



**Recommended
Training Curriculum
For
Digital Radiography
Personnel
(Level I)**

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Federal Working Group on Industrial Digital Radiography (FWGIDR) - The FWGIDR is a self-chartered organization consisting of federal and government contract employees and endorsed by the Defense Working Group on Nondestructive Testing (DWGNDT). This working group provides a platform for identifying common concerns and critical issues facing the federal industrial radiographic community as it transitions from film to digital radiography (DR). The FWGIDR, utilizing expertise from within the community, organizes and coordinates technical committees that formulate positions, guidance, and/or solutions for the community's common concerns and issues.

Background – Recognizing significant difficulties in addressing technical advances in the digital radiographic field, several engineers from the Department of Energy (DOE) and Department of Defense (DoD) organized the FWGIDR in 2007 to address the problems and concerns faced by the industrial radiographic community in transitioning to DR. Digital X-ray systems are revolutionizing medical radiology, as digital cameras revolutionized the photographic community, and similarly have an ever-increasing role in radiographic nondestructive testing. Medical radiology backed by significant development and funding, and digital photography, with rapid public acceptance; have demonstrated the advantages that digital systems offer in image intensive applications. The FWGIDR is focused on a vision for the future radiographic inspection facility, and that vision is digital radiography.

The rapid growth in DR has created transitional issues difficult for the industrial community to assimilate while transitioning from film to digital techniques. These issues include personnel training; data formatting, storage and retrieval; technique development and qualification; equipment qualification and monitoring; process control; and development and acquisition of equipment suitable for industrial applications.

Participants in the FWGIDR are organizations that employ nondestructive testing in support of government contracts. DOE, DoD, prime government contractors, along with other government and contractor personnel are actively contributing to and supporting the efforts of this working group.

Introduction – This paper, “Recommended Training Curriculum for Digital Radiography Personnel (Level I)”, was developed by a task team established by the FWGIDR. It addresses a major concern of the federal industrial radiographic community regarding personnel training. Original equipment manufacturers (OEMs) commonly offer Digital Radiography (DR) equipment familiarization training but provides limited, if any, basic DR training. There has been a need to establish appropriate DR training curriculums for Level I, II and III personnel. In September of 2009, the FWGIDR released a white paper, Paper No. 001-009, which provided a recommended DR training curriculum for Level III personnel. This is a continuation of the FWGIDR efforts to improve DR training. This white paper provides a recommended training curriculum for Level I DR personnel that is specifically designed to ensure compliance with NAS 410 requirements.

Purpose – This paper is intended as a recommended reference/guide for DR training curriculums for Level I radiographic film personnel transitioning to Level I DR functions as well as those that are already employing DR systems and techniques.

Scope – This curriculum covers DR principles, equipment and implementation issues that should be understood by Level I DR personnel. This training curriculum is intended for personnel that will utilize computed radiography systems (CR) and/or digital detector array (DDA) based DR systems.

Prerequisite – This curriculum does not cover basic radiography inspection principles. It was designed for personnel who already have training equivalent to the 40 hours recommended by the ASNT’s recommended practice SNT-TC-1A, Aerospace Industries Association’s NAS 410, or equivalent knowledge.

This training curriculum is intended for certified Level I film radiographers who are transitioning to digital radiography. The recommended training hours for this curriculum is 16 hours. Suggested hours for each section are noted in parenthesis.

Note: Basic computer competency skills are necessary to transition from film radiography to non-film radiography.

1. Introduction (1.0 Hours)
 - 1.1. Definition of Digital Radiography (DR)
 - 1.2. Overview of DR Systems
 - 1.2.1. Basic System Components & Functions
 - 1.2.1.1. Overview of Computed Radiography (CR) and Digital Detector Array (DDA) Systems
 - 1.2.2. System Procedural Steps
 - 1.2.2.1. CR & DDA vs. Film Radiography
 - 1.3. Digital Image Terminology
 - 1.3.1. Bits
 - 1.3.2. Bytes
 - 1.3.3. Pixels
 - 1.3.4. Bit Depth
 - 1.4. Image Format
 - 1.4.1. Tiff, JPG, DICONDE, etc
2. Digital Radiographic System Components (1.0 Hours)
 - 2.1. General DR Component Overview
 - 2.1.1. Source
 - 2.1.2. Detector
 - 2.1.3. Scanner (CR)
 - 2.1.4. Computer
 - 2.2. Detector Types (Overview)
 - 2.3. Detectors (Employer Specific)
 - 2.3.1. Handling Precautions
 - 2.3.1.1. Image Plates
 - 2.3.1.2. DDAs
 - 2.3.2. Review Equipment Operating Procedures
 - 2.3.2.1. Setup, Settings, And Warm-up
 - 2.3.2.2. Operation
 - 2.3.2.3. Performance Checks
 - 2.4. Equipment Safety Emergency Procedures

