



136872

Standard Practice for Design and Use of Ionizing Radiation Equipment for the Detection of Items Prohibited in Controlled Access Areas¹

FAA-01-5725

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^{ε1} NOTE—Keywords were added editorially in July 1993.

1. Scope

1.1 This practice covers the use of ionizing radiation imaging techniques for the detection of questionable items such as weapons and devices intended to trigger explosives, in order to determine their presence in hand-carried baggage, packages, checked or unaccompanied luggage, cargo, or mail at screening points for controlling access to secure areas.

1.2 This practice is intended to establish a method by which an ionizing radiation imaging system may be evaluated. It is not intended to set performance levels.

1.3 This practice specifies a broad range of health, safety, and human factors criteria pertaining to the use of this detection equipment.

1.4 The values as stated in inch-pound units are to be regarded as the standard. The values in parentheses are given for information only.

1.5 *This standard does not purport to address all of the safety problems, 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.*

2. Referenced Documents

2.1 *National Association of Photographic Manufacturers Standard.*²

NAPM Test Method for Determining Film Safety of Radiation Producing Equipment

2.2 *Underwriters Laboratories Standard.*³

UL 187 Standard for X-ray Equipment (Electrical)

2.3 *Military Standard.*⁴

MIL-STD-1472C Human Engineering Design Criteria for Military Systems, Equipment and Facilities (2 May 1981)

2.4 *Other Documents.*⁵

14 CFR 108.17—Use of Airport X-ray Security Systems (Domestic)

14 CFR 129.26—Use of Airport X-ray Security Systems (International)

21 CFR 1020.40 (c) Radiation Safety Requirements for Cabinet X-ray Systems

3. Significance and Use

3.1 This practice is meant to be used by the designers of and also those controlling the operation of ionizing radiation security equipment screening hand-carried items through security checkpoints at transportation terminals, nuclear power stations, correctional institutions, and other high security areas. It is also meant to be used by security equipment operators screening checked or unaccompanied luggage, packages, cargo, and mail at such locations. It may include corporate mail rooms, government offices, or other areas where the threat of receiving harmful devices is great enough to warrant the use of this type of equipment.

3.2 This practice is not intended to be used by police or bomb disposal experts for the disarming of letter or package bombs.

3.3 This practice relies upon the use of a test object to determine the applicable performance levels of the equipment. The specific test object subsequently described in Section 6 may not be appropriate for all types of ionizing radiation security screening systems such as those used for unusually large or dense objects or for those not dependent upon a visual image for making a determination.

3.4 The most significant attributes of this practice are the method for determining the detection capabilities of the equipment, the safety requirements of the equipment, and the training of the operators.

4. Terminology

4.1 Definition:

4.1.1 *weapon*—a device intended to do damage to personnel or equipment without intentionally harming the attacker, but requiring the attacker to physically activate the device. Examples include guns, knives, hand grenades, and similar items.

5. Radiation Levels

5.1 Radiation levels shall be as low as reasonably achievable, commensurate with the radiation source used (for example, pulse radiation or continuous radiation), the detection system used (for example, film, fluorescent screens, or electronic imaging systems), and the objects being screened (for example, briefcases, purses, suitcases, packages, or crates).

¹ This practice is under the jurisdiction of ASTM Committee F-12 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 Available from National Association of Photographic Manufacturers, Inc., 600 Mamaroneck Ave., Harrison, NY 10528.

³ Available from Underwriters Laboratories, Inc., Publication Stock, 333 Pfingsten Rd., Northbrook, IL 60062.

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

⁵ Available from Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

6. System Evaluation

6.1 *Test Step Wedge*—A standard step wedge made of ASTM No. 1100 aluminum or equivalent shall be 10 in. (254 mm) long by 4.0 in. (101.6 mm) wide and shall consist of ten 1.0 by 4.0-in. (25.4 by 101.6-mm) steps. The first step shall be 0.062 in. (1.59 mm) thick and each subsequent step shall be increased by an additional 0.062 in. The sides of each step shall be 90° to the face of the step and corners, and edges shall not be chamfered. The step wedge may be assembled from sheet stock or machined from solid material. If assembled from sheet stock, do not use glue or other adhesives to join the individual sheets.

