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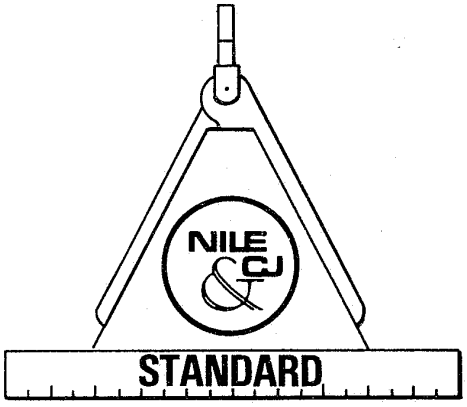
JUNE 1975

LAW ENFORCEMENT STANDARDS PROGRAM

X-RAY SYSTEMS FOR BOMB DISARMAMENT



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LAW ENFORCEMENT STANDARDS PROGRAM

NILECJ STANDARD
FOR
X-RAY SYSTEMS
FOR BOMB DISARMAMENT

A Voluntary National Standard Promulgated by the National Institute of Law Enforcement and Criminal Justice.

JUNE 1975

U.S. DEPARTMENT OF JUSTICE
Law Enforcement Assistance Administration
National Institute of Law Enforcement and Criminal Justice

LAW ENFORCEMENT ASSISTANCE ADMINISTRATION

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This standard was formulated by the Law Enforcement Standards Laboratory of the National Bureau of Standards under the direction of Robert M. Mills, Manager, Investigative Aids Program, and Jacob J. Diamond, Chief of LESL. Technical research was performed by the staff of the NBS Applied Radiation Division under the supervision of Charles N. Smith.

NILECJ STANDARD
for
X-RAY SYSTEMS FOR BOMB DISARMAMENT

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FOREWORD

Following a Congressional mandate[1] to develop new and improved techniques, systems, and equipment to strengthen law enforcement and criminal justice, the National Institute of Law Enforcement and Criminal Justice (NILECJ) has established the Law Enforcement Standards Laboratory (LESL) at the National Bureau of Standards. LESL's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

In response to priorities established by NILECJ, LESL is (1) subjecting existing equipment to laboratory testing and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guidelines, state-of-the-art surveys and other reports.

This document, NILECJ-STD-0603.00 for X-ray Systems for Bomb Disarmament, is a law enforcement equipment standard developed by LESL and approved and issued by NILECJ. Additional standards as well as other documents are being issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles and clothing.

This equipment standard is a technical document consisting of performance and other requirements together with a description of test methods. Equipment which can meet these requirements is of superior quality and is suited to the needs of law enforcement agencies. Purchasing agents can use the test methods described in this standard to determine firsthand whether a particular equipment item meets the requirements of the standard, or they may have the tests conducted on their behalf by a qualified testing laboratory. Law enforcement personnel may also reference this standard in purchase documents and require that any equipment offered for purchase meet its requirements and that this compliance be either guaranteed by the vendor or attested to by an independent testing laboratory.

The necessarily technical nature of this NILECJ standard, and its special focus as a procurement aid, make it of limited use to those who seek general guidance concerning x-ray systems for bomb disarmament. The NILECJ Guideline Series is designed to fill that need. We plan to issue guidelines to this as well as other law enforcement equipment as soon as possible, within the constraints of available funding and the overall NILECJ program.

The guideline documents to be issued are highly readable and tutorial in nature in contrast to the standards, which are highly technical and intended for laboratory use by technical personnel. The guidelines will provide, in nontechnical language, information for purchasing agents and other interested persons concerning the capabilities of equipment currently available. They may then select equipment appropriate to the performance required by their agency. Recommendations for the development of particular guidelines should be sent to us.

NILECJ standards are subjected to continuing review. Technical comments and recommended revisions are invited from all interested parties. Suggestions should be addressed to the Program Manager for Standards, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C. 20531.

Lester D. Shubin, *Manager*
Standards Program
National Institute of Law
Enforcement and Criminal Justice

[1] Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended.

NILECJ STANDARD
for
X-RAY SYSTEMS FOR BOMB DISARMAMENT

1. PURPOSE AND SCOPE

The purpose of this standard is to establish requirements and methods of test for portable x-ray systems for use in bomb disarming operations. This standard does not apply to x-ray systems designed for use in the mass or routine screening of parcels or baggage; the leakage radiation permitted by this standard in order to attain the needed portability makes it unsuitable for such application.

