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# Standard Guide for Acquisition, Maintenance, Storage, and Use of Hazardous Material Detection Instrumentation[1]

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## INTRODUCTION

In today's environment there exists a serious, potential threat to the public and the safety personnel that protect them. This threat comes from chemicals, gases, biological agents, radiation, and explosive materials. In order for Safety officials to mitigate this threat, instrumentation designed to detect and measure their potential to inflict harm must be acquired, maintained, and used in a pre-defined manner.

## 1. Scope

1.1 This guide provides techniques that can be used to ensure the proper operation and use of Hazardous Material detection equipment. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances.

1.2 This guide is not intended to represent or replace any accreditation or certification documents by which the adequacy of a given professional service must be judged.

1.3 This guide 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 guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.4 When using HAZMAT equipment follow the manufacturer's guidance and appropriate safety practices for the expected or suspected threat.

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.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

E2411 Specification for Chemical Warfare Vapor Detector (CWVD)

E2458 Practices for Bulk Sample Collection and Swab Sample Collection of Visible Powders Suspected of Being Biothreat Agents from Nonporous Surfaces

E2770 Guide for Operational Guidelines for Initial Response to a Suspected Biothreat Agent

2.2 *Other Documents:*

NIJ Guide 100-99 Guide for the Selection of Commercial Explosives Detection Systems for Law Enforcement Applications, Sept. 1999

Guide 100-06 Guide for the Selection of Chemical Detection Equipment for Emergency First Responders, 3rd Edition, January 2007, Dept. of Homeland Security

Calibration, Philosophy in Practice, Second Edition, Fluke Corp.

A Directory of Standards Laboratories, NCSL annual publication

NCSL RP-7 Recommended Practices, Laboratory Design

Guide 101-06 Guide for the Selection of Biological Agent Detection Equipment for Emergency First Responders, 2nd Edition, March 2007

DHS Guide 101-04 The Guide for the Selection of Biological Agent Detection Equipment for Emergency First Responders, Volume I, March 2005

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

DHS Guide 101-04 The Guide for the Selection of Biological Agent Detection Equipment for Emergency First Responders, Volume II, March 2005

NIJ Guide 101-00 An Introduction to Biological Agent Detection Equipment for Emergency First Responders, December 2001

ANSI N42.42-2006 American National Standard Data Format Standard for Radiation Detectors Used for Homeland Security

NFPA 472 Standard for Competence of Responders of Hazardous Materials/Weapons of Mass Destruction Incidents

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

UL-913 Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations

## 3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are from NFPA Glossary of Terms, when possible.

3.1.2 *calibrate*—to correlate the reading of an instrument or system of measurement with a standard (NFPA).

3.1.3 *counts per minute (cpm)*—the number of radiological transformations detected by a radiation instrument in one minute.

3.1.4 *detect*—to discover or determine the existence of a material or item of interest.

3.1.5 *dose rate*—the radiation dose delivered per unit of time. Measured for example, in "rem per hour."

3.1.6 *dosimeter*—a portable device used to measure and record the total accumulated exposure to ionizing radiation by an individual.

3.1.7 *flux*—a term referring to the amount of some type of radiation crossing a certain area per unit time.

3.1.8 *functional tests*—tests performed to verify the ability of an element or component of an element to continue to be used for its intended purpose. (NFPA modified).

3.1.9 *jig*—device used to position a test source and/or the instrument such that calibration or functional checks are repeatable.

3.1.10 *quality control*—a system of actions that keep the quality of goods or services at the level expected by their users.

3.1.11 *radionuclide (nuclide)*—radioactive form of an element.

3.1.12 *survey instrument*—a handheld device used to measure the amount and locate hazardous material, hazardous material contamination, and hazardous conditions.

3.1.13 *traceable*—in reference to a calibration standard, the properties of which can be related back to a national standard.

3.2 *Acronyms:*

3.2.1 *BA*—biological agent

3.2.2 *CAD*—chemical agent detector

3.2.3 *CWAs*—chemical warfare agents

3.2.4 *FEMA*—Federal Emergency Management Agency

3.2.5 *HAZMAT*—hazardous materials

3.2.6 *HSEEP*—Homeland Security Exercise and Evaluation Program

3.2.7 *LEL*—low explosive level

3.2.8 *NIOSH*—National Institute for Occupational Safety and Health

3.2.9 *ppm*—parts per million

3.2.10 *TICs*—toxic industrial chemicals

3.2.11 *TIMs*—toxic industrial materials

3.2.12 *TLV*—threshold limit value

3.2.13 *TWA*—time waited average (refers to a time weighted average concentration for a normal 8 hour day in a 40 hour work week in which MOST workers can be exposed REPEATEDLY without adverse effect)

## 4. Summary of Guide

4.1 *Acquisition:*

4.1.1 A review of applicable equipment should be performed to determine which device will be best suited for the identified application and to meet the needs of the organization that will use the equipment. The review should take into consideration potential hazards and the importance of detecting them both as a precautionary measure and once they are discovered. Different equipment may be used before and after a hazard is discovered. For example, a personal radiation detector may be routinely carried to detect the presence of radioactive material. Once radioactive material is detected, other equipment may be used to further analyze the material.

