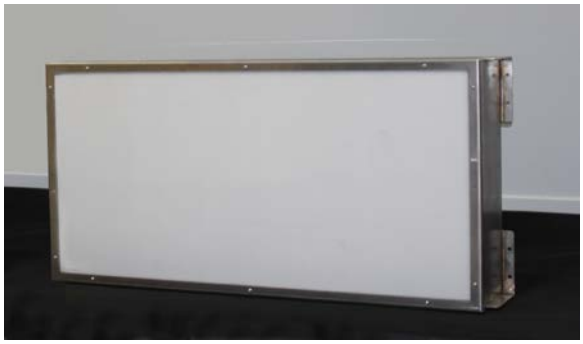
Rapiscan Cargo and Vehicle Radiation Detection Products



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Revisions

With continual development of our products, Rapiscan Systems reserves the right to amend specifications without notice.

1 OVERVIEW

Rapiscan Systems offers cargo and vehicle inspection (CVI) products that automatically detect the presence of radiation in nearby vehicles and cargo containers. The radiation may be from common sources, such as naturally occurring radioactive materials (NORM) or radioisotopes used in medical or industrial application. Radiation may also be emitted by radioactive threats, such as dirty bombs or nuclear materials. The following CVI radiation detection products are currently available:

- Radiation Detection Panel – a single panel for detecting radiation. The radiation detection panel can be deployed in a standalone configuration. Alternatively one or more panels can be mounted on a Rapiscan Eagle high-energy X-ray scanner to detect radiation simultaneously during imaging inspection.

- Radiation Portal Monitor – several radiation detection panels mounted on an arch-shaped structure, so that vehicles are inspected for radiation as they drive through the archway (portal). The Radiation Portal Monitor (RPM) is capable of effectively detecting radiation in accordance with standard specifications for such products.

The results of the radiation detection inspection, including an alarm indicating the presence of radioactive material, are presented to the inspector on an easy to understand display. These radiation detection products are designed to be rugged and to operate in a wide range of environmental conditions, like other Rapiscan CVI products.

Both products employ Rapiscan's technology for passively detecting gamma radiation and optionally neutron radiation. Neutron radiation detection uses state-of-the-art lithium-6 technology that does not rely on helium-3 gas, which is in short supply.

When a radiation detection product, such as the radiation detection panel, is used along with an Eagle scanner, the radiation detection system is fully integrated with the imaging scanner. This close integration ensures that radiation emitted during the imaging process does not adversely affect the radiation detection performance. It also enables the radiation inspection results, including the approximate longitudinal location of an alarm, to be displayed with the X-ray image, so that the inspector can evaluate the potential radiation source.

The Rapiscan radiation detection products have an attractive combination of features:

- Fully automated radiation inspection process
- Detect the presence of gamma radiation
- Optional neutron detection capability using Lithium-6 rather than He-3
- Inspection of vehicles as they drive through the RPM
- Inspect at speeds up to 8 km/hr
- Full integration with Rapiscan Eagle high-energy X-ray scanners
- Operate in wide range of environmental conditions

1.1 Application Scenarios for Rapiscan CVI Radiation Detection Products

Inspection at a Seaport. A Rapiscan radiation portal monitor is installed at the entrance to a seaport. Trucks are scanned as they drive through the RPM to determine if radioactive material is present.

Inspection at a Border Crossing. A Rapiscan radiation detection panel is mounted on an Eagle Gantry scanner located at a border crossing. Trucks inspected at the border crossing are simultaneously subjected to imaging inspection with the Eagle Gantry and radiation inspection with the radiation

detection panel. The panel increases the scope of the inspection with no additional space or infrastructure.

1.2 Rapiscan Approach to Cargo and Vehicle Inspection Products

All Rapiscan cargo and vehicle inspection products reflect our corporate commitment to excellence in imaging performance, design, ease-of-use and quality. This commitment results in products that have best-in-class imaging, low cost of ownership, high reliability and high operator satisfaction. Rapiscan offers its customers the largest selection of cargo and vehicle inspection products that share a common design philosophy.

Modular design elements that are common across multiple products – Common design elements, such as the operating software, enable operating and maintenance staff trained on one product to quickly move to a different product. It also simplifies operation, training, service and spares.

Multiple operation modes for one product – One product is able to inspect in different ways to respond to changing operational requirements. For example, an Eagle P-Series scanner can be used to scan an entire truck, including the driver cab, or just the cargo. This capability provides operational flexibility and maximizes the effectiveness of each scanner.

Products available to meet the full range of inspection requirements – Rapiscan's unmatched range of cargo and vehicle inspection products enables us to work with customers to define a solution that meets their inspection requirements. We can choose from products capable of scanning occupied vehicles to dense cargo in mobile, gantry, portal and fixed deployment configurations, which can be used alone or in combinations.