2. CLASSIFICATION

2.1. Battery Powered X-Ray Systems

2.2. AC Powered X-Ray Systems

2.3. Optional Power X-Ray Systems

X-ray systems for which the operator can select either battery powered or ac powered operation.

3. DIFINITIONS

3.1. Detector Assembly

That part of an x-ray system which includes the component that detects the x-rays (e.g., fluorescent screen, NaI, film, plastic scintillator, etc.), and the component that records or displays the image (e.g., film, viewing screen, etc.).

3.2. Exposure[1]

A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all of the ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in the air, divided by the mass of the air in the volume element. The unit of exposure is the roentgen.

3.3. Ionizing Radiation

Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, by interaction with matter.

3.4. Leakage Radiation

All ionizing radiation, except the useful beam, coming from an x-ray tube assembly.

3.5. Primary Radiation

Ionizing radiation coming directly from an x-ray tube anode.

3.6. Processing Unit

A portable or mobile mechanism for processing sensitized media, such as film, to make a latent image visible.

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[1]Definition based on American National Standard N1.1-1967, Glossary of Terms in Nuclear Science and Technology, available from the American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.

3.7. Scattered Radiation

Ionizing radiation that, during passage through matter, has been deviated in direction and usually has had its energy diminished.

3.8. Useful Beam

That part of the primary and scattered radiation which passes thorugh an aperture, cone or other device used for collimation.

3.9. X-Ray Tube Assembly

That part of an x-ray system which includes the x-ray tube, shielding material, and any permanently attached devices used to restrict the field of the useful x-ray beam.

4. REQUIREMENTS

4.1. Leakage Radiation

The average exposure rate of leakage radiation from the x-ray tube assembly shall not exceed 0.1 roentgen per hour at one meter, when measured in accordance with 5.1.

4.2. Image Quality-Differential Sensitivity

The x-ray system shall be capable of resolving the total length of each of the five #24 and five #26 AWG bare copper wires of the test pattern placed between two steel test plates in each of eight consecutive images, when tested in accordance with 5.2.

4.3. Image Quality-Inherent Sensitivity

The x-ray system shall be capable of resolving the total length of all of the bare copper wires of the test pattern (without steel plates) in each of eight consecutive images, when tested in accordance with 5.3.

4.4. Ruggedness

The x-ray system shall meet the leakage radiation and the image quality-differential sensitivity requirements (4.1 and 4.2) after being subjected to the drop test in accordance with 5.4.

4.5. Temperature

The x-ray system, including any processing unit which is directly attached to the main x-ray system, shall meet the image quality-differential sensitivity requirement (4.2) after being subjected to temperature and relative humidity cycling in accordance with 5.5. A processing unit which is not attached to the main x-ray system need not meet these temperature requirements.

4.6. Power

4.6.1. AC Powered Systems

4.6.1.1.

AC powered x-ray systems shall meet the leakage radiation and the image quality-differential sensitivity requirement (4.1 and 4.2) when tested at 105 and 129 volts, 59 to 61 hertz, in accordance with 5.6.1.

4.6.1.2.

AC powered systems shall not draw more than 10 amperes when tested in accordance with 5.6.2.

4.6.2. Battery-Powered Systems

4.6.2.1.

Battery-powered x-ray systems shall meet the image quality-differential sensitivity requirement (4.2) when tested in accordance with 5.6.3.

4.6.2.2.

Battery-powered x-ray systems shall include a means of determining that the batteries require replacement before the system performance is adversely affected.

4.6.3. Optional Powered Systems

Optional power x-ray systems shall meet the requirements of 4.6.1 and 4.6.2.

4.7. Set-Up and Operating Time

The total elapsed time from removal of components from carrying cases to the production of the visible image, using the longest recommended exposure time listed in the operator's manual, shall be less than 3 minutes.

4.8. Portability

The complete x-ray system, including carrying cases and any required input voltage regulator, but excluding any processing unit not attached to the main x-ray system, shall have a total weight less than 54 kilograms (119 pounds) and shall be packaged to be carried by two persons. The maximum weight for one person to carry shall be 30 kilograms (66 pounds).

