IAEA-CN-70/33

RADIATION DETECTION TECHNOLOGY ASSESSMENT PROGRAM (RADTAP)

DOUGLAS E. SMITH
United States Customs Service
1300 Independence Avenue NW
Washington, D.C. 20229

Abstract

The U.S. Customs Service and the U. S. Department of Energy (DOE) conducted a technical and operational assessment of gamma ray radiation detection equipment during the period May 5-16, 1997 at a testing facility in North Carolina. The effort was entitled, "Radiation Detection Technology Assessment Program (RADTAP)," and was conducted for the purpose of assessing the applicability, sensitivity and robustness of a diverse suite of gamma ray detection and identification equipment for possible use by Customs and other law enforcement agencies. Thirteen companies entered 25 instruments into the assessment program All detection equipment entered had to exhibit a minimum sensitivity of 20 micro-R per hour (background included) from a Cesium-137 point source. Isotope identifying spectrometers entered were man-portable and operable at room temperature with read-out that could be interpreted by non-technical personnel. Radioactive sources used in the assessment included special nuclear material, industrial and health isotopes. Evaluators included Customs inspectors and technical experts from DOE and Customs. No conclusions or recommendations were issued based on the quantitative and qualitative test results, however, the results of the program provided law enforcement agencies with the necessary data to select equipment that best meets their operational needs and budgets.

1. Introduction

The proliferation of nuclear materials available for illicit transfer and sale is a national security concern for the U.S. Among the many border missions of the United States Customs Service (USCS) is the prevention of illicit import or export of nuclear materials (or any radiation-emitting materials that may pose a public health hazard) through U.S. ports of entry. The detection and identification of such materials requires state-of-the-art equipment and trained personnel to effectively counter these threats.

1.1. Background

The USCS operates at more than 300 land, sea and air ports of entry. Approximately 6000 inspectors enforce 400 laws for more than 40 U.S. government agencies. The highest priority, highest profile mission of Customs is the detection and interdiction of drugs. Traffic volumes at the borders are immense. For example; in 1997, border entry crossings: Land--365 million (M) pedestrians; 118 M cars, 6 M tractor-trailers; Sea--8 M passengers, 214 thousand (K) boats, 5 M containers; Air--68 M passengers, 706 K commercial airliners, 130 K private planes. Based on multiple border responsibilities, priorities, and massive border crossing volume, USCS has determined that introduction of radiation detection instrumentation would have to be non-interfering with normal operations, exhibit near real time response, and require minimum technical challenge for inspectors. These requirements greatly influence the equipment to be selected for the detection and identification of radiation sources.

A plethora of radiation detection devices from scores of vendors were known to be available on the open market or under development world-wide. The means to verify objectively, product specifications and vendor representations of their products' capabilities, was lacking. Further, most of the available equipment had not been put to the test in operational environments that approximated real conditions to determine their true utility from a non-technical operator's viewpoint. The need for a comprehensive assessment program was thereby established.

1.2. Purpose

The purpose of RADTAP was to assess the capability, sensitivity and robustness of gamma radiation detection equipment. These assessments evaluated both commercially available and field prototype nuclear radiation detection and identification instruments under laboratory and field simulation scenarios. RADTAP results were to provide unbiased information for use by federal, state, and local law enforcement agencies. Individual test reports, describing the appraised performance of each evaluated instrument system were distributed only to the specific system manufacturers. Reports of all manufac-turers' performance were made available to appropriate enforcement agencies, on a "Government Use Only" basis. Explicit conclusions, recommendations, and rankings were not made regarding the equipment accomplishments. The anticipated utility of RADTAP is to allow agencies to examine the compatibility of the equipment performance with their requirements, applications, detection strategy, and budget.

1.3. Objectives

The objectives of RADTAP were two-fold: (1) to evaluate quantitatively the detection performance of gamma ray radiation detection and identification equipment entered into the assessment program and (2). to provide qualitative information on normal operational aspects of the systems in USCS-specific operational scenarios. The specific detail relating to the satisfaction of these objectives is discussed in Paragraphs 2 and 3 below.

1.4. Equipment Assessed

USCS published an announcement in the Commerce Business Daily [the U.S. government's formal advertising means to solicit vendor/developer participation in procurements], soliciting participation in RADTAP during the period May 5-16, 1997. The specific categories of detection/identification equipment requested and the number of instruments selected and entered into the Program included:

(a) Personnel-worn (pager-type, fanny pack, etc.)--seven systems assessed.
(b) Hand-held--eight systems assessed.
(c) Man portable (backpack)--no submissions for this category.
(d) Small portal system--eight systems assessed
(e) Spectrometer-based system--five systems assessed

Two of the instruments were assessed under two categories, i.e., one hand-held system and one portal system also had spectral analysis capabilities.

2. Quantitative evaluation

2.1. Bench Tests

Two controlled bench tests were developed and conducted for detection equipment to verify the minimum sensitivity and to measure the detection sensitivity (maximum distance to a target response) to a number of radiation sources over a range of energy levels (60 KeV - 2.6 MeV). Tests were conducted in an enclosed structure with background measured at 10-12 microR/hr.

