Designation: E 2339 – 04

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

This standard is issued under the fixed designation E 2339; 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 NDE imaging and data acquisition equipment by specifying the image data file format in commonly accepted terms. This practice represents a harmonization of NDE imaging systems, or modalities, with the NEMA Standards Publication titled Digital Imaging and Communications in Medicine (DICOM, see http://medical.nema.org/dicom/2003.html), an international standard for image data acquisition, review, storage and archival. In addition, this practice will provide a standard set of industrial NDE specific information object definitions, which travel beyond the scope of standard DICOM modalities. The goal of this practice is to provide a standard by which NDE image/signal data may be displayed on by any system conforming to the ASTM DICONDE format, regardless of which NDE modality was used to acquire the data.

1.2 This practice has been developed to overcome the issues that arise when archiving or analyzing the data from a variety of NDE techniques, each using proprietary data acquisition systems. As data acquisition modalities evolve, data acquired in the past must remain decipherable. This practice proposes an image data file format in such a way that all the technique parameters, along with the image file, are preserved, regardless of changes in NDE technology. This practice will also permit the viewing of a variety of image types (CT, CR, Ultrasonic, Infrared and Eddy Current) on a single workstation, maintaining all of the pertinent technique parameters along with the image file. This practice addresses the exchange of digital information between NDE imaging equipment.

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 or DICOM conformance.

2. Referenced Documents

2.1 *ASTM Standards:*

E 1316 Terminology for Nondestructive Examinations

2.2 *Other Documentation:*

NEMA Standards Publication PS3.1, Version 3: Digital Imaging and Communications in Medicine (DICOM)

ACR-NEMA 300–1998 Digital Imaging and Communication in Medicine

3. Terminology

3.1 *Definitions:*

3.1.1 Nondestructive evaluation terms used in this practice can be found in Terminology E 1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *AE*—application entity

3.2.2 *attribute*—a property of an information object. An attribute has a name and a value, which are independent of any encoding scheme.

3.2.3 *conformance statement*—a formal statement associated with a specific implementation of the standard, specifying the service class, information objects, and communications protocols supported by the implementations.

3.2.4 *data dictionary*—a registry of data elements, which assigns a unique tag, a name, value characteristics, and semantics to each data element.

3.2.5 *tag identifier*—an ordered pair (gggg, eeee) where gggg represents the group number and eeee represents the data element.

3.2.6 *type*—the value characteristics associated with the data elements, that is, the data structure definition, based on the negotiated transfer syntax.

3.2.7 *Value Representation (VR)*—the value characteristics associated with the data elements, that is, the data structure definition, based on the negotiated transfer syntax.

4. Summary of Practice

4.1 The basic concept of using DICONDE (or DICOM) is the usage of standardized data tag identifiers. This means all participants are using database entries representing the same information and have a common understanding of communication protocols for mutual use. For standardization of data transfer, the conformance statement, a mutually agreed upon

[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).

Current edition approved May 1, 2004. Published June 2004.

document provides the specific database tag identifiers for every part of the NDE data stream as well as the communications protocols.

4.2 The DICONDE practice will consist of descriptions of the object definitions which are specific to NDE (that is, no equivalent counterpart in medicine) and provide standard database tag identifiers for use with the DICOM database already in existence. The use of this practice is based upon and to be used in conjunction with the medical DICOM standard. This practice, in conjunction with the DICOM standard, will set forth the requirements for the transfer and display of NDE image data from any NDE image modalities equipment.

5. Significance and Use

5.1 Personnel that are responsible for the transfer of NDE data between systems will use this standard. This practice will define a set of NDE information object definitions that along with the DICOM standard will provide a standard means to organize image data. Once conformance statements have been generated, the NDE image data may be displayed on any imaging/analysis device that conforms to the standard. This process of developing conformance statements with both the NDE specific object definitions and the DICOM accepted definitions, will provide a means to automatically and transparently communicate between compliant equipment without loss of information.

