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# Standard Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE) for Thermography (TG) Test Methods<sup>1</sup>

This standard is issued under the fixed designation E3440; 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 thermographic imaging and data acquisition equipment by specifying the image data transfer and archival storage in commonly accepted terms. This document is intended to be used in conjunction with Practice E2339. 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 thermographic test methods.

1.2 This practice has been developed to overcome the issues that arise when analyzing or archiving data from thermography/infrared test equipment using proprietary data transfer and storage methods. As digital technologies evolve, data must remain decipherable using open, industry-wide methods for data transfer and archival storage. This practice defines a method where all the thermography technique parameters and inspection data 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, or

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 *Units*—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. For most attributes, the values stated in SI units are considered standard. However, an exception was made for select attributes that are not always expressed using SI units across the industry.

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:*<sup>2</sup>

E1316 Terminology for Nondestructive Examinations

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

2.2 *NEMA Standard:*<sup>3</sup>

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

## 3. Terminology

3.1 *Definitions:*

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

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [www.astm.org/contact](http://www.astm.org/contact). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 900, Arlington, VA 22209, <http://www.dicomstandard.org>.

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 attribute formats for data communication and storage. This means all systems that are DICONDE compliant use a common data dictionary and common communication protocols. For 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 (for example, Computed Tomography, Digital Radiography, Computed Radiography, Ultrasonic, Eddy Current, and Thermography). 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 thermographic inspection.

4.3 The highest organizational level in the DICONDE information model is the Information Object Definition (IOD). The Information Object Definition is a collection of information modules necessary to represent a set of examination results from a specific modality. This practice contains information object definitions necessary for thermographic inspection.

TABLE 1 TG Image Information Object Definition

| DICOM Module  | DICONDE Module              | Reference                    | Usage <sup>A</sup> |
|---------------|-----------------------------|------------------------------|--------------------|
| General Image | Component                   | E2339, Section 7             | M                  |
|               | Component Study             | E2339, Section 7             | M                  |
|               | Component Series            | E2339, Section 7             | M                  |
|               | NDE Equipment               | E2339, Section 7             | M                  |
|               |                             | DICOM Part 3 Section C.7.6.1 | M                  |
| Image Pixel   |                             | DICOM Part 3 Section C.7.6.3 | M                  |
|               | NDE TG Image                | 7.2                          | M                  |
| SOP Common    | NDE TG Post-processing      | 7.3                          | U                  |
|               |                             | DICOM Part 3 Section C.12.1  | M                  |
|               | NDE TG Component Properties | 7.4                          | U                  |
|               | NDE TG Equipment            | 7.5                          | M                  |
|               | NDE TG Equipment Settings   | 7.6                          | M                  |
|               | NDE Geolocation Module      | E2339, Section 7             | U                  |
|               | NDE Indication              | E2339, Section 7             | U                  |
|               | NDE Geometry                | E2339, Section 7             | U                  |
|               | NDE Approval                | E2339, Section 7             | U                  |
|               |                             |                              | U                  |

<sup>A</sup> Definition of usage codes can be found in Part 3 Section A.1.3 of the DICOM standard.

#### 5. Significance and Use

5.1 Personnel that are responsible for the creation, transfer, and storage of thermographic NDE 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 thermographic test parameters and results. The thermographic examination results may be displayed or analyzed on any device that conforms to the document to help them decode and display the data contained in the DICONDE compliant inspection record.

#### 6. Information Object Definitions

##### 6.1 Thermography Image IOD Description:

6.1.1 The Thermography (TG) Image Information Object Definition specifies an image that has been created by a thermographic inspection system for NDE purposes. The IOD definition is shown in Table 1. Note that thermography has no equivalent medical imaging modality. While the IOD definition utilizes standard information modules from the DICOM standard, there exists no TG IOD within the DICOM standard.

6.1.2 Since there is no TG IOD within the DICOM standard, the option of using a DICOM Standard Extended Service-Object Pair (SOP) Class does not exist. A SOP Class Name and Unique Identifier (UID) have been provided to the TG IOD in Table 2. Note that since this is not a DICOM SOP Class, many standard DICOM image display and storage tools may not accept these images.