6.1.1 Affix five separate wires, 0.5 in. (12.7 mm) apart, each forming three sinusoidal curves length-wise to the bottom of the step wedge on a 0.062 in. (1.59 mm) thick plastic sheet 4.0 in. (101.6 mm) wide by 11.0 in. (279.4 mm) long. The plastic sheet together with the ends of the five wires shall extend 1.0 in. (25.4 mm) out from the step wedge at the thin end. These wires shall be tinned solid copper with plastic insulation and shall be 22, 24, 26, 28, and 30 American Wire Gage (AWG) (0.643 mm, 0.511 mm, 0.404 mm, 0.320 mm and 0.254 mm) respectively in diameter as shown in Fig. 1.

6.1.2 View the test step wedge in the mode in which suspect objects are normally viewed. For vertical beam units, place the step wedge as close to the centerline of the inspection area and as close to the image detector as practical at an angle approximately 45° to the edge of the conveyor belt. For horizontal beam units, place the 4 in. (101.6 mm) side parallel to and as close as practical to the center of the detector with the flat side of the step wedge facing the detector and the 10

in. (254 mm) side positioned diagonally approximately 45° from the surface of the conveyor belt. Record the steps through which each gage wire can be observed on a grid as illustrated in Fig. 2. Use this information to optimize system performance. It may be retained for future reference.

6.1.3 The wires used on the test step wedge are not intended to simulate those which may be used in explosive triggering devices but rather as indicators of the sensitivity of the equipment being evaluated. The maximum number of steps on which a given gage wire can be detected is a measure of the system's performance.

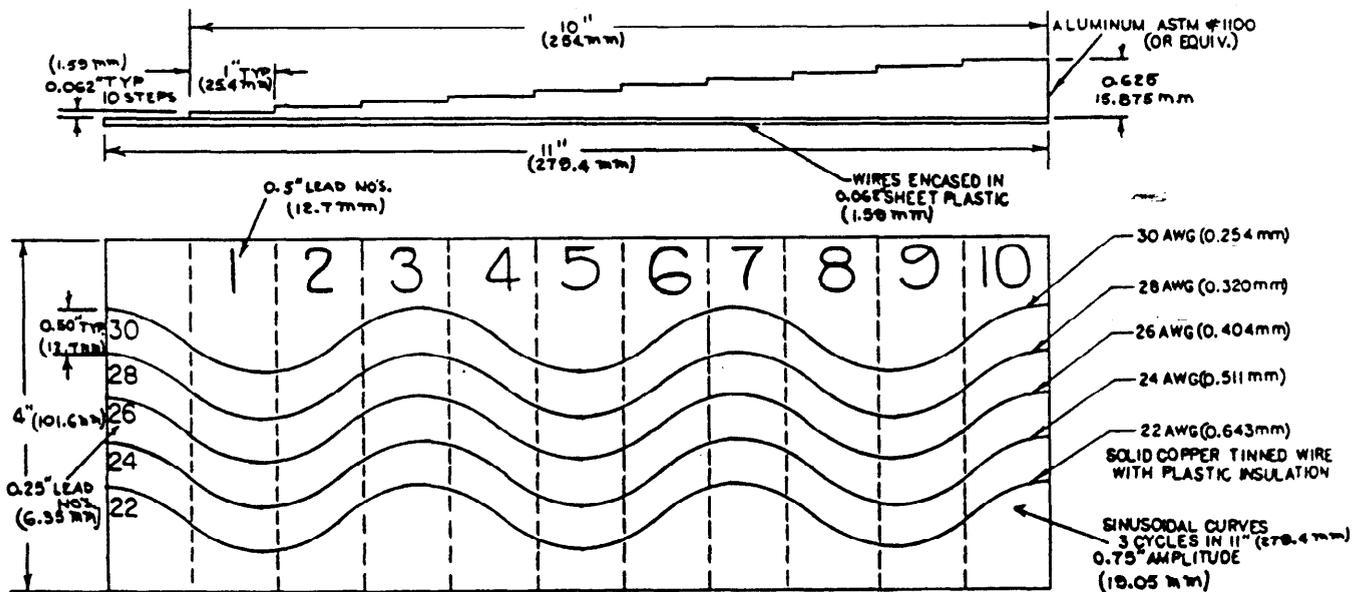
6.2 Make a test step wedge (Fig. 1) available for use at each security checkpoint.