4.1.2 Prior to purchase, a review of testing should be conducted with highest consideration given to those devices that have had independent testing done. If possible other users should be contacted to obtain additional information as to performance, reliability, and ease of maintenance. Appropriate spare parts and reference/calibration sources should be purchased with the chosen instrument.

4.2 *Training:*

4.2.1 Prior to field use, formal training for the designated users should be conducted. This training should be developed based on manufacturer's information and the user organization protocol. Retraining/continuing training should be performed periodically (refer to NFPA 472).

4.3 *Equipment Storage:*

4.3.1 Equipment are typically susceptible to extremes of hot and cold temperatures, humidity, moisture, vibration, and/or shock. All of these factors must be taken into consideration to mitigate their effect on the equipment while in storage.

4.4 *Maintenance/Calibration:*

4.4.1 Repair and calibration requires highly qualified personnel in order to assure that the equipment will function correctly and provide accurate and reliable information to the user. A facility can be set up with the appropriate personnel and test equipment, or the task can be outsourced to a competent facility.

4.5 *Equipment Use:*

4.5.1 Use of the equipment requires knowledge of the function, experience in its use, and acute observation of its response during use. No matter how well trained, experienced, and knowledgeable an individual is, selection of the appropriate equipment for the known or suspected hazard is paramount.

## 5. Significance and Use

5.1 This guide provides information that could be used to:

5.1.1 Establish a hazardous material instrument program;

5.1.2 Help ensure that consistently reliable instruments are available for the detection of hazardous materials; and

5.1.3 Provide the safety professional with the means to evaluate the risk and facilitate the mitigation of the threat from hazardous materials.

5.2 This guide provides information to help perform the following:

5.2.1 Select detection equipment.

5.2.2 Maintain the equipment in a manner that supports its immediate use when required.

5.2.3 Store equipment using proper methods and conditions between uses.

5.2.4 Calibrate equipment in accordance with manufacturer's recommendations and regulatory requirements:

5.2.4.1 At appropriate intervals;

5.2.4.2 Using appropriate standards; and

5.2.4.3 While maintaining proper documentation of calibration and repair.

5.2.5 Use and verify equipment performance:

5.2.5.1 As recommended by the manufacturer for its intended application;

5.2.5.2 By performing functional checks; and

5.2.5.3 By knowing any limitations of use.

5.3 This guide also provides information regarding the types of materials to be included in training programs for the use and maintenance of the equipment.

## 6. Reagents/Test Materials

6.1 Based on intended use and the type of device in any functional group, calibration standards will be required as well as response sources. These are typically gasses, liquids, and/or solids.

6.2 As appropriate, test materials should be in a sealed container to prevent unwanted loss of the material. Means should be provided to permit their intended use in the calibration and response check process without unwanted loss of material and unnecessary exposure of the operator to the sources. Simulants should be used for testing response to toxic substances.

6.3 Typical calibration and response sources needed should include the following:

6.3.1 Compressed gas of various types including simulants for calibration of gas monitors and confined space monitors.

6.3.2 Sealed radionuclide sources for calibration and response checking radiation detection instruments.

6.3.3 Particulate concentrations/dusts, as appropriate.

## 7. Procedure

7.1 *Hazardous Materials Equipment Acquisition:*

7.1.1 When determining which HAZMAT equipment an organization will require to achieve its mission, an analysis of the organization's operational environment should be performed. The following factors should be considered (but not limited to):

7.1.1.1 Hazardous Materials that need to be identified ranked in order of seriousness of hazard to your organization.

7.1.1.2 Environmental factors—is your operational area mostly hot, cold, dry, humid, dusty, or rainy. These factors may help eliminate some choices based on any performance testing the instrument has been subjected to and available manufacturer-stated limitations.

7.1.1.3 Location—city, suburbs, or rural. Personnel would not want to be carrying 15 to 20 pounds of monitoring equipment in addition to their regular gear up a stairwell in a high-rise building.

7.1.1.4 Industry—in your area of responsibility, chemical, manufacturing, and processing. These will have to be investigated to determine the potential hazards of each facility.

7.1.1.5 Should one multipurpose instrument or several specific purpose instruments be acquired? Several single purpose instruments may be adequate when there is a minimal hazard in the organization's location. Where the possibility exists that multiple hazards may present themselves at one time a multipurpose instrument may be more applicable. **All configurations must be verified.**

7.1.2 In addition to the factors listed in section 7.1.1, budgetary limitations may contribute to determining the type and quantity of equipment selected.

7.1.2.1 Is the cost of the equipment acceptable to the organization? An instrument that is slightly higher in cost may provide much better service then a less costly instrument.

7.1.2.2 Most equipment manufacturers have maintenance kits available that will typically include consumables and frequently needed parts.

7.1.2.3 Include in the budget the cost of initial training on the use of the equipment, and initial maintenance supplies for the instrument.

