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Standard Practice for Computed Radiology (Photostimulable Luminescence Method)[1]

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1. Scope

1.1 This practice[2] covers application details for computed radiology (CR) examination using a process in which photostimulable luminescence is emitted by the penetrating radiation detector, a storage phosphor imaging plate (SPIP). Because the techniques involved and the applications for CR examination are diverse, this practice is not intended to be limiting or restrictive, but rather to address the general applications of the technology and thereby facilitate its use. Refer to Guides E 94 and E 2007, Terminology E 1316, and Practices E 747 and E 1025, and 21 CFR 1020.40 and 29 CFR 1910.96 for additional information and guidance.

1.2 The general principles discussed in this practice apply broadly to penetrating radiation CR systems. However, this document is written specifically for use with X-ray and gamma-ray systems. Other CR systems, such as those employing neutrons, will involve equipment and application details unique to such systems.

1.3 *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.* For specific safety statements, see Section 10 and 21 CFR 1020.40 and 29 CFR 1910.96.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

E 94 Guide for Radiographic Examination

E 747 Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology

E 1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology

E 1316 Terminology for Nondestructive Examinations

E 1453 Guide for Storage of Media that Contains Analog or Digital Radioscopic Data

E 1475 Guide for Data Fields for Computerized Transfer of Digital Radiological Examination Data

E 1817 Practice for Controlling Quality of Radiological Examination by Using Representative Quality Indicators (RQIs)

E 2007 Guide for Computed Radiology (Photostimulable Luminescence (PSL) Method)

2.2 *ASNT Standards:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[4]

ANSI/ASNT-CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel[4]

2.3 *Federal Standards:*

Title 21, CFR 1020.40 Safety Requirements of Cabinet X-Ray Systems[5]

Title 29, CFR 1910.96 Ionizing Radiation[5]

2.4 *AIA Standard:*

NAS-410 Certification and Qualification of Nondestructive Testing Personnel [6]

3. Summary of Practice

3.1 A CR examination system can be used for a wide variety of applications. A typical CR examination system consists of a radiation source, a storage phosphor imaging plate detector, a plate reader, an electronic imaging system, a digital image

[1] This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.01 on Radiology (X and Gamma Method).

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[2] For ASME Boiler and Pressure Code applications, see related Practice SE-2033 in Section II of that code.

[3] 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.

[4] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[6] Available from Aerospace Industries Association of America, Inc., 1250 Eye St. NW, Washington, D.C. 20005.

processor, a monitor display, a digital image archiving system, and, if desired, equipment for producing hard copy analog images. This practice establishes the basic parameters for the application and control of the CR method.

4. Significance and Use

4.1 The X-, gamma-ray detector discussed in this practice is a storage phosphor imaging plate, hereafter referred to as SPIP. The SPIP, which is the key component in the CR process, differentiates CR from other radiologic methods. This practice is written so that it can be specified on the engineering drawing, specification, or contract and must be supplemented by a detailed procedure (see Section 6 and Annex A1 and Annex A2).

5. Equipment

5.1 *System Configuration*—Different examination systems configurations are possible, and it is important to understand the advantages and limitations of each. It is important that the optimum system be selected for each examination requirement through a careful analysis of the benefits and limitations of the available system components and the chosen system configuration. The provider as well as the user of the examination services should be fully aware of the capabilities and limitations of the examination system that is proposed for examination of the part. The provider and the user of examination services shall agree upon the system configuration to be used for each application under consideration and how its performance is to be evaluated.

5.1.1 The minimum system configuration will include an appropriate source of penetrating radiation, a phosphor plate detector, a plate reader, and an electronic imaging system with a CRT display.

5.1.2 A more complex system might include a microfocus X-ray system, a digital image processing evaluation system, and an image recording and printing system.

6. General Procedure Considerations

6.1 The purchaser and supplier shall mutually agree upon a written procedure using the applicable annex of supplemental requirements and also consider the following general requirements.

6.1.1 *Equipment Qualifications*—A listing of the system features that must be qualified to ensure that the system is capable of performing the desired examination.

