Designation: E2663 – 23

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

This standard is issued under the fixed designation E2663; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice covers the interoperability of ultrasonic imaging equipment by specifying image data transfer and archival storage methods in commonly accepted terms. This document is intended to be used in conjunction with Practice E2339. Practice E2339 defines an industrial adaptation of NEMA PS3 / ISO 12052 (DICOM, see http://medical.nema.org), an international standard for image data acquisition, review, transfer, 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 test results on any system conforming to the DICONDE standard. Toward that end, Practice E2339 provides a data dictionary and set of information modules that are applicable to all NDE modalities. This practice supplements Practice E2339 by providing information object definitions, information modules, and data dictionary that are specific to ultrasonic test methods.

1.2 This practice has been developed to overcome the issues that arise when analyzing or archiving data from ultrasonic 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 ultrasonic technique parameters and test results are communicated and stored in a standard format 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1316 Terminology for Nondestructive Examinations

E1454 Guide for Data Fields for Computerized Transfer of Digital Ultrasonic Testing Data (Withdrawn 2013)[3]

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

2.2 *Other Documentation:*[4]

NEMA PS3 / ISO 12052 Digital Imaging and Communications in Medicine (DICOM)

3. Terminology

3.1 *Definitions:*

[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] The last approved version of this historical standard is referenced on www.astm.org.

[4] 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

3.1.1 Nondestructive evaluation terms used in this practice can be found in Terminology E1316.

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

4. Summary of Practice

4.1 A fundamental principle of DICONDE is the use of standard definitions and 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 ultrasonic 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 the information object definitions for ultrasonic inspection.

5. Significance and Use

5.1 Personnel that are responsible for the creation, transfer, and storage of ultrasonic test results will use this standard. This practice defines a set of information modules that, along with Practice E2339 and the DICOM standard, provides a standard means to organize ultrasonic test parameters and results. The ultrasonic test results may be displayed and analyzed on any device that conforms to this standard. Personnel wishing to view any ultrasonic inspection data stored in DICONDE format 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 *Ultrasound Image IOD Description:*

6.1.1 The Ultrasound (US) Image Information Object Definition specifies an image that has been created by an ultrasound imaging device for NDE purposes. The IOD definition will follow that for US Images found in Part 3, Section A.6 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.6 of the DICOM standard to have a complete definition of the DICONDE US information object.

6.1.2 This IOD will use the Service-Object Pair (SOP) Classes for the US IOD as defined in Part 4, Section B.5 of the DICOM standard.

6.2 *Ultrasound Multi-Frame Image:*

6.2.1 The Ultrasound Multi-Frame (US-MF) Image Information Object Definition specifies a multi-frame image that has been created by an ultrasound imaging device for NDE purposes. The IOD definition will follow that for US-MF Images found in Part 3, Section A.7 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.7 of the DICOM standard to have a complete definition of the DICONDE US-MF information object.

6.2.2 This IOD will use the Service-Object Pair (SOP) Classes for the US-MF IOD as defined in Part 4, Section B.5 of the DICOM standard.

TABLE 1 US Image Information Object Definition

DICOM Module	DICONDE Module	Reference	Usage
Patient	Component	E2339, Section 7	M
Clinical Trial Subject	Not Applicable		
General Study	Component Study	E2339, Section 7	M
Patient Study	Not Applicable		
Clinical Trial Study	Not Applicable		
General Series	Component Series	E2339, Section 7	M
Clinical Trial Series	Not Applicable		
General Equipment	NDE Equipment	E2339, Section 7	M
Contrast/bolous	Not Applicable		
US Image	NDE US Image	Section 7.1	M
US Region Calibration	Not Applicable		
	NDE US Equipment	Section 7.2	U
	NDE US Equipment Settings	Section 7.3	U
	NDE Indication	E2339, Section 7	U
	NDE Geometry	E2339, Section 7	U
	NDE Data Element Label Dictionary	E2339, Section 7	U
	NDE Geolocation	E2339, Section 7	U

