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Technology Assessment Program

Hand-Held Aerosol Tear Gas Weapons

NIJ Standard 0110.00

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ABOUT THE TECHNOLOGY ASSESSMENT PROGRAM

The Technology Assessment Program is sponsored by the Office of Development, Testing, and Dissemination of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which created NIJ and directed it to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

The Technology Assessment Program is an applied research effort that determines the technological needs of justice system agencies, sets minimum performance standards for specific devices, tests commercially available equipment against those standards, and disseminates the standards and the test results to criminal justice agencies nationwide and internationally.

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FOREWORD

This document, NIJ Standard-0110.00, Hand-Held Aerosol Tear Gas Weapons, is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Bureau of Standards. It is produced as part of the Technology Assessment Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment should meet to satisfy the needs of criminal justice agencies for high quality service. Purchasers can use the test methods described in this standard themselves to determine whether a particular piece of equipment meets the essential requirements, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements. Compliance with the requirements of the standard may be attested to by an independent laboratory or guaranteed by the vendor.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. For those who seek general guidance concerning the selection and application of law enforcement equipment, user guides have also been published. The guides explain in nontechnical language how to select equipment capable of the performance required by an agency.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Program Manager for Standards, National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to: Chief, Law Enforcement Standards Laboratory, National Bureau of Standards, Gaithersburg, MD 20899.

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NIJ STANDARD FOR HAND-HELD AEROSOL TEAR GAS WEAPONS

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COMMONLY USED SYMBOLS AND ABBREVIATIONS

A	ampere	H	henry	nm	nanometer
ac	alternating current	h	hour	No.	number
AM	amplitude modulation	hf	high frequency	o.d.	outside diameter
cd	candela	Hz	hertz (c/s)	Ω	ohm
cm	centimeter	i.d.	inside diameter	p.	page
CP	chemically pure	in	inch	Pa	pascal
c/s	cycle per second	ir	infrared	pe	probable error
d	day	J	joule	pp.	pages
dB	decibel	L	lambert	ppm	part per million
dc	direct current	L	liter	qt	quart
°C	degree Celsius	lb	pound	rad	radian
°F	degree Fahrenheit	lbf	pound-force	rf	radio frequency
diam	diameter	lbf·in	pound-force inch	rh	relative humidity
emf	electromotive force	lm	lumen	s	second
eq	equation	ln	logarithm (natural)	SD	standard deviation
F	farad	log	logarithm (common)	sec.	section
fc	footcandle	*M*	molar	SWR	standing wave ratio
fig.	figure	m	meter	uhf	ultrahigh frequency
FM	frequency modulation	min	minute	uv	ultraviolet
ft	foot	mm	millimeter	V	volt
ft/s	foot per second	mph	mile per hour	vhf	very high frequency
g	acceleration	m/s	meter per second	W	watt
g	gram	N	newton	λ	wavelength
gr	grain	N·m	newton meter	wt	weight

area = unit^2 (e.g., ft^2, in^2, etc.); volume = unit^3 (e.g., ft^3, m^3, etc.)

PREFIXES

d	deci (10^{-1})	da	deka (10)
c	centi (10^{-2})	h	hecto (10^{2})
m	milli (10^{-3})	k	kilo (10^{3})
μ	micro (10^{-6})	M	mega (10^{6})
n	nano (10^{-9})	G	giga (10^{9})
p	pico (10^{-12})	T	tera (10^{12})

COMMON CONVERSIONS
(See ASTM E380)

ft/s × 0.3048000 = m/s
ft × 0.3048 = m
ft·lbf × 1.355818 = J
gr × 0.06479891 = g
in × 2.54 = cm
kWh × 3 600 000 = J
lb × 0.4535924 = kg
lbf × 4.448222 = N
lbf/ft × 14.59390 = N/m
lbf·in × 0.1129848 = N·m
lbf/in^2 × 6894.757 = Pa
mph × 1.609344 = km/h
qt × 0.9463529 = L

