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Second Line of Defense Megaports Initiative Specification Guide for Radiation Detection and Response Systems for the Maritime Shipping Industry

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1 Overview

1.1 Scope

This guide briefly describes high-level criteria for specification development for a typical radiation detection and response system used for monitoring containers in the maritime shipping industry. This guide references performance and operational requirements defined by published technical standards and describes practical implementation issues that must be addressed in defining appropriate system requirements.

1.2 Introduction

Container shipping radiation detection and response systems consist of several integrated elements that must be considered when developing system specification requirements. These elements include radiation detection, container and vehicle identification, traffic control, system state of health, data format and communication, data analysis and processing, data storage and archive, training, and sustainability and maintenance.

Radiation detection and response systems use radiation portal monitors for detecting photon-emitting and neutron-emitting radioactive substances for the purposes of detection, interdiction, and prevention of illicit movements of radioactive materials using shipping containers. These radiation portal monitors may be of a fixed or mobile/transportable design. The radiation portal monitors may also be detection-only devices, or they may be spectroscopy-based portal monitors that have the ability to detect radioactivity and identify radionuclides that may be present through the use of gamma spectroscopy techniques. A discussion of the advantages and disadvantages of fixed and mobile/transportable radiation portal monitors, and of detection-only and spectroscopy-based portal monitors is outside the scope of this guide.

1.3 Concept of Operations

A concept of operations defines a standard methodology for operating a radiation detection and response system for shipping containers at a seaport, shipping terminal, or other defined location. The concept of operations provides a framework that bounds requirements for a specific radiation detection and response system implementation. As such, it is important to develop a site-specific concept of operations prior to developing detailed specification requirements for a radiation detection and response system. This site-specific concept of operations becomes a part of the overall system requirements specification. As part of concept of operations development, it is important to identify all of the systems that will be required to interface with the radiation detection and response system. Any connections to manifest systems, port/terminal operating systems, national data bases, and similar systems need to be identified to define the complexity of the system. In addition, legal requirements for data retention and data sensitivity need to be considered early in development of requirements.

In general, a layered inspection and response concept of operations that consists of four phases is used: Primary Inspection, Primary Response, Secondary Inspection, and Investigation.

1.3.1 Primary Inspection

Primary Inspection occurs when a container transits through the radiation portal monitor. The radiation portal monitor indicates if the radiation level exceeds a preset threshold set as the alarm limit. If there is no alarm condition, the container may proceed without any required action. If the alarm limit is exceeded, the next phase, Primary Response, is initiated.

1.3.2 Primary Response

Primary Response includes evaluating the radiation portal monitor data, verifying the container identification number, and reviewing any available information on the declared contents of the container. This information is used to decide if the radiation alarm profile is consistent with naturally occurring radioactive materials or with radiological sources declared in the shipping documents. If the declared contents are consistent with the data from the radiation portal monitor, the alarm can be cleared with no further investigation of the container. If the alarm cannot be cleared based on this information, the next phase, Secondary Inspection, is initiated.

1.3.3 Secondary Inspection

A Secondary Inspection can be conducted using handheld instruments or spectroscopy-based radiation portal monitor. Handheld instruments include detection-only instruments working together with handheld instruments for the detection and identification of radionuclides. The radionuclide identification information is used to determine whether the source of the alarm is innocent or a significant concern. If the results indicate naturally occurring radioactive materials or legal radiological sources, the alarm can be cleared with no further investigation of the container. If the results indicate isotopes not consistent with the declared contents or isotopes of special nuclear materials, the next phase, Investigation, is initiated.

1.3.4 Investigation

In Investigation, the container is detained and the appropriate response authorities implement their response protocols. The identification of the appropriate response authorities and their roles and responsibilities are defined at each location. Investigation typically includes a physical inspection of the container contents.

2 Specification Criteria

Obtaining performance that meets specifications developed from this guide depends on properly installing all equipment, establishing appropriate operating parameters, providing physical protection and security for installed equipment where needed, providing proper training for operating personnel, maintaining calibrations, and implementing a proper maintenance program. Quality Assurance requirements shall be addressed as a part of the requirements specification.

