AEROSPACE STANDARD

AS6870™

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Nondestructive Inspection Program Requirements for Aerospace Systems

RATIONALE

Implementation of effective NDI processes is critical to ensuring the structural integrity of aerospace systems throughout the design life-cycle.

1. SCOPE

1.1 Purpose

This SAE Aerospace Standard defines the requirements for establishing a Nondestructive Inspection (NDI) program for aerospace systems to include but not not be limited to aircraft structure, aircraft stores (external structures such as antennas, pods, fuel tanks, weapons, radomes, etc.) and missile/rocket structural components when an NDI Program Plan is required by contract. NDI Programs are essential to ensuring NDI processes are implemented to support the lifecycle design requirements of the system and its components. NDI Programs are applicable to all phases of the system life cycle, including acquisition, modification, and sustainment. This standard may also be applicable to mechanical equipment, subsystems, and propulsion systems, but the requirements defined by the NDI Program Plan should be tailored by the contracting agency for such use. An NDI Program Plan shall be developed at the beginning of the technology development phase and shall define all NDI requirements to be adhered to throughout the system life cycle.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific examption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2644	Inspection Material, Penetrant
AMS2647	Fluorescent Penetrant Inspection Aircraft and Engine Component Maintenance
AMS-I-83387	Inspection Process, Magnetic Rubber
AMS-STD-2154	Inspection, Ultrasonic, Wrought Metals, Process for
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AS6870/

ARP4402 Eddy Current Inspection of Open Fastener Holes in Aluminum Aircraft Structures

ARP4462 Barkhausen Noise Inspection for Detecting Grinding Burns in High Strength Steel Parts

AS4787 Eddy Current Inspection of Circular Holes in NonFerrous Metallic Engine Hardware

2.2 ASNT Publications

Available from American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, OH 43228-0518.

SNT-TC-1A Recommended Practice, Personnel Qualification and Certification in Nondestructive Testing

2.3 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NAS410 Nondestructive Testing Personnel Qualification and Certification

2.4 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B244 Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments

ASTM E164 Standard Practice for Contact Ultrasonic Testing of Weldments

ASTM E213 Standard Practice for Ultrasonic Testing of Metal Pipe and Tubing

ASTM E215 Standard Practice for Standardizing Equipment and Electromagnetic Examination of Seamless Aluminum-Alloy Tube

ASTM E309 Standard Practice for Eddy Current Examination of Steel Tubular Products Using Magnetic Saturation

ASTM E376 Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods

ASTM E426 Standard Practice for Electromagnetic (Eddy Current) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys

ASTM E498/E498M Standard Practice for Leaks Using the Mass Spectrometer Leak Detector or Residual Gas Analyzer in the Tracer Probe Mode

ASTM E1004 Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy -Current) Method

ASTM E1316 Standard Terminology for Nondestructive Examinations

ASTM E1417/E1417M Standard Practice for Liquid Penetrant Testing

ASTM E1444/E1444/M Standard Practice for Magnetic Particle Testing

ASTM E2033 Standard Practice for Computed Radiology (Photostimulable Luminescence Method)

ASTM E2375 Standard Practice for Ultrasonic Testing of Wrough Products

ASTM E2339 Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)

ASTM E2445/E2445M Standard Practice for Performance Evaluation and Long-Term Stability of Computed Radiography Systems

ASTM E2580 Standard Practice for Ultrasonic Testing of Flat Panel Composites and Sandwich Core Materials Used in Aerospace Applications

ASTM E2581 Standard Practice for Shearography of Polymer Matrix Composites, and Sandwich Core Materials and Filament-Wound Pressure Vessels in Aerospace Applications

ASTM E2582 Standard Practice for Infrared Flash Thermography of Composite Panels and Repair Patches Used in Aerospace Applications

ASTM E2662 Standard Practice for Radiologic Examination of Flat Panel Composites and Sandwich Core Materials Used in Aerospace Applications

ASTM E2663 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for Ultrasonic Test Methods

ASTM E2698 Standard Practice for Radiological Examination Using Digital Detector Arrays

ASTM E2736 Standard Guide for Digital Detector Array Radiology

ASTM E2737 Standard Practice for Digital Detector Array Performance Evaluation and Long-Term Stability

2.5 EN Publications

Available from the British Standards Institute, 389 Chiswick High Road, London, W4 4AL, United Kingdom, +44 (0)20 8996 9001, www.bsi-global.com.

EN 4179 Qualification and Approval of Personnel for Non-Destructive Testing

2.6 Government Documents

2.6.1 Department of Defense Specifications

Copies of these documents are available online at https://quicksearch.dla.mil.

JSSG-2006 Joint Service Specification Guide Aircraft Structures

MIL-DTL-87929 Manuals, Technical Operation and Maintenance Instructions in Work Package Format

2.6.2 Department of Defense Standards

Copies of these documents are available online at https://quicksearch.dla.mil.

