Structures Bulletin

AFLCMC/EZ
Bldg 28, 2145 Monahan Way
WPAFB, OH 45433-7101
Phone 937-656-9956

Number: EZ-SB-13-003

Date: 9 April, 2013

Subject: Revised Initial Flaw Size Assumptions for Slow Crack Growth (SCG) Metallic Structures

References:

1. Department of Defense Joint Service Specification Guide, Aircraft Structures, JSSG-2006, 30 October 1998.
2. Department of Defense Standard Practice, Aircraft Structural Integrity Program, MIL-STD-1530C, 1 November 2005.
3. Structures Bulletin, EN-SB-12-003, Damage Tolerance Inspection Methodology for Slow Crack Growth Metallic Structure, 23 July 2012.
4. Department of Defense Handbook, Nondestructive Evaluation System Reliability Assessment, MIL-HDBK-1823A, 7 April 2009.
5. W.D. Rummel, *Recommended Practice for Demonstration of Nondestructive Evaluation (NDE) Reliability on Aircraft Production Parts,* Materials Evaluation, Vol. 40, No.9, pp.922-932, American Society for Nondestructive Testing (ASNT), Inc., 1982.

Background:

The basic concept of slow crack growth damage tolerance approach is that damage is assumed to exist in each safety-of-flight element of the aircraft structure in the most critical location and orientation with respect to the stress field. The structure must successfully sustain the growth of the assumed damage for a specified period of service, and must maintain a minimum level of residual strength both during and at the end of this period. USAF damage tolerance design guidelines are specified in References 1, 2, and 3 and apply to all safety-of-flight structure, i.e., structure whose failure could cause direct loss of the aircraft, or whose failure, if it remained undetected, could result in the loss of aircraft or aircrew or cause inadvertent store release.

Purpose:

The purpose of this bulletin is to provide clear guidance on the default initial flaw assumptions to be used in damage tolerance analyses of metallic structures using the slow crack growth approach. The original issuance of this Structures Bulletin will address flaws assumed to exist in pins and fasteners; future revisions will expand the scope to address flaws in other metallic structural features. This Structures Bulletin should be used in addition to the criteria in Reference 1, Table XXX, until it is updated to incorporate the content of this bulletin.

Discussion:

<u>Pins and Fasteners</u>

Reference 1 provides guidance on initial flaw size assumptions and states the following:

"At locations other than holes, the assumed initial flaw is a through the thickness flaw of 0.25 inch length when the material thickness is equal to or less than 0.125 inch. For material thicknesses greater than 0.125 inch, the assumed initial flaw is a semicircular surface flaw with a length (2c) equal to 0.25 inch and a depth (a) equal to 0.125 inch."

Clearly, the use of an initial 0.125 inch radial surface flaw in hardware such as pins, bolts, and fasteners will yield very short or zero damage tolerance lives, since this initial flaw size is often larger than the critical flaw size.

Generally, small components such as pins and fasteners are inspected to a higher level of detail than a large general area (i.e., wing skin, bulkheads, etc.). Additionally, pins and fasteners are usually precision machined to produce very precise, controlled dimensions and very smooth surface finishes. Additionally, many of these components are cold-rolled to induce compressive residual stresses. This has led to the re-evaluation of the initial flaw assumption for these components which presumes the inspection of 100 percent of all fracture critical regions. For Inconel, steel, corrosion resistant steel (CRES), and titanium ***pins and fasteners***, the default initial flaw size should be changed to a 0.05 inch radial flaw size as illustrated in Figure 1 below.

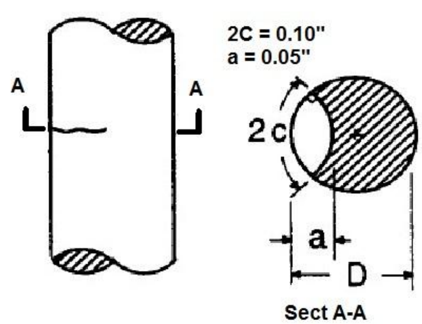

Figure 1: Revised Initial Flaw Size for Pins and Fasteners

As with any other structural part, the use of smaller initial flaws are allowed if the detectable flaw for a given NDI technique can demonstrate a 90 percent probability of detection at a 95 percent confidence level. This capability must be verified by conducting a statistically valid demonstration program and must be approved by the procuring agency. The demonstration program shall be conducted on each selected inspection procedure using production conditions, equipment, and personnel. Implementation of fully automated eddy current inspection is an acceptable approach for reducing the revised initial flaw size for Inconel, steel, CRES, and titanium fasteners and pins.

Capability Demonstrations for Pins and Fasteners

The following provides specific criteria for conducting a capability demonstration program for fasteners and pins.

- Two approaches are considered acceptable for demonstrating inspection capability:

  1) Probability of Detection (POD) studies conducted in accordance with MIL-HDBK-1823 (Reference 4).

  2) Capability demonstrations using the Point Estimation Method (Reference 5).

- The hardware used in capability demonstrations shall contain actual flaws and/or cracks which simulate typical tight fabrication flaws. The use of low cycle fatigue cracks is preferred. The use of electro-discharge machined (EDM) slots is acceptable only for demonstrating eddy current capability using one of the following two approaches:

  1) The ratio of eddy current response between a crack and EDM slot of the same size and aspect ratio is quantified and used to correct the POD results.

     -Or-

  2) A 2:1 ratio (EDM slot response to an actual crack flaw response) is assumed and is accounted for by either increasing the inspection sensitivity by 6 dB above the reference standard flaw at the target POD size (e.g. EDM slot) size or by establishing the rejection threshold at 6 dB below the reference flaw response. The EDM slot dimensions used in the demonstration and instrument calibration shall not exceed 0.004 inch in width. The depth shall be at least 30% shallower than the equivalent crack size (i.e. 3:1 aspect ratio).

- The critical flaw orientation and location shall be determined by the responsible engineering authority. The flaws manufactured in the capability demonstration components must reflect the flaw locations and orientations determined to be critical.

- The flaws shall be randomly located and masked so that they cannot be detected by visual examination or the flaw locations be predicted through a pattern.

- The false positive rate (i.e. the percent of non-damaged components rejected) shall be reported.

Subsequent to successful completion of the demonstration, specifications on these inspection techniques shall become the manufacturing inspection requirements and may not be changed without requalification and acquisition activity approval.

Each facility and inspector shall be qualified to achieve the reduced flaw size capability by successful performance of the capability demonstration. The qualification period shall not exceed three years. Prior to the 3-year anniversary date, each facility and inspector shall be required to re-qualify by repeating the capability demonstration.

Prepared by:

Juan C. Lado
Technical Expert, DADT
AFLCMC/EZFS
WPAFB, Ohio

Approved by:

Richard H. Reams
Technical Advisor, Structures
AFLCMC/EZFS
WPAFB, Ohio

Approved by:

Charles A. Babish IV
Technical Advisor, ASIP
AFLCMC/EZ
WPAFB, Ohio

Coordination

Name	*Function*	*Initials*
Richard B. Tayek	DADT Engineer, AFLCMC/EZFS	RBT
Mark S. DeFazio	Branch Chief, Structures, AFLCMC/EZFS	MSD
John C. Brausch	Lead Engineer, NDE, AFRL/RXSA	JCB
Dr. Lawrence M. Butkus	Chief Engineer, AFRL/RXT	LMB