NOTE 1—Knowledge and understanding of the existing DICOM standard will be required to generate conformance statements and thereby facilitate the data transfer.

6. Background: DICOM (Digital Imaging Communication for Medicine)

6.1 *History*

6.1.1 With the introduction of computed tomography (CT) and other digital diagnostic imaging modalities in the 1970's, and the increasing use of computers in clinical applications, the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) recognized the emerging need for a standard method for transferring images and associated information between devices manufactured by various vendors. These devices produce a variety of digital image formats.

6.1.2 The American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) formed a joint committee in 1983 to develop a standard to:

6.1.2.1 promote communication of digital image information, regardless of device manufacturer;

6.1.2.2 facilitate the development and expansion of picture archiving and communication systems (PACS) that can also interface with other systems of hospital information;

6.1.2.3 allow the creation of diagnostic information data bases that can be interrogated by a wide variety of devices distributed geographically.

6.1.3 ACR-NEMA Standards Publication No. 300-1985, published in 1985 was designated version 1.0. The Standard was followed by two revisions, No. 1 dated October 1986 and No. 2 dated January 1988.

6.1.4 ACR-NEMA Standards Publication No. 300-1988, published in 1988 was designated version 2.0. It included version 1.0, the published revisions, and additional revisions. It also included new material to provide command support for display devices, to introduce a new hierarchy scheme to identify an image, and to add data elements for increased specificity when describing an image.

6.1.5 These standards publications specified a hardware interface, a minimum set of software commands, and a consistent set of data formats.

6.2 *The DICOM Standard*

6.2.1 DICOM, Digital Imaging and Communications in Medicine Version 3.0 embodies a number of major enhancements to previous versions of the standard:

6.2.1.1 It is applicable to a networked environment. The previous versions were applicable in a point-to-point environment only; for operation in a networked environment a Network Interface Unit (NIU) was required. DICOM Version 3.0 supports operation in a networked environment using standard networking protocols such as OSI and TCP/IP.

6.2.1.2 It specifies how devices claiming conformance to the standard react to commands and data being exchanged. Previous versions were confined to the transfer of data, but DICOM Version 3.0 specifies, through the concept of service classes, the semantics of commands and associated data.

6.2.1.3 It specifies levels of conformance. Previous versions specified a minimum level of conformance. DICOM Version 3.0 explicitly describes how an implementer must structure a conformance claim to select specific options.

6.2.1.4 It is structured as a multi-part document. This facilitates evolution of the Standard in a rapidly evolving environment by simplifying the addition of new features. ISO directives which define how to structure multi-part documents have been followed in the construction of the DICOM Standard.

6.2.1.5 It introduces explicit Information Objects not only for images and graphics but also for studies, reports, and so forth.

6.2.1.6 It specifies an established technique for uniquely identifying any information object. This facilitates unambiguous definitions of relationships between Information Objects as they are acted upon across the network.

6.2.2 DICOM was developed in liaison with ACR (the American College of Radiology) and NEMA (the National Electrical Manufacturers Association) and other Standard Organizations including CEN TC251 in Europe and JIRA in Japan, with review also by other organizations including IEEE, HL7 and ANSI in the USA. The DICOM Standard is structured as a multi-part document.

6.2.3 The DICOM standard consists of the following parts:

6.2.3.1 Part 1—*Introduction and Overview*

6.2.3.2 Part 2—*Conformance:* The principles that implementations claiming conformance to the standard shall follow, specifically, the requirements as defined in the DICOM standard. The conformance requirement specifies the general requirements, which must be met by any implementation claiming conformance. The conformance claim defines the structure of a conformance claim and specifies the information, which must be present in a conformance claim. These are

further referenced in the conformance sections of each of the NDE modality practices.

6.2.3.3 Part 3—*Information Object Definitions*

6.2.3.4 Part 4—*Service Class Specifications:* The characteristics shared by all service classes, and how a conformance claim to an individual service class is structured is defined.

