NUCSAFE

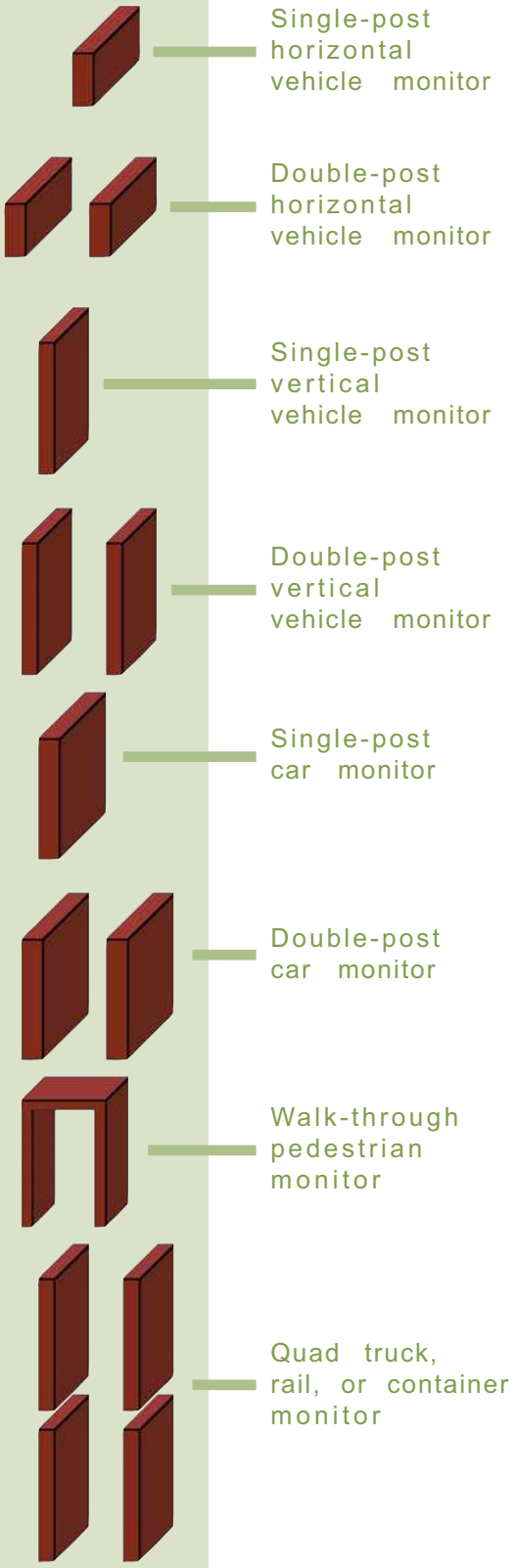
# Continuous Radiation Monitoring Systems

# Guardian CRMS

## Continuous Radiation Monitoring Systems

**A variety of installed configurations are available for everything you might want to monitor: small packages, people, cars, trucks, railcars, containerized freight—and more…**


# Stationary Systems




## Guardian CRMS Configurations

A variety of installed configurations are available for everything you might want to monitor: small packages to people, cars to trucks, or railcars and containerized freight.

### Pedestrian Monitors

A 1,000 $cm^2$ to 5,000 $cm^2$ panel with a 2”x4”x16” NaI or 5,000 $cm^3$ plastic scintillator per post in a weatherproof enclosure. For extra high sensitivity, two opposing 2,000 to 3,000 $cm^2$ panels in a walk-through enclosure.

### Freight and Luggage Monitors

One 500 $cm^2$ or two opposing 500 $cm^2$ panels with mounting hardware for attachment to freight and luggage conveyer systems. Systems also available for containerized freight inspection with 2”x2”, 3”x3”, or 2”x4” NaI or BGO per post.

### Vehicle Monitors

One 3,000 $cm^2$ panel or two opposing 3,000 $cm^2$ panels for passenger vehicles with a 2”x4”x16” NaI or 25,000 $cm^3$ plastic scintillator per post in a weatherproof enclosure.

### Truck Monitors

Two 5,000 $cm^2$ panels in a single or opposing tower configuration for trucks with a 25,000 $cm^3$ plastic scintillator per post. All systems include a weatherproof enclosure suitable for mounting next to a traffic lane.

