CarestreamNDT

WHITE PAPER

Digital transformation is not a destination but a journey.

Digital Radiography and Imaging Terms

INTRODUCTION

At Carestream NDT we want to share not only our technological developments and product portfolio, but also the knowledge and practical experience that our staff obtains by working shoulder-to-shoulder with customers like you. We aim to share this knowledge and experience in a straightforward fashion so that our readers may find practical applications in their everyday activities.

This series is directed but not limited to NDE professionals in the following industries: Oil & Gas, Nuclear, Construction, Foundry and Castings, Energy Generation, Aerospace, Transportation, Automotive, Military and Defense, Agriculture, Art Restoration & Museum Artifacts, and NDE Services Companies.

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Often, while we are starting our exploration of a new field or professional activity, it is good to start with understanding the basic vocabulary in that discipline. This series of support articles should facilitate your understanding of the radiography process.

Regardless if you are already involved in radiography or just want to increase your understanding of the field, this portion of the series is for you.

PART 1 Common NDE Terms

PART 2 General Radiography Terms

PART 3 Film Radiography Terms

PART 4 Digital Radiography and Imaging Terms

In this post, we will arrange the series of terms in two layers or series: the first series provides definitions of basic terms used in digital radiography (DR) and the second series or "one-step-forward" lists new terms that may be understood using some of the terms from the first series.

With this new understanding, we welcome you to explore other articles in this series.

PART 5 Image Quality and Discontinuity Indication Terms

Basic DR Terms

Table 1 proposes a series of digital radiography terms that may establish basic DR and computed radiography (CR) terminology to help understand the fundamental literature available in these subjects; the terms also may constitute the foundation to help research and study the list of "one-step-forward" terminology included in the next section of this article.

This basic terms list is sorted in alphabetical order:

TERM	DEFINITION
analog image	An image produced by a continuously variable physical process (for example, exposure of film).
analog to digital converter (a/d)	A device that changes an analog signal to a digital representation of the signal.
area of interest (AOI)	The portion of the radiograph or digital image that is to be evaluated and interpreted.
cine-radiography	The production of a series of radiographs that can be viewed rapidly in sequence, thus creating an illusion of continuity.
computed radiography (CR)	A two step radiographic imaging process; first, a storage phosphor imaging plate (IP) is exposed by penetrating radiation; second, the luminescence from the IP's photostimulable luminescent phosphor is stimulated, detected, digitized, and displayed on an image display monitor.
computed tomography (CT)	A nondestructive examination technique that captures radiographic projections of an object at various rotational angles, which are mathematically reconstructed to produce a three-dimensional volume data set or one or more two-dimensional cross-sectional images, where each voxel value represents the attenuation coefficient of the incident radiation at a specific location within the object.
digital	The representation of data or physical quantities in the form of discrete codes, such as numerical characters, rather than a continuous stream.
digital image	An image composed of discrete pixels each of which is characterized by a digitally represented luminance level.
digital detector array (DDA)	An electronic device that converts ionizing or penetrating radiation into a discrete array of analog signals that are subsequently digitized and transferred to a computer for display as a digital image corresponding to the radiologic energy pattern imparted upon the input region of the device.
digital radiography	All radiography methods whereby images are in a digital format — for example CR, CT, DDA, and digitized film.
digitize (for radiology)	The act of converting an analog image or signal to a digital presentation.
image data file	A digital file containing radiological image and text information.
image processing	A method whereby digital image data is transformed through a mathematical function.

TERM	DEFINITION
noise	The data present in a radiological measurement that is not directly correlated with the degree of radiation attenuation by the object being examined.
pixel	The smallest addressable element in an electronic image.
pixel size	The length and width of a pixel.
pixel value (PV)	The numeric value of a pixel in a digital image.
recording media	Material capable of capturing or storing, or both, a radiological image in digital or analog form.
recording medium	A film or detector that converts radiation into a visible image.
region of interest (ROI)	A defined group of pixels from which measurements or statistics, or both, can be derived.
saturation	The state at which the pixel value no longer increases as a function of dose.
scintillators	A detector that converts ionizing radiation to light.
signal	The data present in a radiological measurement that is directly correlated with the degree of radiation attenuation by the object being examined.

Table 1 – Basic Digital Radiography Terms - Reprinted, with permission, from ASTM E1316-22, Standard Terminology for Nondestructive Examinations, copyright ASTM International. A copy of the complete standard may be obtained from https://www.astm.org/e1316-22.html

"One-step-forward" DR Terms

Table 2 proposes a series of "one-step-forward" digital radiography terms that may guide you while you explore "one-step-forward" DR and CR literature available in these subjects; those terms also may constitute the platform to help research and use the series of DR and CR technical resources listed in Table 3.

