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# Standard Specification for Ruggedness Requirements for HAZMAT Instrumentation[1]

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## 1. Scope

1.1 This specification describes the ruggedness requirements for equipment used during Hazardous Material (HAZMAT) operations. The conditions defined by this specification include those related to equipment storage, transport, and field use.

1.2 This specification does not address passive personal protective equipment (PPE) such as respirators and protective suits.

1.3 The equipment addressed by this specification includes devices used to detect or monitor for hazardous material.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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. When using a HAZMAT instrument, follow the manufacturer's guidance and appropriate safety practices for the threat expected or suspected in the environment where the instrument will be used.*

## 2. Referenced Documents

2.1 *NFPA Standard:*[2]

National Fire Protection Association (NFPA) 1994, 2007 Edition Cold Temperature: -25°C (-13°F)

2.2 *ANSI Standards:*[3]

NA42.32 American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security

N42.33 American National Standard for Portable Radiation Detection Instrument for Homeland Security

N42.34 American National Standard for Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides

N42.35 American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security

2.3 *IEC Standards:*[4]

IEC 60068-1 Environmental Testing—Part 1: General and Guidance

IEC 60068-2-18 Environmental Testing—Part 2-18: Tests—Test R and Guidance: Water

IEC 60068-2-75 Environmental Testing—Part 2-75: Tests—Tests Eh: Hammer Tests.

IEC 60529 Degrees of Protection Provided by Enclosures (International Protection Rating or IP Code)

IEC 61000-4-1 Electromagnetic Compatibility (EMC)—Part 4-1: Testing and Measurement Techniques—Overview of IEC 61000-4 Series

IEC 61000-4-2 Electromagnetic Compatibility (EMC)—Part 4-2: Testing and Measurement Techniques—Electrostatic Discharge Immunity Test

IEC 61000-4-3 Electromagnetic Compatibility (EMC)—Part 4-3: Testing and Measurement Techniques—Radiated, Radio-Frequency, Electromagnetic Field Immunity Test

2.4 *Underwriters Laboratories:*[5]

UL 2075 Gas and Vapor Detectors and Sensors

2.5 *Federal Standard:*[6]

MIL-Standard 810 Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests

2.6 *Code of Federal Regulations:*[7]

CFR Telecommunications Chapter 1, Rule 15 Unintentional Radiators

[1] This specification is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.01 on CBRNE Sensors and Detectors.

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[2] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland, http://www.iec.ch.

[5] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

[6] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

[7] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol st., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov..

## 3. Terminology

3.1 *Definitions:*

3.1.1 *body-worn*—a HAZMAT instrument that typically weighs no more than 5.4 kg [12 lb] and is no larger than 65 cm (sum of the sides).

3.1.2 *hand-carried*—a HAZMAT instrument that typically weighs no more than 2.3 kg [5 lb] and is no larger than 40 cm (sum of the sides).

3.1.3 *installed*—a HAZMAT instrument that is permanently mounted at a location.

3.1.4 *mobile*—a HAZMAT instrument that is larger than a man-portable, which is mounted to a mobile device to permit relocation of the instrument as necessary for monitoring of HAZMAT. The instrument may be operational while in motion.

3.1.5 *portable*—a HAZMAT instrument that physically weighs no more than 16 kg [35 lb] and is no larger than 120 cm (sum of the sides).

3.1.6 *transportable*—a HAZMAT instrument that typically weighs no more than 22.7 kg [50 lb] and is no larger than 200 cm (sum of the sides).

3.2 A summary of the above can be found in Table 1.

## 4. Purpose

4.1 The purpose of this specification is to define for design and test purposes the environment in which HAZMAT equipment will likely be exposed during storage, transportation, and use. The environments addressed by this specification are related to equipment that are typically man-portable, body worn, hand carried, transportable, mobile, or installed. This could include extremes that range from mid-winter Alaska to mid-summer Death Valley environments.

## 5. Materials and Manufacture

5.1 Materials resistant to extremes of temperature should be used in the manufacture of HAZMAT instrumentation.

5.2 Materials used in the manufacture of body-worn and hand-carried equipment must not support combustion. They should be self extinguishing if they do get hot enough to combust.

5.3 Materials used in the manufacture of body-worn and hand-carried equipment must not flow when melted.

## 6. Physical Properties

6.1 HAZMAT instrumentation should be built from strong, inert, weather-resistant materials with rugged finishes to withstand prolonged use in very harsh environments.

