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

This standard is issued under the fixed designation E2339; 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 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), 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.

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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1316 Terminology for Nondestructive Examinations

2.2 *Other Documentation:*[3]

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 E1316.

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 *attribute tag* —a unique identifier for an *attribute* of an *information object* composed of an ordered pair (gggg, eeee) where gggg represents the group number and eeee represents the data element.

3.2.4 *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.

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

3.2.6 *data element*—a unit of information as defined by a single entry in the *data dictionary*. An encoded IOD attribute

[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.

that is composed of, at a minimum, three fields: a *data element tag*, a *value length*, and a *value field*.

3.2.7 *data element tag*—a unique identifier for a *data element* composed of an ordered pair of numbers (a *group number* followed by an *element number*).

3.2.8 *data element type (type)*—used to specify whether an *attribute* of an IOD is required and must have a non-zero value (Type 1), required but may have a zero value (Type 2), required only under certain conditions (Type 1C and 2C), or optional (Type 3). See Part 5, Section 7.4 of the DICOM standard for additional details.

3.2.9 *element number*—the second number in the ordered pair of numbers that make up a *data element tag*.

3.2.10 *group number*—the first number in the ordered pair of numbers that makes up a *data element tag*.

3.2.11 *information object definition (IOD)*—a data abstraction of a class of similar *real-world objects* which defines the nature and *attributes* relevant to the class of *real-world object* represented.

3.2.12 *module*—a set of *attributes* with an *Information Object Definition*.

3.2.13 *private data element*—additional *data element*, defined by an implementer, to communicate information that is not contained in standard *data elements*. Private *data elements* have odd *group numbers*.

3.2.14 *usage*—used to specify whether an information module is Mandatory (M), Conditional (C), or User Option (U). See Part 3, Section A.1.3 of the DICOM standard for additional details.

3.2.15 *value*—a component of a *value field*. A *value field* may consist of one or more of these components.

3.2.16 *value field*—the field within a *data element* that contains the *value* (s) of that *data element*.

3.2.17 *value length*—the field within a *data element* that contains the length of the *value field* of the *data element*.

3.2.18 *value multiplicity (VM)*—specifies the number of *values* contained in the *value field* of a *data element*.

3.2.19 *value representation (VR)*—specifies the data type and format of the *value* (s) contained in the *value field* of a *data element*. A complete list of all the VR's can be found in 6.2 of Part 5 of the DICOM standard.

3.2.20 *DICONDE version identifier*—unique string placed in the DICONDE object to identify the version of DICONDE used to create the object.

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

4.1.1 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.

4.2 This practice will contain terms and definitions that apply to all NDT methods. DICONDE terms and definitions that apply to a specific NDT method will be contained in a separate standard practice for that method as illustrated in Fig. 1. This practice is intended to be used in conjunction with the method-specific standard practices. If no method-specific practice exists, the user should default back to the DICOM terms and definitions for the modality associated with that test method.

4.3 The DICONDE practices will consist of descriptions of the attribute and object definitions that 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.