MIL-STD-867 Temper Etch Inspection

MIL-STD-1530 Aircraft Structural Integrity Program (ASIP)

MIL-STD-1537 Test Method Standard for Electrical Conductivity Test for Verification of heat Treatment of Aluminum Alloys Eddy Current Method

MIL-STD-1798 Mechanical Equipment and Subsystems Integrity Program

MIL-STD-1907 Inspection, Liquid Penetrant and Magnetic Particle, Soundness Requirements for Materials, Parts, and Weldments

MIL-STD-3024 Propulsion System Integrity Program (PSIP)

MIL-STD-40051 Preparation of Digital Technical Information for IETMs

2.6.3 Department of Defense Handbooks

Copies of these documents are available online at https://quicksearch.dla.mil.

MIL-HDBK-516 Airworthiness Certification Criteria

MIL-HDBK-1783 Engine Structural Integrity Program (ENSIP)

MIL-HDBK-1823 Nondestructive Evaluation System Reliability Assessment

MIL-HDBK-6870 Nondestructive Inspection Program Requirements for Aircraft and Missile Materials and Parts

2.6.4 Other Government Documents, Drawings, and Publications

Available online at https://etims.cce.af.mil/ETIMS/index.jsp.

Technical Orders

JOINT AIR FORCE-NAVY-ARMY TECHNICAL MANUAL

NAVAIR 01-1A-16-2

TM 1-1500-366-23

TO 33B-1-2 Nondestructive Inspection General Procedures and Process Controls

2.6.5 Air Force Service Bulletins

Available from Engineering.Standards@wpafb.af.mil the AF NDI Office, AFRL/RXSST, 4750 Staff Dr., Tinker AFB OK 73145, DSN 339-4931 or 405-739-4931.

EN-SB-008-011 Nondestructive Inspection of Safety-of-Flight Structures

EN-SB-008-012 In-Service Flaw Assumptions for Metallic Structures

EZ-SB-13-003 Revised Initial Flaw Size Assumptions for Slow Crack Growth (SCG) Metallic Structures

EZ-SB-15-001 Aircraft Structures Teardown Inspection and Evaluation Program Protocols

EZ-SB-15-002 Requirements for NDI Procedure Development, Validation and Verification for Aircraft Inspection During Operations and Support Phase

3. DEFINITIONS

3.1 INSPECTOR CERTIFICATION

A written statement from the certifying agency verifying that an individual inspector has met applicable requirements. The certifying agency may be the employer of the inspection personnel.

3.2 CLASSIFICATION

Classification refers to functional reliability requirements of the part and implies a confidence level requirement for NDI. A high-reliability class (i.e., fracture-critical and fracture-critical traceable) may require NDI capability demonstrations to assure the capability and confidence level of the NDI process; applied to that component to meet the intended design requirement. Complex components may also be divided into zones with separate classifications.

3.3 CONTRACTING AGENCY

A contractor, subcontractor, or government agency procuring product or services.

3.4 CONTRACTOR

An organization having contractual responsibility to the government.

3.5 DURABILITY-CRITICAL PART

A non-safety-of-flight structural component that is judged to require additional controls beyond those for normal-control parts.

3.6 FINAL INSPECTION

The last inspection of a part or component usually just prior to final acceptance. This inspection may occur during manufacturing and also before a component is built into an assembly and will become uninspectable. The final inspection may also be an inspection just after some processing step and is not subject to reinspection by the manufacturer after further processing. Final inspection may also occur in maintenance activities just before the component is built into an assembly where subsequent inspection is not possible.

3.7 FRACTURE-CRITICAL PART

A safety-of-flight, structural component that is not single load path nor judged to require serialization and traceability (reference MIL-STD-1530, MIL-STD-3024, MIL-HDBK-516, and JSSG-2006).

3.8 FRACTURE-CRITICAL TRACEABLE PART

A safety-of-flight structural that is either single load path or judged to require serialization and traceability (reference MIL-STD-1530, MIL-STD-3024, MIL-HDBK-516, and JSSG-2006).

3.9 LIFE CYCLE

The entire life of a program or system, including design, development, testing, production, sustainment, modification, and disposal.

3.10 MAINTENANCE-CRITICAL PART

A structural component whose failure will not cause a safety-of-flight condition but the failure of which would not be economical to repair or replace.

3.11 MISSION-CRITICAL PART

A structural component in which damage or failure could result in the inability to meet critical mission requirements or could result in a significant increase in vulnerability.

3.12 MATERIAL REVIEW BOARD (MRB)

A government approved review of discrepant materials by authorized contractor engineering and quality assurance personnel to determine whether material or component can be returned to an acceptable state.

3.13 NONDESTRUCTIVE INSPECTION (NDI)

The inspection of a structure or component in any manner that will not impair its future usefulness. The purpose of NDI may be to detect flaws at or beneath the external surface of a part, measure geometric characteristics, determine material structure or composition, or it may characterize physical, electrical, or thermal properties without causing changes in the part. The five primary methods of NDI are liquid penetrant, magnetic particle, eddy current, ultrasonic, and radiography. Other methods include but are not limited to computed tomography, shearography, and thermography.

3.14 NONDESTRUCTIVE INSPECTION (NDI) PROCEDURE

Step-by-step instructions for performing a particular NDI method on a specific part or family of parts (see 5.3.4).

3.15 GENERAL NDI PROCEDURE

Non-part specific, Step-by-step NDI instructions applicable to common product forms such as plates, composite laminates and bonded assemblies, bar stock, fasteners and tubular products, etc. General NDI procedures may also include those that describe standardization and inspection processes for common inspection methods.