**TABLE 1 HAZMAT Instrumentation Size and Weight**

| Instrument Type | Maximum Weight in kg/lb | Maximum Size[A] Sum of Sides in cm |
|---|---|---|
| Portable | 16/35 | 120 |
| Body-Worn | 5.4/12 | 65 |
| Hand-Carried | 2.3/5 | 40 |
| Transportable | 22.7/50 | 200 |
| Mobile | No Limit | No Limit |
| Installed | No Limit | No Limit |

[A]Not including attachments such as handles, nipples, filter cartridges, and hoses.

6.2 HAZMAT instrumentation should resist the effects from and remain operational when exposed to the following:

6.2.1 Saltwater, when used in coastal environments.

6.2.2 Temperatures as stated in Table 2 and Table 3, both natural and man-made.

6.2.3 Acidic chemicals found during fires and accidents.

6.2.4 Caustic chemicals found during fires and accidents.

## 7. Mechanical Properties

7.1 Mechanical components of HAZMAT instrumentation shall be constructed so that they remain operational in their intended environment of use.

7.2 HAZMAT instrumentation shall be constructed so that they remain operational when exposed to the following conditions:

7.2.1 Impacts from use and transport.

7.2.2 Transport vibration.

7.2.3 Expansion or contraction due to hot or cold temperatures.

7.2.4 Corrosion from harsh environments, that is, salt mist.

## 8. Performance Requirements

8.1 There is a broad spectrum between the different environmental conditions equipment are exposed to during storage and use. Refer to Table 2 for specific environmental conditions for each category of HAZMAT instrumentation.

8.1.1 HAZMAT equipment shall be operable in rain, humidity, heat, and cold at the levels defined in this specification. Environments could also include smoke, toxic chemicals (for example, chlorine, ammonia), caustic chemicals, and extreme heat. Meeting these requirements shall be by agreement between the manufacturer and the user.

8.1.2 Body-worn HAZMAT equipment should endure firefighter environments (heat, water, smoke, cold) on a regular basis.

8.1.3 Storage of HAZMAT equipment varies widely. Some agencies store their HAZMAT equipment inside a temperature controlled area while others use trucks or containers located in uncontrolled environments.

NOTE 1—Agencies surveyed regarding temperature and temperature shock to HAZMAT equipment almost all agree that -30 to 120°F is an appropriate operating range. This temperature range also encompasses most of the extreme temperatures the equipment would be exposed to during storage. Equipment used by firefighters could very easily be exposed to high temperatures of +165°F or more during a fire.

8.1.4 Most HAZMAT detection equipment requires a warm up and stabilization period prior to use. The manufacturer shall state the time required for the system to become operational.

8.2 *Operator Interface:*

8.2.1 Displays and interfaces shall be designed to remain operational during expected conditions of use.

8.2.2 Displays shall be visible in bright sunlight (>10 000 lux) or low light (<150 lux) conditions as required by the user. A useful feature is an LCD that will automatically adjust contrast based on ambient lighting.

8.2.3 Users wearing thermal gloves or those gloves typically worn by firefighters should be able to manipulate controls as needed.

**TABLE 2 Environmental Conditions**

| Equipment Type | Storage | Transport | Use |
|---|---|---|---|
| Portable | Temperature (controlled and uncontrolled), Humidity (condensing and non-condensing), Mold | Mechanical shock, vibration (vehicle-based), temperature shock, condensing moisture, rain, electrostatic discharge, microphonics | Person-based shock and vibration, electrostatic discharge, magnetic field, wide range temperature (-30 to 120°F), rain, radio frequency (RF), emissions, relative humidity (RH), dust, condensing moisture, temperature shock, microphonics |
| Body-Worn | Temperature (controlled and uncontrolled), Humidity (condensing and non-condensing), Mold | Mechanical shock, vibration (vehicle based), temperature shock, condensing moisture, rain, electrostatic discharge, microphonics | Person-based shock and vibration, electrostatic discharge, magnetic field, wide range temperature (-30 to 120°F), rain, RF emissions, RH, dust, condensing moisture, temperature shock, microphonics |
| Hand-Carried | Temperature (controlled and uncontrolled), Humidity (condensing and non-condensing), Mold | Mechanical shock, vibration (vehicle based), temperature shock, condensing moisture, rain, electrostatic discharge, microphonics | Hand-carried shock and vibration, electrostatic discharge, magnetic field, wide range temperature (-30 to 120°F), rain, RF emissions, RH, dust, condensing moisture, temperature shock, microphonics |
| Transportable | Temperature (controlled and uncontrolled), Humidity (condensing and non-condensing), Mold | Mechanical shock, temperature change, condensing moisture, microphonics, rain, jetted water, vehicle based vibration. | Installed equipment shock and vibration, power variations, conducted RF, RF susceptibility, line noise, temperature, RH, rain, jetted water for cleanup, dust |
| Mobile | Temperature (controlled and uncontrolled), Humidity (condensing and non-condensing), Mold, Rain | Mechanical shock, temperature change, condensing moisture, microphonics, rain, jetted water, vehicle based vibration | Vehicle based shock and vibration (platform dependent), RF, power variations, temperature, RH, rain, jetted water, dust |
| Installed | N/A | N/A | Low levels vibration, RF susceptibility, line noise, power quality, temperature, RH, rain, jetted water (orientation specific for rain and jetted water) |