Temperature: $(T_{°F} - 32) \times 5/9 = T_{°C}$

NIJ STANDARD FOR HAND-HELD TEAR GAS WEAPONS

1. PURPOSE AND SCOPE

This standard establishes minimum performance requirements and methods of test, including safety and handling aspects, for hand-held aerosol tear gas (less-than-lethal) weapons used by law enforcement agencies. These devices are used by law enforcement officers to incapacitate or distract one person or several whose behavior must be modified when the situation is not sufficiently dangerous to require the use of a firearm. The scope of this standard is limited to hand-held tear gas weapons that incorporate ortho-chlorobenzylidene malononitrile (CS) or alpha-chloroacetophenone (CN) as the active agent (lacrimator), sprayed from an aerosol dispenser.

2. CLASSIFICATION

For the purpose of this standard, hand-held aerosol tear gas weapons are classified by the physical characteristics of the material delivery.

2.1 Type I—Coherent Liquid Stream

A device that delivers a liquid stream from the nozzle, which may become an aerosol, either immediately or after traveling some distance through the air.

2.2 Type II—Fog

A device that delivers a very fine aerosol that behaves aerodynamically (i.e., as a cloud, traveling with air currents).

3. DEFINITIONS

3.1 Active Agent

The chemical constituent that is the lacrimator in a hand-held tear gas weapon.

3.2 Aerosol

A suspension of fine liquid or solid particles in air or gas, such as fog, mist, or smoke.

3.3 Aerosol Dispenser

A device in which a substance is packaged under pressure with a gaseous propellant in a container that permits release of the substance as an aerosol.

3.4 Inert Ingredients

The chemical constituents of the hand-held aerosol device that are not reactive in nature.

3.5 Lacrimator

A chemical that is an irritant upon contact with the eyes, causing blinding tears (CS, CN).

3.6 Less-than-Lethal

A controlled level of force used as an alternative to firearms, *not* intended to create a high risk of death or permanent injury. A less-than-lethal chemical agent (e.g., tear gas, whose active agent is classed as an irritant) is capable of rapidly producing a temporary and fully reversible incapacitating physiological reaction in humans, except under exceptional circumstances. Recovery should be fast and complete when an affected individual is removed from contact with it. No matter how discrete the use of an irritant agent is, there always exists some risk of injury or of a lethal exposure.

3.7 Lot

The lesser of:

1) All units of identical design constituting a single delivery from a manufacturer, all of which are from the same production batch.
2) All units of identical design continuously produced by a manufacturer without a change in batch number of agent, carrier, propellant, valve, or container.

3.8 Manufacturer

The manufacturer is the company whose name or brand name appears on the label of the device.

3.9 Tear Gas

See Lacrimator.

3.10 Tear Gas Weapon

A device intended for the propulsion of tear gas from a portable source of supply to or toward an intended target individual or group.

4. REQUIREMENTS

4.1 Acceptance Criteria

A hand-held aerosol tear gas device (hereafter referred to simply as device) shall meet all of the requirements of this standard.

4.2 Labeling and Workmanship

Five of five units selected at random from a lot shall conform to this requirement as determined by section 5.2; i.e., the label shall be legible and complete, and workmanship shall conform to standard machine practice.

4.2.1 Minimum Labeling on Device

The information supplied to the user by the manufacturer, in the form of legible labeling on the device itself, shall include:

1) Name and/or model number and serial number identifying the device.
2) Name and address of the manufacturer, and that of the company that assembled and/or filled the device, if other than the manufacturer.
3) The generic name of the active agent (CS or CN) with or without its chemical name. If a colored label is used it shall conform to the convention that indicates agent identity: blue for CS, red for CN.
4) Net weight in grams.
5) An expiration date corresponding to storage life at a maximum of 25 °C (77 °F) and 95 percent RH, under the assumption that the device will experience no extraordinary vibration or handling.
6) The number of 1-s bursts that the device can deliver.