2.1 Construction Standards

All design drawings, specifications, and calculations must meet the requirements for the existing national standards and the local authorities having jurisdiction.

2.1.1 Civil Construction

Design requirements shall address local conditions for soil bearing capacity, frost depth, depth to groundwater, precipitation, seismic loads, wind loads, temperature, humidity, and the effects of salt and corrosion.

Design requirements shall address critical material properties, such as for concrete and steel.

Since sensitive radiation detection equipment will be installed, it is important to monitor the background radiation in any fill or construction material and assure that this material will not affect operation of the detectors.

2.1.2 Electrical Construction

Design requirements shall address available power quality, power protection (surge suppressor, voltage regulators, uninterrupted power supplies (UPS), or generators), and power requirements for selected radiation portal monitors.

Design requirements shall address communications connectivity needs, such as single or multimode fiber optic, category 5e, category 6, or wireless technologies.

2.2 Radiation Detection

2.2.1 Radiation Portal Monitors

Radiation portal monitors shall meet or exceed testing and evaluation criteria defined by the Institute of Electrical and Electronics Engineers (IEEE) American National Standards Institute (ANSI) standards referenced in the following sections and in this guide's Reference section. Related standards, such as those issued by the International Atomic Energy Agency (IAEA) or ASTM International (ASTM) referenced in this guide's Reference Section, may be used for supplemental specification guidance.

2.2.1.1 Radiation Detection Portal Monitors

ANSI N42.35, "American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security," provides testing and evaluation criteria for installed radiation detection portal monitors. These radiation detection portal monitors provide a good solution where only radiation detection is required at a fixed location.

2.2.1.2 Mobile and Transportable Radiation Monitors

ANSI N42.43, "American National Standard Performance Criteria for Mobile and Transportable Radiation Monitors Used for Homeland Security," specifies operational and performance criteria for mobile and transportable radiation monitors. These monitors can be detection-only or spectroscopy-based portal monitors. Mobile monitors are systems that can

be operated while those systems are in motion, such as on a straddle carrier, but they can also be operated while stationary. Transportable monitors are designed to be moved to a temporary location for a specific period of time. They do not need permanent mounting platforms and are operated only when stationary.

2.2.1.3 Spectroscopy-Based Portal Monitors

ANSI N42.38, "American National Standard Performance Criteria for Spectroscopy-Based Portal Monitors Used for Homeland Security," specifies operational and performance requirements for spectroscopy-based portal monitors. Spectroscopy-based portals can both detect the presence of radioactive materials and identify radionuclides through gamma spectroscopy techniques. These portals can be used as Primary Inspection or Secondary Inspection portal monitors.

2.2.2 Handheld Instruments

2.2.2.1 Portable Radiation Detection Instruments

ANSI N42.33, "American National Standard for Portable Radiation Detection Instrumentation for Homeland Security," specifies performance criteria and test methods used to evaluate portable radiation detection instruments. These instruments are used for the detection of photon-emitting radioactive materials, and are typically used to identify possible locations of radioactive sources within a container.

2.2.2.2 Handheld Radiological Isotope Identification Device

ANSI N42.34, "American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides," specifies requirements and test methods for handheld instruments to detect and identify radionuclides. These instruments are typically used in Secondary Inspections.

2.2.2.3 Personal Radiation Detectors

ANSI N42.32, "American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security," specifies performance criteria and test procedures used to evaluate radiation detection instruments that are small, worn on the body, and used to detect the presence of ionizing radiation. These instruments are commonly called "pagers" and are used for personnel safety to alert the user to ambient radiation levels above a preset threshold.

2.3 Container and Vehicle Identification

A means to identify the container number must always be provided. The Concept of Operations will define any additional identification items required, such as vehicle license plate number, trailer license plate number, driver identification, etc. This information can be collected and entered into the database system either manually or automatically, depending on site-specific needs.