### Quad Gate, Container, and Tractor Trailer Monitors

Four 5,000 $cm^2$ panels in a weatherproof enclosure suitable for mounting next to the gate posts and above vehicle.

### Other Configurations Available:

- Single post horizontal vehicle monitor
- Double post horizontal vehicle monitor
- Single post truck/container monitor
- Double post truck/container monitor
- Walk-through pedestrian monitor
- Gate and container monitor
- Single post vertical vehicle monitor
- Double post vertical vehicle monitor


## Radiation Sensor Panels

The modular design of Nucsafe's CRMS systems uses one or more radiation sensor panels (RSPs). Each RSP contains one or more neutron detectors made of a unique neutron-sensitive scintillating glass fiber (PUMA panels) or traditional He-3 pressurized gas tubes and one or more gamma ray detectors made of polyvinyl toluene (PVT) plastic scintillator or sodium iodide NaI(Tl) detectors. The neutron detectors are surrounded by additional polyethylene moderators designed with MCNP statistical format algorithms to optimize the neutron response to a given source. The gamma ray detectors are shadow-shielded with lead and/or steel to reduce their response from the side and behind the detector. The choice of detectors is typically a customer preference, but advantages and disadvantages exist for each type of gamma ray and neutron detection technology.

## Portal Features

- Best sensitivity available
- Simple setup and operation
- CE certified
- Rugged
- Low false alarm rate
- Fast response time
- Safe—no high-pressure gases or toxic detector materials
- Easily transported—meets all FAA and IATA regulations as nonhazardous cargo

**Nucsafe offers both neutron and gamma-ray CRMS detectors—the solid-state option to gas tube detectors.**

## Neutron Detectors

For the neutron detectors, the PUMA fiber technology provides a solid-state alternative to conventional gas tube detectors. These detectors are less susceptible to vibration often encountered in harsh real world environments such as ports, toll booths and borders where large heavy trucks induce road vibrations. These detectors are also designed to distribute the neutron sensitive atoms uniformly over the entire active area of the detector providing a more uniform response to the radiation, important when measuring large objects at larger standoff distances due to the increased geometric efficiency. $^{3}$He detectors are less expensive and provide good intrinsic efficiency for thermal neutrons. Both require proper moderator design for optimal performance. Nucsafe is pleased to offer both detector types.

## Gamma Detectors

For the gamma ray detectors, the choice between polyvinyltoluene (PVT) plastic scintillator and NaI(Tl) is based on cost and purpose. A smaller NaI detector can demonstrate improved sensitivity to PVT because the energy resolution is much better, providing improved signal to background particularly at higher energies. NaI detectors are required for Nucsafe's optional nuclide identification capability. These detectors are more expensive than PVT. When measuring large objects, the PVT plastic scintillator provides a larger geometric efficiency much the same as the neutron sensitive glass fiber does for neutron measurements. PVT is ideal for initial screening when only the presence or absence of radioactivity is needed.
The PVT gamma detectors use two photomultiplier tubes (PMT) to detect the light produced in the detector. The design of these gamma ray detectors maximizes the sensitive volume of the detector and ensures uniformity of response over its active detection area. The user can select coincident or non-coincident operation for the 2 PMTs. Coincident operation provides the ability to reject non-coincident events resulting in a lower background. Our traditional electronics use six regions of interests (ROI) and a total gamma ray counting channel to separate the energies of the gamma rays, providing improved signal to background and enhanced sensitivities. Our new gamma ray electronics use a 1024 channel multichannel analyzer that allows overlapping regions of interest independently for each of the two channels, thereby providing both continuous energy ROI data and data for specific energy intervals such as ROIs around regions where naturally occurring radioactive materials (NORM) or special nuclear materials (SNM) filtering is required.

## RSP Electronics

The electronics process the data calculating background, standard deviation and if the measured data exceed a user-definable alarm set point. The electronics are integrated into the NEMA4 or NEMA4X weatherproof enclosure and can communicate to a host computer up to 3000 meters away via RS-485 or even longer distances via Ethernet. The electronics are DC-powered and provide pulse processing electronics, calculations and communication for each of the RSPs. Data from each RSP can be polled as frequently as every 50 msec, providing over sampling of the radiation data for moving vehicles.

## Host Software

PUMA and PUMA Gold software can be installed on any Windows PC. With this software and an Ethernet connection, all monitored information can be logged and viewed from a remote connection anywhere in the world. Management of multiple systems can be performed from a single PC. See the software section for more information.