4.2.2 Additional Information

The additional information supplied to the user by the manufacturer, on supplementary printed matter which shall accompany each device, shall include:

1) The device classification (i.e., type I or type II) based upon material delivery characterization, and for a device that delivers a coherent liquid stream (type I), range (see sec. 5.8.1) and the impact pattern at 1.5 m (see sec. 5.8.2).
2) The name and/or model number identifying the device.
3) The name and address of the manufacturer.
4) Instructions for use including any cautions to the user.
5) Minimum operating temperature.
6) First aid information, including instructions such as: Remove exposed individual to fresh air; face into wind with eyes open. Avoid rubbing eyes or scratching irritated skin. If necessary, flush affected body areas with *cool* water, especially eyes. After removal to fresh air, an incapacitated individual can normally be expected to recover completely in 15 min or so with no medical attention.
7) The quantity of active agent in grams and as percent of net weight; tare weight of container in grams; and gross weight in grams.
8) The identity of the inert ingredients, both carrier and propellant. The trademarked, generic or chemical name or chemical formula shall be given. Harmless impurities of less than 1 percent each, totaling less than 5 percent of the net weight, need not be listed.

4.3 Container Specifications

The manufacturer shall certify compliance of each device container with DOT Tariff 178.33, Specification 2P, or DOT Tariff 178.33a, Specification 2Q (Code of Federal Regulations, 49 CFR 178.33 or 49 CFR 178.33a).

4.4 Formulation

4.4.1 Agent Identity and Quantity

The net charge (agent, carrier, and propellant) of each type I and type II device shall be stated on the label. The concentration of active agent shall be 1 percent or less of the net weight. When tested in accordance with section 5.7.1, the agent identity shall agree with the labeling, and its concentration shall be within ±20 percent of the labeled value; the net weight shall conform to the labeled weight within ±20 percent. Five of five units shall conform to this requirement.

4.4.2 Inert Ingredient Identity

When tested in accordance with sections 5.7.2 and 5.7.3, the identity of the carrier and/or propellant of each type I and type II device shall be in agreement with the labeling on the device or on supplementary information that accompanies the device. Five of five units shall conform to this requirement.

4.5 Delivery Characterization

When a type I device is tested in accordance with section 5.8.1, the range shall agree with the labeling, and when tested in accordance with section 5.8.2, the discharge shall produce a pattern with a minimum diameter of 0.1 m (4 in) at a distance of 1.5 m. A type II device shall issue a visible cloud which shall persist for several seconds.

Four of five units shall conform to this requirement.

4.6 Number of 1-s Bursts

When tested in accordance with section 5.8.3, the number of 1-s bursts shall agree with the labeling within ±25 percent, with a minimum number of 10. Four of five units shall conform to this requirement, with no unit issuing less than half the number of labeled bursts.

4.7 Thermal Storage

When tested in accordance with section 5.9, following a 30-d period of storage at elevated temperature, each type I and type II device shall exhibit a weight loss of 2 percent or less; deliver a minimum of 75 percent of the average number of 1-s bursts recorded for devices not exposed to thermal storage; at least four of five devices shall assay within ±20 percent of the labeled agent quantity; and upon dissection, show no evidence of corrosion or deterioration.

4.8 Minimum Operating Temperature

When tested in accordance with section 5.10, at least four of five of the type I and type II devices shall function at −29 °C (−20 °F) or at the lowest operating temperature specified by the manufacturer, whichever is less.

4.9 Drop Test Requirement

When type I and type II devices are tested in accordance with section 5.11, following the required number of drops from a height of 1.5 m (4.9 ft), none of the five devices shall rupture or have its valve malfunction, causing a weight loss of more than 20 percent of the net contents. Four of five devices shall experience a weight loss of no more than 10 percent of the net weight, sustain no damage which renders normal handling or storage unsafe, and shall function normally when triggered.

4.10 Separable Housing Devices—Special Requirement

Devices having an outer housing separable from the pressurized agent container, whether intended to give dual capability (e.g., nightstick, flashlight, etc.) or not, will be exposed to all tests with outer housing in place. In cases where configuration prevents attachment to test fixtures (e.g., long nightsticks), nonaerosol-related structures may be altered at the discretion of the test administrator.

5. TEST METHODS

Caution: These tests are to be conducted only by persons familiar with the materials and precautions involved. Some of these tests would be hazardous if performed without proper training or facilities.

