Designation: E2699 – 13

Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for Digital Radiographic (DR) Test Methods[1]

This standard is issued under the fixed designation E2699; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice facilitates the interoperability of digital X-ray imaging equipment by specifying image data transfer and archival methods in commonly accepted terms. This document is intended to be used in conjunction with Practice E2339 on Digital Imaging and Communication in Nondestructive Evaluation (DICONDE). Practice E2339 defines an industrial adaptation of the NEMA Standards Publication titled Digital Imaging and Communications in Medicine (DICOM, see http://medical.nema.org), an international standard for image data acquisition, review, storage and archival storage. The goal of Practice E2339, commonly referred to as DICONDE, is to provide a standard that facilitates the display and analysis of NDE results on any system conforming to the DICONDE standard. Toward that end, Practice E2339 provides a data dictionary and a set of information modules that are applicable to all NDE modalities. This practice supplements Practice E2339 by providing information object definitions, information modules and a data dictionary that are specific to digital X-ray test methods.

1.2 This practice has been developed to overcome the issues that arise when analyzing or archiving data from digital X-ray test equipment using proprietary data transfer and storage methods. As digital technologies evolve, data must remain decipherable through the use of open, industry-wide methods for data transfer and archival storage. This practice defines a method where all the digital X-ray technique parameters and test results are communicated and stored in a standard manner regardless of changes in digital technology.

1.3 This practice does not specify:

1.3.1 A testing or validation procedure to assess an implementation's conformance to the standard.

1.3.2 The implementation details of any features of the standard on a device claiming conformance.

1.3.3 The overall set of features and functions to be expected from a system implemented by integrating a group of devices each claiming DICONDE conformance.

1.4 Although this practice contains no values that require units, it does describe methods to store and communicate data that do require units to be properly interpreted. The SI units required by this practice are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1316 Terminology for Nondestructive Examinations

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

E2597 Practice for Manufacturing Characterization of Digital Detector Arrays

2.2 *Other Standard:*[3]

DICOM National Electrical Manufacturers Association Standard for Digital Imaging and Communications in Medicine (DICOM), 2011

3. Terminology

3.1 *Definitions:*

3.1.1 Nondestructive evaluation terms used in this practice can be found in Standard Terminology for Nondestructive Examinations, E1316.

3.1.2 DICONDE terms used in this practice are defined in Practice E2339.

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.11 on Digital Imaging and Communication in Nondestructive Evaluation (DICONDE).

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 1752, Rosslyn, VA 22209, http://www.nema.org.

***A Summary of Changes section appears at the end of this standard**

3.1.3 Digital detector array terms used in this practice are defined in Practice E2597.

4. Summary of Practice

4.1 A fundamental principle of DICONDE is the use of standard definitions and attribute formats for data communication and storage. This means all systems that are DICONDE compliant use a common data dictionary and common communication protocols. To further standardization, the elements in the data dictionary are organized into common groups referred to as information modules. The data dictionary and information modules common to all NDE modalities are defined in Practice E2339.

4.2 The data dictionary and information modules specified in Practice E2339 do not cover the information storage requirements for each individual modality (CT, DR, CR, UT, etc.). Additions to the data dictionary and information modules are required to support the individual modalities. This practice contains the additions to the DICONDE data dictionary and information modules necessary for digital X-ray inspection.

4.3 The highest organizational level in the DICONDE information model is the information object definition (IOD). An information object definition is a collection of the information modules necessary to represent a set of test results from a specific modality. This practice contains information object definitions for digital X-ray inspection.

5. Significance and Use

5.1 Personnel that are responsible for the creation, transfer, and storage of digital X-ray test results will use this standard. This practice defines a set of information modules that along with Practice E2339 and the DICOM standard provide a standard means to organize digital X-ray test parameters and results. The digital X-ray test results may be displayed and analyzed on any device that conforms to this standard. Personnel wishing to view any digital X-ray inspection data stored according to Practice E2339 may use this document to help them decode and display the data contained in the DICONDE-compliant inspection record.

6. Information Object Definitions

6.1 *Digital X-ray Image IOD Description:*

6.1.1 The digital X-ray (DX) Image Information Object Definition specifies an image that has been created by a direct digital X-ray imaging device for NDE purposes. To avoid duplication of relevant material from the DICOM standard, the IOD definition will follow that for DX Images found in Part 3, Section A.26 of the DICOM standard except as noted in Table 1. Table 1 is not stand-alone and must be used in conjunction with Part 3, Section A.26 of the DICOM standard to have a complete definition of the NDE DX information object.

6.1.2 This IOD will use the Service-Object Pair (SOP) Classes for the DX IOD as defined in Part 4, Section B5 of the DICOM standard.

