Designation: F 792 – 01$^{\epsilon 1}$

Standard Practice for Evaluating the Imaging Performance of Security X-Ray Systems[1]

This standard is issued under the fixed designation F 792; 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.

ϵ^1 NOTE—Note from Table 1 was deleted editorially in February 2002.

1. Scope

1.1 This practice applies to all X-ray based screening systems, with tunnel apertures up to 1 m wide × 1 m high, whether it is a conventional X-ray system or an explosives detection system (EDS) that provides a projection or projection/scatter image for an operator to interpret.

1.2 This practice applies to X-ray systems used for the screening for prohibited items such as weapons, explosives, and explosive devices in baggage, packages, cargo, or mail.

1.3 This practice establishes quantitative and qualitative methods for evaluating the systems. This practice does not establish minimum performance requirements for any particular application.

1.4 The values as stated in SI units are to be regarded as the standard.

1.5 This practice relies upon the use of a standard test object (ASTM X-ray Test Object) to determine the applicable performance levels of the systems. The specific test object is subsequently described and referred to in this document as the "Test Object."

1.6 *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.* Examples are Title 21 Code of Federal Regulations, Section 1020.40 in the United States and Health & Safety Regulation No. 1333 in the United Kingdom.

1.7 *Film Safety*—If film safety, defined as <2.58×10^{-7} C/kg (<1 mR) per screening, is of importance, refer to Test Method F 1039.

2. Referenced Documents

2.1 *ASTM Standards:*

B 258 Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors[2]

E 1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology[3]

E 1316 Terminology for Nondestructive Examinations[3]

E 1647 Practice for Determining Contrast Sensitivity in Radioscopy[3]

F 1039 Test Method for Measurement of Low Level X Radiation Used in X-ray Security Screening Systems[4]

2.2 *Other Documents:*

Part 21 Code of Federal Regulations, Section 1020.40, Cabinet X-ray Systems (United States)[5]

Health & Safety Regulation 1333 (United Kingdom)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *contrast sensitivity*—a measure of the minimum change in an object that produces a perceptible brightness change in the radiological image on a monitor.

3.1.2 *effective atomic number (Z eff)*—the effective atomic number of a chemical compound or mixture of compounds is the atomic number of a single hypothetical element which would exhibit essentially identical X-ray attenuation characteristics.

3.1.3 *explosive*—a material that can be detonated, that is, undergo a chemical reaction, expand suddenly, and create a shock wave.

3.1.4 *explosive device*—a device containing explosives, a detonator, a timer/switch and an energy source.

3.1.5 *image quality indicator (IQI)*—in industrial radiography, a device or combination of devices whose demonstrated image or images provide visual or quantitative data, or both, to determine radiological quality and sensitivity. **E 1316**

3.1.6 *IQI sensitivity*—in radiography, the minimum discernible image and the designated hole in the plaque type or the designated wire image in the wire type IQI. **E 1316**

[1] This practice is under the jurisdiction of ASTM Committee F12 on Security Systems and Equipment and is the direct responsibility of Subcommittee F12.60 on Controlled Access Security, Search and Screening Equipment.

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[2] *Annual Book of ASTM Standards*, Vol 02.03

[3] *Annual Book of ASTM Standards*, Vol 03.03

[4] *Annual Book of ASTM Standards*, Vol 15.08

[5] Available from the United States Government Printing Office, 732 North Capitol St. NW, Washington, DC 20401.

3.1.7 *organic differentiation*—the ability of an X-ray system to differentiate, on a video monitor, between organic materials of different effective atomic numbers.

3.1.8 *organic/inorganic differentiation*—the ability of an X-ray system to differentiate, on a video monitor organic and inorganic matter.

3.1.9 *radiation chamber*—the X-ray shielded enclosure in which an item is exposed to X-radiation.

3.1.10 *radiation monitor*—an instrument to measure X-radiation.

3.1.11 *scatter block*—a block of soft wood (for example, pine or similar) that measures at least 300 mm by 300 mm by 75 mm, used as X-ray scattering material to create a difficult case when measuring radiation levels.

3.1.12 *simple penetration*—the ability of an X-ray system to penetrate through steel and display, on a video monitor, lead objects that would otherwise be hidden by the steel.

3.1.13 *spatial resolution*—the ability of an X-ray system to display as separate, on a video monitor, high contrast wires separated by a wire diameter (Line Pair Test Pattern; see Terminology E 1316).

3.1.14 *thin organic imaging*—the ability of an X-ray system to display, on a video monitor, thin organic material.