7.1.2.4 Research and project maintenance costs for the instrument in the future. Can the expected future budgets support these costs?

7.1.3 Once the type of equipment is established, specific makes and models must be determined based on factors related to the organization such as; funding, number of personnel, physical space, and organizational structure. A market analysis and review should be performed to identify a specific instrument within each category of instrument needed. This should be based on factors such as reliability, durability, maintenance requirements, and usability.

7.1.3.1 As to the equipment's primary function; will it detect the suspected potential hazard?

7.1.3.2 Safety of operation; ensure that use of the instrument does not interfere with the safety of personnel when used in the field. Does the use or calibration of the instrument in and of itself present a safety concern? Are instruments that will be brought into a flammable environment intrinsically safe?

7.1.3.3 If possible obtain a device of the exact type being considered for purchase. Evaluate this device in the field to see if it meets the manufacturer's specifications and the organizations analyzed criteria (refer to Appendix X1, "Suggested Criteria for Field Testing Instruments").

7.1.3.4 Identify and consult with other owners/users of the instrument being considered to determine how they view the instrument. Discuss its strong points and weak points.

7.2 *Training Basics:*

7.2.1 This section only provides general guidance. Refer to federal training programs implemented by FEMA and HSEEP at the state and local levels for requirements and more specific guidance.

7.2.2 Obtain initial vendor training when available. Most manufacturers offer training in the use of their equipment.

7.2.2.1 The format may be a video or detailed printed material. The organization's training person or lead person should present the class.

7.2.2.2 Some manufacturers may offer formal instructor-conducted classes.

7.2.3 In cases where several devices are being purchased, a training fee may be waived by the vendor/manufacturer. Consultants familiar with HAZMAT equipment may also provide unbiased training.

7.2.4 Prior to use of the equipment in the field, formal training on operation for the designated users should be conducted. This training should be conducted in a manner which makes it as realistic as possible.

7.2.5 Training should be developed based on manufacturer's information and user organization protocol.

7.2.5.1 Hands-on training in a classroom should be conducted to permit trainees to become familiar with the equipment.

7.2.5.2 Periodic review sessions should be performed to maintain proficiency with each device. These could be conducted as one-on-one or small group sessions during down time.

7.2.5.3 Field use in various environmental conditions should also be conducted so that trainees can observe any physical or mechanical limitations the instrument may have.

7.2.5.4 All training must be documented. Competency sign-offs (e.g., qualification cards) should be established and utilized to document an individual's abilities.

7.2.6 Use of some equipment such as radiation dosimetry or $CO_2$ monitors should become an integral part of daily activities dependent on the organization's mission.

7.2.7 Retraining/Continuing training should be performed periodically. The time period should be based on the complexity of the equipment and the frequency of actual use. The more complex the operation and the longer the periods between uses should require a shorter time between training. No personnel should exceed 1 year for retraining on the equipment.

7.2.8 Training modules on the usage techniques must be developed. Included in these modules should be discussion on the risk from the expected hazardous material and means to mitigate this risk while still performing the task. Safety guidelines and protective equipment for the associated hazard should also be included.

7.2.9 Field training under simulated conditions should be conducted with all the instruments to familiarize personnel with the specific functions and peculiarities of each instrument. Some equipment that are more complex to operate may have to be designated for use by specific individuals that have had specialized training.

7.3 *Equipment Storage:*

7.3.1 HAZMAT equipment will typically consist of a detector, display, and electronics to process the signal from the detector. All three of these components collectively or individually may be susceptible to extremes of hot and cold temperatures, humidity, moisture, vibration, and/or shock. When storing equipment consideration must be given to mitigating the effect of these factors on the device.

7.3.2 To maintain functionality during long-term storage, it is best that the storage facility have a controlled atmosphere. Items such as batteries or filter media should be removed to prevent corrosion or mildew buildup.

7.3.3 For short term storage, i.e., the equipment is maintained ready for immediate use, containers and padding should be provided to protect the equipment from environmental assault and rough handling as such storage might be in an emergency response vehicle.

7.4 *Equipment Calibration and Maintenance:*

7.4.1 It is absolutely critical that equipment be calibrated in accordance with the manufacturer's recommendations. Failure to do so could jeopardize the people whose lives depend on the instruments proper operation.

7.4.2 Calibration frequency should be based on the manufacturer's requirements or recommendation, and shall meet any federal, state, local requirements and/or regulations. The calibration interval may be extended for some equipment with justification based on maintenance history, performance check history, and type of equipment. This is considered performance based calibrations. Performance based calibration frequency may be longer or shorter than the manufacturer's recommendation.

7.4.3 Without a proper calibration and adequate documentation of the calibration, data acquired may have questionable value.

7.4.4 Repair and calibration of equipment requires highly qualified personnel and a well supplied calibration facility. A facility can be set up with the appropriate personnel and equipment or the task can be outsourced to a competent facility.

7.4.5 The use of traceable sources is required to perform calibrations. This provides a documented path back to National Standards. Traceable sources, a written calibration process, and good calibration records validates the quality of the calibration process and the equipment's ability to perform its intended function. This also supports the monitoring results obtained in the field as a legal document.