**TABLE 3 Field Use Temperature Requirements**

| Use Environment | Temperature Range |
|---|---|
| Portable | -34 to +55°C [-30 to +131°F] |
| Body-Worn | -34 to +49°C [-30 to 120°F] |
| Hand-Carried | -34 to +49°C [-30 to +120°F] |
| Transportable | -34 to +55°C [-30 to +131°F] |
| Mobile | -34 to +55°C [-30 to +131°F] |
| Installed in uncontrolled environment | -34 to +55°C [-30 to +131°F] |
| Installed in controlled environment | +5 to +40°C [+41 to +104°F] |

8.3 *Audible Alerts/Alarms:*

8.3.1 Audible alerts and alarms shall be designed to remain operational during expected conditions of use (temperature, moisture, etc.).

8.3.2 For hand-held or body-worn equipment, the frequency of an audible indication should be within the range of 1000 to 4000 Hz and have a volume at a distance of 30 cm from the emission source (instrument, remote speaker) of at least 85 dB (A) and shall not exceed 100 dB (A).

8.3.3 For other devices, volume and frequency requirements shall be by agreement between the manufacturer and the user.

## 9. Environmental Requirements

9.1 *Ambient Temperature:*

9.1.1 *Field-Use:*

9.1.1.1 The manufacturer shall state the field-use temperature range. Table 3 provides temperature ranges for each instrument type based on expected usage environments. The ranges stated shall be used unless otherwise required by the user, such as firefighters who may require and upper temperature limit of 74°C [165°F].

9.1.1.2 The manufacturer shall state the temperature range for displays or user interface components intended for use in weather-protected locations.

9.1.1.3 Verification testing should be done using a temperature change rate of not more than 10°C/h with a minimum of 2 h exposure at each temperature extreme. The equipment being tested should remain operational during the entire test.

9.1.2 *Storage:*

9.1.2.1 Unless otherwise stated, equipment shall be able to withstand long-term storage over a temperature range from -40 to +71°C [-40 to 160°F].

NOTE 2—Certain equipment may be stored in more extreme temperature climates (that is, an enclosed container located in the desert). These conditions will require different temperature limits such as +85°C [185°F].

9.1.2.2 If specific components may be damaged by exposure to the stated temperature range, they should be stored separately. This information shall be provided by the manufacturer.

9.1.2.3 Verification testing should be performed with the equipment unpowered. The temperature change rate should be 10°C/h with a 24-h exposure to the low temperature set point and a 2-h exposure for the high temperature set point.

9.2 *Temperature Shock:*

9.2.1 It is expected that only hand-carried and body-worn equipment will be exposed to rapid temperature changes. Installed, portable, mobile, and transportable equipment typically have a relatively large mass, meaning that thermal change, even when the temperature change is rapid, is relatively slow.

9.2.2 For hand-carried and body-worn equipment, the manufacturer shall provide the time required for the instrument to become fully functional following exposure to a change in temperature from a controlled environment (typically ~22°C [72°F]) to either the high or low temperature limit (Table 3) or from the high or low temperature limit to a temperature associated with a controlled environment. For testing purposes,

the temperature change shall take place over a period of 5 min. The recovery time after each temperature change should be no more than 15 min.

9.3 *Relative Humidity (RH):*

9.3.1 Equipment designed to operate in uncontrolled environments shall be able to function at RH levels of up to 95 % over the temperature range from 5°C [41°F] to the upper temperature limit as stated by the manufacturer and required based on the application of use as stated in this specification.