4.3.1 DICONDE, utilizing the existing DICOM database of object definitions, provides both replacement and additional

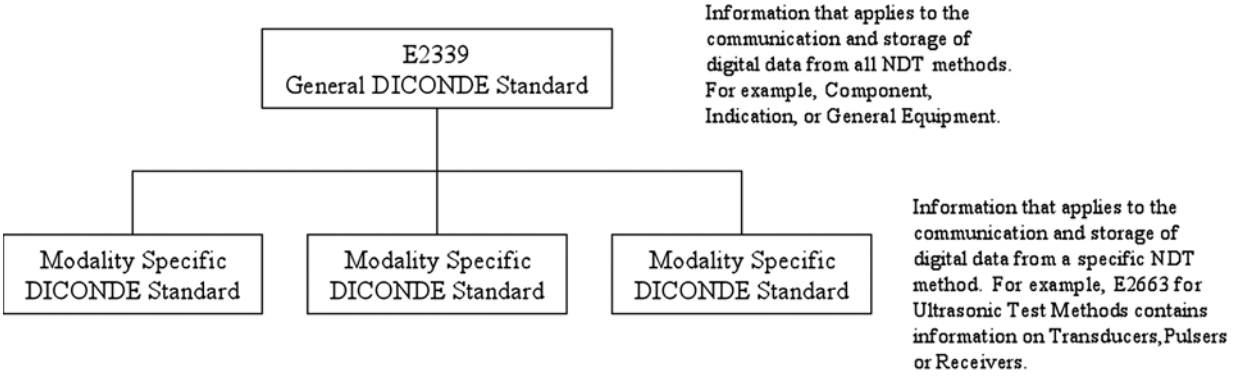

FIG. 1 DICONDE Document Relationships

module definitions that represent a conversion between the medical community language present in DICOM, to the terminology appropriate for NDE. For the DICONDE practices, only the attributes and object definitions that differ from the medical implementation will be discussed. In the case where no replacement attribute or object exists, the DICOM standard should be followed.

4.4 The key to interoperability using the DICOM standard is the conformance statement. This formal statement is associated with a specific implementation of the DICOM standard. It specifies the service classes, information objects, communication protocols, and media storage application profiles supported by the implementation. Complete information on DICOM conformance statements, including several examples, can be found in Part 2 of the DICOM standard.

4.4.1 Specific implementations of the DICONDE standard should also provide conformance statements. The majority of the conformance statement for DICONDE will be similar to DICOM. The exception being that the information objects listed in the conformance statement should be the DICONDE specific information objects that the implementation supports.

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. Information Object Definitions

6.1 *Information Object Definitions*

6.1.1 Details of the DICOM Information Object Definitions can be found in the DICOM Standard Part 3, Annexes A and B.

6.2 *DICOM to DICONDE Information Object Definition*

6.2.1 The DICOM standard specifies mandatory, conditional, and user option information modules for each DICOM IOD. The relationship between the IODs and modules is found in the DICOM Standard Part 3. The DICONDE standard will follow that relationship except as noted.

6.2.2 The terminology associated with certain modules of the DICOM information objects must be changed for use in an industrial context. For instance, industry deals with components not patients. In the industrial objects, the equivalent medical information modules will be reused when possible. For example, a component information module will be assigned to the Patient information module.

6.2.3 In some cases, there will exist no equivalent medical information module for a required set of industrial data. When no equivalent DICOM information module exists, an industrial specific data module will be created as part of that object.

7. DICONDE Information Modules

7.1 *Information Module Definitions*

7.1.1 Details of the DICOM Information Module Definitions can be found in the DICOM Standard Part 3, Annex C.

7.1.2 All data elements in the information modules must be described by an *attribute* name, a *data element tag*, a *value representation (VR)*, a *value multiplicity (VM)*, and a *data element type*.

7.2 *DICOM to DICONDE Information Module Definition*

7.2.1 The terminology associated with certain elements of the DICOM information modules must be changed for use in an industrial context. For instance, industry deals with parts not patients. The DICONDE standard defines industrial information modules that are equivalent to those found in the DICOM standard. In the industrial modules, the equivalent medical data elements will be reused when possible. For example, a component ID number or serial number will be assigned to the Patient ID attribute.

7.2.2 In some cases, there will exist no equivalent medical data element for a required industrial data element. There is no equivalent of Component Manufacturer in the current DICOM data model. When no equivalent DICOM data element exists, an industrial specific data element will be created as part of that module.

7.2.3 When a logical correspondence exists, an existing DICOM data element, with an NDE meaning associated with them, will be used for industrial data. For example, the Patient Name data element (0010, 0010) is used to store Component Name for NDE applications.

7.2.4 Some industrial data element tags are unique and do not duplicate any existing medical tags. These NDE data elements are stored as DICOM Private Data Element Tags. Private *data elements tags* are defined in Part 5, Section 7.8 of the DICOM standard.

7.2.5 The version identifier of the DICONDE file will be stored in the Software Versions data element (0018, 1020) in the NDE Equipment Module. The Software Versions data element is multi-valued. If additional software versions are stored in this data element the DICONDE version must be the first value stored in the data element. The current DICONDE version identifier is “DICONDE10”. No changes in capitalization or spacing is allowed in the DICONDE version identifier.

7.3 *DICONDE Information Modules*

7.3.1 The DICONDE practice contains the common modules that are needed for every technique. Any technique specific modules for NDE will have information modules, attributes, and data elements identified in a technique specific practice.

7.3.2 Table 1 summarizes the current list of industrial modules and, if appropriate, the medical modules that they supersede.

7.4 *Component Module*

7.4.1 Table 2 specifies the attributes that describe components.