TABLE 2 US-MF Image Information Object Definition

DICOM Module	DICONDE Module	Reference	Usage
Patient	Component	E2339, Section 7	M
Clinical Trial Subject	Not Applicable		
General Study	Component Study	E2339, Section 7	M
Patient Study	Not Applicable		
Clinical Trial Study	Not Applicable		
General Series	Component Series	E2339, Section 7	M
Clinical Trial Series	Not Applicable		
General Equipment	NDE Equipment	E2339, Section 7	M
Contrast/bolous	Not Applicable		
US Image	NDE US Image	Section 7.1	M
US Region Calibration	Not Applicable		
	NDE US Equipment	Section 7.2	U
	NDE US Equipment Settings	Section 7.3	U
	NDE Indication	E2339, Section 7	U
	NDE Geometry	E2339, Section 7	U
	NDE Data Element Label Dictionary	E2339, Section 7	U
	NDE Geolocation	E2339, Section 7	U

TABLE 3 NDE US Image Module Attributes

Attribute Name	Tag	VR	VM	Type	Description
Samples Per Pixel	(0028,0002)	US	1	1	Number of samples per pixel (planes) in this image. See 7.1.1.1.
Photometric Interpretation	(0028,0004)	CS	1	1	Specifies the intended interpretation of the pixel data. See 7.1.1.2.
Bits Allocated	(0028,0100)	US	1	1	Number of bits allocated for each pixel data. See 7.1.1.3.
Bits Stored	(0028,0101)	US	1	1	Number of bits stored for each pixel data. See 7.1.1.4.
High Bit	(0028,0102)	US	1	1	Most significant bit for pixel data.
Planar Configuration	(0028,0006)	US	1	1C	Indicates whether the pixel data is sent color by plane or color by pixel. Required if Samples Per Pixel (0028, 0002) has a value greater than 1. See 7.1.1.5.
Pixel Representation	(0028,0103)	US	1	1	Representation of pixel data. See 7.1.1.6.
Frame Increment Pointer	(0028,0009)	AT	1-n	1C	Contains the Data Element Tag of the attribute that is used as the frame increment in multi-frame pixel data. Required if number of frames is sent. See 7.1.1.7.
Image Type	(0008,0008)	CS	1-n	1	Image identification characteristics. See 7.1.1.8.
Lossy Image Compression	(0028,2110)	CS	1	1C	Specifies whether an image has undergone lossy compression. Enumerated Values 00 = NO lossy compression 01 = Lossy compression Required if lossy compression has been performed on the image.
Number of Surfaces	(0008,2124)	IS	1	3	Number of distinct scan surfaces on the inspection specimen.
Number of Gates in Surface	(0008,212A)	IS	1	3	Number of inspection gates associated in this scan surface.
Surface Name	(0008,2120)	SH	1	3	Name of this scan surface.
Surface Number	(0008,2122)	IS	1	3	Number of this scan surface.
Gate Name	(0008,2127)	SH	1	3	User defined name of this inspection gate. See 7.1.1.9 for definition of Gate.
Gate Number	(0008,2128)	IS	1	3	User defined number of this inspection gate. See 7.1.1.9 for definition of Gate.
Acquisition Date / Time	(0008,002A)	DT	1	3	The date and time that the acquisition of data that resulted in this image started.
Physical Units X Direction	(0018,6024)	US	1	1	The physical units of the dimension of the region. See 7.1.1.10 for valid values.
Physical Units Y Direction	(0018,6026)	US	1	1	The physical units of the dimension of the region. See 7.1.1.10 for valid values.
Physical Delta X	(0018,602C)	FD	1	1	The physical value per positive X pixel increment. The units are as specified in the Physical Units X Direction (0018,6024). See 7.1.1.11.
Physical Delta Y	(0018,602E)	FD	1	1	The physical value per positive Y pixel increment. The units are as specified in the Physical Units Y Direction (0018,6024). See 7.1.1.11.

7. Information Modules

7.1 *NDE US Image Module:*

7.1.1 Table 3 specifies the Attributes that describe NDE ultrasound images.

7.1.1.1 For NDE US Images, Samples per Pixel (0028, 0002) is specified to use the following values for specified Photometric Interpretations.

NDE US Image Samples Per Pixel

Photometric Interpretation	Samples Per Pixel Value
MONOCHROME2	1
RGB	3
PALETTE COLOR	1

7.1.1.2 For NDE US Images, Photometric Interpretation (0028,0004) is specified to use the following defined terms. See Part 3 Section C.7.6 of the DICOM standard for definitions of the terms.

MONOCHROME2	PALETTE COLOR	RGB

7.1.1.3 For NDE US Images, Bits Allocated (0028,0100) is specified to use the following values for specified Photometric Interpretations.