6.2 *Digital X-ray Multi-Frame Image IOD Description:*

6.2.1 The digital X-ray (DX) Multi-frame (MF) Image Information Object Definition specifies an image that has been created by a direct digital X-ray imaging device for NDE purposes. To avoid duplication of relevant material from the DICOM standard, the IOD definition will follow that for Enhanced X-ray Angiographic (Enhanced XA) Images found in Part 3, Section A.47 of the DICOM standard except as noted in Table 2. Table 2 is not stand-alone and must be used in conjunction with Part 3, Section A.47 of the DICOM standard to have a complete definition of the NDE DX-MF information object.

6.2.2 This IOD will use the Service-Object Pair (SOP) Classes for the Enhanced XA IOD as defined in Part 4, Section B5 of the DICOM standard.

7. Information Modules

7.1 *NDE DX Detector Module:*

7.1.1 Table 3 specifies the Attributes that describe NDE Direct Digital X-ray (DX) Detectors.

7.1.1.1 For NDE DX Images, Detector Type (0018,7004) is specified to use the following defined terms.

DIRECT
SCINTILLATOR

TABLE 1 DX Image Information Object Definition

DICOM Module	DICONDE Module	Reference	Usage[A]
Patient	Component	Practice E2339, Section 7	M
Specimen Identification	Not Applicable		
Clinical Trial Subject	Not Applicable		
General Study	Component Study	Practice E2339, Section 7	M
Patient Study	Not Applicable		
Clinical Trial Study	Not Applicable		
General Series	Component Series	Practice E2339, Section 7	M
Clinical Trial Series	Not Applicable		
General Equipment	NDE Equipment		M
Contrast/Bolus	Not Applicable		
DX Anatomy Imaged	Needed for DICOM compatibility		
DX Detector	NDE DX Detector	7.1	M
	NDE Indication	Practice E2339, Section 7	U
	NDE Geometry	Practice E2339, Section 7	U
	NDE DX Calibration Data	7.2	U
Acquisition Content	Needed for DICOM compatibility		
	NDE Source Radiography		U

[A] Definition of usage codes can be found in Part 3, Section A.1.3 of the DICOM standard.

TABLE 2 DX MF Image Information Object Definition

DICOM Module	DICONDE Module	Reference	Usage[A]
Patient	Component	Practice E2339, Section 7	M
Specimen Identification	Not Applicable		
Clinical Trial Subject	Not Applicable		
General Study	Component Study	Practice E2339, Section 7	M
Patient Study	Not Applicable		
Clinical Trial Study	Not Applicable		
General Series	Component Series	Practice E2339, Section 7	M
Clinical Trial Series	Not Applicable		
General Equipment	NDE Equipment	Practice E2339, Section 7	M
Enhanced Contrast/Bolus	Not Applicable		
Acquisition Context	Needed for DICOM compatibility		
Cardiac Synchronization	Not Applicable		
Respiratory Synchronization	Not Applicable		
X-Ray Detector	NDE DX Detector	7.1	M
	NDE Indication	Practice E2339, Section 7	U
	NDE Geometry	Practice E2339, Section 7	U
	NDE DX Calibration Data	7.2	U
	NDE Source Radiography		U

[A] Definition of usage codes can be found in Part 3, Section A.1.3 of the DICOM standard.