3.16 PART SPECIFIC NDI PROCEDURES

Step-by-step instructions for inspection of a designated part or component, which incorporates all processing criteria. The contractor's or customer's general procedures may be used to form part of specific NDI procedures when supplemented by part specific information, permitted by contract and approved by the customer. With approval from the contracting agency, part specific NDI procedures may be used in lieu of company process specifications.

3.17 NDI FACILITY

Organizations responsible for providing NDI services in support of the program in any phase of the system life cycle.

3.18 NDI PROGRAM PLAN

Document that defines the approach for implementing NDI processes throughout the system life cycle.

3.19 NDI PROCESS SPECIFICATION

NDI process specifications define the requirements for equipment, reference standards, materials, personnel, etc., for a particular NDI method or for the testing of a particular product.

3.20 NDI REQUIREMENTS REVIEW BOARD (NDIRRB)

An advisory team (also known as an NDI Advisory Board) comprised of representatives from pertinent disciplines that guides the NDI Program. NDI, durability and damage tolerance, design, materials and processes (M&P) subject matter experts (SMEs) representing the prime, major subcontractors and government/customer. The NDIRRB shall be formed early in the conceptual phase of a weapons system to provide guidance to the prime contractor, major sub-contractors, System Program Office (SPO), and subsequently to the System Program Manager (SPM), on all technical matters necessary to establish, implement, and maintain an effective life cycle NDI Program responsive to the quality assurance, structural integrity and sustainment requirements of the program. The NDIRRB shall review and assess inspection requirements and processes during all phases of the program from initial design through production and in-service operation.

3.21 PROBABILITY OF DETECTION (POD)

A statistical measurement of the likelihood, with a specified confidence level, of finding a flaw of a defined size using a specific inspection process.

3.22 QUALIFICATION

The verified ability of personnel or products to meet the minimum capability, technical or performance requirements for a specified level of capability.

3.23 SAFETY-OF-FLIGHT STRUCTURE

Structures whose single failure could cause loss of the weapon system, aircrew, or cause inadvertent store release. The loss could occur either immediately upon failure or subsequently if the failure remained undetected.

3.24 SUBCONTRACTORS

Organizations responsible to the contractor for a portion of the overall government contracted product.

3.25 SUPPLIER

Organizations directly responsible for delivering a material, part or service to the government, a contractor, or a subcontractor.

3.26 VALIDATION

The process of demonstrating the applicability of a proposed inspection process (equipment and procedures) to meet a specified requirement.

3.27 VERIFICATION

The process of certifying the efficacy of an inspection process (equipment, reference standards, and written procedures) through a demonstration, on a representative structure, in a representative environment, and by representative inspection personnel.

4. REQUIREMENTS

4.1 General Requirements

The acquisition or modification of aircraft, aircraft stores, missiles, rockets, and their propulsion systems shall stress the inclusion and use of NDI throughout the system life cycle. A detailed life cycle NDI Program Plan is an important and integral component of structural maintenance plans.

4.2 Preparation of the NDI Program Plan

For programs where an NDI Program Plan is a contractual requirement, the prime contractor shall establish in writing an overall systems plan to assure adequate NDI of structural components. For example, MIL-STD-1530 requires and NDI Program Plan as part of an Aircraft Structural Integrity Program. This plan shall include provisions for conducting NDI throughout all phases of the program life cycle. This systems plan is referred to herein as the NDI Program Plan. The NDI Program Plan shall be subject to review by the NDIRRB and approval by the customer. It is paramount that the NDIRRB program plan be frequently updated to include evolving program requirements as each new phase of the program is implemented. The NDI program shall consider and implement appropriate NDI processes into all phases of the program life cycle. For United States Department of Defense (DoD) programs, refer to MIL-HDBK-6870, Appendix A for a template NDI Production Plan.

4.3 Responsibility for NDI

Unless otherwise specified in the contract, the contractor is responsible for the performance of all production inspection requirements as specified in the NDI Program Plan. Except as otherwise specified in the contract, the contractor may use their own or any other facilities qualified in accordance with 5.5.7 for the performance of the inspection requirements unless disapproved by the customer. The contractor will be responsible for NDI sustainment tasks as specified in the contract.

4.3.1 Objective

The objective of the NDI Program Plan is to assure a level of NDI capability, for both production and sustainment inspections, consistent with the prime contractor's design requirements.

4.3.2 Applicability

The NDI Program Plan shall be applicable to structural components produced under the program contract. It is the prime contractor's responsibility to flow down the NDI Program Plan requirements to all subcontractors and suppliers supporting the Program.

