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Stress Corrosion Crack Detection on HU-25 Guardian Aircraft

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Abstract

Several ultrasonic inspection methods were developed at the Federal Aviation Administration's Airworthiness Assurance NDI Validation Center (AANC) to easily and rapidly detect hidden stress corrosion cracks in all vertical windshield posts on the United States Coast Guard (USCG) HU-25 Guardian aircraft. The inspection procedure locates cracks as small as 2.0 millimeters emanating from internal fastener holes and determines their length. A test procedure was developed and a baseline assessment of the USCG fleet was conducted. Inspection results on twenty-five aircraft revealed a good correlation with results made during subsequent structural disassembly and visual inspection.

Program Background

The USCG deploys HU-25 Guardian aircraft for medium range surveillance to satisfy the needs of the maritime community. The USCG monitors radio coverage on distress frequency bands for recreational boats and commercial craft. When emergencies occur, the HU-25 is deployed to aid the search and rescue mission. Other HU-25's are specifically outfitted to perform other unique functions such as drug interdiction and environmental compliance monitoring. The Aircraft Repair & Supply Center (ARSC) is the engineering center for the fixed wing aircraft [1]. One major engineering role of ARSC is to examine existing or impending maintenance and inspection problems for the HU-25 fleet (airframe and engines). Then, ARSC seeks solutions based upon scientific advancements in material science and nondestructive inspection (NDI) technology. ARSC has created an aggressive research program in the area of nondestructive inspection to support advancements in the HU-25 programmed depot maintenance (PDM) schedule. The engineering staff continually monitors the aircraft during maintenance for areas where there is a potential for high payoff to increase quality, productivity, efficiency and improve mission effectiveness. In 1994, ARSC initiated a program with AANC to assist in conducting nondestructive inspections in conjunction with its support activities [2]. AANC's major role in the present program is to assess current NDI technologies and recommend techniques that can help extend the service life of the HU-25 fleet.

During a routine functional cabin pressure check, maintenance personnel could not achieve the correct pressure differential. A visual inspection was conducted on the outside of the aircraft. The maintenance crew found a large air leak in a center window frame. Figure 1 displays the aircraft window section. During the removal of the center windshield, ARSC discovered exfoliation corrosion and several stress corrosion cracks in the vertical widow post (Figures 2 – 3).

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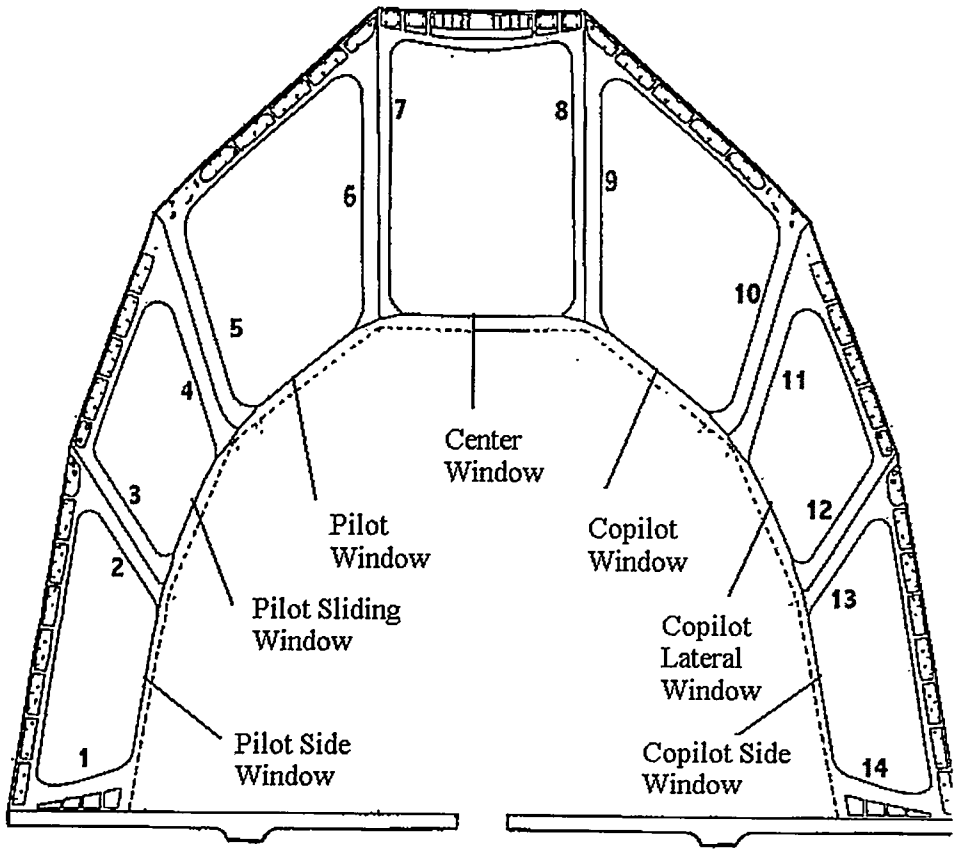

