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**Radiation Detection Instrument Standards  
for Homeland Security Applications**

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## Chapter 17

# Radiation Detection Instrument Standards for Homeland Security Applications

**Morgan Cox and Mark D. Hoover**

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### Introduction

This chapter describes the origin and status of a family of four new consensus standards on radiation detection instruments for Department of Homeland Security (DHS) applications. The standards were developed under the auspices of American National Standards Institute (ANSI) committees N42 (Nuclear Instrumentation) and N42-RPI (Radiation Protection Instrumentation) and cover the following:

- Alarming personal radiation detectors for photons and neutrons (ANSI N42.32);
- Portable photon radiation exposure rate detection instruments (ANSI N 42.33);
- Portable radionuclide detectors with neutron detection capability (ANSI N 42.34);  
and
- Portal radiation monitors for personnel, packages, and vehicles (ANSI N 42.35).

The application of these types of instruments to homeland security had not previously been considered by ANSI. In addition, there was a need to encourage the instrument manufacturing community to develop new technologies and better-performing instruments. The origin, leadership, contributors, timelines, and highlights of the standards are presented below, along with information about the extensive testing and evaluation (T&E) protocols that were developed for use by DHS to rate candidate instrumentation. Critical issues for matching appropriate instruments to expected applications and the need for effective user training are also discussed. Together, the standards, T&E protocols, and associated guidance and training documents should ensure that appropriate radiation detection instruments are placed in the hands of capable users.

### Rationale for the Standards

The traumatic events of 11 September 2001 led to the creation of the U.S. Department of Homeland Security. The DHS now encompasses a number of U.S. government agencies and was established to detect, prevent, and mitigate terrorist attacks. Events leading to the release of radioactive materials are of special concern to DHS because such releases could cause injury, death, or panic among the population and cause destruction of near-term and long-term assets. As DHS began working with its stakeholders, it became clear that “consumer reports” and guidance-type information were needed to ensure that taxpayers’ money would be prudently spent in purchasing and deploying the appropriate radiological instruments by the various governmental and private agencies. Some state and local agencies have already purchased radiation detectors for emergency response without the benefit of

expert guidance encompassed in these standards. Other agencies already had some radiation detectors, but purchases to date have largely been made using best “guesstimates” of the capabilities and reliability of commercially available instruments. The use of DHS funds for future purchases is expected to involve adherence to the letter and spirit of the standards.

The standards described in this chapter were developed to provide appropriate guidance for the development, purchase, and use of radiation detection instrumentation. Because the early detection of radioactive materials in containers, with people, and in various vehicles could prevent a radiological or nuclear event, incident, or accident, the primary purpose of these standards is radiation *detection*, rather than radiation *protection*. Note that traditional health physics standards have focused on radiation protection, rather than detection. Thus, development of these standards represents a definite role change for health physicists who have been traditionally trained and are skilled in radiation safety, radiation protection, and radiation dosimetry. Initial stages of the standards development process involved a shift in thinking to focus on radiation detection in light of the requirements of the DHS.

### **Organization and Chronology for Preparation of the Standards**

The prompt preparation of these critical standards demanded a process to (1) recruit qualified personnel to fill the writing committees, (2) use relevant established standards as references, (3) use a consistent set of definitions and terminology, and (4) establish a comprehensive bibliography. Volunteer experts were chosen from a balanced cross section of knowledgeable users, instrument manufacturers, and regulatory agencies. The volunteers included 14 certified health physicists.