4.3.3 Elements

The NDI Program Plan shall present the scheme for establishing the NDI requirements and implementing processes and procedures to meet these requirements. The NDI Program Plan documents how NDI processes will be implemented, executed, controlled, and monitored for compliance across the supplier base throughout the system life cycle. It shall include descriptions of processes and requirements that will be used to accomplish the following tasks:

a. Inspect parts in accordance with part classification requirements.

b. Coordination of design requirements and production NDI procedures.

c. Establishment, review, and concurrence of NDI drawing notes by the contractor's NDI Level III representative to the NDIRRB prior to drawing release.

d. Preparation, review, and approval of production NDI process specifications and written inspection procedures.

e. Demonstration of production NDI capability.

f. Qualification of prime contractor, sub-contractor, and supplier facilities where NDI will be conducted.

g. Obtaining and maintaining qualified NDI staff and an accredited NDI training/certification program.

h. Implementation of production NDI procedures.

i. Storage and retention of production NDI records and digital records (e.g., digital radiographs, ultrasonic C-scans).

j. Coordination and documentation of inspection requirements to support long-term sustainment including structural repairs.

k. Preparation of NDI technical data for long term sustainment.

l. Validation and verification of inspection technical data for sustainment.

m. Assessment and documentation of sustainment NDI capability.

n. Coordination of NDI requirements for test articles (coupon, component, destruct, full-scale static, and fatigue) and development of NDI methods and procedures to support test articles.

o. Development of NDI training and supporting materials for sustainment inspections that have elements or requirements unique to the system (e.g., NDI methods, NDI equipment, materials, and/or manufacturing processes requiring procedures that sustainment personnel supporting the system do not have experience with).

p. Qualification of new technologies for use during any phase of the system life cycle.

q. Qualification of NDI methods adapted for the purpose of in-situ structural damage sensing.

4.3.4 Coordination

For DoD programs the NDI Program Plan will be delivered to the government for review and approval per contract requirements. This plan shall be coordinated with the contractor, the integrity program managers (ASIP/PSIP/MECSIP) as applicable, and the NDI Requirements Review Board (NDIRRB). When MIL-STD-1530 is a contractual requirement, the Aircraft Structural Integrity Plan (ASIP) manager is responsible for review and approval. When MIL-STD-3024 is invoked, the customer Propulsion Integrity Plan (PSIP) manager is responsible for review and approval. When MIL-STD-1798 is a contractual requirement the Mechanical Equipment and Subsystems Integrity Program (MECSIP) manager is responsible for review and approval.

4.4 Parts Classification

4.4.1 Structural Parts Classification

The contractor shall classify all structural components according to the structural integrity requirements of MIL-STD-1530, MIL or other contractual requirements. Complex components may be divided into zones and a separate classification or quality grade assigned to each zone in accordance with the reliability requirements. Classification shall be noted on the drawing of the component or other released engineering data. NDI requirements may vary with part classification. Part classification categories include (see Section 3 for definitions):

a. Fracture-critical

b. Fracture-critical traceable

c. Durability-critical

d. Mission-critical

e. Maintenance-critical

f. Normal controls (all parts not included in one of the above categories)

4.4.2 Propulsion Systems Parts Classification

When this standard is used to establish an NDI Program Plan for propulsion system components the parts classification requirements of MIL-STD-3024 shall be used.

4.4.3 Mechanical Equipment and Subsystem Parts Classification

When this standard is used to establish an NDI Program Plan for mechanical equipment or subsystem components, the parts classification requirements of MIL-STD-1798 shall be used.

4.5 NDI Requirements Review Board (NDIRRB)

For DoD programs where MIL-STD-1530 is a contractual requirement or the contract requires an NDI Program Plan in accordance with this standard, the contractor shall establish and maintain a Nondestructive Inspection Requirements Review Board (NDIRRB) (also known as an NDI Advisory Board (NDIAB)) for oversight and execution of the NDI Program Plan. The NDIRRB shall be formed early in the design phase to review and assess product form concepts for inspectability in terms of process control and quality monitoring. The NDIRRB shall also be responsible for review and approval of inspection methods and detectability assumptions implemented in the Force Structures Maintenance Plan. The board's decisions are subject to customer approval. The customer shall retain the right of disapproval of NDIRRB decisions. For DoD programs refer to MIL-HDBK-6870, Appendix B for a template NDIRRB Charter.

4.5.1 Purpose

The NDIRRB shall:

a. Review and approve changes to the NDI Program Plan over the life cycle of the system.

b. Production Inspections: determine the NDI requirements for those components identified in accordance with 4.4, and assure that the most appropriate inspection methods(s) have been selected for the components being tested, and that the level of inspection is commensurate with the quality required. Assure NDI requirements are adhered to and are consistent across the NDI suppler base for the system.

c. Sustainment Inspections: Determine the NDI processes, procedures, technologies, and support equipment required to maintain the integrity of components throughout their service life.

d. Determine the requirements for demonstration of NDI capability (e.g., MIL-HDBK-1823) for inspection processes implemented in all phases of the program.

4.5.2 NDI Requirements Review Board (NDIRRB) Membership

When the formation of an NDIRRB is required by contract or standard governing, NDIRRB should be comprised of the prime contractor, major subcontractor and customer NDI, design and materials and processes (M&P) experts. The customer may also designate an independent team to participate as representatives to the NDIRRB customer representatives to include subject matter experts (SMEs) from the respective NDI service organizations, maintenance facilities, and users. The NDIRRB functions as an advisory panel to the prime contractor, major subcontractors and customer and assures NDI Program Plan and contractual NDI requirements are met. NDIRRB shall have the authority to review/recommend/approve technical issues/solutions related to NDI within the confines of the contract and NDI Program Plan; however, the NDIRRB cannot make contractual changes or direct a contractor, subcontractor, or customer to take any action outside the scope of the contract.