Window Post Number	Frame Angle (degrees)
1, 14	98
2, 3, 12, 13	84
4, 11	67
5, 10	88
6, 9	61
7, 8	89

Figure 1. Window post frames in the HU-25 Guardian aircraft.

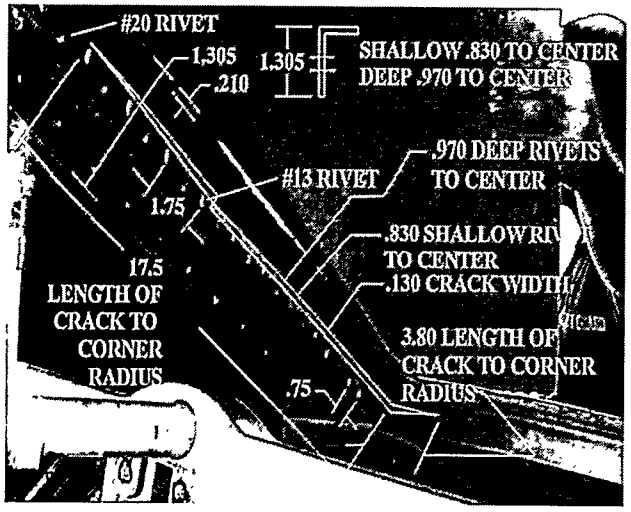

Figure 2. Center widow frame with stress corrosion cracks present. Note: All dimensions are in inches.

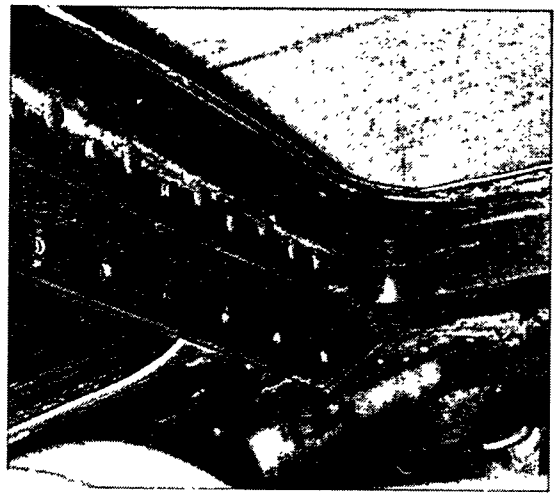

Figure 3. Center window frame with exfoliation corrosion present.

From this initial engineering investigation, it was determined that additional aircraft in the USCG fleet could contain similar cracks. To visually inspect this area, each windshield must be removed. This visual inspection method could not be accomplished in a timely manner and maintain fleet readiness. ARSC requested AANC to develop a portable inspection technique that could detect and characterize stress corrosion cracks without performing the window disassembly and visual inspection.