Senior health physicists Joe McDonald of the Battelle’s Pacific Northwest National Laboratory (PNNL), Peter Chiaro of Oak Ridge National Laboratory (ORNL), Brian Rees, CHP, of Los Alamos National Laboratory (LANL), and Morgan Cox, CHP, were asked to chair writing groups for the four consensus standards. ANSI committee N42, “Nuclear and Health Physics Instrumentation,” was selected to develop the four new DHS standards. As noted in the recent review of standards for measuring airborne radioactivity (Cox et al. 2003), there are a number of national and international bodies that set standards involving radioactive materials, and it was determined that ANSI N42 had the appropriate scope and experience to conduct the needed work. ANSI N42 is chaired by Louis Costrell of the National Institute for Standards and Technology (NIST) and vice-chaired by Mike Unterweger of NIST. ANSI N42 Radiation Protection Instrumentation (RPI), co-chaired by Jack Selby, CHP, and Morgan Cox, CHP, was tasked with supervision and coordination of the actual standards development and approval process.

The initial discussion of the need for the new standards began at NIST in November 2002. The organizing meeting was held at NIST in December 2002. The direction of activities from the DHS at that meeting was provided by Bert Coursey of NIST-DHS, Holly Dockery of Sandia National Laboratories-DHS, and Mike Unterweger of NIST. The four

writing groups for development of the standards were established and initial documents leading to the standards were drafted following general guidelines offered by the DHS and representatives from NIST. The chairs of the writing groups were cautioned to produce performance-based standards that would encourage innovation and technical advances and would not restrict the instrumentation to current technological concepts.

The target date of 3 mo was set for the preparation and review of first drafts at a public hearing. The “first drafts” of the standards were presented on 27 March 2003 for review and comment by invited members of the public and representatives of a number of agencies within the DHS. With comments in hand the standards committees then proceeded to refine the early drafts and prepare the standards for approval and publication by early 2004.

To ensure the timely and practical application of the standards, the Department of Homeland Security requested concurrent development of the T&E protocols to accompany each standard. These protocols will be used for testing and evaluating candidate instruments at qualified and accredited U.S. Department of Energy (USDOE) laboratories such as Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Battelle’s Pacific Northwest National Laboratory. Results of the T&E process are to be incorporated into a “consumers’ report” or guide for use by potential purchasers and users.

### Key Elements of the Standards

The following sections summarize the purposes, scopes, and key elements of the four standards for homeland security applications.

#### **Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security (ANSI N42.32)**

The purpose of this standard is to specify performance criteria and test methods used to evaluate self-reading, alarming radiation detection instruments that are pocket-sized, carried on the body, and used to detect the presence and magnitude of ionizing radiation for homeland security. The standard describes design and performance criteria along with testing methods for evaluating the performance of instruments that may be used in a variety of environmental conditions. The performance criteria contained in the standard are meant to provide a means for verifying the capability of these instruments to reliably detect significant changes above background levels of radiation and alert the user to these changes.

The key performance requirements are as follow:

- Size: 8 × 4 × 2 inches (20 × 10 × 5 cm) maximum, 0.9 lb (4.1 kg) maximum;
- Drop test: 1.5 m onto a concrete floor on all six faces;

- Batteries: capable of powering a continuous alarm for 30 min, low battery indication when there is less than 4 h remaining, and commercially available replacement batteries;
- Alarm level of 85 dB at 1 foot (30 cm); and
- Proper operation during exposure to electromagnetic (EM) and radio-frequency (RF) radiations.

Key performance tests include the following:

- Alarms at a change in background of  $30 \mu\text{R h}^{-1}$  ( $300 \text{ nSv h}^{-1}$ );
- Responds in less than 2 s to a change of  $50 \mu\text{R h}^{-1}$  ( $500 \text{ nSv h}^{-1}$ );
- Displays within  $\pm 30\%$  of the conventionally true value of exposure rate;
- Provides less than one false alarm per hour;
- Has an over-range indication;
- Range of temperature tests:  $-30^\circ$  to  $+50^\circ\text{C}$ ; and
- Humidity to range up to 95%; and
- Resistance to water spray.