5. DETAILED REQUIREMENTS FOR PRODUCTION

5.1 Documentation of the Review

Drawings for each fracture-critical, fracture-critical traceable, and mission-critical structural component, if applicable, (see 4.3) shall be reviewed and approved by the contractor's authorized NDI Level III representative to the NDIRRB. The drawing shall include the signature of the contractor’s authorized NDI Level III as documented evidence of the review.

5.2 Drawings

The NDIRRB review shall provide guidance to the contractor’s responsible NDI Level III for defining NDI requirements on engineering production drawings or other released engineering specifications addressing part manufacturing requirements. The drawing shall reference all NDI procedures, process specifications, acceptance criteria, and/or class/grade requirements that are relevant to the manufacture of the part. If the inspection requirements are zonal, the zones and associated inspection requirements shall be referenced on the drawings or other released engineering specifications as appropriate. Drawings shall specify raw material and finished part inspection requirements.

5.3 Preparation of NDI Process Specifications and Procedures

5.3.1 Use of General NDI Process Specifications

The use of process specifications, such as those listed in 2.2 and 2.3, as sole controlling specifications, should not be permitted. These specifications reflect minimum quality requirements and are broad in scope.

5.3.2 Company NDI Process Specifications

Company process specifications shall be prepared incorporating the requirements of the referenced process specifications. The company process specifications shall meet or exceed the requirements of the referenced process specifications using the particular equipment, personnel, and test facilities required to meet the reliability requirements of the product. If no general process specification exists for a particular method, a company process specification or general NDI procedure shall be generated and shall incorporate sufficient information and criteria to adequately describe the NDI method and control the process.

5.3.2.1 Special NDI Procedures

Special procedures to inspect designated components may be used in lieu of or to supplement company process specifications. A contractor may elect to incorporate all processing criteria into each NDI procedure in lieu of generating process specifications. Special procedures shall require the same approval processes as both process specifications and part specific NDI procedures. When special procedures are used to implement new technology or to deviate from accepted practices with common NDI technology (e.g., reduced flaw size assumptions), customer and NDIRRB (if applicable) approval is also required.

5.3.2.2 NDI Standardization

The company process specification shall reflect procedures, acceptance criteria, personnel qualification requirements, certification requirements, and records requirements to assure adequate quality assurance measures are being enforced to keep the NDI process in control. Basic processes, equipment, reference standards, materials, and method specific variables, as applicable, shall be monitored to assure adequate control of the inspection process. For DoD contracts, sustainment inspections shall use standard DoD NDI equipment and procedures (e.g., TO 33B-1-2/TM 1-1500-366-23/NAVAIR 01-1A-16-2) wherever possible to streamline the development and transition of field and depot level inspection solutions (see Section 7 for additional guidance).

5.3.2.3 Approval

Company process specifications and special procedures shall be coordinated with an authorized representative of the contractor and shall be subject to review and approval by the customer and NDIRRB (if applicable) prior to use on components. Deviations from or revisions to company process specifications or special procedures throughout the system life cycle shall also be submitted to the customer and NDIRRB (if applicable) for review and approval prior to implementation.

5.3.3 NDI Processes

Company process specifications shall comply to the minimum requirement of industry standards as specified by contract and/or the NDI Program Plan. Company process specifications, including revisions, shall be subjected to the review and approval of the NDIRRB. The following nondestructive inspection methods and the associated specifications are acceptable and are recommended as the base requirements for the associated company process specifications:

a. Magnetic particle, in accordance with ASTM E1444/E1444M or MIL-STD-1907, as applicable.

b. Penetrant, in accordance with ASTM E1417, MIL-STD-1907, AMS2644, and AMS2647, as applicable.

c. Film Radiography, in accordance with ASTM E1742/E1742M.

d. Digital or Computed Radiography, in accordance with ASTM E2033, E2445/E2445M, E2662, E2698, E2736, or E2737, as applicable.

e. Ultrasonic, in accordance with AMS-STD-2154 and ASTM E213, E164, E2375 or E2580, as applicable.

f. Eddy current, in accordance with MIL-STD-1537 and ASTM B244, E215, E309, E376, E426 or E1004, AS4787, and ARP4402, as applicable.

g. Thermography, in accordance with ASTM E2582.

h. Magnetic rubber, in accordance with AMS-I-83387.

i. Leak testing, in accordance with ASTM E498.

j. Temper etch, inspection in accordance with MIL-STD-867.

k. Shearography, in accordance with ASTM E2581.

l. Barkhausen Noise Inspection, in accordance with ARP4462

5.3.4 NDI Procedures

Written inspection procedures shall be developed for inspection of each part requiring NDI. These procedures shall be in accordance with the requirements of the component drawing, the company process specification and other engineering requirements if applicable. Written inspection procedures shall contain the information listed below at a minimum:

a. Specific part or drawing reference.

b. Specific part material; surface finish and part preparation, as applicable.

c. Consumable Materials.

d. Warnings, Cautions, and Notes, as applicable. For Cautions related to inspection of DoD safety-of-flight structures, refer to EN-SB-008-011.

e. Manufacturer and model number of all instrumentation to be used, indicating optional equivalents, if desired.

f. Fixturing requirements, as applicable.

g. Manufacturer and identification of required inspection materials.

h. Reference to applicable company process specification.

i. Level of inspector qualification required.

j. Calibration/standardization procedure and reference standard identification as applicable, including requirements for re-checking the calibration/standardization and a requirement to re-inspect all parts since the last satisfactory calibration/standardization if the re-check fails.

k. Identification of areas to be inspected, detailed inspection steps including indexing and scan direction if applicable.

l. Defect sizing, locating, and marking requirements.

m. Acceptable defect criteria including location and critical orientation (based upon primary stress condition and direction) or equivalent drawing or specification reference for these criteria.

n. Post inspection and reporting requirements.