5.1 Test Specimens

A total of 30 test specimens, selected at random from a single lot, are required to conduct the tests that follow.

5.2 Physical Inspection

Inspect five units and manufacturer-provided user information for compliance with sections 4.2 and 4.3 of this standard.

5.3 Test Conditions

Unless otherwise stated, all tests shall be performed under laboratory conditions, i.e., at ambient atmospheric pressure and room temperature [approx 20 °C (68 °F)].

5.4 Instrumentation and Miscellaneous Equipment

The following items are necessary to perform the required tests:

a) Gas chromatograph(s) equipped with thermal conductivity or flame ionization detector.
b) A recorder or similar device to obtain a record of each chromatogram.
c) A suitable device or method for obtaining areas under the gas chromatographic peaks.
d) Vacuum sampling bottles (250 mL).
e) Volumetric pipets and flasks.
f) Hacksaw and/or metal shears.
g) Can-piercing valve with gas-tight septum.

h) Microsyringes.
i) Chemicals, best purity available.
j) CS and CN of known purity.
k) Vacuum pump.
l) Various carriers and propellants of known chemical purity.
m) Environmental chamber(s) capable of maintaining −29±2 °C (−20±3.6 °F) for 6 h and 55±2 °C (131±3.6 °F) for 30 d.
n) Laboratory balances capable of weighing devices $\geqslant$100 g to an accuracy of ±0.1 g and devices $<$100 g to an accuracy of ±0.01 g.
o) A mechanical or electromechanical timer that will control the test specimen actuator so the device will issue bursts of 1.0±0.1 s.

5.5 Preliminary Measurement

Prior to conducting the tests that follow, weigh each of the 30 test specimens as received from the manufacturer. Devices with a gross weight $\geqslant$100 g shall be reported to the nearest 0.1 g and those $<$100 g shall be reported to the nearest 0.01 g.

5.6 Constituent Sampling

Select five test specimens at random. Affix a can-piercing valve with septum to the side of the container of each device, and collect a 0.1-mL specimen of the gas from each using a gas-tight syringe. Inject each 0.1-mL sample into a separate evacuated 250-mL gas sampling bottle and retain the five samples for subsequent analysis in accordance with sections 5.7.2 and 5.7.3.

After collecting propellant samples, slowly depressurize the container of each sample device by completely venting the headspace gas through the can-piercing valve.

As an alternative to venting the headspace gas through the can-piercing valve, the entire device can be frozen in a liquid nitrogen bath and the contents can then be removed by dissecting the container with a hacksaw or metal-cutting shears. If the contents will freeze at a temperature of −76 °C (−105 °F), a dry ice-alcohol bath may be used. The contents of each container should be immediately placed in a covered Petri dish of known weight and placed in a chemical fume hood for a short time to allow the volatile vehicle (carrier/propellant) to evaporate at room temperature. When evaporation is complete, weigh the Petri dish to the accuracies stated in section 5.5 and calculate the net weight of the remaining constituents.

If the propellant has been removed from the container by venting, the container should simply be dissected and the contents removed to a covered Petri dish of known weight to enable determination of the net weight of the residual constituents.

Once the residual constituents have been removed from each container, the container parts shall be weighed, and the net weight of the container charge calculated as the difference between the gross and empty container weights.

Note whether the net weight of the total container contents agrees with that stated by the manufacturer to within ±20 percent.

5.7 Chemical Assay

The chemical analysis of the constituents of the devices shall be performed by gas-liquid chromatographic techniques.

5.7.1 Agent

Either a thermal conductivity or flame ionization detector is recommended. Operating parameters and detection sensitivities will depend on the particular gas chromatograph and detector combination. Recent publications give the following gas chromatographic conditions for analysis of CS and CN:

A. Column: 1.8-m glass column packed with 3 percent OV-101 on 80–100 mesh Supelcoport.

Column Temperature: Programmed from 150 to 250 °C over a 5-min period and held at 250 °C for 5 min [1] [1].

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[1] Numbers in brackets refer to the references in appendix A.