### **Performance Requirements for Portable Radiation Detectors for Homeland Security Applications (ANSI N42.33)**

The scope of this standard is to establish design and performance criteria, test and calibration requirements, and operational requirements for portable radiation exposure rate detectors for homeland security applications. This standard covers only portable radiation detection instruments for exposure rate measurements of photons. Expected users include firefighters, police, customs and border officials, and additional emergency personnel. The standard covers two general classes of portable exposure rate measuring instruments: Type 1 for detection and interdiction to determine whether radioactive materials are present (dynamic range of detection:  $0 \mu\text{R h}^{-1}$  ( $0 \text{ nSv h}^{-1}$ ) to  $1 \text{ mR h}^{-1}$  ( $10 \mu\text{Sv h}^{-1}$ ) and Type 2 for hazard assessment (dynamic range of detection:  $100 \mu\text{R h}^{-1}$  ( $1 \mu\text{Sv h}^{-1}$ ) to  $1,000 \text{ R h}^{-1}$  ( $10 \text{ Sv h}^{-1}$ )).

The key performance requirements are as follow:

- Mechanical: Type 1 instruments should fit into a storage space of less than  $1 \text{ foot}^3$  ( $\sim 28,300 \text{ cm}^3$ ), excluding extendable probes, and should weigh less than 10 pounds (4.55 kg); Type 2 instruments should fit into a storage space of less than  $0.12 \text{ foot}^3$  ( $\sim 3,400 \text{ cm}^3$ ), excluding extendable probes, and weigh less than 6 pounds (2.73 kg); both types should have markings indicating the center line of the detector.
- Electrical and electronic: battery life  $> 24 \text{ h}$  over range of the instruments, easy to read display, alarm intensities of 75 dB (A) at the ear of the user and 85 dB (A) at 1 foot (30.5 cm);
- Radiological: requirements for accuracy, precision, linearity, energy response, and reference radiations; and

- Environmental: requirements for temperature, humidity and rain, pressure, EMF/RF response, and explosive atmospheres.

### **Performance Criteria for Handheld Instruments for the Detection and Identification of Radionuclides (ANSI N42.34)**

The scope of this standard for homeland security applications addresses instruments to detect and identify photon-emitting radionuclides and provide an indication of neutrons. The standard addresses general requirements and test procedures; radiation response; and electrical, mechanical, and environmental requirements. The standard advises potential users that successful completion of the tests described in the standard should not be construed as an ability to successfully identify all radionuclides in all environments.

Key performance requirements are as follow:

- Hand-held (portable) and battery-powered;
- Warm-up time less than 10 min;
- Operational for 2 h of continuous use;
- Operational over the temperature range of  $-20^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$ ;
- Self-contained, not requiring external devices; and
- A user interface that is intuitive and user-friendly, has a menu structure that is simple and easy to follow, and has two different operating modes: a routine mode for general operation and a restricted mode for setting measurement and functional parameters;
- A communications interface capable of transferring data such as gamma spectra to an external device such as a personal computer;
- Moisture protection to prevent water ingress from rain and condensation;
- Intrinsically safe design for possible use in explosive atmospheres;
- Proper operation in the presence of electromagnetic and radio-frequency fields;
- Appropriate external and internal markings;
- A battery-test circuit, having a manufacturer-certified battery lifetime during continuous operation, a low-battery indication, and capable of using standard, commercially available batteries;
- Design that ensures operation with minimal accidental switch movement;
- Capability for single radionuclide identification;
- Capability for simultaneous identification of two radionuclides;
- Radionuclide identification in the presence of other ionizing radiation and backscattered radiation;
- Exposure rate range of  $0.1 \text{ mR h}^{-1}$  to manufacturer-stated upper limit;
- Neutron indication insensitive to gamma radiation;
- Operation and components unaffected by vibration at 2 G for 15 min from 10–33 Hz in three axes; and
- Operating detector assembly unaffected by mechanical shock in all direction to 10 shock pulses of peak acceleration 50 G over 18 ms.

## **Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security (ANSI N42.35)**

This standard addresses portal monitors for pedestrians, packages, vehicles, and rail cars consisting of fixed and mobile systems with single and multiple detector systems. The standard does not address communications, threat, response, special nuclear materials-specific applications, or training.