2.3.1 Manual Identification Systems

Manual identification systems require an operator to enter identification information for any alarm event. This can be accomplished by an operator physically viewing the container and

vehicle of interest, or by viewing video images from cameras located at the radiation portal monitor. For video camera systems, the following items shall be addressed when developing requirements:

- Number and type of video cameras required
- Image collection intervals (from 1 to *x* frames per second)
- Amount of pre- and post-video associated with each event
- Video data storage requirements
- Camera environmental and physical protection
- Time of day and weather condition video collection capabilities

2.3.2 Automatic Identification Systems

Automatic identification systems will associate identification numbers with alarm events automatically, without operator intervention. Automatic identification systems can include optical character recognition systems, radio frequency, card reader, or other systems.

For automatic identification systems, the following items shall be addressed when developing requirements:

- Radiation portal monitor alarm event data and automatic identification system data synchronization
- Operator review, confirmation, and editing of automatic identification system provided identification numbers
- Automatic identification system confidence factor information
- Automatic identification system capabilities for various container/trailer configurations, such as 20-foot, 40-foot, and various combinations of 20- or 40-foot containers.
- Allowable vehicle speeds through the automatic identification system
- Automatic identification system reliability
- Backup video camera needs

2.4 Traffic Control

Traffic control addresses how a vehicle is stopped following an alarm and how it is released or directed to further phases of the concept of operations, such as Secondary Inspection. Traffic control also addresses how vehicles are controlled as they pass through a radiation portal monitor to assure that speed is controlled for proper detector performance. The following items shall be considered when developing traffic control requirements:

- Speed control
- Queuing control
- Prevention of vehicles stopping or parking while in the radiation portal monitor

In addition, traffic control addresses how a terminal operator or shipper is contacted regarding making containers available for inspection, blocking containers, and releasing containers. Requirements shall address this form of traffic control as needed.

2.5 System State of Health

The current system state of health shall be monitored for all critical system elements. These elements include radiation portal monitors, video cameras, workstations, servers, auxiliary systems such as automatic identification systems, external interfaces such as links to terminal operating systems, and data communication elements. The current status of critical system elements, such as on-line or off-line, shall be displayed to the operator. State of health degradation of select critical system elements shall be automatically communicated to the system operator as a system fault event.

The following items shall be addressed when developing system state of health requirements:

- State of health status information displayed
- Priority of state of health events as presented to the operator
- Type of state of health event information displayed to the operator

2.6 Data Format and Communication

ANSI N42.42, "American National Standard Data Format Standard for Radiation Detectors Used for Homeland Security," specifies the data format that shall be used for both required and optional data output from radiation instruments. Data format and communication goals that shall be addressed with developing data format and communication requirements include:

- Data readability: Data should be in a format that can be read and understood without the need for proprietary software
- Data compatibility: Data should be in a format that is compatible with accepted standards
- Data extensibility: Data should be in a format adaptable to unforeseen future needs and requirements
- Data impartiality: Data should be in a format that does not favor any particular commercial entity

2.7 External Interfaces

System requirements specifications shall address any necessary external interfaces to ancillary or support equipment necessary for proper alarm evaluation and response. The following items shall be considered in the development of external interface requirements:

- Handheld radiation detection and radiological isotope identification devices
- Spectroscopy-based portal monitors
- Non-intrusive inspection equipment
- Terminal and gate operating systems

2.8 Data Analysis and Processing

A user interface shall be provided that will allow an operator to perform alarm or other event data analysis and processing. The user interface shall provide a consistent and logical means to view all necessary alarm and event information, such that an operator can make decisions

on how to process the alarm. The user interface shall also be designed to provide alarm and event type specific sequential procedures for the operator to follow to properly process the alarm or event data. System performance is also a critical element for timely data analysis and processing.

