Structures Bulletin

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Subject: Aircraft Structure Teardown Inspection and Evaluation Program Protocols

References:

1. Department of Defense Standard Practice, MIL-STD-1530D Change 1, “Aircraft Structural Integrity Program”, 13 October 2016.
2. USAFA-TR-2020-01, “CAStLE Teardown Analysis Program Protocol 1: Data Management System”, USAF Academy, CO, May 2020
3. USAFA-TR-2020-02, “CAStLE Teardown Analysis Program Protocol 2: Identification and Tracking”, USAF Academy, CO, May 2020
4. USAFA-TR-2020-03, “CAStLE Teardown Analysis Program Protocol 3: Teardown Section Extraction”, USAF Academy, CO, May 2020
5. USAFA-TR-2020-04, “CAStLE Teardown Analysis Program Protocol 4: Teardown Section Disassembly”, USAF Academy, CO, May 2020
6. USAFA-TR-2020-05, “CAStLE Teardown Analysis Program Protocol 5: Part Coating Removal”, USAF Academy, CO, May 2020
7. USAFA-TR-2020-06, “CAStLE Teardown Analysis Program Protocol 6: Lap Joint and CPC Evaluation”, USAF Academy, CO, May 2020
8. USAFA-TR-2020-07, “CAStLE Teardown Analysis Program Protocol 7: Nondestructive Inspection”, USAF Academy, CO, May 2020
9. USAFA-TR-2020-08, “CAStLE Teardown Analysis Program Protocol 8: Root Cause Analysis”, USAF Academy, CO, May 2020

Introduction:
Aircraft structure teardown inspection and evaluation programs are conducted on durability test specimens and retired aircraft to discover, characterize and thoroughly document structural damage that was not detected via other methods. In this context, they are destructive inspections as opposed to disassembly to enable inspections. The data obtained from these efforts are used in the durability analysis, damage tolerance analysis, risk analysis, and corrosion assessment to determine the aircraft structure service life capability and to establish the appropriate maintenance program.

Paragraph 5.3.4.5 in Reference 1 states: “At the end of the full-scale durability test, including any scheduled damage tolerance tests and/or residual strength tests, a teardown inspection and evaluation program shall be conducted. The teardown inspection and evaluation shall include careful and deliberate disassembly of the entire durability test article, and close visual inspection of all structural elements shall be performed while the disassembly is performed. NDI [non-destructive inspection] of those critical areas identified in design as well as additional critical structure identified during testing shall be performed. Fractographic examinations shall be conducted to obtain damage growth data to validate or correct the damage growth analysis and to assist in the assessment of the initial quality of the aircraft structure. The EIDS [equivalent initial damage size] distribution shall be derived from the damage discovered during testing and the teardown inspection and evaluation. Prior to teardown, consideration should be given to evaluation of the effectiveness of the anticipated NDI methods that may be applied to fielded aircraft. The durability test article parts to include pieces subjected to fractographic examination shall be retained after teardown inspection and evaluation to enable future examination.”

In addition, paragraph 5.5.15 in Reference 1 states: “An aircraft structure teardown inspection and evaluation should be performed if an aircraft is expected to operate beyond its certified service life or to validate or correct the onset of WFD [widespread fatigue damage] analysis”

Purpose:
The purpose of this bulletin is to recommend protocols to be used in aircraft structure teardown inspection and evaluation programs.

Discussion:
One of the primary objectives of an aircraft structure teardown inspection and evaluation program is to discover, characterize and thoroughly document structural damage that exists in the as-received condition. An aircraft structure teardown inspection and evaluation program consists of five primary execution elements: extraction, disassembly, coating removal, nondestructive inspection (NDI), and root cause analysis (often referred to as failure analysis). Procedures and processes used to extract sections (areas of interest) and disassemble them to the part level for detailed inspections (e.g. cutting, fastener removal, coating removal, cleaning) should be carefully planned and controlled to prevent accidental or incidental damage. In addition, the detailed methods for coating removal, NDI and root cause analysis to maximize damage detection and to adequately characterize the damage (e.g. location, orientation, type, and dimensions) must be established to support the teardown inspection and evaluation program fidelity requirements.

However, there are other critical aspects of a properly executed aircraft structure teardown inspection and evaluation program that must be developed and implemented that are not as obvious. For example, the number of parts and amount of data generated

demands a carefully planned and flawlessly executed data management system throughout the entire chain of custody to ensure traceability at each step in the process. This is not a trivial task considering that parts may be further sectioned to enable root cause analysis.

Procedures and processes to accomplish the above have evolved based on lessons learned and have culminated in a set of protocols that have been used successfully in several aircraft structure teardown inspection and evaluation programs over the past 15 years. These protocols are documented in References 2 through 9 and are summarized as follows:

1. Establish a data management system that serves as the permanent electronic record of the entire teardown inspection and evaluation program and that provides the ability to create and maintain continuity of data visibility and control through every stage of the program (Reference 2).
2. Identify and track all teardown sections, individual components and parts, and sections of parts subjected to root cause analysis to ensure identification and continuous tracking throughout the teardown inspection and evaluation program. (Reference 3).
3. Perform teardown section extraction from the subject aircraft that removes structural assemblies while preventing incidental damage (Reference 4).
4. Conduct precision teardown section disassembly in a deliberate and organized manner that minimizes damage induced by disassembly (Reference 5).
5. Perform coating removal of the disassembled parts while preventing substrate material damage in order to optimize nondestructive inspection results (Reference 6).
6. Where applicable and as needed, perform lap joint and corrosion preventive compound (CPC) evaluation that determines the presence of corrosion in the occluded region of the lap joint and that ascertains whether CPC applied on the lap joint helped to mitigate the corrosion. Also where applicable and as needed, determine the residual strength and residual life in these structural elements (Reference 7).
7. Perform nondestructive inspection (NDI) to interrogate structures and materials for discontinuities, defects (to include original production defects), and operationally induced damage without causing incidental damage which could result in a loss of vital metallographic evidence (Reference 8).
8. Conduct root cause analysis of prioritized inspection findings (close visual and NDI indications) and document the Aircraft Structural Integrity Program (ASIP) relevant characteristics of each finding (Reference 9).

Recommendation:
Use References 2 through 9 to establish program-specific protocols for aircraft structure teardown inspection and evaluation programs. When doing so, the program office should determine the primary objective(s) of the teardown inspection and evaluation program such as: (1) identifying new critical locations for follow-on durability and damage tolerance analysis and corresponding updates to the maintenance program, (2) providing data for follow-on quantitative structural risk analysis, (3) providing data for follow-on corrosion assessments and corresponding updates to the maintenance program, (4) determining if the onset of widespread fatigue damage has occurred. The primary objective(s) can lead to different fidelity requirements to include selecting how many and which NDI indications are subjected to root cause analysis. Therefore, the primary objective(s) should be determined early so that the teardown inspection and evaluation program has the proper scope and the program-specific protocols ensure success.

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