## User Selectable Nuclide Library

*72 reference spectra of gamma nuclides are categorized based on their main practical occurrence:*

**Medical**

- I-131; Tc-99m; Ga-67; I-123; I-126; In-111; Pd-103; Tl-201

**Nuclear**

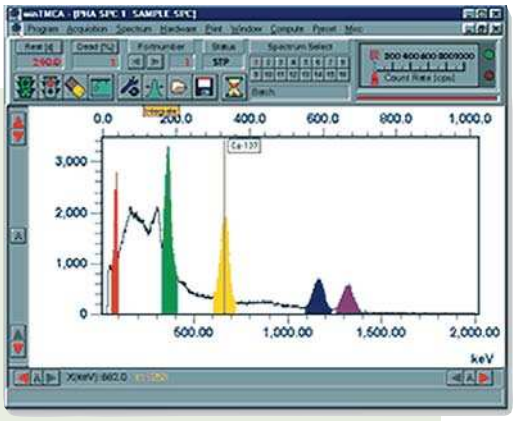
- Pu-239 ; U-233 ; U-235 ; Np-237

**OSI**

- Ba-140; Cd-116; Ce-141; Ce-144; I-132; La-140; Mo-99; Nb-96; Nd-147; Pr-144; Rh-106; Ru-103; Sb-125; Te-132; Xe-131m; Xe-133; Xe-133m; Xe-135; Zr-95

**Industrial**

- Ag-110m; Am-241; Ba-133; Bi-207; Cd-109; Co-57; Co-58; Co-60; Cs-134; Cs-137; Cr-51; Eu-152; Eu-155; Fe-59; Ir-192; K-40; Mn-54; Na-22; Ra-226; Se-75; Th-232; U-238; Zn-65; Ac-228; Ag-109m; Be-7; Bi-212; Bi-214; Ce-139; Hf-181; I-133; I-134; I-135; Mn-56; Pb-214; Ru-106; Sb-124; Sb-127; Tl-208; Y-88; Annihilation Radiation




*Versatile Windows-based software is used for NaI-spectroscopy.*

### Occupancy Sensors

An occupancy sensor is a device that senses the presence of an object (package, person, vehicle, container) in front of the radiation sensor panel. Nucsafe offers a choice of occupancy sensors including ultrasonic, active infrared pressure pads and magnetic loop sensors. Ultrasonic sensors allow a single sensor to be used and works well in all weather condition including fog. Active IR sensors work well in most weather conditions and can detect both the presence of an object and its speed. With the IR sensor, Nucsafe offers a unique directional occupancy capability that allows traffic only moving in one direction to trigger the system alarm. This feature is useful when only a single lane of traffic is available such as freight movement from a hangar at an airport. Two sensors are required for speed or directional measurements.

### Nuclide Identification

Nucsafe is the first and currently, the only company to offer real-time nuclide identification in a CRMS system. Using NaI detectors and whole spectrum fitting analysis, nuclide identification is reported within a second or two of the vehicle's passage. This option is well-suited to truck stops and inspection stations. Because of the high incidence of nuisance alarms caused by legal transport of NORM and TENORM materials as well as medical radionuclides, this capability reduces the secondary inspection frequency saving time and money. The software identifies both shielded and unshielded sources.

The Guardian CRMS is equipped with a user selectable nuclide library: 72 reference spectra of gamma nuclides are categorized, based on their main practical occurrence.

The operator can select from 6 sub-libraries: nuclear, industrial, medical, customs, CTBTO, and user. All sub-libraries except CTBTO can be edited to add or delete specific nuclides from the list. Ten reference spectra can be measured by the user and added to the predefined library spectra. Identification is done by a template-matching correlation procedure.

**The CRMS exceeds requirements of ITRAP agreements in laboratory tests.**

## Gamma/Neutron False Detection

False detection is when either a gamma-ray alarm is initiated by a neutron source or a neutron alarm is initiated by a gamma-ray source. The neutron detectors are insensitive to gamma radiation up to 100 mrad/h (1 mGy/h), gamma. The gamma-ray detectors are insensitive to neutron radiation up to 50,000 n/sec (neutron on contact). Estimated false detection rates in actual use is less than 1:100,000 alarms. Meaning, given 100,000 alarm conditions, only one will be misidentified as a gamma or neutron alarm.