NDE US Image Bits Allocated

Photometric Interpretation	Bits Allocated Value
MONOCHROME2	8
RGB	8
PALETTE COLOR	8 – 8 bit palette, or 16 – 16 bit palette

7.1.1.4 For NDE US Images, Bits Stored (0028,0101) is specified to use the following values for specified Photometric Interpretations.

NDE US Image Bits Stored

Photometric Interpretation	Bits Stored Value
MONOCHROME2	8
RGB	8
PALETTE COLOR	8 – 8 bit palette, or 16 – 16 bit palette

7.1.1.5 For NDE US Images, Planar Configuration (0028, 0006) is specified to use the following values for specified Photometric Interpretations.

NDE US Planar Configuration

Photometric Interpretation	Planar Configuration Value
RGB	0 – color by pixel, or 1 – color by plane

7.1.1.6 For NDE US Images, Pixel Representation (0028, 0103) is specified to use the following Enumerated Value:

0000H = unsigned integer

0001H = signed integer

7.1.1.7 For NDE US multi-frame images, the Attribute Frame Increment Pointer (0028,0009) of the Multi-frame Module (see DICOM Part 3 Section C.7.6.6) is specified by the following defined terms:

00181063 = sequencing by Frame Time (0018,1063)

00181065 = sequencing by Frame Time Vector (0018,1065)

7.1.1.8 For NDE US Images and NDE US-MF Images, Image Type (0008,0008) is specified to be Type 2. The defined terms for value 3 are:

C_SCAN	B_SCAN	TOF C_SCAN
VOLUME SCAN		

Value 4 contains information about the ultrasonic inspection mode. The defined terms for value 4 are:

LONGITUDINAL	SHEAR	SURFACE WAVE
TOFD	THRU TRANS	LAMB
SHEAR HORIZ	SHEAR VERT	

7.1.1.9 For Gate Name (0008,2127) and Gate Number (0008,2128), the term 'Gate' refers to a period of time over which ultrasonic data is collected. Gates are typically associated with regions within the test specimen, the front surface echo or the back surface echo.

7.1.1.10 Physical Units X Direction (0018,6024) and Physical Units Y Direction (0018,6026) provide Enumerated Values indicating the physical units of the dimensions of the image.

Value	Meaning	Value	Meaning
0000H =	None or not applicable	0001H=	percent
0002H=	dB	0003H=	cm
0004H=	seconds	0005H=	hertz ($seconds^{-1}$)
0006H=	dB/sec	0007H=	cm/sec
0008H=	cm^2	0009H=	cm^2/sec
000AH	cm^3	0000BH=	cm^3/sec
000CH	degrees		

7.1.1.11 The Physical Delta X (0018,602C) is the physical value increment per positive X pixel increment, which is left to right. The Physical Delta Y (0018,602E) is the physical value increment per positive Y pixel increment, which is top to bottom.