7.4.6 The challenges in setting up a calibration facility will depend on the variety and volume of instruments to be calibrated and the philosophy applied to the calibrations. With the primary function of a calibration lab being instrument calibration, the secondary function of any calibration facility is to maintain traceability of the calibration documents for the

instruments being calibrated. The function of records is to add discipline to the calibration process and ensure that any audits of calibration activity will be successfully passed.

7.4.6.1 The physical layout of a calibration facility is up to the discretion of the facility's operator. A helpful document is NCSL RP-7, Recommended Practices, Laboratory Design. It can be simply a work bench at the side of a larger work area (least desired) to a separate set of rooms (most desired). The choice is largely dictated by cost, available space, and volume of work.

7.4.6.2 Whatever configuration is determined to meet the needs of the organization, the area must be large enough to support work and accommodate the items required for calibration such as:

*(1)* An area of sufficient size to permit minimal impediments to the calibration process.

*(2)* Sufficient electrical power. Many devices used to support calibration require electrical power, typically 120 volts.

*(3)* A well-lighted work bench to provide sufficient space to stage the calibration equipment and the devices to be calibrated.

*(4)* Good ventilation and air circulation; when working with calibration gases and agents, sufficient ventilation and humidity control must be maintained so as not to compromise the calibration or cause discomfort to the calibration personnel. Sudden changes in temperature during a calibration can affect the validity of the calibration.

*(5)* Sources with which to perform the calibration; gasses, radionuclides, liquids, and particulates as appropriate.

*(6)* A large supply of the appropriate batteries should be available.

*(7)* Equipment being calibrated should have new or freshly charged batteries prior to calibration.

*(8)* An adequate set of tools and analytical equipment to perform routine maintenance and minor repairs.

*(9)* Appropriate jig(s) to ensure repeatable positioning of devices.

*(10)* A substantial filling cabinet, preferably lockable and fireproof, for maintaining completed calibration records and other pertinent documents. Off-site duplicate storage should also be considered.

*(11)* A fireproof cabinet for combustible sources and chemicals.

*(12)* A lockable, secure cabinet for sources that must be guarded such as radiation sources.

7.4.6.3 Once a facility is established, detailed calibration procedures must be written. Calibration procedures specific to each device must be developed to facilitate accurate and reproducible calibrations such that the equipment provide consistently similar readings during field use. Each procedure will need to provide the following information as a minimum:

NOTE 1—Most operating manuals have a detailed outline of the steps needed for calibration.

*(1)* The identification of the specific type of device to which this procedure is applicable.

*(2)* A list of the materials, specialty tools, and source(s) necessary for the calibration.

*(3)* A step by step description of the calibration process. This will include preparation, setup, performance, and documentation. Use the equipment operating manual or information from the manufacturer as guidance in writing the steps in this part.

*(4)* The procedure should contain or reference the appropriate form to document the calibration data. Complete legible documentation is a must for maintaining a working history of the equipment. Equipment history will provide insight into how well the equipment is performing over time and spotlight any slow degradation of instrument performance.

*(5)* Once a procedure is written, have another individual that has not been part of the writing process perform a walk-through of the procedure. This will find many assumptions that should have been a step in the procedure. It will also validate the flow and order of the steps in the procedure.

7.4.6.4 The manufacturer and/or the vendor of the equipment will typically have "calibration kits" available for the equipment they sell. These kits provide the basic materials needed to perform a calibration. These provide an ideal start for building a good calibration process.

7.4.7 Calibrating some devices requires expensive equipment and time consuming methods. The cost to establish a facility to perform a full calibration on these devices may not be justified. It may be more cost effective to outsource this activity. A minimal calibration lab where calibration checks on the more complex devices and full calibration on others may be the most appropriate method.

7.4.7.1 Many equipment manufacturers provide calibration services for their products. In addition a large number of independent laboratories offer calibration services to the public. The quality of service offered can range from unacceptable to excellent.

7.4.7.2 When choosing calibration services, look beyond the price. A calibration laboratory's capabilities and operations should be audited before its services are utilized.

7.4.7.3 The NCSL annual publication, A Directory of Standards Laboratories, lists the services provided and contact information for member labs.

7.4.8 Maintaining quality records is a must—a calibration and repair history should be established for each device. This can be as formal as a running log that details all evolutions of an instrument's life or as simple as a file folder containing documents of calibration and repairs. Either way the data should be recoverable for legal use when required. All records should be maintained for the life of the instrument and possibly 75 years thereafter. The actual amount of time for record storage must be established by the user organization.

7.5 *Equipment Use:*

7.5.1 Prior to each use, a functional check must be performed to ensure that the device is operating as specified. A functional check should include:

7.5.1.1 Visual inspection for damage that could affect the device's operating ability.

7.5.1.2 Battery/charge verification; batteries should be changed or the device not used if the batteries are weak or the charge is inadequate.