4.9. Fire and Shock

The x-ray system shall meet the requirements of Underwriters Laboratories Standard for Safety, X-Ray Equipment UL187 (ANSI C33.67–1971).[2]

4.10. Remote Control and Viewing

The x-ray system shall have an activation switch which permits the generation of x-rays only when actuated by the operator. The activation switch and any image viewing screen shall both be operable at a location at least 8 meters (26 feet) from the x-ray tube assembly.

4.11. Exposure Control

X-ray systems which utilize sensitized media to record the image shall be equipped for exposure control with a timer or pulse counter which is actuated by the activation switch.

4.12. Warning Lights and Labels

4.12.1. The housing containing the x-ray tube assembly shall:

(a) Have one or more red lights, visible within a radius of 10 meters, which serve the dual purpose of warning that x-rays are being produced when they are on, and preventing the production of x-rays when they are off.

(b) Be labelled on two external sides with the radiation symbol designated by ANSI N2.1–1969 [3] and with words to the effect, "Caution—x-rays when red light is on."

4.12.2. The housing containing the control unit shall be labelled in a prominent position with the following directive: "Operate the activation switch at least 8 meters (26 feet) from the x-ray tube."

4.13. Instructions

An operator's manual shall be supplied by the manufacturer or distributor with each x-ray system. This manual shall clearly state the instructions for the interconnection, checkout, operation and maintenance of the complete x-ray system and shall:

a. Inform the user concerning government regulations and industry standards applicable to the operation of x-ray systems.

b. Inform the user of the need for proper training and supervision in the use

[2] Copies of this standard may be obtained from Underwriters Laboratories, Inc., 207 E. Ohio Street, Chicago, Ill. 60611.

[3] Copies of this standard may be obtained from the American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.

of x-ray systems and discuss the hazards involved in improper use.

c. Describe the appropriate personnel radiation monitoring devices for use with the x-ray system. Such instructions may include references to specific commercially available monitoring devices, and shall include a description of the radiation and how the radiation should be measured.

d. List recommended x-ray tube assembly to object distances for various object sizes, and recommended exposure settings for these recommended distances and various types of objects (e.g., pipe bomb, shoebox bomb, etc.).

e. State the approximate operational time or number of x-ray pulses before battery replacement or recharging is necessary.

5. TEST METHODS

Unless specified otherwise, at the time of the tests, the ambient temperature shall be between 10° C and 27° C (50° to 81° F), the relative humidity shall be between 10 percent and 90 percent, and the line voltage shall be between 110V ac and 120V ac at 59 Hz to 61 Hz. Install new or recharged batteries in battery-operated systems. Thereafter, replace or recharge the batteries when and only when the battery indicator required by 4.6.2.2 indicates the need to do so.

5.1. Leakage Radiation Test

Warning: Due to the radiation hazard, this test must be performed by a qualified expert who has the knowledge and training to measure ionizing radiation and to evaluate safety techniques. Guidance relating to the competence of an individual to discharge the responsibilities of a qualified expert may be obtained from the American Board of Health Physics, the American Board of Radiology, or the American Board of Industrial Hygiene.[4]

Block the window of the x-ray tube assembly with at least 10 HVL (half-value layers) of absorbing material. With the x-ray system operating at the maximum voltage setting and the maximum current for that setting, scan the x-ray tube assembly for leakage radiation from a distance of 1 meter (40 inches) using suitable exposure measuring equipment. Average each exposure over a 100 square centimeter (15 square inch) area with no linear dimension greater than 20 centimeters (8 inches).

5.2. Image Quality-Differential Sensitivity Test

5.2.1.