5.3.5 General NDI Procedures

General procedures or company process documents are acceptable for common product forms such as metallic plate, bar stock, fasteners, tubular products, as well as composite and hybrid material product forms when approved by the customer and NDIRRB (if applicable).

5.4 Reference Standards

Reference standards shall be used in support of raw material and component inspections. Reference standards shall represent the materials and components being inspected. Permanent markings shall be applied that note the reference standard part number or identifier. Key features of the reference standard such as edges of steps; location, depth, and size of reference defects; and reference defect identifiers shall be per drawing and marked on the standard where practical. Prior to their use, reference standards shall be certified to be within drawing tolerances and specification requirements. Reference defect dimensions shall be verified by physical measurements when feasible, or by nondestructive evaluation when reference defects cannot be physically measured. Composite reference standards for critical components shall be ultrasonic C-scan inspected and the digital C-scan record shall be maintained for the life of the standard. Porosity content should be determined, documented, and within acceptable limits for composite reference standards use on inspections where porosity evaluation is performed. Documentation substantiating reference standard certification, including reference defect measurements, shall be maintained for the life of the reference standard and be available to the customer upon request. Any deviations from drawing or specification requirements shall be documented and approved by the Responsible Level III and shall not inhibit the use of any reference defects within the standard unless redundant reference defects exist. Additionally, the customer and NDIRRB (if applicable) shall review and concur with deviations to reference standards when they are being used for inspection of fracture-critical, fracture-critical traceable, and mission-critical components. Reference standards shall be recertified whenever damage to the reference standard is suspected.

5.5 Implementation of NDI Procedures

5.5.1 Personnel

The contractor shall have available records of certification for personnel conducting and interpreting nondestructive inspections in accordance with the applicable sections of NAS410, EN 4179, or other alternate specifications in accordance with the contract requirements.

5.5.2 NDI Reports and Records

The contractor's NDI reports and data records shall be kept on file for the minimum amount of time as required by the contract. Reports shall be signed or stamped (ink or electronic signatures or stamps) by an authorized representative of the inspection facility. NDI procedures and equipment that produce digital records shall be utilized on fracture-critical and fracture-critical traceable parts and assemblies. In instances where it is not technically feasible to obtain digital records, substantiation shall be provided to the customer for concurrence or rejection. Digital NDI records (e.g., ultrasonic C-scans, radiographs, shearography images, etc.) used for final acceptance of fracture-critical traceable parts (including assembly bond lines) shall be delivered with each aircraft and shall be in a DICONDE compliant format (ASTM E2339, ASTM E2663) electronic format as specified by the contract. Ultrasonic scan data shall include full-waveform captures to facilitate reprocessing the scan images at some future date, shall the need arise. When full waveform data is captured, it shall be retained. Digital NDI records for fracture-critical traceable parts shall be traceable to aircraft number, part/assembly number, and part serial number, as applicable. Records shall include NDI of repairs performed to achieve part conformance to requirements.

5.5.3 Equipment and Materials

The equipment and materials used for inspection shall be in accordance with the applicable company process specification. Specified equipment shall have adequate maintenance to assure that it is fully operational when used to conduct inspections. When being used on critical components, equipment and material compliance shall be verified by the contractor and the customer shall be given the opportunity to be present if requested. Any data generated during equipment qualification shall be submitted to the customer and NDIRRB (if applicable) and for concurrence.

5.5.4 NDI Procedure Validation

All procedures and procedure families shall be validated by the responsible NDI Level III to assure repeatable defect detectability sufficient for the classification of the part. Procedures shall be validated on parts or on test pieces simulating the actual part and which provide the essential features of the part with regard to the important application variables which may affect defect sensitivity and confidence level. Redundant inspections may be utilized as a means to meet reliability requirements. Procedures for critical components and raw material to be used for fracture-critical components shall be submitted to the customer and NDIRRB (if applicable) for review and concurrence prior to use, although formal approval of the procedures still resides with the contractor’s responsible NDI Level III.

5.5.5 Removal of Discontinuities

When NDI reveals discontinuities in excess of the level permitted by applicable drawings or documents, such discontinuities shall be removed or repaired if permitted by applicable drawings and documents or authorized by Materials Review Board action. Evidence of removal or successful repair shall be confirmed by reinspection.

5.5.5.1 Reinspection

Reinspection for removal of discontinuities shall be conducted using the same procedure used during the initial inspection that detected the discontinuities. If a modified or different procedure is necessary, an addendum or temporary change to the original procedure action shall be prepared and approved by the responsible NDI Level III and Materials Review Board showing the essential features of the repair test. If the original procedure was reviewed by the customer and/or NDIRRB any proposed modifications shall be submitted to the NDIRRB and/or customer for review and concurrence.