##### 6.2 Thermography Multi-Frame Image:

6.2.1 The Thermography Multi-Frame (TG-MF) Image Information Object Definition specifies a multi-frame image, for example, a thermographic video that was created by a thermographic inspection system for NDE purposes. This includes data collected during both passive and active thermography inspections. Flash thermography is a classic example where multi-frame thermography data are generated. The IOD definition is shown in Table 3. Note that thermography has no equivalent medical imaging modality. While the IOD definition utilizes standard information modules from the DICOM standard, there exists no TG-MF IOD within the DICOM standard.

TABLE 2 SOP Class Definitions

| SOP Class Name                         | SOP Class UID                 | IOD Specification   |
|----------------------------------------|-------------------------------|---------------------|
| Thermography Image Storage             | 1.2.840.10008.5.1.4.1.1.601.3 | TG IOD (See 6.1)    |
| Thermography Multi-frame Image Storage | 1.2.840.10008.5.1.4.1.1.601.4 | TG-MF IOD (See 6.2) |

**TABLE 3 TG-MF Image Information Object Definition**

| DICOM Module                                                              | DICONDE Module               | Reference                     | Usage <sup>A</sup> |
|---------------------------------------------------------------------------|------------------------------|-------------------------------|--------------------|
| General Image<br>Image Pixel                                              | Component                    | E2339, Section 7              | M                  |
|                                                                           | Component Study              | E2339, Section 7              | M                  |
|                                                                           | Component Series             | E2339, Section 7              | M                  |
|                                                                           | NDE Equipment                | E2339, Section 7              | M                  |
|                                                                           |                              | DICOM Part 3 Section C.7.6.1  | M                  |
|                                                                           |                              | DICOM Part 3 Section C.7.6.3  | M                  |
|                                                                           | NDE TG Image                 | 7.2                           | M                  |
|                                                                           | NDE TG Image Post-processing | 7.3                           | U                  |
|                                                                           |                              | DICOM Part 3 Section C.7.6.6  | M                  |
|                                                                           |                              | DICOM Part 3 Section C.7.6.16 | M                  |
| Multi-frame<br>Multi-frame Functional Groups<br>Cine Module<br>SOP Common |                              | DICOM Part 3 Section C.7.6.5  | M                  |
|                                                                           |                              | DICOM Part 3 Section C.12.1   | M                  |
|                                                                           | NDE TG Component Properties  | 7.4                           | U                  |
|                                                                           | NDE TG Equipment             | 7.5                           | M                  |
|                                                                           | NDE TG Equipment Settings    | 7.6                           | M                  |
|                                                                           | NDE Geolocation Module       | E2339, Section 7              | U                  |
|                                                                           | NDE Indication               | E2339, Section 7              | U                  |
|                                                                           | NDE Geometry                 | E2339, Section 7              | U                  |
|                                                                           | NDE Approval                 | E2339, Section 7              | U                  |
|                                                                           |                              |                               |                    |

<sup>A</sup> Definition of usage codes can be found in Part 3 Section A.1.3 of the DICOM standard.

6.2.2 Since there is no TG-MF IOD within the DICOM standard, the option of using a DICOM Standard Extended Service-Object Pair (SOP) Class does not exist. A SOP Class Name and Unique Identifier (UID) have been provided to the TG-MF IOD in [Table 2](#). Note that since this is not a DICOM SOP Class, many standard DICOM image display and storage tools may not accept these images.

## 7. Information Modules

### 7.1 Component Series Module:

7.1.1 The Component Series Module for thermographic images will be as described in Practice [E2339](#) Section 7, except as noted below.

7.1.1.1 For thermographic images, the Modality attribute (0008,0060) will have a value of TG.

### 7.2 NDE TG Image Module:

7.2.1 [Table 4](#) specifies the attributes that describe NDE TG images.

7.2.1.1 For NDE TG images, Samples Per Pixel (0028,0002) is specified to use the values in [Table 5](#) for specified Photometric Interpretations.

7.2.1.2 For NDE TG 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.

MONOCHROME1  
MONOCHROME2  
RGB  
PALETTE COLOR

7.2.1.3 For NDE TG Images, Planar Configuration (0028,0006) is specified to use the values in [Table 6](#) for specified Photometric Interpretations.

7.2.1.4 For NDE TG Images, Pixel Representation (0028,0103) is specified to use the following Enumerated Values:

0000H = unsigned integer  
0001H = signed integer

7.2.1.5 For NDE TG 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

7.2.1.6 For NDE TG Images, Image Type (0008,0008) is specified to be Type 1. The defined terms for Value 3 are shown in [Table 7](#) below.