7.5.1.3 Calibration verification; the device must have a valid calibration date to permit use. Measurements using out of date equipment can be considered suspect.

7.5.1.4 If any deficiency is found during the functional check and that deficiency cannot be corrected immediately remove the device from service and tag it inoperable with a description of the problem.

7.5.2 A response check must be performed according to manufacturer recommendations. This may involve a thorough check once per week where the instrument is run for an extended period of time and a verification check upon start-up as well. Instruments that are used on a daily basis should be checked at the beginning of each day/shift and/or prior to each use in order to verify the operability of the instrument. Some instrument types and those that are frequently used throughout a 24-hour period may only need a response check once each 24 hours. Others may require a response check before and after each use to validate the instrument's field readings. All results should be documented.

7.5.2.1 If the device fails the response check, remove it from service and tag it inoperable with a description of the problem. The device will need to be repaired and/or recalibrated.

7.5.3 The equipment should only be used for what they were designed to do and within the specification bounds that the manufacturer or testing has established.

7.5.4 When equipment is first turned on, a warm up time must be allowed before proper operation can be assured. Consult manufacturer literature for the appropriate warm-up period.

7.6 *Use of Biological Agent (BA) Detection Instrument:*

NOTE 2—Refer to Guide for the Selection of Biological Agent Detection Equipment for Emergency First Responders, 2nd Edition, Guide 101-06, March 2007 for detailed information on equipment, technologies, and vendors available.

7.6.1 The effective detection of biological agents in the environment requires a multi-component analysis system because of the complexity of the material. BA detection systems need to exhibit high **sensitivity**, a high degree of **specificity**, a rapid **response time**, and be **easy to use**.

7.6.2 Since sampling is a key issue for all analytical devices, the way a sample is taken and how it is handled will affect the outcome of the analysis. Refer to E2458, Standard Practices for Bulk Sample Collection and Swab Sample Collection of Visible Powders Suspected of Being Biological Agents from Nonporous Surfaces, and E2770, Standard Guide for Operational Guidelines for Initial Response to a Suspected Biothreat Agent.

7.6.3 Detection systems must exhibit a high degree of specificity for biological agents. The specificity of a detection system can be defined as its ability to discriminate between the target agent and the environmental interference. A new development using Linear After the Exponential Polymerase Chain Reaction of "LATE-PCR" technology for detection of biological agents in the environment provides high specificity and is currently commercially available.

7.6.4 Because commercially available biological warfare (BW) detection systems and/or components are costly, it is strongly recommended that first responders research the detection method and company background prior to purchasing any device that claims to detect BW agents.

7.6.5 All users of equipment designed to detect biological agents must be trained on the use of each device. Training should be based on the manufacturer's operational manual and organizational safety practices/policies. Hands-on training should be included in the program. Initial training must be performed prior to an individual being permitted to use the equipment in the field and retraining should occur at least annually thereafter, especially if the equipment is not frequently used.

7.7 *Use of Toxic Industrial Material Equipment (TIMS):*

7.7.1 Equipment in this category are used for the rapid identification of unknown solids and liquids, including narcotics, TICs, TIMs, explosives. These materials are considered hazardous and possibly life threatening. When using this type of equipment, manufacturer's instructions and warnings must be followed to assure proper and safe operation. In addition all organizational safety precautions should be implemented to minimize the risk of personal injury or death.

7.7.2 Detection equipment for TIMs are designed to look at solids or liquids and either classify or identify the chemical(s) or compound(s). They can be either hand held or portable bench top type, light to moderate weight instruments featuring digital read out on a large LCD screen which is usually backlit for ease of use under less than ideal conditions.

7.7.3 Several detection techniques are used to detect TIMs such as:

7.7.3.1 Infrared spectrometry.

7.7.3.2 Ionization mobility spectrometry.

7.7.3.3 Electrochemical.

7.7.3.4 Raman spectroscopy.

7.7.3.5 Surface acoustic wave and others.

7.7.4 The equipment will attempt to identify the chemical or agent. When there is a mixture of chemicals and/or agents the percentage of each may be given.

7.7.5 This equipment can be used for rapid classification or identification of unknown solids and liquids, including narcotics, TICs, TIMs, explosives and more. A warm-up time as specified by the manufacturer or at least 10 minutes should be allowed prior to use.

7.7.6 These devices typically do not provide quantitative values therefore requiring no calibration in the field. Vendor repair must be done if the devices are not identifying correctly.

7.7.7 Prior to each use a functional check should be performed to ensure that the equipment is capable of operating as specified. A functional check should include:

7.7.7.1 Visual inspection for damage that could affect operating ability.

7.7.7.2 Verification that the calibration due date has not been exceeded.

7.7.7.3 Battery/charge verification, batteries should be changed or the device not used if the batteries are weak or the charge is inadequate.