- 3. Image Fidelity Attributes (2.5 Hours)
 - 3.1. Image Fidelity Indicators (System Characterization)
 - 3.1.1. Line Pair Gages
 - 3.1.2. Phantoms
 - 3.1.3. Image Display Monitor Test Pattern
 - 3.2. Technique Verification
 - 3.2.1. Image Quality Indicators (IQIs) and Gages
 - 3.2.1.1. Plaque (Hole Type)
 - 3.2.1.2. Wire Type
 - 3.2.1.3. Line Pair Gages
 - 3.2.1.4. Representative Quality Indicators (RQIs)
 - 3.2.2. Pixel Value (Gray Value)
 - 3.2.3. Signal to Noise Ratio (SNR)
 - 3.2.4. Contrast to Noise Ratio (CNR)
 - 3.2.5. Basic Spatial Resolution (SR_b)
 - 3.2.6. Total Image Unsharpness (U_{im})
- 4. Detector Issues (Employer Specific) (1.5 Hours)
 - 4.1. Scatter Sensitivity
 - 4.1.1. Scatter Control
 - 4.2. Radiation Tolerance
 - 4.3. Portability
 - 4.4. Handling Issues
 - 4.5. Erasure and Ghosting
 - 4.6. Artifacts
 - 4.7. Bad Pixels
- 5. Exposure Documentation - Technique Sheets (1.0 Hours)
 - 5.1. Image Acquisition
 - 5.2. Geometric Magnification
 - 5.3. IQI/RQI use and placement
 - 5.4. Image Viewing
 - 5.4.1. Optimization of Displayed Image
 - 5.4.1.1. Window/Level
 - 5.4.1.2. Digital Magnification (Zoom)
 - 5.4.2. Image Qualification
 - 5.5. Software Tools (Available/Allowed)
 - 5.6. Storage of Acquired Images, e.g. DVD, Server, etc.

- 6. Process Control (1.0 Hours)
 - 6.1. DDA
 - 6.1.1. Acquisition of Gain and Offset Corrections
 - 6.2. CR
 - 6.2.1. IP Cleaning (Caution: IP handling precautions should addressed in 2.3)
 - 6.2.2. IP Scanner
 - 6.2.3. Acquisition of CR Phantom Images

- 7. Specific Equipment Training (8 hours)
 - 7.1. Software
 - 7.2. Hardware
 - 7.3. Total System

Note: The listed 8 hours may be conducted separately from a classroom environment, and shall be conducted on specific equipment and procedures used by the employer.

8. Reference Documents

Government Documents:

United States Air Force Research Lab

AFRL-RX-WP-TR-2009-4069, Development of USAF Computed Radiography (CR) Process Control

Industry Documents:

Aerospace Industries Association of America (AIA/NAS)

NAS 410 NAS Certification and Qualification of Nondestructive Test Personnel

ASME Boiler and Pressure Vessel Code (BPVC)

Section V – Nondestructive Examination, Article 2 – Radiographic Examination

America Society for Nondestructive Testing (ASNT)

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

ASTM International

E746 Standard Practice for Determining Relative Image Quality Response Industrial Radiographic Imaging Systems

E747 Standard Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E1000 Standard Guide for Radioscopy

E1025 Standard Practice for Design, Manufacture and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology

E1161 Standard Practice for Radiologic Examination of Semiconductors and Electronic Components

E1165 Standard Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging

- E1255 Standard Practice for Radioscopy
- E1316 Standard Terminology for Nondestructive Examinations
- E1411 Standard Practice for Qualification of Radioscopic Systems
- E1416 Radiologic Examination of Semiconductors and Electronic Components
- E1647 Standard Practice for Determining Contrast Sensitivity in Radiology
- E1734 Standard Practice for Radioscopic Examination of Castings
- E1742 Standard Practice for Radiographic Examination
- E1817 Standard Practice for Controlling Quality of Radiological Examinations by using Representative Quality Indicators (RQIs)
- E1936 Standard Reference Radiograph for Evaluating the Performance of Radiographic Digitization Systems
- E2002 Standard Practice for Determining Total Image Unsharpness in Radiology
- E2007 Standard Guide for Computed Radiology (Photostimulable Luminescence Method)
- E2033 Standard Practice for Computed Radiology (Photostimulable Luminescence Method)
- E2104 Standard Practice for Radiological Examination of Advanced Aero and Turbine Materials and Components
- E2339 Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)
- E2422 Standard Digital Reference Images for Inspection of Aluminum Castings
- E2445 Standard Practice for Qualification and Long Term Stability of Computed Radiology Systems
- E2446 Standard Practice for Classification of Computed Radiology Systems
- E2597 Standard Practice for Manufacturing Characterization of Digital Detector Arrays
- E2660 Standard Digital Reference Images for Investment Steel Castings for Aerospace Applications
- E2662 Standard Practice for Radiological Examination of Flat Panel Composites and Sandwich Core Materials Used in Aerospace Applications
- E2669 Standard Digital Reference Images for Titanium Castings
- E2698 Standard Practice for Radiological Examination Using Digital Detector Arrays
- E2699 Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for Digital Radiographic (DR) Test Methods
- E2736 Standard Guide for Digital Detector Array Radiology
- E2738 Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for Computed Radiology (CR) Test Methods
- E2737 Standard Practice for Digital Detector Array Performance Evaluation and Long Term Stability

European Standards

- EN12534-5 Characteristics of Focal Spots in Industrial X-Ray Systems for Use in Non-Destructive Testing, Part 5: Measurement of the Effective Focal Spot Size of Mini and Micro Focus X-Ray Tubes

Society of Motion Picture and Television Engineers (SMPTE)

- SMPTE RP 133 Specification for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard Copy Recording Cameras