7. System Safety Requirements

7.1 *Personal Health and Safety Requirements*—The health and safety of operators and other persons using or coming in contact with the equipment must be considered in the equipment design.

7.1.1 *Mechanical*—The equipment shall be free of sharp corners or protrusions that can puncture the skin or clothing or injure persons moving normally within the immediate area. All mechanically driven components shall be protected against accidental entrapment of, or attachment to any part of the human body or clothing which could be expected to come close to the moving component during normal operation.

7.1.2 *Electrical*—The equipment shall be free of potential electrical shock hazards during operation. For this purpose, the spirit and intent of UL187 shall apply.



UNLESS OTHERWISE SPECIFIED
2 PLACES ± .030
3 PLACES ± .010
ANGLES ± °

NOTE—Aluminum step wedge can be made from sheet stock or machined from bar stock. If laminated from sheet stock, glue or other adhesives may not be used to join the sheets.

FIG. 1 Step Wedge for Testing X-Ray Security Screening Systems

Steps	Wire Size				
	22	24	26	28	30
P	X	X	X	X	X
1	X	X	X		
2	X	X	X		
3	X	X			
4	X	X			
5	X	X			
6	X				
7	X				
8					
9					
10					

NOTE—Positioning of Xs on illustration do not necessarily indicate a preferred response, but are for illustrative purposes only.

FIG. 2 Recommended Chart Format for Recording Step Wedge Information

7.1.3 Radiation—The ionizing radiation system shall meet all of the requirements of 21 CFR 1020.40(c) as given in Annex A1.

7.2 Product Safety Requirements—To be considered safe for screened items, the security search and screening methods used must not produce effects that will interfere with the normally intended use of the items or their contents, or both.

7.2.1 Unprocessed Photographic Film—X-ray exposure to any part of an item that may contain unprocessed photographic film shall not exceed 1 mR (0.001 R) in any one screening and not more than 5 mR (0.005 R) in accumulated exposure from repetitive screenings while containing the same film. The item must be reoriented or moved relative to the X-ray beam between exposures for the repetitive screening limit to apply. See Appendix X1. In order to meet these requirements, the equipment shall automatically limit each exposure to not more than the maximum specified limit.

7.2.2 Other Products—To date, no other known products including magnetic recording media and semi-conductor memory devices, are significantly affected by low level X-ray screening procedures.

8. Human Factors Design Criteria

NOTE 1—For further information regarding Human Factors Design Criteria, see MIL-STD-1472C and "Human Engineering Guide to Equipment Design."⁶

8.1 Controls and Indicators:

8.1.1 Operator-adjusted controls shall, at a minimum, include an on-off key switch to ensure that radiation generation is not possible with the key removed, a device to ensure operator presence in the control area during generation of radiation, start-up controls (if required, television monitor controls, if unit is television equipped), and conveyor controls

(if unit is conveyor equipped). Indicators, at a minimum, shall include power "on" light, radiation "on" light and a second radiation indicator showing when radiation is being produced.

8.1.2 Controls for use by qualified service personnel only (for example, television camera adjustments, X-ray kilovoltage and milliampere adjustment and timer adjustments) shall be secured in compartments accessible to authorized personnel only. A permanent label shall be affixed to the unit in a conspicuous location stating:

CAUTION: INTERNAL CONTROLS ARE FOR USE BY QUALIFIED SERVICE PERSONNEL ONLY. NO OPERATOR ADJUSTABLE CONTROLS INSIDE.

8.2 Ambient Illumination—Units designed for direct or reflected viewing of an X-ray fluorescent screen shall be operated in an area with subdued ambient lighting. Units designed for television monitor or image intensifier viewing shall be shielded against direct light reflections.

9. Operator Training

9.1 Adequate training should be given to operators. This training shall include initial, on-the-job, and recurrent training as described in 9.2 through 9.4.

9.2 Initial training shall provide the following:

9.2.1 Introduce new employees to the job, and teach proper use of operator controls, including procedures to retain the image on the screen for a sufficient time to determine if physical inspection is required.