5.5.6 Inspection Stages

5.5.6.1 First Article Destruct Inspections

Inspections of all first article components shall be conducted as part of manufacturing qualification and to assure the components meet the applicable engineering requirements. The requirements for first article inspections shall be defined and may exceed requirements for subsequent receiving inspections. The effectiveness of the NDI processes performed on the first article component shall be evaluated, and any necessary revisions to written procedures shall be made and implemented prior to inspection of the next production representative component.

5.5.6.2 Receiving Inspections

Incoming materials, parts or assemblies shall be inspected in accordance with the contractor's quality assurance requirements to assure they meet the applicable engineering requirements.

5.5.6.3 Manufacturing and Assembly

Inspections shall be performed during manufacture and assembly of components to assure the quality of final parts or assemblies is commensurate with the part or assembly classification and the criticality of the manufacturing processes. These inspections shall be approved by the contractor's designated NDI Level III.

a. NDI shall be performed subsequent to operations which may adversely affect the quality of material or part, such as heat treating, forging, cold working, and autoclave curing. When processing operations may interfere with or be detrimental to the capability of the required inspection, inspections shall be performed prior to such operations or actions shall be taken to eliminate the condition interfering with inspection (e.g., potential for smeared metal from a machining operation requiring pre-penetrant acid etch).

b. NDI shall be also performed when composite parts may be damaged as a result of machining operations or final assembly.

c. NDI procedures for composite parts shall demonstrate the capability of detecting foreign material that may inadvertently be left in the material stack-up during the layup process, typically including any material in the clean room. The contractor's process for demonstrating foreign material detection shall be detailed in the NDI Program Plan. Successful demonstration is required for each inspection procedure on each piece of equipment used in a facility, therefore multiple demonstrations may be required at a single facility. Requests for waiving a demonstration based on similarity may be proposed and substantiated to the customer and NDIRRB (if applicable) for consideration. In cases where materials cannot be detected by NDI, those material types shall be documented and reported to the customer for awareness such that additional material controls can be implemented by Materials and Processes Engineering, as necessary.

5.5.7 Vendor Qualification

All facilities, including sub-tier suppliers, performing inspection of fracture-critical, fracture-critical traceable and mission-critical structural components, shall be qualified by the contractor to assure their NDI processes and procedures meet design requirements. The NDI Program Plan shall address the criteria for qualification, including facility and personnel capability demonstrations, required for each inspection method employed. The vendor's NDI process specifications and fracture-critical, fracture-critical traceable and mission-critical part specific procedures shall be reviewed and approved by the contractor's Level III prior to the initial vendor qualification audit. The qualification process shall include initial and periodic audits of the vendor's facility. The audits shall be performed by personnel knowledgeable in the NDI methods being qualified, using a Level III approved checklist as a framework for conducting the audit. The auditor shall witness the vendor performing sample fracture-critical, fracture-critical traceable and mission-critical part specific procedures as part of the audit. The initial audits of vendors manufacturing fracture-critical, fracture-critical traceable and mission-critical parts shall be performed by an NDI Level III in that method. The recurring audits frequency may be dependent on past performance and audit results, but shall not exceed two years for vendors of fracture-critical, fracture-critical traceable, and mission-critical parts. Customer NDI representatives shall be given advance notice of audits and be given the opportunity to be present.

5.5.8 Capability Demonstration

The capability of nondestructive inspection processes used for production process monitoring and quality control of components shall be established, as required by MIL-STD-1530, to mitigate risk of missing defects. Special emphasis shall be given to inspection processes applied to fracture-critical, fracture-critical traceable, and mission-critical parts. If a procedure is required to detect flaws smaller than the accepted capability for the particular method, a capability demonstration shall be performed to prove that the technique can reliably detect flaws of that size. For acceptable detection capability values for establishing initial flaw sizes, for DoD contracts refer to JSSG 2006 and Structures Bulletin EZ-SB-13-003. Capability demonstrations shall also be required for qualification of new inspection processes or technologies prior to implementation. The requirement and approach for conducting capability studies shall be addressed within the NDI Program Plan.

6. DETAILED REQUIREMENTS FOR TEST ARTICLES

NDI requirements for and procedures used on test articles shall be submitted to customer and NDIRRB (if applicable) for review and approval prior to use.

6.1 First Article Testing

Structural components undergoing first article testing shall receive, as a minimum, production representative NDI. Additional NDI may be utilized to further quantify the component as part of the first article evaluation.

6.2 Static Test Articles

Static test articles shall receive, as a minimum, production representative NDI prior to testing. Additional NDI may be utilized to further quantify the component during or after the completion of the static test. The NDI requirements for static test articles shall be detailed in a Static Test Plan, if such a plan is required by contract, and submitted for review and approval prior to the commencement of the test.