### **The Future**

The family of standards for DHS instrumentation was completed and published at a record-setting pace within 1 y by volunteer members from the Health Physics Society, from the manufacturers of radiation detection instruments, and from the regulatory bodies. The standards are available from ANSI. Coupled with proper implementation and training, they will serve our country well in the continuing battle against terrorism from a radiological standpoint. Rapid implementation of these standards will help guarantee that taxpayers' money will be prudently spent on purchasing and deploying the appropriate radiological instruments by the various governmental and private agencies.

The subject of "extreme conditions" has surfaced to some extent in all four of the standards for DHS applications and remains to be addressed. The term needs to be defined as necessary to address conditions such as operation in extreme cold, underwater, or in the presence of intense electromagnetic fields. Development of instrumentation for use in a wide range of conditions, special conditions, or changing conditions can benefit from a "life-cycle" process that considers issues from mission evaluation, through development and testing, to applications, and including periodic testing to ensure continued proper performance (Hoover and Cox 2004).

A number of other standards for radiation detection may be needed. Radioactive airborne and surface contamination can contribute to injury, or worse, to personnel responding to an unplanned or surprise nuclear or radiological release. These forms of contamination can also render assets such as farmland, other real estate, and equipment unusable until they are decontaminated, discarded, or held for an appropriate period of radioactive decay. Airborne monitoring, primarily for gamma rays and secondarily for neutrons, may be the safest method of characterizing the consequences and distribution of radioactive materials following a significant nuclear or radiological release. There are also instrumentation needs for "emergency receivers" at hospitals where patients will need to be triaged and decontaminated upon entry to minimize cross-contamination of hospital facilities.

There is need for data networking, especially for the systems of radiological instruments at nuclear power plants, in USDOE facilities and other large nuclear laboratories, or in any facility or agency wanting to integrate or correlate radiation detection data from multiple detectors. This class of technology would be most helpful, or even necessary, following a nuclear or radiological incident. Work on a standard for real-time accessible data

networking (RADNet) is underway. This open protocol can be used by a wide variety of radiological instrument types and manufacturers. Implementing the RADNet protocol would greatly simplify command and control following a nuclear event of concern to the DHS or other agencies. Portable radiation detectors, dosimeters, contamination monitors, aerosol monitors, and nonradiation instruments of various kinds, including those for detection of biological and chemical agents, could all be coordinated and data readily retrieved using RADNet.

Experiences with the four new standards may dictate or point to the need to expand one or more of the four. For example, ANSI N42.33 could be expanded to include beta radiation and/or neutron detection. ANSI N42.35 could also be expanded to include neutron detection. Experiences with the standards and T&E protocols may simply point out the need to improve either or both with more and better information.

### International Implications

The International Atomic Energy Agency (IAEA) convenes an annual meeting for improvement of technical measures to detect and respond to illicit trafficking of nuclear and other radioactive materials. The most recent of these meetings was held in Vienna on 1–5 December 2003 and included an exhibition of relevant and commercially available monitoring systems and instruments. The main topics of discussion included the (1) the current status of border monitoring, (2) IAEA specifications for border monitoring equipment, and (3) a proposal for testing by international test laboratories. The meeting also included breakout sessions devoted to a review of current and needed new technologies, harmonization of international and national standards for personal detectors, portal monitors, portable instruments including radionuclide-identifying detectors, and neutron detectors.

The need for some new and improved technology was inherent in many of the discussions. Particular future needs that are apparent include (1) better radionuclide-identifying equipment, (2) new scintillation detectors and better spectral methods for photons, (3) better fast-neutron detection systems, and (4) improved portals and other complex networked systems.

Russia and some of the other former contiguous republics are well into implementation of border monitoring and training of responders. The United States has some catching up to do in these areas.

The American contributions of the four new standards and technology from the United States added immeasurably to the success of this harmonization process.

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