This "one-step-forward" terms list also is sorted in alphabetical order:

TERM	DEFINITION
amorphous selenium (a-Se) radiation detector array	An array employing a biased amorphous selenium photo- conductor that directly converts incident radiation into electrical charge which can then be read to form a digital image.
amorphous silicon (a-Si) detector	An amorphous silicon (a-Si) radiation detector consists of a glass substrate with an array of photodiodes and thin film transistors; the photo- diodes are illuminated by light photons emitted from a scintillator which is irradiated by X-rays or gamma rays, and is in intimate contact with the photodiode array.
bad pixel	a DDA pixel that does not conform to a specified performance. *DISCUSSION – Bad pixel criteria may include, but are not limited to, non-responding, over-responding, under-responding, noisy, non-uniform, non-persistent, or bad neighborhood; non-persistent bad pixels may have flickering or poor lag performance.*

TERM	DEFINITION
bad pixel map	A binary image that represents the physical locations of bad pixels on a DDA.
contrast-to-noise ratio (CNR)	Quotient of the difference of the mean linear pixel values between two image areas (Digital image contrast) and the standard deviation of the linear pixel values.
digital driving level (DDL)	A digital value that when given as input to a display system produces a luminance.
digital image acquisition system	A system of electronic components which, by either directly detecting radiation or converting analog radiation detection information, creates an image of the spatial radiation intensity map comprised of an array of discrete digital intensity values (see pixel).
digital image enhancement	Any operation used for the purpose of enhancing some aspect of the original image
digital image processing system	A system which uses algorithms to process digital image data.
digital magnification (zoom)	Any change in the pixel map- ping ratio between the captured image and the displayed image, effectively making objects in the image appear larger or smaller.
dynamic range (for radiography)	The span of signal intensity that defines the system's range of performance.
iSRb image	The interpolated basic spatial resolution of the imaging system, which corresponds to the dimension of the smallest feature that can be resolved at a modulation of twenty percent with geometric magnification.
iSRb detector	The interpolated basic spatial resolution of a detector, which corresponds to the dimension of the smallest feature that can be resolved at a modulation of twenty percent without geometric magnification. *NOTE —Typical units of resolution measurement are micrometers.*
line pairs per millimetre	A measure of the spatial resolution of an image conversion device. A line pair test pattern consisting of one or more pairs of equal width, high contrast lines and spaces is utilized to determine the maximum density of lines and spaces that can be successfully imaged. The value is expressed in line pairs per millimetre.
line pair test pattern	A pattern of one or more pairs of objects with high contrast lines of equal width and equal spacing. The pattern is used with an imaging device to measure spatial resolution.
linear digital image contrast	Mean linear pixel value difference between any two regions of interest within a digital image. Linear digital image contrast = PV2 – PV1, where PV2 is the mean linear pixel value of region of interest "2" and PV1 is the mean linear pixel value of region of interest "1" on a digital image.
linear pixel value	The numeric value of a pixel in a digital image, which is directly proportional to the radiation dose of the corresponding detector element where a zero value represents the unexposed detector.

TERM	DEFINITION
normalized signal-to-noise ratio (SNRN)	The SNR normalized to a prescribed detection area of a 100 micron diameter circle, or an 88.6 micron × 88.6 micron square. *DISCUSSION – SNRN is calculated using the measured basic spatial resolution SRb, as measured directly in the digital image and calculated by SNRN = SNR × (88.6 µm/SRb).*
relative digital image contrast	Digital image contrast normalized to the average linear pixel value of the two regions of interest in a digital image.
signal-to-noise ratio (SNR)	Quotient of mean value of the linear pixel values and standard deviation of the mean linear pixel value (noise) in a given region of interest in a digital image.
SR_b image	The basic spatial resolution of the imaging system, which corresponds to the dimension of the smallest feature that can be resolved at a specified modulation and geometric magnification. *NOTE – Typical units of resolution measurement are micrometers.*
SR_b detector	The basic spatial resolution of a detector, which corresponds to the dimension of the smallest feature that can be resolved at a specified modulation without geometric magnification. *NOTE – Typical units of resolution measurement are micrometers.*

Table 2 – "One-step-forward" Digital Radiography Terms - Reprinted, with permission, from ASTM E1316-22, Standard Terminology for Nondestructive Examinations, copyright ASTM International.
A copy of the complete standard may be obtained from https://www.astm.org/e1316-22.html.