The test pattern shall consist of straight, solid, bare copper wires attached to a $25 \times 25 \times .32$ centimeter (approximately $10 \times 10 \times 1/8$ inch) acrylic plastic sheet in a configuration as shown in figure 1. The outside wire in each of the five L-shaped sets shall be 16 ± 1 centimeters (6.3 ± 0.4 inches) long. The right angle bend in each wire shall be within 0.5 centimeter (0.2 inch) of its midpoint. The wire separation within each of the L-shaped sets shall be 0.4 ± 0.2 centimeter (0.16 ± 0.08 inch). The diameter of each leg shall be as follows:

#24 AWG . . . 0.0511 ± 0.0015 cm; 0.0201 ± 0.0006 inch
#26 AWG . . . 0.0404 ± 0.0013 cm; 0.0159 ± 0.0005 inch
#28 AWG . . . 0.0320 ± 0.0010 cm; 0.0126 ± 0.0004 inch
#30 AWG . . . 0.0254 ± 0.0008 cm; 0.0100 ± 0.0003 inch
#32 AWG . . . 0.0203 ± 0.0005 cm; 0.0080 ± 0.0002 inch

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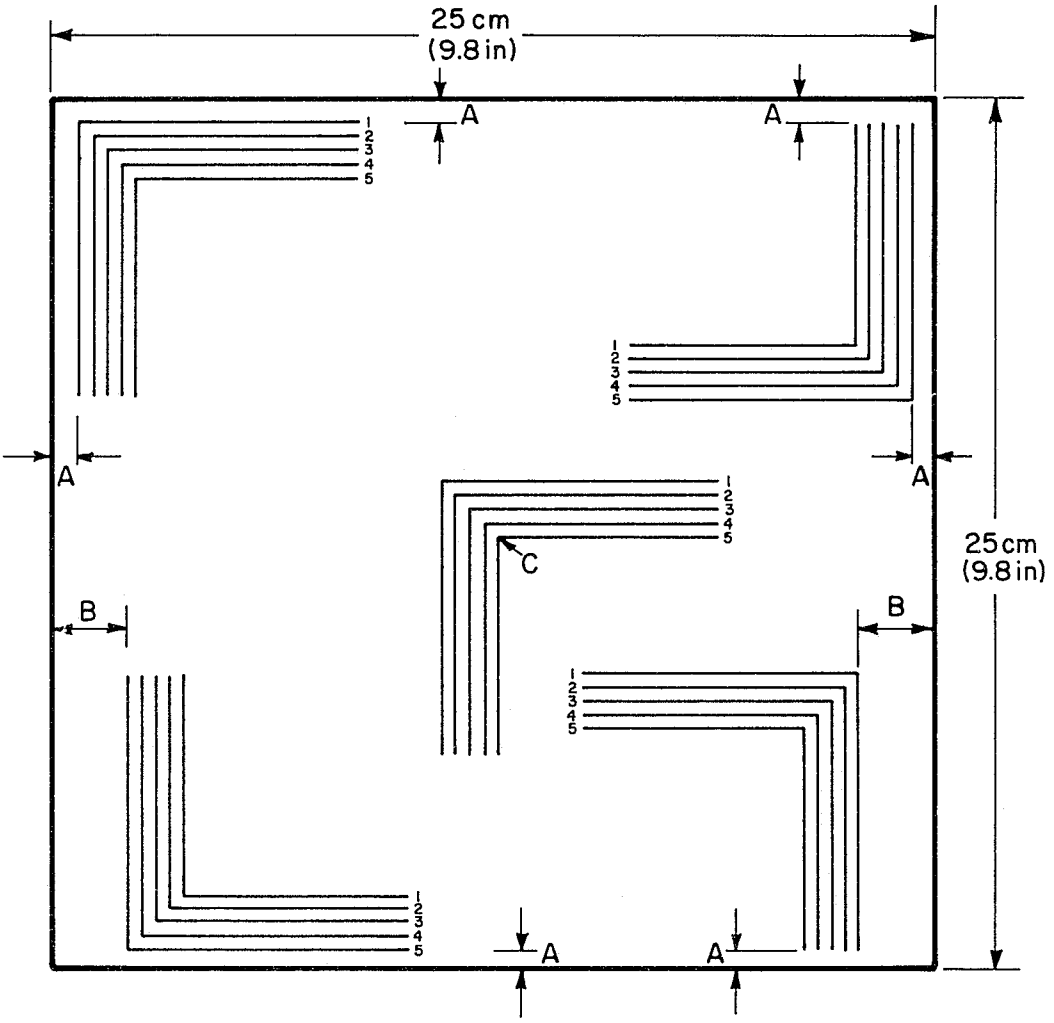
[4]American Board of Health Physics, c/o Mr. H. Wade Patterson, Chairman, Bldg. L-518, Lawrence Livermore Laboratory, P. O. Box 808, Livermore, Calif. 94550.