7.7.7.4 Observe startup for error messages.

7.7.7.5 Readings using known materials with results compared to what was expected determined from previous tests.

7.7.8 All users of a specific device must be trained on its use.

7.8 *Use of Combustible Gas Equipment:*

7.8.1 Equipment in this category can be used to detect combustible gases, oxygen deficiency, elevated oxygen levels, carbon monoxide, hydrogen sulfide, nitrous oxide, etc. These concentrations and gases are considered hazardous and possibly life threatening. When using these types of equipment, manufacturer's instructions and warnings must be followed to assure proper and safe operation. In addition, all organizational safety precautions should be implemented to minimize the risk of personal injury or death.

7.8.2 These devices are typically hand held and lightweight featuring digital readout on an LCD screen which is usually backlit for ease of use under less than ideal lighting conditions. They may also be designed to function as confined space monitors.

7.8.3 It is absolutely critical that any combustible gas detector be used and maintained in accordance with the manufacturer's recommendations. Failure to do so could jeopardize the people whose lives depend on proper operation.

7.8.4 Most combustible gas instruments provide data in %LEL or %volume. Most combustible gas instruments are calibrated to methane. It is important to note that an LEL of 50% for methane could actually be an LEL of 100% for another combustible gas. This will be dependent on the methane to the unknown gas conversion factor for any given device. Consult the manual or specification data base for a LEL Hydrocarbon conversion chart.

7.8.5 A warm-up time as specified by the manufacturer or at least 10 minutes should be allowed prior to use. The actual time will be dependent on the ambient temperature.

7.8.6 Combustible gas detection instruments must not be used for any other purpose other than that specified by the manufacturer. Other types of gasses or vapors, such as; silicones, free halogens, halogenated hydrocarbons and metallic oxides can seriously affect the operation of the device and in high enough concentration act as a poison to the individual detectors. This will require the replacement of the affected detector cell.

7.8.7 A daily calibration check and functional check is recommended for combustible gas detection equipment. Instruments should fall within 10% of the actual gas value or within the tolerance specified by the manufacturer. If the measurement result falls outside the tolerance a full calibration must be performed.

7.8.8 If a device is exposed to a high concentration of combustible gasses, vapors, or toxic gases the device should be fully recalibrated.

7.8.9 The sensors of some equipment degrade over time. This will have a direct bearing on the frequency of calibration checks.

7.8.10 For equipment where the data could be used in a legal situation, the device should be checked prior to and directly after each use.

7.8.11 A functional check should include:

7.8.11.1 Visual inspection for damage that could affect functionality.

7.8.11.2 Verification that the calibration due date has not been exceeded.

7.8.11.3 Battery/charge verification, batteries should be changed or the device not used if the batteries are weak or the charge is inadequate.

7.8.11.4 Observe startup for error messages.

7.8.11.5 Readings using known materials with results compared to what was expected determined from previous tests.

7.8.12 All users of a specific device must be trained on its use.

7.9 *Use of Toxic Vapor and Gas Equipment—Toxic Industrial Chemicals (TICs), Explosives, Chemical Warfare Agents (CWAs):*

7.9.1 Equipment in this category are used to detect vapor and gases from compounds that are considered hazardous and possibly life threatening. When using this equipment, manufacturer's instructions and warnings must be followed to assure proper and safe operation. In addition, all organizational safety precautions should be implemented to minimize the risk of personal injury or death.

7.9.2 The devices are typically hand held and lightweight featuring digital read out on a large LCD screen which is usually backlit for ease of use under less than ideal conditions.

7.9.3 The equipment will have multiple sensor cells (detectors) each designed for a specific vapor, gas, or chemical agent or families of various vapors, gases, and agents. The equipment responds to vapor from TICs and gases or agents released into the atmosphere.

7.9.4 Typically this equipment provides a read out in µg or mg per cubic meter, or ppm. The detector response may be a simple bar-graph in which each bar corresponds to a specific concentration depending on the agent it detects. The specific unit reported is based on the instrument's sensitivity and the level at which the gas or vapor can be detected.

7.9.5 A warm-up time as specified by the manufacturer or at least 10 minutes should be allowed prior to use.

7.9.6 Each device will be specific for a given selection of gases, agents, and/or vapors. The same model may have sensor cells for different vapors and/or gases. Some may use a chromatographic column for TIC identification.

7.9.7 Use will depend on what is suspected to be present at the incident site. The use of several devices may be required to establish the presence or absence of various vapors or gases.

7.9.8 Calibration and functional checks vary for each device. Some may have self diagnostic software while others will require the user to validate operability prior to use. The frequency of checks will depend on the amount of use and its required readiness mode. As a minimum, functional checks should include the following:

7.9.8.1 Visual inspection for damage that could affect operating ability.

7.9.8.2 Verification that the calibration due date has not been exceeded.

7.9.8.3 Battery/charge verification, batteries should be changed or the device not used if the batteries are weak or the charge is inadequate.

7.9.8.4 Observe startup for error messages.

7.9.8.5 Readings using known materials with results compared to what was expected determined from previous tests.

7.9.9 All users of a specific device must be trained.

7.10 *Use of Radiation Detectors—Surface Contamination Instruments:*

7.10.1 Surface Contamination instruments (commonly called friskers) are portable, hand held devices designed to locate small amounts of radioactive material. A frisker consists of packaged control circuits with a meter or digital readout. A Geiger-Mueller (GM) detector is typically at the end of a cable attached to the control circuit container.