B. Column: 1-m by 2-mm i.d. glass column packed with 2 percent OV-17 coated on Supelcoport acid washed-dimethyldichlorosilane (AW-DMCS) (100–120 mesh).

Column Temperature: Programmed from 100 to 270 °C at 15 °C/min.

Detector Temperature: 260 °C [2].

Dissolve a weighed sample of CS or CN of known purity, as appropriate for the device under test, in a suitable solvent and dilute the solution serially to yield three standard solutions spanning the concentration range of interest, based upon the manufacturer-stated net weight of contents and agent concentration. A suitable internal standard may be used to obtain results of greater precision. At least two syringe injections of each of the three standards are then run on the gas chromatograph and the average area responses are plotted vs. the concentration (mg/mL or μg/mL) of agent, corrected to 100 percent purity. This calibration curve is used in determining the quantity of active agent.

Following calibration of the chromatograph, weigh an appropriate sample of the residue from each test specimen and dissolve each sample in an appropriate volume of solvent, using serial dilution if necessary, to obtain a final solution concentration in the range of the calibration curves. Record all dilution factors.

Perform the gas chromatographic analyses of each test specimen in the same manner as for the calibration standards. Use the calibration curve to determine the percent by weight of the agent, taking into account the weight of the test sample and the serial dilution factors.

Calculate the total weight of active agent in the residue of each device as the product of the percent by weight of the active agent and the total weight of the residual constituents of the device as determined in section 5.6.

Divide the total weight of the active agent of each device by the calculated net weight of the contents (sec. 5.6) and multiply by 100 to determine the percent of active agent in the contents of the device. Note whether the concentration of the active agent (%w/w) agrees with that stated by the manufacturer.

5.7.2 Propellant

The propellants used in the devices typically include N_2, CO_2, or propane. Determine the chemical composition of the propellant constituent from the information provided by the manufacturer (sec. 4.1). Obtain a sample of the stated propellant gas of known purity. Select a chromatograph column and a detector (flame ionization or electron capture), appropriate for use with that gas, and determine the retention time of the standard gas using standard chromatograph calibration procedures.

Next, inject a sample from each of the specimens retained in the five 250-mL gas sample bottles into the chromatograph and determine the retention time and peak patterns under conditions of operation identical to those used to obtain the standard chromatogram. Note whether the propellant is the chemical stated by the manufacturer.

5.7.3 Carrier

The carriers used in the devices typically include dichlorodifluoromethane (Freon-12), chlorodifluoromethane (Freon-22), methylene chloride, 1,1,2-trichlorotrifluorethane (Freon-TF), or 1,1,1-trichloroethane. Determine the chemical composition of the carrier constituent from manufacturer-provided information (sec. 4.2). Obtain a sample of the stated carrier of known purity. Select a chromatograph column and detector appropriate to the carrier chemical, and determine the retention time of the standard sample using standard chromatograph calibration procedures.

Inject samples collected from each device in accordance with section 5.6 into the chromatograph and determine the retention time under conditions of operation identical to those used to obtain the standard chromatogram. Note whether the carrier is the chemical stated by the manufacturer.

5.8 Firing Tests

5.8.1 Range Test

Mount the device on a test stand such as shown in figure 1 and connect a solenoid actuator to a timing device that meets the requirements of section 5.4. (An electronic photographic timer is suitable, or a cam-actuated microswitch driven by a low-rpm synchronous motor can be used.) Place type I test devices, mounted