6.1.2 *Source Parameter*—A listing of all the radiation source-related variables that can affect the examination results for the selected system configuration such as: source energy, intensity, focal spot size, range of source to object distances, range of object to image plane distances, and source to image plane distances.

6.1.3 *Image Processing Parameters*—A listing of the image processing variables, if any, necessary to enhance fine detail detectability in the part and to achieve the required image quality. These would include, but are not limited to, techniques such as noise reduction, contrast enhancement, and spatial filtering. Great care should be exercised in the selection of directional image processing parameters such as spatial filtering, which may emphasize features in certain orientations and suppress them in others. The listing should indicate the means for qualifying image processing parameters.

6.1.4 *Image Display Parameters*—A listing of the techniques and the intervals at which they are to be applied for standardizing the video image display as to brightness, contrast, focus, and linearity.

6.1.5 *Accept-Reject Criteria*—A listing of the expected kinds of part imperfections and the rejection level for each.

6.1.6 *Performance Evaluation*—A listing of the qualification tests and the intervals at which they are to be applied to ensure the system is suitable for its intended purpose.

6.1.7 *Image Archiving Requirements*—A listing of the requirements, if any, for preserving a historical record of the examination results. The listing may include examination images along with written or electronically recorded alphanumeric or audio narrative information, or both, sufficient to allow subsequent reevaluation or repetition of the examination.

6.1.8 *Qualifications*—Nondestructive testing (NDT) personnel shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or a standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, or a similar document.

7. CR Examination System Performance Considerations and Measurement

7.1 *Factors Affecting System Performance*—Total examination system performance is determined by the combined performance of the system components that includes the radiation source, storage phosphor plate detector, plate reader, electronic image processing system, image display, and examination record archiving system.

7.1.1 *Radiation Sources*—Examination systems may utilize either radioisotope or X-ray sources. The energy spectrum of the X-radiation contains a blend of contrast enhancing longer wavelengths as well as the more penetrating, shorter wavelengths. X-radiation is adjustable in energy and intensity to meet the CR examination requirements and has the added safety feature of discontinued radiation production when switched off. A radioisotope source has the advantages of small physical size, portability, simplicity, and uniformity of output.

7.1.1.1 X-ray machines produce a more intense X-ray beam emanating from a smaller focal spot than do radioisotope sources. X-ray focal spot sizes range from a few millimeters down to a few micrometers. Reducing the source size reduces geometric unsharpness, thereby enhancing detail sensitivity. X-ray sources may offer multiple or variable focal spot sizes. Smaller focal spots produce higher resolution with reduced X-ray beam intensity, while larger focal spots can provide higher X-ray intensity with lower resolution. Microfocus X-ray tubes are available with focal spots that may be adjusted to as small as a few micrometers in diameter while still producing an X-ray beam of sufficient intensity so as to be useful for the CR examination of finely detailed parts.

7.1.1.2 Conventional focal spots of 1.0 mm and larger are useful at low geometric magnification values close to 1×. Fractional focal spots ranging from 0.4 mm up to 1.0 mm are useful at geometric magnifications up to approximately 2×. Minifocus spots in the range from 0.1 mm up to 0.4 mm are

useful at geometric magnifications up to about 6×. Greater magnifications suggest the use of a microfocus spot size of less than 0.1 mm to minimize the effects of geometric unsharpness. Microfocus X-ray tubes are capable of focal spot sizes of less than 10 µm (10^{-8} m) and are useful for geometric magnifications of more than 100×.

7.1.2 *SPIP*—The storage phosphor imaging plate is a key element. It has the function of converting the radiation input signal containing part information into a corresponding optical signal while preserving the maximum amount of part information. The SPIP is a two-dimensional area detector providing an area field of view.

7.1.3 *SPIP Reader*—The SPIP reader has the function of optically scanning the imaging plate, collecting the emitted light, converting the light to an electronic signal, then converting this signal to a digital format.

7.1.4 *Electronic Imaging Processing System*:

7.1.4.1 The function of the electronic imaging processing system is to take the output of the SPIP reader and present a digital file for image display and operator interpretation.