9.3.2 Verification testing shall be performed to ensure the equipment remains operational during and after exposure to RH levels of up to 93 % RH at an ambient temperature of +35°C [95°F].

NOTE 3—93 % RH is used for test purposes due to the limitations of humidity sensors.

9.4 *Condensing Moisture:*

9.4.1 HAZMAT equipment for use in uncontrolled environments shall be designed to withstand condensing moisture. This requirement is typically verified through the performance of tests where the temperature is cycled while the RH level is elevated. The upper temperature setting should be based on the upper operational temperature value with the lower temperature being typically no less than 21°C [70°F]. There shall be no ingress of moisture and the device shall function normally throughout the exposure.

9.5 *Moisture and Dust Protection:*

9.5.1 *Design Requirements:*

9.5.1.1 HAZMAT equipment designed for use in an unprotected environment where water will only be splashed (usage platform is not mobile) shall meet the requirements stated for IP code 54 (ingress of dust and splashing waste). For IP 54, the ingress of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with satisfactory operation of the equipment or to impair safety, and water splashed against the enclosure from any direction shall have no harmful effects.

9.5.1.2 If the equipment is mounted to the exterior of a vehicle or other platform that can be transported, the enclosure shall meet IP 55 requirements (no damage by jetted water).

9.5.1.3 Equipment that could be exposed to salt mist shall be designed to prevent the ingress of salt. Components expected to be exposed shall be manufactured using materials that resist corrosion. Verification of compliance involves exposing the equipment to cyclic testing that includes heat, salt mist, and drying.

9.6 *Electrical and Electromagnetic Performance Requirements:*

9.6.1 *Radio Frequency (RF):*

9.6.1.1 All equipment that does not use interconnecting cables of at least 1 m in length should be resistant to RF fields over the frequency range of 80 to 2500 MHz at an intensity of 10 volts per metre (V/m).

9.6.1.2 Non body-worn equipment should be resistant to RF fields over the frequency range of 80 to 2500 MHz at an intensity of 10 V/m.

9.6.1.3 Body-worn equipment, because they could be used in close proximity to radio transceivers, may be exposed to higher RF intensities. The field intensity from 80 to 1000 MHz is 50 V/m.

NOTE 4—HAZMAT equipment may be exposed to radio frequency fields from 2 to 5 watt radios and other equipment over frequencies from 50 to 800 MHz. Other devices operating in the ISM bands of approximately 900 MHz and 2.4 GHz may also be used. It is recommended that a frequency range from 80 to 2500 MHz be used for all equipment that do not use interconnected cables of at least 1 m in length.

9.6.2 *Radiated Emissions:*

9.6.2.1 HAZMAT equipment should not interfere with other devices located nearby. To prevent this from occurring, unintentional RF emissions when measured at 3 m shall be less than what is shown in Table 4.

9.6.3 *Electrostatic Discharge (ESD):*

9.6.3.1 HAZMAT equipment shall be unaffected by exposure to electrostatic discharges at intensities of up to 6 kV using the contact discharge technique. The verification technique involves placing the ESD test probe in contact with portions of the equipment that are accessible by the user (that is, switches, buttons, etc.).

9.6.4 *AC Line Powered Equipment Requirements:*

9.6.4.1 Equipment capable of operating from line power shall function normally if the line voltage varies by ±12 % of the nominal voltage and ±3 % for frequency.

9.6.5 *Conducted Disturbances Induced by Bursts and Radio Frequencies:*

9.6.5.1 Equipment that use an external conducting cable of at least 1 m in length shall be unaffected by RF fields over the frequency range of 150 kHz to 80 MHz at an intensity of 10 V/m.

9.6.5.2 Immunity is verified by exposing the device to a conducted RF field over the frequency range of 150 kHz to 80 MHz at an intensity of 140 dB (μV) 80 % amplitude modulated with a 1 kHz sine wave.

9.6.6 *Surges and Oscillatory Waves:*

9.6.6.1 Line powered equipment should not be affected by surges or oscillatory waves of up to 2 kV in amplitude that are classified as "combination waves" (damped surges) with rise/decay times of 1.2/50 μs (open-circuit voltage waveform) and 8/20 μs (short-circuit current waveform) or "ring waves" (single-shot oscillatory transients or non-repetitive damped oscillatory transients) with 0.5 μs rise time and 100 kHz oscillation frequency.