The following items shall be addressed when developing user interface requirements:

- Unique visual and audio indicators for specific alarm and event types (such as neutron-gamma pair, neutron, gamma, gamma high fault, gamma low fault, neutron high fault, system faults)
- Graphing of neutron and gamma radiation profiles (radiation portal monitor data output relative to time)
- Graphical plots of individual detectors from a radiation portal monitor
- Multiple alarm or other event prioritization
- Video data displayed and synchronization with displayed radiation data
- Operator acknowledgement of an alarm or other event
- Sequential procedures for processing alarms or other events
- Data entry by operator
- Alarm or other event closing
- Standard disposition codes
- User interface language
- User interface configuration authority
- Use of site overview maps and drill down capability
- Use of alarm or other event processing timers
- Print capabilities
- Report type and generation capabilities

The following items shall be addressed when developing system performance requirements:

- Maximum allowable time for alarm or radiation portal monitor fault events to be displayed to the operator
- Maximum allowable time for state of health fault events to be displayed to the operator
- Capabilities to process multiple, simultaneous alarms and other events

2.9 Data Storage and Archive

The following items shall be addressed when developing data storage and archive requirements:

- Data storage capacity (based on number of radiation portal monitors, expected number of occupancies and alarms including video images)
- Query and review closed or archived alarm or other event data
- Offline data archive methods and media

2.10 Training

The following items shall be addressed when developing training requirements:

- System operator training
- System administrator training
- Maintenance training
- Training manuals, materials, and other training aids
- System users guide
- System administrator guide

2.11 Sustainability and Maintenance

Sustainability and maintenance focus on keeping the system operational. Sustainability includes system administration, system reliability, and system security.

2.11.1 System Administration

The following items shall be addressed when developing system administration requirements:

- Capability to modify system configuration
- Capability to modify assessment procedures
- Capability to add or remove users
- Capability to set and modify user permissions
- Generation of system logs for significant system activities
- Capability to collect and store radiation portal monitor settings

2.11.2 System Reliability

The following items shall be addressed when developing system reliability requirements:

- Maximum allowable system downtime
- Database backup and restore capability and frequency
- Electrical power availability and quality
- Backup power

2.11.3 System Security

The following items shall be addressed when developing system security requirements:

- Closed or open network
- Prevention of unauthorized software modifications
- Data encryption
- Audit logs

2.11.4 Maintenance

The following items shall be addressed when developing maintenance requirements:

- Identification of warranty items and warranty period
- Maintenance plan identifying maintenance items and maintenance schedules
- Original equipment manufacturer's manuals
- System manual
- System maintenance tools
- Spare and replacement parts
- Virtual private network connectivity

3 Other Considerations

3.1 System Acceptance Testing

The following items shall be addressed when developing system acceptance testing requirements:

- System acceptance test plan development
- System acceptance test support

3.2 System Upgrades

The following items shall be addressed when developing system upgrade requirements:

- Capability of adding future features with minimum system re-design
- System configuration control

3.3 Documentation

The following items shall be addressed when developing documentation requirements:

- User manuals and quick reference guides
- Maintenance manuals
- System design documentation
- Interface control documents
- Test plans to address testing during development, as well as system acceptance testing
- Document configuration control

4 References

ANSI N42.32-2006, “American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security,” 22 January 2007.

ANSI N42.33-2006, “American National Standard for Portable Radiation Detection Instrumentation for Homeland Security,” 22 January 2007.

ANSI N42.34-2006, “American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides,” 22 January 2007.

ANSI N42.35-2006, “American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security,” 22 January 2007.

ANSI N42.38-2006, “American National Standard Performance Criteria for Spectroscopy-Based Portal Monitors Used for Homeland Security,” 22 January 2007.

ANSI N42.42-2006, “American National Standard Data Format Standard for Radiation Detectors Used for Homeland Security,” 23 March 2007.

ANSI N42.43-2006, “ American National Standard Performance Criteria for Mobile and Transportable Radiation Monitors Used for Homeland Security,” 23 April 2007.

IAEA Nuclear Security Series No. 1 Technical Guidance, “Technical and Functional Specifications for Border Monitoring Equipment,” June 2006.

ASTM C1129-99, “Standard Guide for Application of Radiation Monitors to the Control and Physical Security of Special Nuclear Material,” 2005.

ASTM C1236-99, “Standard Guide for In-Plant Performance Evaluation of Automatic Vehicle SNM Monitors,” 2005.

ASTM C1237-9, “Standard Guide to In-Plant Performance Evaluation of Hand-Held SNM Monitors,” 2005.