9.2.2 Teach and familiarize new operators with the identification of objects viewed (for tasks requiring visual detection) and the meaning of any alarms used.

9.2.3 Explain the use of radiation monitors where required to indicate radiation safety.

9.2.4 Include instruction concerning commonly used methods of smuggling weapons past security points and techniques for overcoming them.

9.2.5 Advise operators of the effects of X-rays on certain unprocessed photographic materials and the proper response to requests for manual inspection of them.

9.2.6 Provide motivation for the operator and verify proficiency.

9.2 On-the-job training shall allow new operators to apply their skills in an actual security environment under supervision.

9.3 Recurrent training shall refresh target characteristics (especially those which are rarely encountered) and maintain motivation and proficiency standards.

10. Keywords

10.1 baggage check; controlled access areas; explosives; ionizing radiation equipment; ionizing radiation imaging systems; luggage check; screening points; weapons

⁶ Van Cott, H. P. and KinKade, R. G., *Human Engineering Guide to Equipment Design*, John Wiley & Son, Inc., New York, NY 10158, 1972.

ANNEX

(Mandatory Information)

A1. 21 CFR 1020.40(c) RADIATION SAFETY REQUIREMENTS FOR CABINET X-RAY SYSTEMS

(1) *Emission Limit:*

(i) Radiation emitted from the cabinet X-ray system shall not exceed an exposure of 0.5 mR in 1 h at any point 5 cm outside the external surface.

(ii) Compliance with the exposure limit in paragraph(c) (1) (i) of this section shall be determined by measurements averaged over a cross-sectional area of 10 cm² with no linear dimension greater than 5 cm, with the cabinet X-ray system operated at those combinations of X-ray tube potential, current, beam orientation, and conditions of scatter radiation which produce the maximum X-ray exposure at the external surface, and with the door(s) and access panel(s) fully closed as well as fixed at any other position(s) which will allow the generation of X-radiation.

(2) *Floors*—A cabinet X-ray system shall have a permanent floor. Any support surface to which a cabinet X-ray system is permanently affixed may be deemed the floor of the system.

(3) *Ports and apertures*—(i) The insertion of any part of the human body through any port into the primary beam shall not be possible.

(ii) The insertion of any part of the human body through any aperture shall not be possible.

(4) *Safety Interlock:* (i) Each door of a cabinet X-ray system shall have a minimum of two safety interlocks. One, but not both of the required interlocks shall be such that door opening results in physical disconnection of the energy supply circuit to the high-voltage generator and such disconnection shall not be dependent upon any moving part other than the door.

(ii) Each access panel shall have at least one safety interlock.

(iii) Following interruption of X-ray generation by the functioning of any safety interlock, use of a control provided in accordance with paragraph (c) (6) (ii) of this section shall be necessary for resumption of X-ray generation.

(iv) Failure of any single component of the cabinet X-ray system shall not cause failure of more than one required safety interlock.

(5) *Ground Fault:* A ground fault shall not result in the generation of X-rays.

(6) *Controls and Indicators for All Cabinet X-Ray Systems.* For all systems to which this section is applicable there shall be provided:

(i) A key-actuated control to ensure that X-ray generation is not possible with the key removed.

(ii) A control or controls to initiate and terminate the generation of X-rays other than by functioning of a safety interlock or main power control.

(iii) Two independent means which indicate when and only when X-rays are being generated, unless the X-ray generation period is less than ½ s, in which case the indicators shall be activated for ½ s, and which are discernible from any point at which initiation of X-ray generation is possible. Failure of a single component of the cabinet X-ray system shall not cause failure of both indicators to perform their intended

function. One, but not both of the indicators required by this subdivision may be a milliammeter labeled to indicate X-ray tube current. All other indicators shall be legibly labeled "X-RAY ON".

(iv) Additional means other than milliammeters which indicate when and only when X-rays are being generated, unless the X-ray generation period is less than ½ s in which case the indicators shall be activated for ½ s, as needed to ensure that at least one indicator is visible from each door, access panel, and port, and is legibly labeled "X-RAY ON".
(7) *Additional Controls and Indicators for Cabinet X-Ray Systems Designed to Admit Humans.* For cabinet X-ray systems designed to admit humans there shall also be provided:

(i) A control within the cabinet for preventing and terminating X-ray generation, which cannot be reset, overridden or bypassed from the outside of the cabinet.