7.2 *NDE US Equipment Module:*

7.2.1 Table 4 specifies the Attributes that describe NDE ultrasound equipment.

7.2.1.1 For NDE US Images, Pulser Type (0014,4004) is specified to use the following defined terms.

POSITIVE SPIKE	SQUARE WAVE	SINUSOIDAL
NEGATIVE SPIKE	TONE BURST	

7.2.1.2 For NDE US Images, Amplifier Type (0014,400A) is specified to use the following defined terms.

LINEAR	LOGARITHMIC

7.2.1.3 For NDE US Images, Transducer Type (0018,6031) is specified to use the following defined terms.

SINGLE CRYSTAL	SPLIT CRYSTAL	LINEAR ARRAY
CURVED LIN ARRAY	SECTOR ARRAY	SECTOR ANN ARRAY
MATRIX ARRAY		

7.2.1.4 For NDE US Images, Element Shape (0014,4013) is specified to use the following defined terms.

CIRCLE	ELLIPSE
RECTANGLE	RING

7.3 *NDE US Equipment Settings Module:*

7.3.1 Table 5 specifies the Attributes that describe NDE ultrasound equipment settings.

7.3.1.1 For NDE US Images, Modulation Type (0014,4026) is specified to use the following defined terms.

HANNING

7.3.1.2 For NDE US Images, Rectification Type (003A, 0302) is specified to use the following defined terms.

FULL	HALF
HALF POSITIVE	HALF NEGATIVE
NONE	

7.3.1.3 For NDE US Images, Transducer Mode (0018,9178) is specified to use the following defined terms.

LONG	SHEAR
REFRACT LONG	SURFACE

7.3.1.4 For NDE US Images, Trigger Source (0018,1061) is specified to use the following defined terms.

MAIN BANG	FRONT INTERFACE
BACK INTERFACE	INTERFACE

7.3.1.5 For NDE US Images, Gate Type (0018,106A) is specified to use the following defined terms.

FLAW	BACK ECHO
TRANS AMP	PE AMP

7.3.1.6 For NDE US Images, DAC Type (0014,4036) is specified to use the following defined terms.

LINEAR	QUADRATIC
SPLINE	

7.3.1.7 For NDE US Images, Acquisition Compression Type (0014,4032) is specified to use the following defined terms.

SMOOTHING	PAIRING

TABLE 4 NDE US Equipment Module Attributes

Attribute Name	Tag	VR	VM	Type	Description
Pulser Equipment Sequence	(0014,4002)	SQ	1	3	This sequence describes the Pulser Euipment. Only a single item is permitted in this Sequence.
>Gate Name	(0008,2127)	SH	1	3	User defined name of this inspection gate. See 7.1.1.9 for definition of Gate.
>Gate Number	(0008,2128)	IS	1	3	User defined number of this inspection gate. See 7.1.1.9 for definition of Gate.
>Manufacturer	(0008,0070)	LO	1	3	Manufacturer of the equipment used to pulse the transducer.
>Model Number	(0008,1090)	LO	1	3	Manufacturer's model number for the equipment used to pulse the transducer.
>Serial Number	(0018,1000)	LO	1	3	Manufacturer's serial number for the equipment used to pulse the transducer.
>Pulser Type	(0014,4004)	CS	1	3	Type of pulser used in data collection. See 7.2.1.1.
>Time of Last Calibration	(0018,1201)	TM	1-n	3	Time of the last calibration for the equipment used to pulse the transducer.
>Date of Last Calibration	(0018,1200)	DA	1-n	3	Date of the last calibration for the equipment used to pulse the transducer.
>Pulser Notes	(0014,4006)	LT	1	3	User-defined comments on the pulser equipment.
Receiver Equipment Sequence	(0014,4008)	SQ	1	3	This sequence describes the Receiver Equipment. Only a single item is permitted in this Sequence.
>Gate Name	(0008,2127)	SH	1	3	User defined name of this inspection gate. See 7.1.1.9 for definition of Gate.
>Gate Number	(0008,2128)	IS	1	3	User defined number of this inspection gate See 7.1.1.9 for definition of Gate.
>Manufacturer	(0008,0070)	LO	1	3	Manufacturer of the equipment used to receive the ultrasound signal.
>Model Number	(0008,1090)	LO	1	3	Manufacturer's model number for the equipment used to receive the ultrasonic signal.
>Serial Number	(0018,1000)	LO	1	3	Manufacturer's serial number for the equipment used to receive the ultrasonic signal.
>Amplifier Type	(0014,400A)	CS	1	3	Type of amplifier used in data collection. See 7.2.1.2.
>Time of Last Calibration	(0018,1201)	TM	1-n	3	Time of the last calibration for the equipment used to receive the ultrasonic signal.
>Date of Last Calibration	(0018,1200)	DA	1-n	3	Date of the last calibration for the equipment used to receive the ultrasonic signal.
>Receiver Notes	(0014,400C)	LT	1	3	User-defined notes on the receiver equipment.
Pre-Amplifier Equipment Sequence	(0014,400E)	SQ	1	3	This sequence describes the Pre-Amplifier Equipment. Only a single item is permitted in this Sequence.
>Gate Name	(0008,2127)	SH	1	3	User defined name of this inspection gate. See 7.1.1.9 for definition of Gate.
>Gate Number	(0008,2128)	IS	1	3	User defined number of this inspection gate. See 7.1.1.9 for definition of Gate.
>Manufacturer	(0008,0070)	LO	1	3	Manufacturer of the equipment used to pre-amplify the ultrasound signal.
>Model Number	(0008,1090)	LO	1	3	Manufacturer's model number for the equipment used to pre-amplify the ultrasonic signal.
>Serial Number	(0018,1000)	LO	1	3	Manufacturer's serial number for the equipment used to pre-amplify the ultrasonic signal.
>Time of Last Calibration	(0018,1201)	TM	1-n	3	Time of the last calibration for the equipment used pre-amplify the ultrasonic signal.
>Date of Last Calibration	(0018,1200)	DA	1-n	3	Date of the last calibration for the equipment used pre-amplify the ultrasonic signal.