3.1.15 *useful organic differentiation*—the ability of an X-ray system to penetrate through steel and differentiate on a video monitor between organic materials of different effective atomic number.

3.1.16 *useful penetration*—the ability of an X-ray system to penetrate through aluminum and display, on a video monitor, wires that would otherwise be hidden by the aluminum.

3.1.17 *weapon*—a device intended to do damage to personnel or equipment without harming the attacker, but requiring the attacker to physically activate the device. Examples include gun, knife and hand grenade.

3.1.18 *wire display*—the ability of an X-ray system to display, on a video monitor, metal wires.

4. Significance and Use

4.1 This practice applies to and establishes a method to measure the imaging performance of X-ray systems used for the screening for prohibited items such as weapons, explosives and explosive devices in baggage, packages, cargo or mail.

4.2 This practice is intended for use by manufacturers to assess performance and by evaluators of security and contraband screening X-ray systems to verify performance.

4.3 This practice is intended to establish whether an X-ray system meets the manufacturer's specification or if the system's performance has deteriorated over time.

4.4 This practice may be used for manufacturing control, specification acceptance, service evaluation or regulatory statutes.

4.5 This practice is intended for use at both the point of manufacture and where the system is operated. The latter includes locations such as security checkpoints of transportation terminals, nuclear power stations, correctional institutions, corporate mailrooms, government offices and other security areas.

4.6 The most significant attributes of this practice are the design of a standard Test Object and standard methods for determining the performance levels of the system.

4.7 In screening objects with X-ray systems video images are the primary inputs provided to operators. The better the quality of these images, the better the potential performance of the operator.

5. Test Object

5.1 The following describes the ASTM X-ray Test Object (Fig. 1) to be used throughout the test procedures to determine the applicable performance levels of a system. It was developed to assess an X-ray based screening system's image quality in 9 distinct areas. A Drawings Index for the Test Object is provided in Table 1. Copies of the AutoCad drawings listed in Table 1 are available from ASTM International Headquarters.

5.2 *Test 1–Wire Display*—To determine how well an X-ray system displays wires, the test object incorporates a set of unobstructed wires. The gauge of these wires provides a sufficient range to characterize the system's ability to display wires. These wires are laid out on the test object in a sinusoidal pattern. For details as to the type, quantity and gauge of the wires or regarding the spacing between each wire refer to Fig. 1.

5.3 *Test 2–Useful Penetration*—To determine the useful penetration of an X-ray system, the test object incorporates a set of wires placed under aluminum which varies in thickness. The gauge of these wires and the thickness of the aluminum provides sufficient range to characterize the system's Useful Penetration. The wires shall be laid out on the test object, under an aluminum step wedge in a sinusoidal pattern. For details as to the type, quantity, gauge and spacing between the wires or regarding the thickness of the aluminum refer to Fig. 1.

5.4 *Test 3–Spatial Resolution*—To determine the spatial resolution of an X-ray system, the test object incorporates a set of narrowly-spaced wires. The gauge of these wires and the spacing between them provides sufficient range to characterize the system's Spatial Resolution. For details as to the type, quantity, gauge or spacing between the wires refer to Fig. 1.

5.5 *Test 4–Simple Penetration*—To determine the simple penetration of an X-ray system, the test object incorporates lead digits placed on top of steel which varies in thickness. The thickness of the steel provides sufficient range to characterize the system's Simple Penetration. For further details regarding the test object refer to Fig. 1.

5.6 *Test 5–Thin Organic Imaging*—To determine the thin organic imaging capability of an X-ray system, the test object incorporates plastic of various thicknesses. The thickness of the plastic provides sufficient range to characterize the system's ability to image thin organic material. For details regarding the plastic samples refer to Fig. 1.

5.7 *Test 6–IQI Sensitivity*—To determine the IQI sensitivity of an X-ray system, the test object incorporates a set of flat-bottom holes drilled into steel and plastic samples which vary in thickness. The diameter of these holes, the depth of these holes, and the thickness of the steel and plastic samples provides sufficient range to characterize the system's IQI Sensitivity. For details as to the diameter and depth of these holes or regarding the thickness of the steel and plastic refer to Fig. 1.