9.7 *Mechanical Conditions:*

9.7.1 *Microphonics/Impact:*

9.7.1.1 *Hand-Carried and Body-Worn*—The equipment shall be unaffected by microphonic conditions such as those that may occur from low intensity sharp contacts at energies of up to 0.2 J.

**TABLE 4 Emission Levels**

| MHz | Field Strength (micro volts/metre) |
|---|---|
| 30 to 88 | 100 |
| 88 to 216 | 150 |
| 216 to 960 | 200 |
| >960 | 500 |

9.7.2 *Vibration:*

9.7.2.1 *Installed Operations:*

*(1)* Installed equipment shall function normally after exposure to conditions associated with truck transportation over U.S. highways for two-wheeled trailers and wheeled vehicles. The limits are taken from MIL-STD 810F, Category 4 and are shown in Table 5.

*(2)* The physical condition of the device should not be affected by exposure (for example, solder joints shall hold, nuts and bolts shall not come loose).

9.7.2.2 *Mobile Operations*—Equipment should function normally during exposure to the vibration environments shown in Table 5.

9.7.2.3 *Hand-Carried or Body-Worn*—The equipment shall function normally while being subjected to a random vibration at 0.01 $g^2$/Hz (spectral density) using a 5 and 500 Hz for the frequency endpoints. This exposure represents conditions expected during hand-carried or body-worn activities.

9.7.3 *Mechanical Shock:*

9.7.3.1 *Installed*—Non-installed HAZMAT equipment shall function normally after exposure to 30 g mechanical shocks in the vertical direction with the device positioned as it would be mounted in the field. The physical condition of the monitor should not be affected by exposure (for example, solder joints shall hold, nuts and bolts shall not come loose).

9.7.3.2 *Portable, Hand-Carried, and Body-Worn*—HAZMAT equipment shall function normally during exposure to ten shock pulses of 50 g peak acceleration, each applied for a normal 18 ms in each of three mutually orthogonal axes. The physical condition shall not be affected by these shocks (for example, solder joints shall hold, nuts and bolts shall not come loose).

**TABLE 5 Information from Table 514.5c-VII Break Points for Curves of Figures 514.5C-1**

| Vertical | | Transverse | | Longitudinal | |
|---|---|---|---|---|---|
| Hz | $g^2$/Hz | Hz | $g^2$/Hz | Hz | $g^2$/Hz |
| 10 | 0.01500 | 10 | 0.00013 | 10 | 0.00650 |
| 40 | 0.01500 | 20 | 0.00065 | 20 | 0.00650 |
| 500 | 0.00015 | 30 | 0.00065 | 120 | 0.00020 |
| | | 78 | 0.00002 | 121 | 0.00300 |
| | | 79 | 0.00019 | 200 | 0.00300 |
| | | 120 | 0.00019 | 240 | 0.00150 |
| | | 500 | 0.00001 | 340 | 0.00003 |
| | | | | 500 | 0.00015 |
| 1.04 | g RMS | 0.204 | g RMS | 0.740 | g RMS |

## 10. Dimensions, Mass, and Permissible Variations

10.1 HAZMAT instrumentation, to be usable by an individual wearing PPE such as cold weather gear or firefighters turnout gear must be of a size to permit comfortable handling and operation while wearing this gear. Instrumentation must be lightweight, moderate in size, or have a grasping surface or handle.

10.2 Handles shall be designed such that an individual with cold weather or firefighter-type protective gloves shall be able to easily hold the instrument by the handle.

10.3 HAZMAT instrumentation shall be no smaller than 8 cm in length and width nor thinner than 5 cm.

## 11. Workmanship, Finish, and Appearance

11.1 The quality of the HAZMAT instrumentation should be reflected in its appearance. Readouts, labels, and exterior instructions should be of high professional quality.

11.2 View screen cover glass should have a mat finish to reduce glare.

11.3 Cases for HAZMAT instruments shall have the following construction features:

11.3.1 Be of rigid construction to the extent possible.

11.3.2 Have minimal openings and those necessary openings be closed and sealed when not in use to preclude internal exposure to environmental insults.

11.3.3 All access points such as battery compartments and component attachment points have a gasket seal.

11.3.4 Smooth finish to facilitate decontamination and cleaning.

## 12. Keywords

12.1 body-worn; hand-carried; HAZMAT; installed; instrumentation; mobile; portable; ruggedness; transportable