Window Post Inspection Development for Frames with an Angle Above 83 Degrees

AANC was able to inspect frames with an angle above 83° by modifying an existing USCG inspection procedure using an ultrasonic contact probe [3]. This procedure uses a 3 mm, 20 MHz diameter contact probe. The contact probe is standardized on a cut-out section of a removed widow frame. The probe is placed on the window frame surface. Ultrasonic signals from the web thickness, deep and shallow fastener holes were verified on each window frame. This technique proved to be very successful in finding cracks. The center vertical window posts (Frames 7 and 8), pilot and copilot side window vertical posts (Frames 1, 2, 13 and 14) lateral windows (Frames 3 and 12) and pilot and copilot window (Frames 5 and 10) were all inspected using the contact ultrasonic inspection method. However, this technique could not inspect the acute angles present in the pilot and copilot lateral windows (Frames 4, 6, 9 and 11).

Acute Angle (Below 68 Degrees) Window Post Inspection Development

A 12.7-mm diameter, 15 MHz, 5.08-cm focal length immersion transducer was placed inside a WEEPER manufactured by TESTECH, Incorporated. A flawed window frame removed from an aircraft was used to develop the technique. The immersion transducer was placed in the WEEPER housing and the water path delay was set to 10.16 mm. A 14° wedge was machined in the WEEPER end cap. This incident angle produces a 30° shear wave into the window frame. The instrument was calibrated using a shallow fastener hole at a known depth. The ultrasonic signals from the window frame revealed the location of the shallow and deep rivet fastener holes and stress corrosion cracks emanating from fastener holes. The technique was then deployed on the HU-25 at the AANC hangar. After a successful hangar demonstration, a field test was conducted on aircraft at ARSC. Five HU-25 aircraft were inspected. Two aircraft were clear of stress corrosion cracks and three possessed cracks in the window posts. No cracks were found in the acute angle window posts. After this field demonstration, ARSC conducted a baseline inspection on all its operational aircraft using the ultrasonic inspection techniques.

Baseline Inspection Results

The baseline inspection of the USCG HU-25 operational fleet was conducted in three months at the following Coast Guard Air Stations: 5 aircraft at Mobile, Alabama, 3 aircraft at Corpus Christi, Texas, 4 aircraft at Cape Cod, Massachusetts, 8 aircraft at Miami, Florida, and 5 aircraft at Elizabeth City, North Carolina. Of the 25 aircraft inspected, 10 were found to be clear of detectable stress corrosion cracks in the vertical window posts. Of the fifteen that possessed cracks, six were considered small, i.e. less than 38.1 mm. Five aircraft had medium size cracks in the window posts

i.e. greater than 38.1 mm but less than 88.9 mm. One aircraft had a large crack with a length of 11.43 cm. Two aircraft had two small cracks in separate window frames and one aircraft had three cracks-two small sized cracks and one medium sized crack.

Conclusions

AANC was able to modify an existing USCG inspection procedure using an ultrasonic contact probe. The contact ultrasonic probe was able to find cracks in window post with a frame angle above 83 degrees. AANC was able to develop an ultrasonic inspection technique to inspect the acute angle window frames using an immersion transducer. Both these techniques were able to detect stress corrosion cracks in the vertical post of the window frames. The application of the ultrasonic inspection proved to be a rapid method of determining the presence and extent of cracks in the widows without removing each window.

Application of this ultrasonic inspection requires less than six man-hours. Additional advantage of using NDI is that it does not require any mechanical disassembly, reassembly or pressurization verification testing. This represented a fleet-wide savings in excess of $400,000 and 100 operational days. In addition, 15 operational aircraft were able to be kept in service and placed in an NDI monitoring program.

References

1. Connor, D. C., *et. al.* "Coast Guard Effort to Deal with Aging Aircraft", The Second Joint NASAS/FAA/DoD Conference on Aging Aircraft, August 31 – September 3, 1998, Williamsburg, Virginia, USA, p. 3.

2. Interagency Agreement Between Sandia National Laboratories and United States Coast Guard Proposal #027940413, Work-for-Others Agreement established on September 15,1994.

3. Moore, D. G., Jones, C. R., and Mihelic, J. E., "Crack Detection on HU-25 Guardian Aircraft", 1997 Fall Conference and Quality Testing Show, Seattle, Washington, USA, October 14-18, 1996, SAND96-1930C, pp.152-154.