7.1.1.2 For NDE DX Images, Detector Configuration (0018, 7005) is specified to use the following defined terms.

AREA

LINEAR

7.2 *NDE DX Calibration Data Module:*

7.2.1 Table 4 specifies the Attributes that describe NDE direct digital X-ray calibration data.

7.3 *NDE Source Radiography Module:*

7.3.1 Table 5 specifies the attributes that describe NDE Source Radiography Module.

8. Keywords

8.1 DICOM; DICONDE; direct digital X-ray; DX; digital data transmission; digital data storage; database; file format

TABLE 3 NDE DX Detector Module Attributes

Attribute Name	Tag	VR	VM	Type[A]	Description
Detector Type	(0018,7004)	CS	1	2	The type of detector used to acquire projection data.
Detector Configuration	(0018,7005)	CS	1	3	The physical configuration of the detector.
Detector Description	(0018,7006)	LT	1	3	Free-text description of the detector.
Detector Mode	(0018,700A)	LT	1	3	Text description of the operating mode of the detector.
Detector ID	(0018,7008)	SH	1	3	The ID or serial number of the detector used to acquire projection data.
Date of Last Detector Calibration	(0018,700C)	DA	1-n	3	Date of the last calibration for the equipment.
Time of Last Detector Calibration	(0018,700E)	TM	1-n	3	Time of the last calibration for the equipment.
Detector Active Time	(0018,7014)	DS	1	3	Time in msec that the detector is active during acquisition of this data.
Detector Activation Offset from Exposure	(0018,7016)	DS	1	3	Offset time in msec that the detector becomes active after the X-ray beam is turned on during the acquisition of this data. May be negative.
Detector Binning	(0018,701A)	DS	2	3	Number of active detectors used to generate a single pixel. Specified as the number of row detectors per pixel followed by the number of column detectors.
Internal Detector Frame Time	(0014,3011)	DS	1	3	The time in msec that the detector is acquiring an image.
Number of Frames Integrated	(0014,3012)	DS	1	3	The number of frames integrated to form an image.
Detector Manufacturer's Name	(0018,702A)	LO	1	3	Name of the manufacturer of the detector component of the acquisition system.
Detector Manufacturer's Model Number	(0018,702B)	LO	1	3	Model number of the detector component of the acquisition system.
Detector Conditions Nominal Flag	(0018,7000)	CS	1	3	A flag that indicates whether or not the detector is operating within normal tolerances during data acquisition. This flag is intended to indicate whether there has been some compromise of the diagnostic quality of the data due to some operating condition (for example, overheating).
Sensitivity	(0018,6000)	DS	1	3	Detector sensitivity in manufacturer specific units.[B]
Field of View Shape	(0018,1147)	CS	1	3	Shape of the Field of View, that is, the image pixels.
Field of View Dimension(s)	(0018,1149)	IS	1-2	3	Dimensions in mm of the Field of View.
Field of View Origin	(0018,7030)	DS	2	1C	Required if the Field of View has been rotated or flipped. Offset of the Top Left Hand Corner (TLHC) of arectangle circumscribing the Field of View before rotation or flipping, from the TLHC of the physical detector area measured in physical detector pixels as a row offset followed by a column offset.
Field of View Rotation	(0018,7032)	DS	1	1C	Required if the Field of View has been rotated. Clockwise rotation in degrees of the Field of View relative to the physical detector.
Field of View Horizontal Flip	(0018,7034)	CS	1	1C	Required if the Field of View has been rotated. Whether or not a horizontal flip has been applied to the Field of View after rotation relative to the physical detector as described in the Field of View Rotation.
Imager Pixel Spacing	(0018,1164)	DS	2	1	Physical distance measured at the front plane of the detector housing between the center of each image pixel specified by a numeric pair – row spacing value followed by a column spacing value in mm.
Detector Element Physical Size	(0018,7020)	DS	2	3	Physical dimensions of each detector element in mm that comprises the detector matrix. Expressed as the rowdimension followed by the column dimension.
Detector Element Spacing	(0018,7022)	DS	2	3	Physical distance between the center of each detector element, specified by a numeric pair – row spacing value in mm followed by column spacing value in mm.
Detector Active Shape	(0018,7024)	CS	1	3	Shape of the active area.
Detector Active Dimension(s)	(0018,7026)	DS	1-2	3	Dimension(s) in mm of the active area.
Detector Active Origin	(0018,7028)	DS	2	3	Offset of the TLHC of a rectangle circumscribing the active detector area from the TLHC of a rectangle circumscribing the physical detector area, measures in physical detector pixels as a row offset followed by a column offset.
Detector Temperature Sequence	(0014,3020)	SQ	1	3	Sequence that contains detector temperature information.
>Sensor Name	(0014,3022)	ST	1	3	The name of the sensor.
>Horizontal Offset	(0014,3024)	DS	1	3	The horizontal offset in mm from the left position of the detector.
>Vertical Offset	(0014,3026)	DS	1	3	The vertical offset in mm from the top position of the detector.
>Temperature	(0014,3028)	DS	1	3	Temperature in Celsius of the sensor.

[A] Definition of type codes can be found in Part 5, Section 7.4 of the DICOM standard.

[B] This value is intended to provide a single location where the manufacturer-specific information can be found for annotation on a display or film that has meaning to a knowledgeable observer.