7.1.4.2 The electronic imaging processing system includes all of the electronics and interfaces after the SPIP reader, including image enhancement and image display.

7.1.4.3 The digital image processing system warrants special attention because it is the means by which examination information will be interpreted. Great care must be exercised in determining which image processing techniques are most beneficial for the particular application. Directional spatial filtering operations, for example, must be given special attention as certain feature orientations are emphasized while others are suppressed.

7.1.5 *Image Display*:

7.1.5.1 The function of the image display is to convey information about the part to the system operator. The image display size, spatial resolution, magnification, and ambient lighting are important system considerations.

7.1.6 *Examination Record Archiving System*—Many applications require an archival quality examination record of the examination. The archiving system may take many forms, a few of which are listed in 7.1.6.1 through 7.1.6.5. Each archiving system has its own peculiarities as to image quality, archival storage properties, equipment, and media cost. The examination record archiving system should be chosen on the basis of these and other pertinent parameters, as agreed upon by the provider and user of services. The reproduction quality of the archival method should be sufficient to demonstrate the same image quality as was used to qualify the examination system.

7.1.6.1 Film or paper radiographs of the part made under the same conditions as the examination image.

7.1.6.2 Photograph of the actual image display.

7.1.6.3 CRT hard copy device used to create a paper copy image from the CRT signal.

7.1.6.4 Digital recording on magnetic disk or tape used to store the image of the part digitally.

7.1.6.5 Digital recording on optical disk used to store the image of the part digitally.

7.1.7 *Examination Record Data*—The examination record should contain sufficient information to allow the examination to be reevaluated or duplicated. Examination record data should be recorded contemporaneously with the CR examination image. Examination record data should be in accordance with Guide E 1475 and may be in writing or a voice narrative, providing the following minimum data:

7.1.7.1 Examination system designation, examination date, operator identification, operating turn or shift, and other pertinent and customer data;

7.1.7.2 Specific examination data as to part number, batch, serial number, and so forth (as applicable);

7.1.7.3 Part orientation and examination site information by reference to unique part features within the field of view; and

7.1.7.4 System performance monitoring by recording the results of the prescribed examination system performance monitoring tests, as set forth in Section 5, at the beginning and end of a series of examinations.

7.2 *Performance Measurement*—System performance parameters must be determined initially and monitored regularly to ensure consistent results. The best measure of total CR examination system performance can be made with the system in operation, utilizing a representative quality indicator (RQI) similar to the part under actual operating conditions. This indicates the use of an actual or simulated part containing actual or simulated features that must be reliably detected. Such an RQI will provide a reliable indication of the system's capabilities. Conventional wire or plaque-type Image Quality Indicators (IQIs) may be used in place of, or in addition to, the RQI. Performance measurement methods are a matter of agreement between the provider and user.

7.2.1 *Performance Measurement Intervals*—System performance measurement techniques should be standardized so that performance measurement tests may be readily duplicated at specified intervals. System performance should be evaluated at sufficiently frequent intervals, as agreed upon by the supplier and user, to minimize the possibility of time-dependent performance variations.

7.2.2 *Measurement with IQIs*—System performance measurement using IQIs shall be in accordance with accepted industry standards describing the use of IQIs. The IQIs should be placed on the part as close as possible to the area of interest. The use of wire-type IQIs should also take into account that the system may exhibit asymmetrical sensitivity, in which case the wire diameter axis shall be oriented along the system's axis of least sensitivity. Selection of IQI thickness should be consistent with the thickness of the part along the radiation path length. IQIs are described in Practices E 747 and E 1025.

7.2.3 *Measurement with RQIs*—The RQI may be an actual part with known features that are representative of the range of features to be detected or may be fabricated to simulate the part with a suitable range of representative features. Alternatively, the RQI may contain known imperfections that have been verified independently. RQIs containing known, natural defects are useful on a single-task basis. Where standardization among two or more CR systems is required, a duplicate RQI should be used. The RQIs should approximate the part as closely as is practical, being made of the same material with similar