wire routing precludes contact with screw heads, bracket edges and structural fasteners.

Fuel Tank Inspections

- See anything wrong?

Fuel Tank Inspections

- See the potential wiring problem ?
- Post-inspection review of this photo revealed problem with flapper valve contacting compensator. This resulted in an AD.

Fuel Tank Inspections

- Another example of typical corrective actions
- Better orientation of p-clips, reduced wire slack and better wire routing precludes contact with screw heads, top edge of bracket

Fuel Tank Inspections

- Post corrective actions. Everything is great, right?

Fuel Tank Inspections

- Post corrective actions (stand-off's). Everything is great, right?

Conducting In-Tank Wire Inspections - Preparation (This was written for ACO's. Others can benefit)

- ACO's should work with their MIDO, and request that they initiate, and conduct the inspections with ACO support
- Make sure it is clear that you will only enter the tank after Quality Assurance has accepted it, and it is ready to close
- Attempt to get confined space and dry fuel cell entry training. It is not actually required, however, it is useful and contributes to safety. (For Boeing, these are courses 6C66193 and 6C64314)
- Assure that responsible DER's, design engineer's and Quality Assurance personnel will be available. Ask them to have drawings available, and prepare a short familiarization briefing.
- Sign out camera (preferably digital)

Conducting In-Tank Wire Inspections - The Day of

- Bring camera
- Wear sneakers and “very casual” clothes. Don’t wear jewelry.
- Typically, you will be issued tank-entry equipment. Ask for guidance in using all of this.
- Regarding the digital camera - verify it’s OK to use in the dry fuel cell. DO NOT USE A CAMERA IN A WET TANK (a tank that has had fuel in it is considered wet.)
- When entering or exiting tanks, watch how other’s do it. Relax, take your time. Let others assist you.
- When taking pictures, have someone shine a flashlight on the component to help the camera focus. If you keep getting over-exposures, partially cover the flash with your finger. (Sony Mavica’s work great, but take a while to focus)
- Sealant vapors can be strong. Take breaks as needed.

Fuel Tank Inspections

- ANM-130S Engineer Mr. Steve Oshiro Demonstrates Correct Tank Entry Protocol

Fuel Tank Inspections

- ANM-130S Engineer Louie Natsiopoulos endures many hardships in the name of safety.

Fuel Tank Inspections - What to look for

- FQIS and other in-tank wiring problems discussed herein
- Missing, or loose sealant
- Debris
- Damage to components
- Missing components, such as fuel pump inlet screens
- Missing or poorly installed bonding wire on tank plumbing
- Inappropriate faying surfaces (Consider spot-checking brackets for appropriate faying surfaces. Note bracket location, check drawing requirements later).
- If you are inexperienced in what to look for, consider going in with someone more experienced in fuel tank inspections

Fuel Tank Inspections

- CWT Override Pump Installation

Fuel Tank Inspections - Documentation

- Do it right away, while still on site
- Download digital pictures and use a laptop
- Nominate a scribe to document results
- Discuss each photo. Get other's input
- Go back and re-inspect if you disagree on a problem
- Typically, QA & engineers will want to go back and discuss appropriate fixes
- Often, you are presented with the rejection tags or similar paperwork. If not, request that it be sent to you (so you can verify it was correctly documented).

Fuel Tank Inspections - Example of FAA ACO Engineer's Documentation

Photos taken during the XYZ Fuel System Safety Review on (date)
XYZ, Airplane No. 3
Photo's taken, and this summary by L. Reising, FAA Seattle ACO, ANM-140S
All files are named PIC000X.JPG, where X is provided below

File	Location	Summary
01	R Cheek, looking aft	FQIS transducer Wire contact w/FQIS shaft possible?
02	R Cheek, upper stringers	Detail of bundle run inside stringers (reference only, no problems noted)
03	R cheek, inner most bulkhead, looking inward	Densitometer shown. Noted wire contacting vertical row of fasteners (between first densitometer mounted P-clips and first bundle P-clip.) Noted that densitometer mounted P-clips did not adequately grip wire. Needs to be corrected.
04	Same as 03	Compensator in foreground. Note: 1) wire routing over (rounded) corned of compensator (OK?). 2) Apparent close proximity to bottom stringer (OK?). 3) Wire routed over 2 mounting bolt heads between two P-clips (needs to be corrected).
05	Same as 03, looking forward	FQIS probe shown. Note long wire overhang, with capability to chafe on probe shaft. OK?
06	L landing gear bay, looking forward, inward side	Bundle appeared very tight, concern of wire/connector damage. OK? (noted by Dick Johnson)
07	Same as 6, looking outward	Wire was contacting hydraulic tube – chafing potential. OK?
08	Center Tank, aft bay,	R override pump shown. Noted that inlet check valve had unused bracket containing two floating head nuts. Question – Is this OK inside a fuel tank? Consider bonding, rattling, steel to steel contact, eventual wear leading to debris in tank. Needs to be addressed to see of correction required. What is in the Manufacturer's guides?
09	Same as 08	FQIS probe. See comments for 05. Note also possible contact with fuel line.
10	Center tank, one of the middle bays	Vent channel valve shown (for reference only). General question - this can is a high vibration environment (consider engine beat). Can these valves handle this without rattling? Consider internal spring failure or hang-up. Is steel to steel contact possible. Consider that these are always exposed to vapor.
11	R Main, looking forward	Compensator shown. Note wire contacting compensator housing and assembly screw head. Needs to be corrected.
12	Same as 11	Better picture than 11. Question – can flapper valve impact compensator housing? Does this matter? Also should verify Ok wire transition into bundle. Photo looks like contact with structure may be possible. Is it ?
13	Same as 11	Densitometer shown. Wire was found riding on top of sharp edge (mounting bracket). Needs to be corrected.
14	Same as 11	Sideways shot of densitometer. Better view of wire situation.
15	Same as 11	Front shot of densitometer
16	Same as 11	Note close proximity of wires to structure (is this OK, can the wire slip inside the P-clip to eventually allow contact?)
17	EE bay, just above lower access door, looking left, forward	Noted high current wire to TRU riding against metal edge. Oshiro concerned with this
18	Same as 17	Same wire also against edge lower in EE bay (Oshiro)
19	Same as 17	Another shot of TRU
20	Outside of airplane	Mr. Oshiro demonstrates correct tank entry protocol
21	Looking up at R wing to body interface	Reference only

Fuel Tank Inspections - Corrective Actions

- Typically involves both engineering changes and enhanced QA activity
- Recognize that factories can have relatively high turn-over in both assembly personnel and in QA inspectors. For this reason, the better fix is a better design (i.e. one that does not require extreme attention to detail during assembly and inspection)
- Clarification notes in drawings are rarely effective in the long run
- If you find an unacceptable condition in the factory, be sure to assess the need for corrective actions for in-service airplanes.

In-Tank Wire Inspections - Long Term Effectiveness

- Experience is that in-tank wire installation quality improves significantly after FAA inspection, but drops off after time
- Consider asking the manufacturer to set up a quality team to assure that lessons learned get transferred across airplane models, and that the in-tank wire quality is maintained over time
- For FAA ACO personnel - consider working with MIDO to set up periodic FAA inspections to verify the results of the manufacturer’s quality team(s)