6.3 Component, Full-Scale Durability Test Articles

Structural components undergoing full-scale durability test shall receive a production representative NDI prior to test. NDI shall be utilized during component and full-scale durability testing. These tests provide a valuable opportunity to verify NDI procedures that may be required to sustain the aircraft. Additionally, the application of NDI during durability tests provides early detection of impending failures which facilitates more accurate determination of the onset of cracking, the opportunity to monitor crack growth rates, the development and demonstration of repair concepts and the extension of the test by preventing premature catastrophic failure of the test article. Durability test articles provide an excellent opportunity to evaluate standard and emerging NDI technologies and embedded structural damage sensing (structural health monitoring) systems for use as sustainment tools once the system is fielded. The NDI requirements for full-scale durability test articles shall be detailed in a Full-Scale Durability (Fatigue) Test Plan and submitted to the customer and NDIRRB (if applicable) for review and approval prior to the commencement of the test.

6.4 Teardown Inspections

NDI shall be performed on component and full-scale test durability articles during the teardown inspections that are performed after cyclic testing. Fatigue test inspections require special part preparation and inspection techniques. Part disassembly, paint stripping, sealant removal, and cleaning processes shall be carefully performed to avoid damaging any fatigue crack fracture surfaces. Crack detection sensitivity is also heightened to make sure even the smallest cracks are detected with lessened concern for false positive calls. Additionally, crack orientation information is paramount to any break-open and fractography efforts. The teardown NDI requirements for static and full-scale durability test articles shall be detailed in the Static Test Plan and Full-Scale Durability (Fatigue) Test Plan, when such plans are required by contract, and submitted to the customer and NDIRRB (if applicable) for review and approval prior to the commencement of the tests. If teardown inspections are performed at subcontractor facilities, the facilities shall be audited by a contractor NDI Level III in the method(s) used prior to the commencement of the teardown effort to ensure compliance with NDI requirements. For best practices for conducting teardown program, refer to Structures Bulletin EZ-SB-15-001.

6.5 Flight Testing

NDI shall be utilized as required during flight testing to monitor fracture-critical, fracture-critical traceable, and mission critical structures where durability and damage tolerance analysis identifies a shortfall. These tests also provide a valuable opportunity to verify NDI procedures and reference standards that may be required to sustain the aircraft. The NDI procedures that support flight test shall be developed considering their eventual inclusion into the sustainment requirements for the system. Inspection procedures developed to support flight test shall reference the equipment available to the flight test maintenance organization and be written in accordance with 7.3.1.

6.6 Test Support Monitoring Inspections

NDI shall be utilized as necessary to assess the onset of damage other than fatigue, including corrosion, thermal, and impact damage to components and structures. The test support NDI procedures shall also be developed considering their eventual inclusion in the sustainment requirements for the system.

7. DETAILED REQUIREMENTS FOR SUSTAINMENT

7.1 Defining Sustainment Inspection Requirements

The initial and recurring inspections shall be identified and inspection solutions shall be implemented to maintain the safety of the structure throughout the intended design life. These inspections shall be established in accordance with MIL-STD-1530, MIL-STD-3024, or MIL-STD-1789 or other contractual requirements for structural integrity. Sustainment requirements shall be considered throughout the design, development and pre-production phases. Inspection requirements for component, full-scale and flight test articles shall be leveraged as opportunities to develop and validate sustainment inspection procedures.

7.2 Sustainment Inspection Requirements Review

The customer and NDIRRB (if applicable) shall:

a. Review the requirements and proposed inspection processes for initial and recurring in-service inspections and determine whether the proposed methods and the associated detection capabilities are sufficient to address the inspection requirements.

b. Review plans for conducting probability of detection (PoD) and/or proficiency studies to quantify detection capability used to establish realistic reinspection intervals.

c. Review and approve the capability assumptions used to establish inspection intervals for recurring inspections.

d. Assess the need for system specific NDI equipment and propose a plan to address any deficiencies that were identified.

e. Assess the need for system specific NDI training and propose a plan to address any deficiencies that were identified.

f. Provide recommendations and guidance directly to the prime contractor, major subcontractors, and SPO/SPM/PMA for decision making regarding all aspects of the NDI Program.

g. Recommend technology development or demonstration programs to identify and transition inspection solutions as required to address commercial-off-the-shelf capability shortfalls.

7.3 Preparation of NDI Procedures

The NDI Program shall consider and implement appropriate NDI processes to address sustainment requirements. Inspection procedures shall be written to utilize existing standard-issue NDI methods and equipment to the greatest extent possible. Any proposed use of non-standard NDI methods/equipment shall be technically justified to the customer including evidence to document its capability to meet the specific inspection requirements. Justification shall address capability as well as costs for procurement, training, and sustainment of the non-standard support equipment. Inspection procedures shall include or be supplemented with pictures, graphics, and videos to ensure the procedure details are clearly conveyed to the inspector. For DoD contracts, MIL-DTL-87268, MIL-DTL-87269, and MIL-STD-40051-1A provide detailed guidance for graphics, pictures, and multimedia content inclusion in procedures.

7.3.1 Sustainment NDI Procedure Content

NDI procedures shall be provided for inspection of each part requiring inspection. Each procedure shall contain the following information:

a. Inspection purpose or intent.

b. Specific part or drawing reference. When appropriate for the inspection, detailed information about part constructions such as cross sectional views, thicknesses, and fabrication features shall also be included in the part description and associated figures.

c. Applicable weapon system configuration.

d. Specific part material; surface finish and part preparation, as applicable.