7.10.2 These instruments provide users with readings indicating the strength of radiation from a source in units representing the amount of radiation flux or photons/beta particles per unit of time, typically per minute or per second. Displayed units can be counts per minute (cpm), counts per second (cps), or Becquerel's (equivalent to disintegrations per second). The displayed unit will depend on the instrument's intended use.

7.10.3 Friskers are used to find small amounts of radioactive material by detecting low levels of radiation emitted by this material. They can be used to determine if an individual or area is radiologically contaminated, that is radiological materials have adhered to the individual or surfaces in an area.

7.10.4 Once every 24-hour period a response check should be performed. Response checks are typically performed using a sealed radiation source in a fixed geometry in relationship to the detector. The resulting reading must fall within a predetermined range for that instrument. This range is established during or just after the instrument's calibration. The range is typically written on a sticker placed on the side of the instrument. All findings should be documented.

7.10.5 Prior to each use, a functional check should be performed to ensure that the instrument is operating as specified. A functional check should include:

7.10.5.1 Visual inspection for damage that could affect the instruments operating ability.

7.10.5.2 Verification that the calibration due date has not been exceeded.

7.10.5.3 Battery/charge verification; batteries should be changed or the instrument not used if the batteries are weak or the charge is inadequate.

7.10.5.4 Response check and calibration verification; the instrument must have a valid calibration date to permit use. Out of date instruments are suspect as to proper operation and the results can be legally challenged as to validity. The instrument should not be used if it is past the calibration due date or a response check has not been performed in the past 24 hours.

7.10.5.5 Observe the background reading. A typical reading will be 50 to 200 counts per minute (cpm). Some locations may have an even lower background reading. This verifies that the instrument is functional and the background is low enough to perform a measurement of an individual or object.

7.10.6 Once radioactive contamination is located the radioactive material may be isolated or removed.

7.10.7 Only personnel trained in the use of the frisker/count rate instrument and "frisking" techniques should be permitted to use these instruments.

7.10.8 These instruments should only be used in very low radiation fields, typically background (<300 cpm). Therefore there is very little risk associated with tasks involving the use of a count rate instrument. When a background reading is greater than 300 cpm at a given location, low levels of contamination may be missed. An off-scale reading on the highest scale of this instrument could indicate a high radiation field.

7.11 *Use of Radiation Detection—Dose Rate Instruments:*

7.11.1 Dose rate instruments are portable, hand held devices designed to locate radiation emitted from radioactive material. A dose rate instrument consists of packaged control circuits with a meter or digital readout and a detector. The detector can be either positioned inside the container or at the end of a cable attached to the control circuit in the container.

7.11.2 Dose rate instruments provide users with readings indicating the strength of radiation field in units representing the amount of radiation exposure or absorbed dose per unit of time, typically one hour. These units can be micro-R (roentgen), milli-R, micro or milli-rem, micro or milli-severts etc. The units provided will depend on the intended use.

7.11.3 Dose rate instruments are used to determine the presence of a radiation dose field at a given location. The amount of radiation depends on the radioactive material present and the quantity. A dose rate instrument will permit the user to locate sources of radiation and their relative strength at various locations. With this information the user can establish boundaries for limiting exposure to other personnel and the public. These instruments will also facilitate evaluation of cleanup efforts. A warm-up time as specified by the manufacturer or at least 5 minutes should be allowed prior to use.

7.11.4 Once every 24-hour period a response check should be performed. Response checks are typically performed using a sealed radionuclide source in a fixed orientation relative to the instrument's detector. The resulting reading must fall within a predetermined range for that instrument. This range is established during or just after calibration. The range may be written on a sticker placed on the side of the instrument or kept in a log book. All findings should be documented.

7.11.5 Prior to each use, a functional check should be performed to ensure that the instrument is operating as specified. A functional check should include:

7.11.5.1 Visual inspection for damage that could affect the instruments operating ability.

7.11.5.2 Battery/charge verification; batteries should be changed or the instrument not used if the batteries are weak or the charge is inadequate.

7.11.5.3 Response check and calibration verification; the instrument must have a valid calibration date to permit use. Out of date instruments are suspect as to proper operation and the results can be legally challenged as to validity. The instrument should not be used if it is past the calibration due date or a response check has not been performed in the past 24 hours.

7.11.6 Only personnel trained in the use of the dose rate instrument and associated risks should be permitted to use these instruments.

7.11.6.1 Radiation field strength could be in the R/hr range where these instruments may be in use. The risk of unnecessary

radiation dose to the user is high without training in the proper use of these instruments. Use of a predetermined radiation level commonly referred to as a turn back level should be established and adhered to.

7.12 *Use of Radionuclide Identification Instruments (RIID):*

7.12.1 These instruments are comprised of a miniaturized multi-channel analyzer with a radiation detector that responds to the energy of the measured radiation. This permits identification of the nuclides.