6.2.3.5 Part 5—*Data Structure and Semantics:* The encoding rules necessary to construct a Data Stream to be conveyed in a message are addressed.

6.2.3.6 Part 6—*Data Dictionary:* The centralized registry, which defines the collection of all data elements available to represent information, is called the data dictionary.

6.2.3.7 Part 7—*Message Exchange:* The message exchange specifies the rules to establish and terminate associations provided by the communications support; the rules that govern the exchange of command requests and responses; and the encoding rules necessary to construct command streams and messages.

6.2.3.8 Part 8—*Network Communication Support for Message Exchange:* The communication services and the upper layer protocols necessary to support, in a networked environment, the application message exchange are specified.

6.2.3.9 Part 9—*Point-to-Point Communication Support for Message Exchange:* The service and protocols used for point-to-point communications (the physical interface and signaling protocols) are specified. The OSI-like data link and session/transport/network protocols and the services of the protocol stack to be used on this physical interface are defined.

6.2.4 The Parts are related but independent documents. Their development level and approval status may differ.

7. DICONDE Introduction

7.1 This practice provides an introduction and overview of DICONDE standard, the industrial NDE extension of the medical community DICOM standard published by NEMA.

7.1.1 *General Structure of DICONDE*

7.1.1.1 DICONDE, utilizing the existing DICOM database of object definitions, provides additional object definitions that represent a conversion between the medical community language in DICOM, to the terminology appropriate to NDE. Each Image Information Object Definition specifies an image, which has been created by an NDE imaging device. For this practice, only the common NDE Image Information Object Definition Modules which differ from the medical system will be discussed. For each specific NDE modality, refer to the practice that describes that specific technique. Refer to NEMA Standards Publication PS3.1, Version 3 for additional specifics.

7.1.1.2 Table 1 is a matrix, called the Composite Information Object Modules Overview, which describes the requirements for each of the different techniques. It shows which of each of the Information Object Definition (IOD) modules are required or optional for each of the NDE modalities. Each of the specific NDE modalities IOD's will be covered in their own standards. This practice will describe only the common NDE specific composite object modules that differ from the existing DICOM Standard.

8. Information Object Definitions

8.1 *Information Object Definitions*

8.1.1 For all modules shown as DICOM IODs, the details of the Composite Information Object Definition can be found in the NEMA Standard Part 3 Sections A.1.1 through A.1.3.

8.2 *DICOM to DICONDE I Information Object Definition*

8.2.1 The composite information object modules developed for DICOM include specifications for Computed Radiography (CR), Computed Tomography (CT), Magnetic Resonance (MR), Nuclear Magnetic Resonance (NM), Ultrasonics (US), Ultrasonics-multi-frame (US-mf), and non-image signal. Industrial NDE has additional requirements for the additional methods used.

8.2.2 In addition to certain technique changes, certain aspects of the modules must refer to different aspects of the industrial NDE community. For instance, industry deals with parts not patients. Ultimately, this will require the additional standard object definitions pertinent to industrial NDE, though the majority of the modules of DICOM can still be utilized. These common industrial NDE specific information object definition modules are defined in this practice. These changes will still permit the use of the DICOM standard for industrial use, with only a minor change in the object definitions protocols.

NOTE 2—The entries grayed out are those modules that are not typically used for industrial NDE.

8.2.3 In summary, only three additional common information object definitions modules must be defined for industrial NDE: Component, Component Summary and Component Study.

8.2.4 The following Table 1 represents the Composite Information Object Modules Overview with the DICOM and the additional DICONDE module requirements information. Where similarities exist, the DICONDE modules will use existing DICOM module information. For example, the Patient Module will be used extensively to correlate to the Component Module for industrial NDE. An M in the Table means a "Mandatory" module, a C means "Conditional" use of the module, and "U" means "User Option" for use of the module. Refer to the corresponding Information Object Definitions in the DICOM Annex for details.