American Board of Radiology, Kahler East, Rochester, Minn. 55901.

American Board of Industrial Hygiene, c/o Mr. James Barrett, Secretary Treasurer, 1825 N. Willow Road, Lansing, Mich. 48917.



A. 0.1 to 0.6 centimeter (0.04 to 0.24 inch)

B. 2 to 3 centimeters (0.8 to 1.2 inches)

C. Center of plastic sheet

1. #24 AWG
2. #26 AWG
3. #28 AWG
4. #30 AWG
5. #32 AWG

FIGURE 1. Test pattern.

5.2.2.

Each steel plate shall be 30×30 centimeters (11.8×11.8 inches) cold-rolled, low carbon steel (AISI 1015–1020) with thickness 0.634 ± 0.005 centimeter (0.240 ± 0.002 inch), as measured at any point more than 1 centimeter (0.4 inch) from an edge.

5.2.3.

Center the test pattern between the two steel plates and place the combination

flush with the face of the detector, with the plastic part of the test pattern closest to the detector.

5.2.4.

Place the x-ray tube head at the distance from the test pattern recommended in the operator's manual for 25×25 centimeter (10×10 inch) objects and irradiate the entire face of the detector using the exposure setting recommended in the manual. Produce a total of eight consecutive images.

5.3. Image Quality-Inherent Sensitivity Test

Repeat 5.2 without the steel plates.

5.4. Drop Tests

Remove the x-ray tube. Drop each of the regular carrying cases, containing the other components that make up the x-ray system, one time onto a concrete slab from a height of 75 ± 1 centimeters (29.5 ± 0.4 inches). Replace the x-ray tube before testing in accordance with 5.1 and 5.2.

5.5. Temperature Test

5.5.1.

Place the x-ray system, with the exception of any processing unit not attached to the main x-ray system, into a test chamber maintained at $60 \pm 2°$ C ($140 \pm 3.6°$ F) and 80–90 percent relative humidity for 4 hours. Change the conditions to $50 \pm 2°$ C ($122 \pm 3.6°$ F) and 80–90 percent relative humidity for 1 hour. Then, while maintaining this temperature and humidity, test in accordance with 5.2.

5.5.2.

Place the x-ray system, with the exception of any processing unit not attached to the main x-ray system, into a test chamber maintained at $-35 \pm 2°$ C ($-31 \pm 3.6°$ F) and 30–50 percent relative humidity for 4 hours. Change the conditions to $-18 \pm 2°$ C ($0 \pm 3.6°$ F) and 30–50 percent relative humidity for 1 hour. Then, while maintaining this temperature and humidity, test in accordance with 5.2.

5.5.3.

Repeat 5.5.1 and 5.5.2 for optional powered x-ray systems to test separately battery and line powered operation under temperature extremes.

5.6. Power Test

5.6.1. AC Voltage

5.6.1.1.

Apply ac line power to the x-ray system through an autotransformer having an output variable from 0 to 140 volts and a current rating as required by the x-ray system under test. Any voltage regulating device used with the x-ray system shall be connected between the variable autotransformer and the x-ray system under test.

5.6.1.2.

Monitor the autotransformer output voltage with an rms ac voltmeter having an accuracy of plus or minus 2 percent in the range of 100 to 130 volts.

5.6.1.3.

Adjust the output of the autotransformer to 105 volts. After at least 1 hour, check the voltage and readjust to 105 volts if necessary. Then immediately repeat the leakage radiation test (5.1) and the image quality-differential sensitivity test (5.2).

5.6.1.4.

Increase the voltage to 129 volts. After at least 1 hour, readjust the voltage

to 129 volts if necessary. Then immediately repeat the leakage radiation test (5.1) and the image quality-differential sensitivity test (5.2).

5.6.2. AC Current

Using an rms ac ammeter having plus or minus 5 percent accuracy, measure the ac current drawn by the x-ray system when the supply voltage is 129 volts and the x-ray tube assembly is actuated.

5.6.3. Battery Power

Install new or fully charged batteries of the type specified by the manufacturer. Operate the x-ray system until one-half of the manufacturer's stated useful time or number of pulses per battery charge remains. Then repeat the image quality-differential sensitivity test (5.2).

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