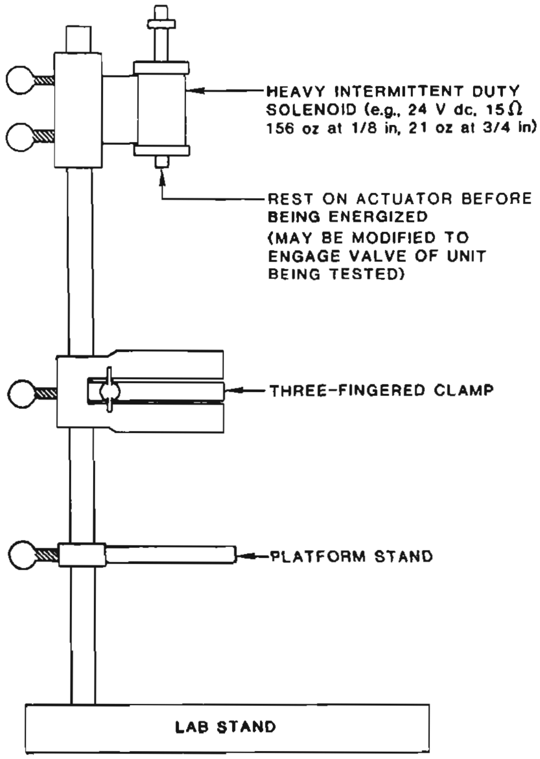

FIGURE 1. *Aerosol device test stand.*

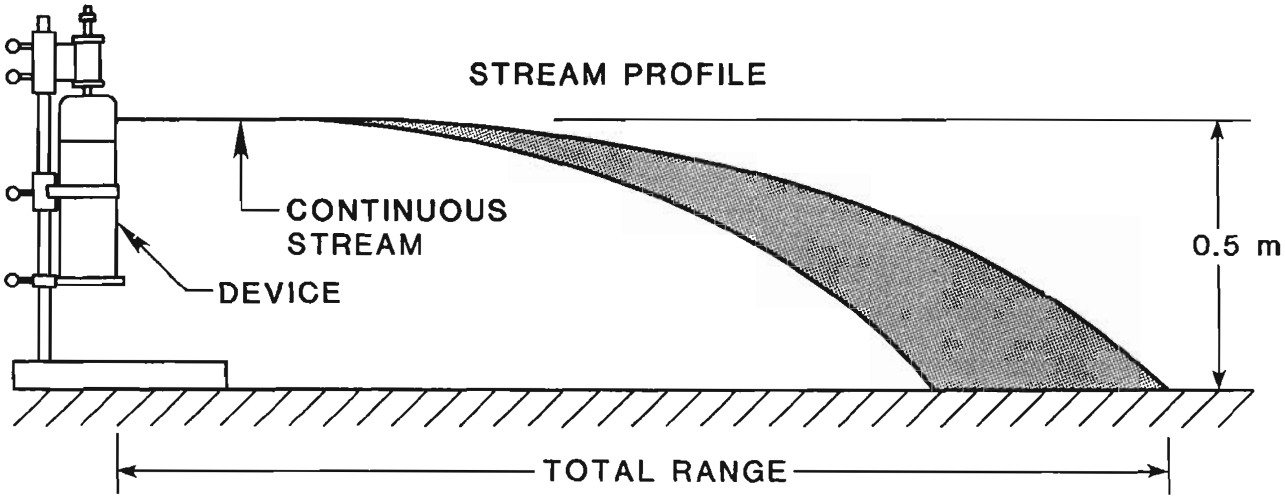

FIGURE 2. *Test range.*

on the test stand, in a test range as shown in figure 2. Use the timing devices to fire 1-s bursts from the device, while counting the number of bursts, until a consistent range measurement to the nearest 0.25 m has been observed.

For type II devices, conduct the test described above, noting whether the device produces a fine aerosol fog or mist that persists and remains visible for several seconds, with no attempt to determine the delivery range.

Repeat this test for each of the required five test specimens.

5.8.2 Impact Pattern (Type I Devices Only)

Following completion of the tests described in section 5.8.1, the device still mounted on the test stand shall be placed in a test range as shown in figure 2. At 1-min intervals, fire 1-s bursts against a paper target as shown in figure 3 and measure the impact pattern (fig. 4) to the nearest 0.5 cm. Again, maintain a record of the number of 1-s bursts fired during this test.

Repeat the above test for each of the required five test specimens.