9. DICONDE Modules

9.1 Each module, for industrial NDE specific data, must be described by an Attribute Name and a Data Element Tag. The following Modules with Attribute Name and Tag Identifier will be used for the common NDE Composite Information Object Definition Modules. Notice that unique Attribute Name and Tag Identifiers are being defined as the common IOD Modules for industrial NDE application. To prevent possible confusion between medical and industrial applications, the NDE Tag Identifiers are unique to industrial NDE and do not duplicate any existing medical tags.

9.2 The following tags are to be used to identify the information in the Component Module and the Component Study Module. The DICONDE practice represents the common modules that are needed for every technique, and the following table identifies the tags that are applicable for the common modules. The remaining tags for the data files can be found in the DICOM standard. Any technique specific modules

TABLE 1 Composite Information Object Modules Overview, DICOM with DICONDE Additions

Existing DICOM Information Object Definitions (IODs) Modules	Additional DICONDE "common" IODs Modules to be defined	CR	CT	US	US-mf	Sec. Capt	St. Over-lay	St. Curve	Study Descr.	St. Mod LUT	St. VOI LUT
Patient[A]	Component	M[B]	M	M	M	M	M	M		M	M
Patient Summary[A]	Component Summary								M		
General Study		M	M	M	M	M	M	M		M	M
Patient study[A]	Component Study	U[C]	U	U	U	U	U	U		U	U
Study Content											
General Series		M	M	M	M	M	M	M		M	M
CR Series		M									
NM Series[A]											
Frame Of Reference			M	U	U						
US Frame of Ref.				C[D]	C						
General Equipment		M	M	M	M	U	M	M		M	M
NM Equipment[A]											
SC Equipment						M					
General Image		M	M	M[E]	M	M					
Image Plane			M								
Image Pixel		M	M	M[E]	M	M					
Contrast/Bolus		C	C	C[E]	C						
Cine					C						
Multi-frame					M						
CR Image		M									
CT Image			M								
MR Image[A]											
NM Image[A]											
NM SPECT[A]											
NM Multi-Gated[A]											
US Region Calibration				U[E]	U						
US Image				M[E]	M						
SC Image						M					
Overlay Identification							M				
Overlay Plane		U	U	U[E]		U	M				
Multi-frame Overlay											
Curve Identification				M[E]	M[E]			M			
Curve				M[E]	M[E]			M			
Audio				U	U						
Modality LUT		U				U				M	
VOI LUT		U	U	U[E]	U	U					M
LUT Identification										M	M
SOP Common		M	M	M[E]	M[E]	M	M	M	M	M	M

[A]These IODs are typically not used for industrial NDE.
[B]"M" is for Mandatory.
[C]"U" is for User Option.
[D]"C" is for Conditional.
[E]Special condition for these modules. Refer to the corresponding IODs in the DICOM Annex for details.

for industrial NDE will have standard tags identified in the technique specific practices.

9.3 Where possible, the existing DICOM tags are used, with an industrial NDE meaning associated with them, as shown in the tables below. For these cases of using the existing DICOM tags, the tables below show joint tag numbers for both DICOM and DICONDE. Those attributes that are industrial NDE specific, and not mandatory requirements, will be shown as PrivID and have Private ID tags for them. Private ID tags are internally generated tag numbers.

10. Conformance

10.1 *Introduction*

10.1.1 The key to utilization of the DICOM/DICONDE standardization format is the conformance statement. This statement is the document that defines the current data configuration, the necessary configuration to which the NDE data format must be supplied, and the communications protocols to achieve an actual transfer of data over some transfer medium. The documentation of the current data configuration consists of using the information object definitions and the associated database element identifiers (tags) to specify the order in which the data is generated. The conformance statement also includes information on the transfer of data and what types of media are to be used.

10.2 *Conformance Statement*

10.2.1 From the DICOM standard a conformance statement consists of the following major parts:

10.2.1.1 an implementation model which describes the application entities in the implementation and how they relate to both local and remote real-world activities;

10.2.1.2 a more detailed specification of each application entity, listing the SOP classes supported and outlining the policies with which it initiates or accepts associations;