(ii) No means by which X-ray generation can be initiated from within the cabinet.

(iii) Audible and visible warning signals within the cabinet which are actuated for at least 10 s immediately prior to the first initiation of X-ray generation after closing any door designed to admit humans. Failure of any single component of the cabinet X-ray system shall not cause failure of both the audible and visible warning signals.

(iv) A visible warning signal within the cabinet which remains actuated when and only when X-rays are being generated, unless the X-ray generation period is less than ½ s in which case the indicators shall be activated for ½ s.

(v) Signs indicating the meaning of the warning signals provided pursuant to paragraphs (c) (7) (iii) and (iv) of this section and containing instructions for the use of the control provided pursuant to paragraph (c) (7) (i) of this section. These signs shall be legible, accessible to view, and illuminated when the main power control is in the "on" position.

(8) *Warning Labels:* (i) There shall be permanently affixed or inscribed on the cabinet X-ray system, at the location of any controls which can be used to initiate X-ray generation, a clearly legible and visible label bearing the statement:

CAUTION: X-RAYS PRODUCED WHEN ENERGIZED

(ii) There shall be permanently affixed or inscribed on the cabinet X-ray system adjacent to each port a clearly legible and visible label bearing the statement:

CAUTION: DO NOT INSERT ANY PART OF THE BODY WHEN SYSTEM IS ENERGIZED—X-RAY HAZARD.

(9) *Instructions:* (i) Manufacturers of cabinet X-ray systems shall provide for purchasers, and to others upon request at a cost not to exceed the cost of preparation and distribution, manuals and instructions which shall include at least the following technical and safety information: Potential, current,

and duty cycle ratings of the X-ray generation equipment; adequate instructions concerning any radiological safety procedures and precautions which may be necessary because of unique features of the system; and a schedule of maintenance necessary to keep the system in compliance with this section.

(ii) Manufacturers of cabinet X-ray systems which are intended to be assembled or installed by the purchaser, shall provide instructions for assembly, installation, adjustment and testing of the cabinet X-ray system adequate to assure that the system is in compliance with applicable provisions of this section when assembled, installed, adjusted and tested as directed.

(10) Additional requirements for X-ray baggage inspection systems. X-ray systems designed primarily for the inspection

of carry-on baggage at airline, railroad, and bus terminals, and at similar facilities, shall be provided with means, pursuant to subdivisions (i) and (ii) of this subparagraph, to ensure operator presence at the control area in a position which permits surveillance of the ports and doors during generation of X-radiation.

(i) During an exposure or preset succession of exposures of $\frac{1}{2}$ s or greater duration, the means provided shall enable the operator to terminate the exposure or preset succession of exposures at any time.

(ii) During an exposure or preset succession of exposures of less than $\frac{1}{2}$ s duration, the means provided may allow completion of the exposure in progress but shall enable the operator to prevent additional exposures.

APPENDIXES

(Nonmandatory Information)

X1. PHYSICAL INSPECTION OF PHOTOGRAPHIC FILMS

X1.1 Federal Aviation Administration regulations 14 CFR 108.17 for domestic carriers and 14 CFR 129.26 for foreign carriers specifically provide for the physical inspection of photographic equipment and film packages if requested by the passenger when an X-ray system is used for carry-on baggage inspection.

X1.2 The regulations provide for a sign to be posted advising the passengers that X-ray and scientific film should

be removed from their carry-on baggage. If the X-ray system exposes any item to more than 1 mR during inspection, the carrier must post a sign that advises a passenger to remove film of all kinds from their baggage.

X1.3 Operators should be made aware of the right of the passenger in some countries to prevent X-ray exposure to unprocessed film and operator training should include proper handling techniques of cameras and film.

X2. OPERATOR VIEWING RECOMMENDATION

X2.1 Operators should not be required to continuously view the presented image for periods exceeding 30 min at one time. Operators should be assigned to other duties in the security area for minimum periods of 15 min between the viewing periods. This is to maintain alertness while viewing

the image display. In the case of unamplified X-ray fluorescent screen viewing, the operator should be dark-adapted by remaining in subdued light for a minimum of 5 min prior to viewing the fluorescent screen.

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