2.1.1. Minimum Sensitivity Verification

For participation in RADTAP a minimum sensitivity requirement of 20 microR/hr (background included) from a Cesium 137 source was required of all detection instruments. Three instruments, all personnel-worn dosimeters, failed the minimum sensitivity requirement and were disqualified from further participation in RADTAP. Dosimeters require time to accumulate counts that exceed a threshold dose rate and then produce an alarm. They were not intended as primary detection/alarm instruments.

2.1.2. Target Response

For the personnel-worn and hand-held instruments that passed minimum sensitivity verification, additional measurements were taken to determine sensitivity to a sequence of gamma ray radiation sources. Each instrument under evaluation was placed in a fixed location. In turn, each of several radiation sources was placed directly in front of the detection instrument, causing the instrument to alarm. The radiation source was then moved away from the detector to the point that the alarm stopped, i.e. the point that the detection threshold was reached). The distance was recorded, along with readings from a calibrated health physics instrument. Table I is an example of the results obtained for one of the personnel worn detectors.

2.2. Detection Performance Assessment

A series of scenarios simulating realistic USCS operational environments were developed and configured to assess the capability of each instrument to detect and locate radiation sources in a "field" setting. DOE personnel, serving in the capacity of evaluation controllers, randomly emplaced radiation sources in various locations typical to the corresponding scenario (e.g., baggage, cargo containers, parcels/packages, and vehicles). The operational scenarios (which simulated typical Customs environments) used to assess the performance of the various classes of detector are shown in Table II. For each scenario, the USCS inspectors readied and deployed the appropriate detection instrument, conducted an inspection using standardized procedures, and recorded inspection events. Inspectors did not have prior knowledge of the type or placement of the target radiation sources. An example of the data generated from these scenario-based assessments is depicted in Table III for one of the hand-held detectors entered into the program.

2.3. Spectrometer Performance Assessment

The inclusion of room temperature, gamma ray spectrometers in RADTAP was intended to identify instruments that provide accurate isotopic analysis in simple, non-technical terms for USCS and other law enforcement personnel. The spectrometer should be capable of identifying isotopes within the general categories of special nuclear material (SNM), medical, industrial, elevated potassium (^{40}K), or background radiation. Employment of a spectrometer would usually coincide with an alarm from a gross gamma count instrument when the results could not be resolved through normal procedures. Upon detection and approximate localization of a radioactive source, the suspect item would be directed to a secondary inspection area or secured in place. Thus, the spectrometer is used as a second step for further inspection and analysis of a suspect item.

Using the source emplacements configured for the detection performance scenarios, the above procedure was simulated and individual spectrometers were assessed. The instruments were readied and deployed by the inspector, the detector element was placed as close as possible to the approximate location of the source (i.e. on contact with the vehicle, shipping container, luggage item, etc.) to obtain an optimum measurement, and the analysis results were recorded.

3. Qualitative evaluation

The qualitative assessment was designed to obtain data from non-technical personnel (i.e., USCS inspectors) relative to the physical attributes and usefulness of assessed equipment in a USCS operational environment. Although somewhat subjective, the inspectors conferred after use of each instrument and provided collaborative ratings and comments within the context of the operational scenario being conducted. Each of the following criteria was rated using a numeric scale of 1 through 5, with 1 being least favorable and 5 being most favorable:

(a) Display characteristics and ease of interpretation (readability and understandability)
(b) Utility and clarity of user controls (ease of use, understandability, robustness)
(c) Handling (weight, portability, handle and sensor placement).
(d) Alarm enunciation (audible, visual, response time)
(e) Ease of battery replacement
(f) Overall usefulness in a USCS environment

4. ASSESSMENT RESULTS

Results of this assessment are documented in a 150 page document entitled, "Radiation Detection Technology Assessment Program (RADTAP)." The report is intended solely as a reference document for govenment agencies and contains no explicit recommendations with respect to the assessment results. Data contained therein are considered proprietary with distribution for "Government Use Only," at the discretion of USCS, Applied Technology Division, 1300 Pennsylvania Avenue, Washington, D.C. 20229.

Table I
Personnel Worn Detector--Target Response
(The maximum distance at which the instrument alarms for specific isotopes)

Source	^{241}Am	^{57}Co	^{133}Ba	^{137}Cs	^{88}Y	^{232}Th	^{131}I	LEU	HEU	^{239}Pu
Radioactivity	50μCi	212μCi	195μCi	68.2μCi	170μCi	59.7μCi	104.7μCi	2.2mCi	590μCi	63 mCi
Distance	83 in	283 in	232 in	79 in	227 in	26 in	53 in	49 in	149 in	466 in

Table II
Detection Performance Assessment
Hand-held Detector

Scenario	Source (radioactivity)	Container	Source Strength (in container)	Source Placement	Source Strength (where placed)	Detect?
Land Border, Veh Walk-By	I-131 (104.7 μCi)	Bag S16	5 mR/h contact, 125μR/h @ 1m.	White Chev Celebrity, front ctr of trunk	200 μR/h contact, 18μR/h @ 1m.	Yes
	U-235 (2.2 mCi) LEU, 4.3% enrch	Bag S18	120 μR/h cntct, 24 μR/h @ 1m	Red Corsica, rear seat, driver's side	100 μR/h contact, 18 μR/h @ 1 m.	Yes