7.12.2 These instruments will attempt to identify the nuclide(s) present and the radiation field strength at the instruments location. Radiation field strength is usually given in microRoentgen (μR)/hr or milliRoentgen (mR)/hr.

7.12.3 These instruments are typically used in a low radiation field for the purpose of identifying the nuclides that are present. A warm-up time as specified by the manufacturer or at least 10 minutes should be allowed prior to use. This should take place in a low radiation background area where no sources are present.

7.12.4 Most of these instruments include a spectrum stabilization source and associated software. This functions automatically during start up of the instrument. Others may have a charging base with an associated source, usually Cs-137. At startup, the instrument must be on this base and a spectrum validation performed.

7.12.5 Prior to each use of a RIID instrument a functional check should be performed to ensure that the instrument is operating as specified. A functional check should include:

7.12.5.1 Visual inspection for damage that could affect the instrument's operating ability.

7.12.5.2 Battery/charge verification; batteries should be changed or the instrument not used if the batteries are weak or the charge is inadequate.

7.12.5.3 Calibration verification; the instrument must have a valid calibration date to permit use. Out of date instruments are suspect as to proper operation and the results can be legally challenged as to validity. The instrument should not be used if it is past the calibration due date or a response check has not been performed in the past 24 hours.

7.12.6 Only personnel trained in the use of the rate instrument and associated risks should be permitted to use these instruments. Several modes of operation are usually permitted with these types of instruments. The basic identification mode is intended for the user in the field, while the analysis mode is intended for a highly trained individual.

7.12.7 Radiation field strength could be in the R/hr range where these instruments may be in use. The risk of unnecessary dose is high without training in the proper use of these instruments.

## 8. Keywords

8.1 biological agents; chemical agents; confined space; explosive gasses; hazardous materials; HAZMAT; instruments; radiation; safety; toxic chemicals; toxic gases

## APPENDIX

**(Nonmandatory Information)**

### X1. SUGGESTED CRITERIA FOR FIELD TESTING INSTRUMENTS

*(1)* Is the instrument rugged enough to withstand normal use of your organization? Has it been tested against MIL-STD 810G or other reputable testing criteria such as EPA's Environmental Testing Program? Ask for a copy of the results.

*(2)* Weight and size; can the instrument be carried by a fully equipped firefighter or rescue person without adding appreciably to his/her load and not hinder their movements?

*(3)* The manufacturer should state whether the instrument is certified for use in explosive atmospheres. If certification is claimed, documentation should be provided. Certification may be based on UL-913.

*(4)* The manufacturer should state the time required for the instrument to become fully functional from either a dead start or when in a standby mode.

*(5)* Is the instrument's readout screen large enough and bright enough to be readable in minimal lighting conditions? Is screen backlit so that it can be read in blackout conditions or bright sun light? The display should be easily readable over the required temperature range of –40°F to +140°F (–40°C to 60°C) (typical).

*(6)* Does the instrument have the ability to change readout display font sizes?

*(7)* Do the readout units relate to your personnel and use? Data output in metric units for one instrument and US units for other instruments may lead to confusion in the field.

*(8)* Are the controls user-friendly for routine operation and where appropriate a menu structure that is simple and easy to be followed intuitively?

*(9)* Are the controls and switches designed in a way to permit easy operation and to minimize accidental operation when the user is wearing gloves?

*(10)* Does the instrument provide the ability to mute audible alarms?

*(11)* External markings should be easily readable and permanently fixed under normal conditions of use including the use of standard chemical agent decontaminates.

*(12)* Can the unit be easily decontaminated without damage? Minimal requirements should be a wipe down with a wet cloth containing a mild household bleach solution.

*(13)* HAZMAT equipment should have the ability to self-calibrate, self-monitor, and self diagnose malfunctions without user interaction.

*(14)* Does the device have the ability to switch off or on wireless operation when a wireless, "tethered" controller is available?

*(15)* Where an instrument has the capability of data output to a computer, connections for all such instruments in an organization should be the same.

*(16)* Data output should be rendered in an XML document format as specified by ANSI N42.42 for radiation instruments. All collected data reports will have the same look, thus limiting interpretation errors when reading data reports from various devices.

*(17)* Battery:

*(a)* The manufacturer should state the expected continuous operating time using the recommended batteries and the conditions (functional and environmental) used to determine this time.

*(b)* The instrument should have the ability to support a continuous mission time of 8 hours on battery power.

*(c)* The battery should not be special or hard to obtain.

*(d)* Access to the battery compartment should be simple, not require special tools.

*(e)* Investigate battery life verses cost of the batteries, if cost is high and the life is short (<40 hours) the cost of operation for the instrument may be prohibitive.

*(f)* If chargeable batteries are standard, determine the length of use per charge and time of recharge. Determine if the rechargeable batteries are easily replaced with other rechargeable batteries or standard batteries.

*(g)* Instruments should be equipped with a test circuit or other visible direct indicator of battery condition for each battery circuit.

*(h)* The low-battery indication should be no lower than the minimum voltage required for proper operation.