For those readers who are involved, or are interested in radiographic processes for equipment fabricated under ASME Boiler and Pressure Vessel Code (BPVC) requirements, we advise you to refer to ASME BPVC Section V, Article 1, Mandatory Appendix I: Glossary Of Terms For Nondestructive Examination to find the definition of these terms in a BPVC specific context. The terms and definitions provided in that Appendix apply to the nondestructive examination methods and techniques described in ASME BPVC Section V. Some terms are identical to those provided in ASTM E1316, while others are BPVC Code specific. The terms in that appendix are grouped by examination method, in the order of the Articles contained in ASME BPVC Section V.

This document is available for acquisition at: https://www.asme.org/codes-standards/bpvc-standards

Table 3 proposes a series of supplementary information resources related to digital radiography that may be useful for you, regardless if you are only curious in this subject, taking the first steps in this transformative path or are a seasoned DR user:

Source	Resource Description	Available at:
American Society of Nondestructive Testing (ASNT)	**Nondestructive Testing Handbook, Fourth Edition: Volume 3, Radiographic Testing (RT)** The first update of the Radiographic Testing Handbook in over 15 years, this edition offers revised and expanded content throughout, including over 150 new color images contributed by practitioners around the world. A chapter on neutron radiography has been added, as well as new technical information in the areas of digital imaging, data processing, and digital image reconstruction. 768 pages.	https://www.asnt.org/store
	Aerospace NDT ASNT Industry Handbook Methods included: Visual, Ultrasonic, X-ray, Penetrant, Magnetic, Eddy Current, Acoustic, Leak, Infrared, Shearography, Bond Testing, In Situ NDT for Structural Health Monitoring, Microwave Testing, Coating Measurement, Surface Quality, and Fundamental Formulas, and glossary. 450 pages.	
	Personnel Training Publications: Radiographic Testing (RT), Classroom Training Book Second Edition This edition includes new chapters on radiographic interpretation of castings and welds with sample radiographs, and on digital radiography (DR), computed radiography (CR), and computed tomography (CT).	
	Radiographic Interpretation, Revised Edition 2020 This book has been recently updated to reflect the expanded content of the fourth edition of the Radiographic Testing Handbook, including digital radiography.	
	ASNT NDT Library In this library you will find published papers in RT from ASNT's Periodic Publications such as Materials Evaluation (ME), Research in Nondestructive Evaluation (RNDE), and The NDT Technician, as well as proceedings from our Annual Conference, Research Symposium, and regular topical events.	https://ndtlibrary.asnt.org
Carestream NDT	**Carestream NDT Virtual Tour** In this virtual facility you may find supplementary information and resources related to the products and services available from Carestream curated by type of industry, along with a very user-friendly interface.	https://www.carestream.com/specials/virtual-ndt/index.htm
	Carestream NDT Corporate Website On this site you can find detailed information and support resources related to Carestream's complete portfolio of imaging solutions.	https://www.carestream.com/en/us/nondestructive-testing-ndt-solutions

Table 3

How to make use of the information in this post

Here are some supplementary information resources from Carestream's products and services portfolio:

Carestream NDT DR Products:

- HPX-DR 3543 PE Non-Glass, Large Format Detector
- HPX-DR 2530 PH High-Resolution, Compact Detector
- HPX-DR 2530 PC High-Speed, Compact Detector
- HPX-DR 4336 GH High-Resolution, Large Format Detector
- HPX-DR 2329 GK, High-Resolution, Compact Detector
- INDUSTREX Digital Viewing Software

Training Services:

- **Advanced Industrial Radiographic Training Academy**
  Computed Radiography - 40 Hour Online Course
  Digital Imaging - 40 Hour Classroom Training

Other Carestream NDT Resources:

- Carestream NDT Virtual NDT Showcase
- Carestream NDT Resource Center

Resources from ASNT:

- Radiographic Interpretation, Revised Edition 2020:
https://www.asnt.org/Store/ProductDetail?productKey=826c3c22-42a3-4250-9040-913d40aa0946

- Nondestructive Testing Handbook, fourth edition: Volume 3, Radiographic Testing:
https://www.asnt.org/Store/ProductDetail?productKey=83ea27b3-d68f-483d-9354-e447ef2b3915

References:

1. ASNT, (2019), Nondestructive Testing Handbook, fourth edition: Volume 3, Radiographic Testing, Bossi, R. and Gordon, T. (eds), Columbus, OH, American Society of Nondestructive Testing.
2. ASTM (2021), ASTM E1316 – 21a, Standard Terminology for Nondestructive Examinations, West Conshohocken, PA, ASTM International, 2020.

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