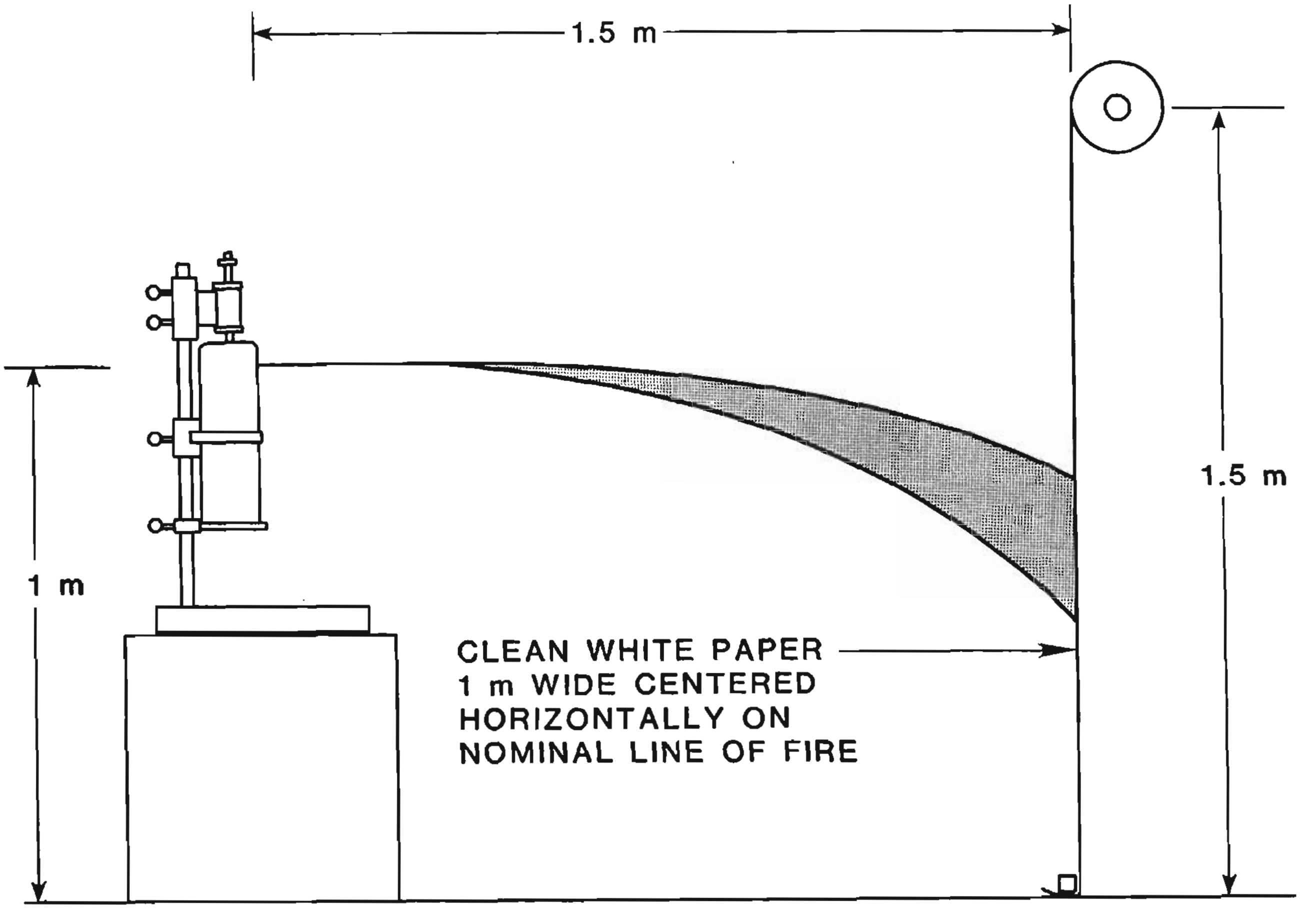

FIGURE 3. *Impact pattern test.*

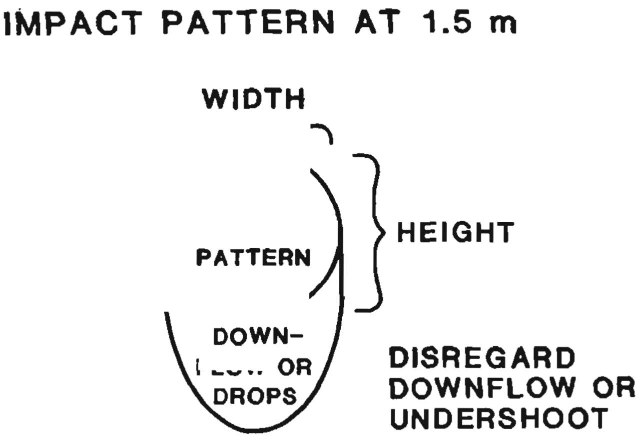

FIGURE 4. *Impact pattern measurements.*

5.8.3 Number of 1-s Bursts

Following the completion of the tests described in sections 5.8.1 and 5.8.2, as appropriate for the device under test, use the timing device to fire 1-s bursts, at 1-min intervals, until the visible spray is interrupted. Agitate the device as needed, if recommended by the manufacturer, and resume firing 1-s bursts until no additional product or gas is expelled. Record the total number of 1-s bursts, including those accumulated in sections 5.8.1 and 5.8.2. Note whether the total number of 1-s bursts is in agreement with that stated by the manufacturer (sec. 4.2.1).

Repeat this test for each of the five required test specimens.

5.9 Thermal Storage Test

Place the 10 required test specimens in a chamber meeting the requirements of section 5.4 and store the devices at a controlled temperature of 55 °C (131 °F) for a period of 30 d. Inspect the device periodically, at least once a week, throughout the storage period for any evidence of deterioration or leakage.

At the end of the 30-d high temperature storage, the 10 devices shall be allowed to cool to ambient temperature. Weigh each device to the accuracies specified in section 5.5, and calculate the percent weight loss, if any.

Subject five of the test devices to the tests specified in section 5.8.3, and note the number of devices that deliver a minimum of 75 percent of the average number of 1-s bursts as determined previously by testing in accordance with section 5.8.3.

Subject the remaining five test devices that have been subjected to thermal storage to the active agent analysis as described in section 5.7.1. Examine each of the five devices, following dissection, for any evidence of corrosion or deterioration.

5.10 Minimum Operating Temperature