7.2.1.7 TG Pixel Data Unit (0014,6060) provides Enumerated Values indicating the type of data encoded in the pixel data values.

7.2.1.8 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.

7.2.1.9 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.

### 7.3 NDE TG Post-Processing:

7.3.1 The attributes of TG Post-processing module are described in [Table 10](#). This module can be used to document operations performed on unprocessed thermographic data (TG or TG-MF) generated by the imaging system.

7.3.1.1 For TG-MF images, defined values, and the corresponding meaning for Temporal Filtering scheme (003A,0322) are shown in [Table 11](#).

7.3.1.2 For TG and TG-MF images, the defined values for Cutoff Filter Type (0014,6029) are:

LOW PASS  
HIGH PASS  
BAND PASS  
BAND REJECT  
OTHER

7.3.1.3 For TG and TG-MF images, the defined values for Moving Window Type (0014,604D) are:

AVERAGE  
MEDIAN  
CUSTOM

**TABLE 4 NDE TG Image Module Attributes**

| Attribute                      | Tag         | VR | VM  | Type | Description                                                                                                                                                                                               |
|--------------------------------|-------------|----|-----|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Samples Per Pixel              | (0028,0002) | US | 1   | 1    | Number of samples per pixel (planes) in this image. See 7.2.1.1.                                                                                                                                          |
| Photometric Interpretation     | (0028,0004) | CS | 1   | 1    | Specifies the intended interpretation of the pixel data. See 7.2.1.2.                                                                                                                                     |
| 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 7.2.1.3.                                             |
| Pixel Representation           | (0028,0103) | US | 1   | 1    | Representation of pixel data. See 7.2.1.4.                                                                                                                                                                |
| 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 7.2.1.5.                                          |
| Image Type                     | (0008,0008) | CS | 1-n | 1    | Image identification characteristics. See 7.2.1.6.                                                                                                                                                        |
| Image Comments                 | (0020,4000) | LT | 1   | 3    | User-defined comments about the image.                                                                                                                                                                    |
| Lossy Image Compression        | (0028,2110) | CS | 1   | 1C   | Specifies whether an image has undergone lossy compression.<br>Enumerated Values<br>00 = NO lossy compression<br>01 = Lossy compression<br>Required if lossy compression has been performed on the image. |
| Lossy Image Compression Ratio  | (0028,2112) | DS | 1-n | 1C   | Describes the approximate lossy compression ratio(s) that have been applied to this image. Required if image has been subjected to lossy compression.                                                     |
| Lossy Image Compression Method | (0028,2114) | CS | 1-n | 1C   | A label for the lossy compression method(s) that has been applied to this image. Required if image has been subjected to lossy compression.                                                               |
| Number of Surfaces             | (0008,2124) | IS | 1   | 3    | Number of distinct scan surfaces on the inspection specimen.                                                                                                                                              |
| Surface Name                   | (0008,2120) | SH | 1   | 3    | Name of this scan surface.                                                                                                                                                                                |
| Surface Number                 | (0008,2122) | IS | 1   | 3    | Number of this scan surface.                                                                                                                                                                              |
| Thermography Pixel Data Unit   | (0014,6060) | CS | 1   | 3    | The units of pixel values in the image. See 7.2.1.7 for valid values.                                                                                                                                     |
| Physical Units X Direction     | (0018,6024) | US | 1   | 1    | The physical units of the dimension of the region. See 7.2.1.8 for valid values.                                                                                                                          |
| Physical Units Y Direction     | (0018,6026) | US | 1   | 1    | The physical units of the dimension of the region. See 7.2.1.8 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 7.2.1.9.                                                                 |
| 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 7.2.1.9.                                                                 |
| Acquisition Date/Time          | (0008,002A) | DT | 1   | 3    | The date and time that the acquisition of data that resulted in this image started.                                                                                                                       |

**TABLE 5 NDE TG Image—Samples Per Pixel**

| Photometric Interpretations | Samples Per Pixel Value |
|-----------------------------|-------------------------|
| MONOCHROME1                 | 1                       |
| MONOCHROME2                 | 1                       |
| RGB                         | 3                       |
| PALETTE COLOR               | 1                       |

**TABLE 6 NDE TG Image—Planar Configuration**

| Photometric Interpretations | Planar Configuration Value            |
|-----------------------------|---------------------------------------|
| RGB                         | 0-color by pixel, or 1-color by plane |