



Structures Bulletin

ASC/EN

Bldg 28, 2145 Monahan Way

WPAFB, OH 45433-7101

Phone 937-255-5312

Number: EN-SB-12-001

Date: 25 April 2012

Subject: Requirements for Evaluation and Authorization of Digital Radiography for Inspection of Aerospace Castings

References:

1. JSSG-2006, Department of Defense, *Joint Service Specification Guide, Aircraft Structures*, 30 October 1998.
2. JSSG-2009, Department of Defense, *Joint Service Specification Guide, Air Vehicle Subsystems*, 30 October 1998.
3. JSSG-2007C, Department of Defense, *Joint Service Specification Guide, Engines, Aircraft, Turbine*, 10 June 2011.
4. Military Standard, "Castings, Classification and Inspection of", MIL-STD-2175A, 25 August 1993¹.
5. SAE Aerospace, Aerospace Material Specification, *Castings, Classification and Inspection of*, SAE AMS2175, June 2010.
6. Military Standard, "Inspection, Radiographic", MIL-STD-453, 27 Dec 1984².
7. ASTM International, *Standard Practice for Radiographic Examination*, E1742/E1742M -11, January 2011.
8. ASTM International, *Standard Practice for Radioscopy*, E 1255 – 09, July 2009.
9. ASTM International, *Standard Practice for Radioscopic Examination of Castings*, E1734-09, July 2009.
10. Metals Affordability Program, "Guidelines for the Use of Digital Detector Arrays and Computed Radiology for Aerospace Casting Inspections", 18 Aug 2011³.

¹ This standard was replaced with SAE-AMS-2175.

² This standard was replaced with ASTM E1742.

³ This document is available from AFRL/RXSA and has been submitted to ASTM for review in committee E07 as WK30625.

DISTRIBUTION A. Approved for public release; distribution unlimited.

11. MIL-STD-1530C, *Aircraft Structural Integrity Program*, 18 April 2002.
12. MIL-STD-1798B, *Mechanical Equipment and Subsystems Integrity Program*, 24 January 2010.
13. MIL-STD-3024, *Propulsion System Integrity Program*, 15 April 2008.

Background:

Airframe requirements of Reference 1 state that “castings shall be classified and inspected, and all castings shall conform to applicable process requirements...factors, tests, and inspections must be applied in addition to those necessary to establish foundry quality control”. Also, “critical castings, castings used in primary structure, or castings with a casting factor less than 1.33 must meet the following requirements: a. Receive 100 percent inspection by visual and magnetic particle or penetrant or approved equivalent non-destructive inspection (NDI) methods.” (Requirements b through e are not shown for brevity.)

Reference 2 requirements for subsystems take a similar approach by stating that “for all castings, a safety factor of 1.33 should be applied to the limit and ultimate load factors...unless the castings have been fully characterized”; however, NDI requirements are not specified. Engine requirements of Reference 3 provide the same option to use a 1.33 safety factor or fully characterize the casting, and provide lessons learned that radiographic inspections are the preferred methods to detect subsurface flaws in castings.

References 4 and 5 describe the NDI acceptance criteria for the inspection of aerospace structural castings (i.e., castings in airframe and subsystem applications that perform a structural function). Inspection criteria are segregated by class and grade, which pertain to the criticality and the quality of a casting, respectively. A Class 1 designation applies to those castings of which the single failure would endanger the lives of operating personnel, or cause the loss of a missile, aircraft, or other vehicle. Class 2 castings are those whose failure would result in a significant operational penalty to include loss of major components, unintentional release or inability to release stores, or failure of weapon installation components. Class 3 and 4 apply to castings not included in Class 1 or 2, and are defined by the use (or not) of a casting factor.

For Class 1, 2, and 3 structural castings, References 4 and 5 require that castings be visually and radiographically inspected, and either magnetic particle inspected (ferromagnetic materials) or liquid penetrant inspected (non-ferromagnetic materials). Class 4 castings require the same NDI methods with the exception of radiographic inspection. Visual inspection is required on 100% of all castings in all classes, magnetic particle or penetrant are required on 100% of Class 1, 2, and 3 castings, and radiographic inspection is required on 100% of Class 1 castings. All other inspection frequencies are dependent upon the specific class. Ultimately though, the specific NDI requirements will be governed by the contractual requirements.

DISTRIBUTION A. Approved for public release; distribution unlimited.

Turbine engine castings are not typically classified using the above criteria, but are similarly classified based on their criticality (i.e. – safety critical, mission critical, durability critical, or durability non-critical). As is the case for structural castings, the criticality determines the NDI methods and inspection frequencies.