Place the required five test specimens in a chamber meeting the requirements of section 5.4, and adjust the temperature to −29 °C (−20 °F), or the minimum operating temperature specified by the manufacturer (sec. 4.2.2), whichever is lower. Allow the test specimen to equilibrate at the test temperature, and store at that temperature for a period of 6 h. Immediately following the storage at low temperature, remove the devices from the chamber one at a time, inspect for any evidence of thermal damage, and then operate the devices as specified by the manufacturer. Note any malfunctions that occur during operation.

5.11 Drop Test

Each of the five test specimens shall be dropped one time in each of five orientations: 1) base down, 2) top down with main axis of the device vertical to impact surface, 3) main axis of the device horizontal to impact surface, 4) base down with main axis of the device at an angle of 45° to the impact surface, and 5) top down with main axis of the device at an angle of 45° to the impact surface.

In all cases, the device shall be dropped from a height of 1.5 m (as measured from the bottom edge of the device to the impact surface) and allowed to strike a smooth concrete slab 10-cm (4 in) thick, or a concrete floor. A suitable protective barrier shall be installed between the test fixture and the test personnel.

Any suitable release system or guide may be employed, to ensure that the test specimen is dropped at the appropriate test angle, so long as it does not interfere with the free fall of the device under test.

Following the drop tests as described above, each device shall be weighed to the accuracies required by section 5.5, to determine loss of contents as a percent of gross weight, and inspected for physical damage. Each device shall then be operated to determine whether it continues to function in a normal manner.

APPENDIX A—REFERENCES

[1] Nowicki, J. Analysis of chemical protection sprays by gas chromatography/mass spectroscopy. J. Forensic Sci. 27(3): 704–709; 1982 July.

[2] Martz, R. M., Reutter, D. J., and Lasswell, L. D., III. A comparison of ionization techniques for gas chromatography/mass spectroscopy analysis of dye and lachrymator residues from exploding bank security devices. J. Forensic Sci. 29(1): 200–207; 1983 January.

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