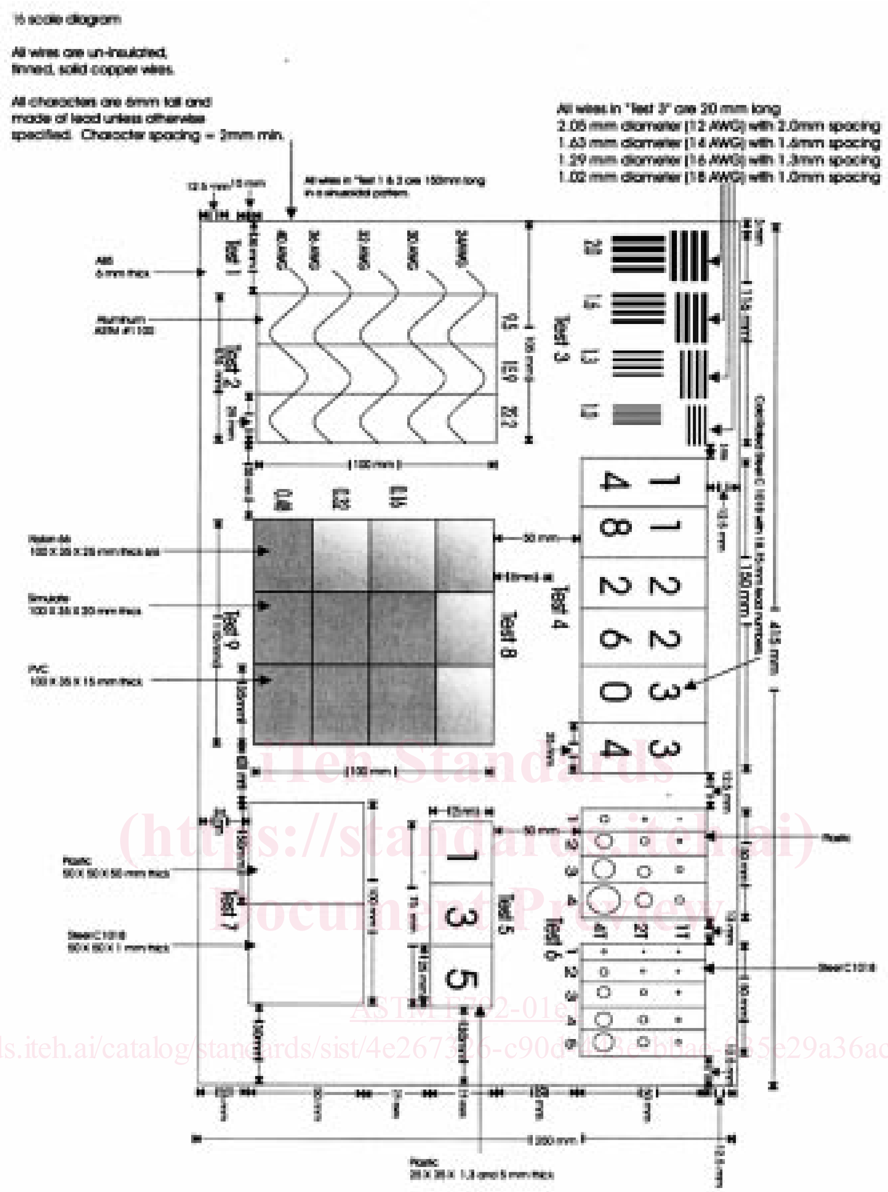

FIG. 1 ASTM X-Ray Test Object Assembly Plan

5.8 *Test 7–Organic/Inorganic Differentiation*—To determine the organic/inorganic differentiation capability of an X-ray system, the test object incorporates a steel and plastic sample. For details regarding the steel and plastic samples refer to Fig. 1.

5.9 *Test 8–Organic Differentiation*—To determine the organic differentiation capability of an X-ray system, the test object incorporates various samples of plastic. The plastics chosen shall have different effective atomic numbers but nominally identical attenuation. For details regarding the plastic samples refer to Fig. 1.

5.10 *Test 9–Useful Organic Differentiation*—To determine the useful organic differentiation of an X-ray system the test object incorporates various samples of plastic placed on top of steel which varies in thickness. For details regarding the steel and plastic samples used in this test refer to Fig. 1.

6. Test Procedures

6.1 The location and orientation of the test object in the following procedures depends on the X-ray source and detector arrangement. The position of the test object for these tests shall be chosen to obtain the best picture possible. Additional locations may be used as desired. The X-ray manufacturer should be consulted to establish the optimum location. Also, to achieve the best video image practical it may be necessary to use enhancement features such as Zoom, High Penetration, etc. This is an acceptable practice but for each test, the enhancement features used to meet the requirement must be recorded. The results of the following tests are to be retained as part of the system record and compared to performance requirements or to previously recorded results.

6.2 *Wire Display*—Scan the test object with the X-ray