Bath-tub Fittings Case Study

Having one ESDU Data Item to re-design cracked bath-tub fittings cited in FAA directive "saves company over a million dollars" according to senior Engineer

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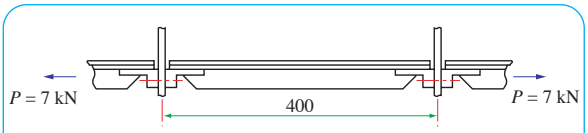
Case Study

On 23rd June 2005, FAA Airworthiness Directive (AD) 90-09-09, Amendment 39 6586 was superseded by AD 2005-10-21 Boeing: Amendment 39-14098. Docket No. FAA-2004-19538; Directorate Identifier 2003-NM-99-AD.

Excerpts from the new FAA directive state:

"The superseded AD, AD 90-09-09, applied to certain Boeing Model 747 airplanes and required inspections to detect cracks in the front spar pressure bulkhead chord, and be repaired if necessary. The new AD, which was prompted by reports of cracks in the body station (BS) 1000 bulkhead chord, requires repetitive high frequency eddy current (HFEC) inspections of the bulkhead chord for cracks and repetitive detailed inspections of the bathtub fittings, if installed, for cracks, and corrective action if necessary. This AD was issued to detect and correct fatigue cracks in the bulkhead chord, which, if not repaired before they reach critical length, could result in the failure of the adjacent structure and skin and lead to in-flight depressurisation of the airplane.

Consider the costs of compliance. Worldwide, there were about 1,350 Model 747 airplanes of the affected design. The actions required by AD 90-09-09 took about 84 man-hours per airplane, at an average labour rate of $65 per hour and an estimated 102 airplanes registered in the U.S. were affected. Based on these figures, the estimated cost of the actions that would have been required by AD 90-09-09 is $556,920, or $5,460 per airplane, per inspection cycle. The inspections required by the new AD take about 14 man-hours per airplane and about 245 airplanes registered in the U.S. are affected. Based on these figures, the estimated cost of the actions specified in the new AD for U.S. operators is $222,950, or $910 per airplane, per inspection cycle."



Overall layout of bulkheads and fittings

Ensuring that the design of the 'bath-tub' fittings is correct is obviously crucial and mistakes costly. Given that plastic deformation of some parts of the fittings are likely to occur, analysis of the component geometry and material properties cannot be achieved by conventional (finite element-based) stress analysis alone.

For decades, a number of companies around the world have used certain formally and informally documented methods for analysing 'bath-tub' type tension fittings. These methods followed a known industry practice but elements of the analyses were not fully validated. These companies have reviewed their design procedures and, as certification standards are tightened, many have felt forced to prohibit their Engineers from using these methods.

Most of these companies subscribe to the ESDU Data Series and were therefore immediately able to adopt the validated method described in ESDU 84039, "Strength of angles and club-foot fittings (transmitting tensile loads)" (bath-tub fittings are also known as 'club-foot' fittings!). The methods presented in the Data Item are easily and immediately applicable to the design and analysis of their bath-tub fittings on all existing and future aircraft, helicopter, missile and other systems.

As with all ESDU Data Items, the work on ESDU 84039 was closely monitored and guided by an independent Technical Committee (in this case the Aerospace Structures Committee) of specialist experts drawn from industry, research and the universities, to ensure that the methods presented were fully validated. The Engineer who wrote the Data Item had to satisfy the Committee, all of whose independent Members give their time voluntarily, on the assessment of the available technical information and on the quality of the presentation. Without the unanimous approval of the members of the Committee, the Data Item could not have been released for publication. The FAA is well aware of the ESDU validation process. Although not explicitly representing the FAA, one of their Engineers is a member of the Fatigue Committee and, similarly, another is a member of the panel that is responsible for ESDU 00932, the Metallic Materials Data Handbook.

Most of the major Aerospace organisations, including the FAA, CAA, EASA, Northrop Grumman, Jet Propulsion Laboratory, NASA, Airbus, Boeing, British Aerospace Systems, ESA, Saab etc. generously allow a number of their Engineers the time to participate in ESDU Committee work.

During the development of the methods described in ESDU 84039, actual test data, including data from at least three aircraft manufacturers and two university studies (University of Illinois and Cranfield University), were evaluated. The reports from the aircraft manufacturers were unpublished internal reports that were made available to ESDU. Many ESDU Data Items include data from unpublished company reports, classified reports, Technical Notes etc.

Regarding ESDU 84039, one senior Engineer stated, "Having that one ESDU Data Item saved our company at least a million dollars". The Engineer's company had estimated an 8 to 12 month project to develop and validate their own method. One can see evidence of the level of cost involved from the compliance figures estimated in the FAA directive.

The Engineer was further impressed when he learned that he was able to discuss the subject with the ESDU Engineer responsible for the Data Item - at no further cost to his company! ESDU 84039 is only one of over 1380 Data Items currently published by ESDU. In addition, approximately 250 of those Data Items are accompanied by computer programs.

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