TABLE 4 NDE DX Calibration Data Module Attributes

Attribute Name	Tag	VR	VM	Type[A]	Description
Dark Current Sequence	(0014,3040)	SQ	1	2	
> Photometric Interpretation	(0028,0103)	US	1	1	Pixel representation.
> Bits allocated	(0028,0100)	US	1	1	Number of bits allocated.
> Bits stored	(0028,0101)	US	1	1	Number of bits stored.
> High bit	(0028,0102)	US	1	1	Most significant bit.
> Dark Current counts	(0014,3050)	OW or OB	1	1	A data stream of the pixel samples which comprise the dark current counts.
Gain Correction Reference Sequence	(0014,3060)	SQ	1	2	
> Photometric Interpretation	(0028,0103)	US	1	1	Pixel representation.
> Bits allocated	(0028,0100)	US	1	1	Number of bits allocated.
> Bits stored	(0028,0101)	US	1	1	Number of bits stored.
> High bit	(0028,0102)	US	1	1	Most significant bit.
> Air counts	(0014,3070)	OW or OB	1	1	A data stream of the pixel samples which comprise the air counts.
> kV Used in Gain Calibration	(0014,3071)	DS	1	3	Kilovoltage Used in Gain Calibration.
> mA Used in Gain Calibration	(0014,3072)	DS	1	3	mA * Sec Used in Gain Calibration.
> Number of Frames	(0014,3073)	DS	1	3	Number of Frames Used for Integration.
> Filter Material Used in Gain Calibration	(0014,3074)	LO	1	3	Filter Material Used in Gain Calibration.
> Filter Thickness Used in Gain Calibration	(0014,3075)	DS	1	3	Filter Thickness of Material Used in Gain Calibration.
> Date of Gain Calibration	(0014,3076)	DA	1-n	3	Date of Gain Calibration.
> Time of Gain Calibration	(0014,3077)	TM	1-n	3	Time of Gain Calibration.
Bad Pixel Image	(0014,3080)	OB	1	3	Byte image with the same number of rows and columns as the Pixel Data (7FE0,0010). The pixel data of this image will contain a ″1″ for a good pixel and a ″0″ for a bad pixel.
Calibration notes	(0014,3099)	LT	1	3	User-generated notes on the calibration data.
Image Quality Indicator Type	(0014,40A0)	LO	1-n	3	Description of the type of Image Quality Indicator used.
Image Quality Indicator Material	(0014,40A1)	LO	1-n	3	Description of the material used to manufacture the Image Quality Indicator.
Image Quality Indicator Size	(0014,40A2)	LO	1-n	3	Description of the size of the Image Quality Indicator used. A typical size designation is ‘2-2T’ where the first number indicates that the IQI thickness is two percent of the test material thickness and second number defines the hole diameter as twice the IQI thickness.

[A] Definition of type codes can be found in Part 5, Section 7.4 of the DICOM standard.

TABLE 5 NDE DX Calibration Data Module Attributes

Attribute Name	Tag	VR	VM	Type[A]	Description
Source Type	(300A,0214)	CS	1	1	Type of Source: Defined Terms: POINT LINE CYLINDER SPHERE
Source Manufacturer	(300A,0216)	LO	1	3	Manufacturer of Source
Active Source Diameter	(300A,0218)	DS	1	3	Diameter of active Source (mm)
Active Source Length	(300A,0220)	DS	1	3	Length of active Source (mm)
Material ID	(300A,00E1)	DS	1	3	User-supplied identifier for encapsulation material of active Source
Source Encapsulation Nominal Thickness	(300A,0222)	DS	1	3	Nominal thickness of wall of encapsulation (mm)
Source Encapsulation Nominal Transmission	(300A,0224)	DS	1	3	Nominal transmission through wall of encapsulation (between 0 and 1)
Source Isotope Name	(300A,0226)	LO	1	1	Name of Isotope
Source Isotope Half-Life	(300A,0228)	DS	1	1	Half-life of Isotope (days)
Source Strength Units	(300A,0229)	CS	1	1C	Measurement of Source Strength Required if the source is not a gamma-emitting (photon) source. May be present otherwise. Enumerate values: AIR Kerma Rate = Air Kerma Rate if Source is Gamma-emitting Isotope
Reference Air Kerma Rate	(300A,022A)		1	1	Air Kerma Rate in air of Isotope specified at Source Strenth Reference Date (300A,022C) and Source Strength Reference Time (300A,022E) (in μGy h^{-1} at 1 m). Values shall be zero for non-gamma sources.
Source Strength	(300A,022B)		1	1C	Source Strength of Isotope at Source Strength Reference Date (300A,022C) and Source Strength Reference Time (300A,022E), in units specified in Source Strength Units (300A,0229). Required if the source is not a gamma-emitting (photon) source.
Source Strength Reference Date	(300A,022C)	DT	1	1	Reference date for Reference Air Kerma Rate (300A,022A) or Source Strength (300A,022B) of Isotope.
Source Strength Reference Time	(300A,022E)	TM	1	1	Reference time for Reference Air Kerma Rate (300A,022A) or Source Strength (300A,022B) of Isotope.

[A] Definition of type codes can be found in Part 5, Section 7.4 of the DICOM standard.

SUMMARY OF CHANGES

Committee E07 has identified the location of selected changes to this standard since the last issue (E2699 - 11) that may impact the use of this standard. (December 15, 2013)

(1) Added 7.3 to describe NDE Source Radiography module.