Introduction:

This bulletin provides requirements for evaluation and authorization of non-film digital radiography (DR) systems for inspections of aerospace castings. DR refers to all types of digital radiography systems including but not limited to digital detector arrays (DDA) and computed radiography (CR) systems. DR is rapidly replacing legacy radiographic methods because it eliminates the expense and environmental impacts of traditional X-ray film and its associated chemicals, developers, etc.

The focus of this bulletin is on the radiographic inspection of castings. References 6 and 7 outline standard practices for radiographic inspections using traditional film techniques. Standard practices for analog (non-film) radioscopic inspections are presented in References 8 and 9.

To ensure that DR systems provide equivalent performance to film radiography, the guidelines contained in Reference 10 were developed under the USAF Metals Affordability Initiative (MAI) program entitled “Digital Radiography for Final Acceptance of Production Aerospace Castings”. The guidelines are considered interim guidance until such time that industry standards (e.g. ASTM) are available and formally adopted by USAF programs. Information concerning the MAI program and the participating government and industry members can be obtained from AFRL/RXSA. The guidelines are based primarily on best practices from the American Society for Testing and Materials (ASTM International), experience of the MAI program members, and data generated in the MAI program.

Purpose:

The purpose of this bulletin is to ensure that the proper testing and evaluation of a DR system is performed to verify that it meets or exceeds the performance of radiographic film NDI, and that the system is sufficiently sensitive to resolve to the required quality level. Therefore, this bulletin is provided to assist with the implementation of DR systems prior to the formal issuance of an appropriate industry (e.g. – ASTM) or military specification.

Note: It should NOT be assumed that a DR system will provide equivalent performance as a film radiography system. A DR inspection system is not a “drop in” replacement for a film inspection system – capabilities of inspection systems vary, whether using DR or film. It is possible to have a DR system with more or less capability than a film system for a given application.

DISTRIBUTION A. Approved for public release; distribution unlimited.

Applicability:

This bulletin is applicable to any agency, original equipment manufacturer (OEM), casting vendor, etc., responsible for in-process weld repair inspections and final acceptance inspections of production USAF aerospace castings.

Requirements:

The following procedures must be followed in order for digital radiography to be authorized as an inspection method for in-process weld repair and final acceptance of production aerospace castings in USAF systems:

- 1) Reference 10, "Guidelines for the Use of Digital Detector Arrays and Computed Radiology for Aerospace Casting Inspections," shall be used to develop a process specification, subject to approval by the appropriate Integrity Manager (i.e. ASIP, MECSIP, or PSIP; References 11, 12, and 13 respectively) and NDI Level 3, prior to implementation of a digital radiography system.
- 2) When NDI capability demonstrations were required to originally authorize film radiography, the original film radiography capability demonstrations should be reviewed by the Integrity Manager and NDI Level 3 to determine if a digital radiography capability demonstration is required. The results of these capability reviews (or demonstrations if required) shall be documented, reviewed, and approved by the Integrity Manager and NDI Level 3 prior to implementation of a DR system.

Summary:

Digital radiography inspection systems are not "drop in" replacements for film radiography. Successful implementation of a DR system requires development and approval of a new process specification, and where necessary, completion of an NDI capability review and/or demonstration.

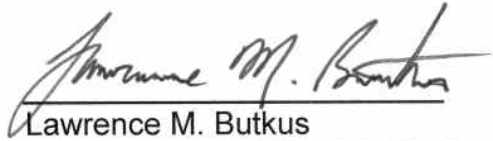
DISTRIBUTION A. Approved for public release; distribution unlimited.

Prepared by:



Kenneth J. LaCivita
Senior Nondestructive Inspection Engineer
AFRL/RXSA
WPAFB, Ohio

Approved by:



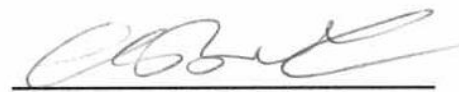
Lawrence M. Butkus
Lead, Structural Materials Evaluation
AFRL/RXSA
WPAFB, Ohio

Prepared by:



Richard H. Reams
Technical Advisor, Structures
ASC/ENFS
WPAFB, Ohio

Approved by:



Charles A. Babish IV
Technical Advisor, ASIP
ASC/EN
WPAFB, Ohio

Coordination

<i>Name</i>	<i>Function</i>	<i>Initials</i>
Larry P. Perkins	Chief Engineer, Systems Support Division	LPP
John C. Brausch	Nondestructive Evaluation Lead Engineer	JCB
Thomas J. Condron	Technical Advisor, Aircraft Subsystems	TJC
Vincent S. Spanel	Technical Advisor, Propulsion	VSS

DISTRIBUTION A. Approved for public release; distribution unlimited.