## False/Missed Alarm Specifications

The false alarm probability for both the gamma-ray channel and the neutron channel is better than 1:10,000 under normal test conditions (10 µR/h) and < 0.01 n/cm2/sec at sea-level (neutron). Background update algorithms adjust the background for diurnal and environmental changes. At alarm settings of 5.2 standard deviations over background, the system statistical alarm rate is 3 in 100,000 (1:30,000) as measured in the ITRAP program. The missed alarm rate at these same setting is less than 1:1000.

## Nominal Detection Sensitivities

The CRMS design is modular and can be configured to meet any national or international sensitivity specification. Geometric sensitivity is scaled by adding or subtracting RSPs to a given CRMS system. Nucsafe CRMS system performance can be delivered to meet ASTM Category I, II, III, or IV SNM standards or ASTM Category NI, NII, or NIII SNM standards; or ANSI, ITRAP, IAEA, US Customs, and IEC requirements.

The sensitivity specifications presented here are for the nominal CRMS system, which is designed to meet ANSI N42.35, ASTM category II and NII (pedestrian), and US Customs specifications for portal monitoring

**Sensitivity Specifications**

| Isotope or SNM | Pedestrian (2 posts, 2 meters high) 0.5M distance | Vehicle (2 posts, 4 meters high) 2M distance | Rail/Container (2 posts, 4 panels per side, 4 meters high) 2M distance |
|---|---|---|---|
| $^{57}$Co | 15 µCi | 30 µCi | 30 µCi |
| $^{133}$Ba | 8 µCi | 16 µCi | 16 µCi |
| $^{137}$Cs | 7 µCi | 14 µCi | 14 µCi |
| $^{60}$Co | 3 µCi | 4 µCi | 4 µCi |
| $^{228}$Th | 6 µCi | 7 µCi | 7 µCi |
| $^{241}$Am | 200 µCi | 450 µCi | 450 µCi |
| Neutron (252Cf) | 1.2E4 n/sec | 1.2E4 n/sec | 1.2E4 n/sec |
| HEU (ASTM) | 10 g | 800 g | 800 g |
| Pu (ASTM), gamma | 0.3 g | 9 g | 9 g |
| Pu (ASTM), neutron | 30 g | 180 g | 180 g |


## Hardware Features

- Modular system electronics
- 1000 to 6000 $cm^2$ neutron sensor configurations
- 3”x3” to 2”x4”x20” NaI gamma sensor or 3800 to 76000 $cm^3$ PVT gamma sensor
- User adjustable N/G thresholds
- Solid-state glass fiber sensor or $He^3$ gas-neutron sensor
- Separate neutron or gamma ray visible alarm
- Medium- or high-level audible alarm
- Over-sampling of data intervals
- Multiple integration times
- Integrated PC104 processor and computer connectivity
- Independent or summed operation
- User or factory installation
- Selectable count modes
- Advanced shielding design
- Transportable configurations
- Universal power supply
- Occupancy sensor (IR standard)
- Tamper sensor
- One-year manufacturer’s warranty

systems (ref 6). Independent laboratory testing is still underway to certify sensitivity specifications. Sensitivity values are provided under the following test conditions:

- Background: Gamma-ray background of 10 µR/h
- Background: Neutron background of < 0.01 n/cm2/sec
- False alarm rate: no more than 1:1000 occupancies (gamma or neutron)
- Source distance: closest approach to detector (1.6 feet pedestrian, 7.8 feet vehicle)
- Source shielding: none
- Source neutron moderation: none
- Source travel velocity: 1.2 m/sec (pedestrian), 5mph (vehicle)
- Source activity certified to ± 20%
- Alarm probability of greater than 0.5 at a 95% confidence interval (ASTM C 1236-99)

Nucsafe’s Guardian Systems are certified as meeting the IAEA Illicit Trafficking Radiation Assessment Program (ITRAP) requirements. Actual performance exceeds these requirements in laboratory tests. Our system performed perfectly in field tests at the bus lane on the Austrian-Hungarian border and at the Vienna International Airport. Visit the Austrian Research Center web site at ***www.arcs.ac.at*** and download the *overview.pdf* file for the complete report.

Nucsafe has also successfully participated in the DTRA/NSSA Unconventional Nuclear Warfare Defense Program during 2002-2003.