Minimize cost of ownership – Rapiscan recognizes that a customer's price for a scanner must include the cost of ownership over the unit's lifetime as well as the cost of acquisition. Therefore, we are constantly working to reduce cost of ownership. For example, the Eagle P-Series products require a small crew, which reduces labor costs associated with the cargo inspection operation

2 RADIATION DETECTION

Rapiscan's radiation detection products are designed to effectively detect the presence of radiation during inspection of vehicles and cargo.

2.1 Sources of Radiation

Sources of radiation include

- Naturally occurring radioactive materials (NORM), which are found in everyday life
- Radioactive materials used in medical and dental applications
- Radioactive materials used in industrial applications
- Radioactive threats

Everyone encounters numerous instances of exposure to radiation each day. The largest source of this radiation is from natural sources such as cosmic rays from the Sun and radioactive elements, such as Uranium and Thorium, in the Earth. Additionally we are exposed to radiation from Naturally Occurring Radioactive Material (NORM), such as building material products made from various kinds of clay, from ceramics, and even from some foods. These exposures are summed together into what is called "natural background" radiation.

The amount of exposure from this natural background radiation changes from place to place depending on the altitude and the local geology. For example, much of the eastern part of the United States, which is near sea level, has a natural background level of approximately 10 microrem/hour. In Denver, the mile

high city, which is closer to the sun, the natural background is twice as high, approximately 20 microrem/hour. These radiation levels are not generally considered dangerous. (A rem is a unit of radiation dose equivalent. A rem is a large dose of radiation, so the millirem, which is one thousandth of a rem, is often used for the dosages commonly encountered, such as the amount of radiation received from medical x-rays and background sources. A microrem is one millionth of a rem. The SI unit of radiation dose equivalent is the sievert (Sv), where 1 Sv=100 rem.)

Other sources of radiation to which the general public may be exposed are medical isotopes used in radio pharmaceutical treatments, X-rays for medical or dental purposes, such as medical imaging. Industrial isotopes are commonly used for numerous purposes in industry. We all have in our homes a prime example of an industrial use of a radioactive material – a smoke detector, which contains a very small radioactive source. The stronger sources of radiation, particularly those that are potentially dangerous, are licensed and carefully controlled to minimize exposure to the public.

Radioactive Threats. Radioactive threat materials include special nuclear materials (SNM) that can be used in a nuclear weapon, such as uranium (U-235 and U-233) and plutonium (Pu-239) and common medical or industrial radioisotopes that can be used in radiological dispersive devices (dirty bombs), such as cesium (Cs-137) and cobalt (Co-60).

We are certainly familiar with the large scale destruction and loss of life from detonation of a nuclear weapon from photos of Japan in World War II. Highly enriched uranium, which can be used in nuclear weapons, is of particular concern because of unsecured material that may be available from the former Soviet Union. The threat from a dirty bomb, which does not cause such massive property damage, is the threat to the population and infrastructure of large scale radioactive contamination with attendant loss of use and cost of clean-up. Each of these threat scenarios is different in many aspects but each should be considered in the determination of the over-all threat that each one represents as well as the difficulty in planning and conducting an operation that would result in such a threat.

2.2 Radiation Detection

The presence of radioactive materials is sensed by detecting gamma radiation and neutrons. Both are ionizing radiation with sufficient energy to remove an electron from an atom or molecule. Approaches to detecting both gamma radiation and neutrons utilize passive radiation detection methods, where detectors are stationed near the anticipated source location waiting for a source to come by. Rapiscan radiation detectors are designed to detect gamma radiation with additional capability to detect neutrons, if required.

Gamma Radiation. Gamma radiation (gamma rays) is electromagnetic radiation, like radio waves or X-rays, of high frequency (short wavelength). Gamma rays are usually naturally produced on Earth by decay of high energy states in nuclei of atoms, a process called gamma decay. Reactions with cosmic rays also create gamma rays.

Gamma radiation is commonly detected using a plastic scintillator, a plastic material, such as polyvinyl toluene (PVT), that converts gamma ray energy to light energy. The light is then converted to electrical signals.

Neutron Radiation. A neutron is a subatomic particle with no electric charge and a mass slightly larger than that of a proton. Neutrons are detected during the neutron capture process, when an atomic nucleus collides with one or more neutrons and they merge to form a heavier nucleus.

In a neutron detector, the energy released from neutron capture is converted into electrical signals. Until recently, helium-3 was the material typically used for this purpose. However, helium-3, which is produced artificially, is increasingly scarce. Therefore, Rapiscan's radiation detection panel uses lithium-6 for neutron detection. A neutron radiation detector can be added to a gamma radiation detector panel to produce a single panel that detects both types of radiation.

3 RAPISCAN CVI RADIATION DETECTION PRODUCTS

Rapiscan CVI radiation detection products consist of

- Radiation detection panel
- Radiation portal monitor

3.1 Radiation Detection Panel

A Rapiscan radiation detection panel is shown in Figure 1. The plastic scintillator for gamma radiation detection and the electronics are inside the panel behind the protective white plastic cover. If required, an optional neutron radiation detection device is also contained inside the unit.

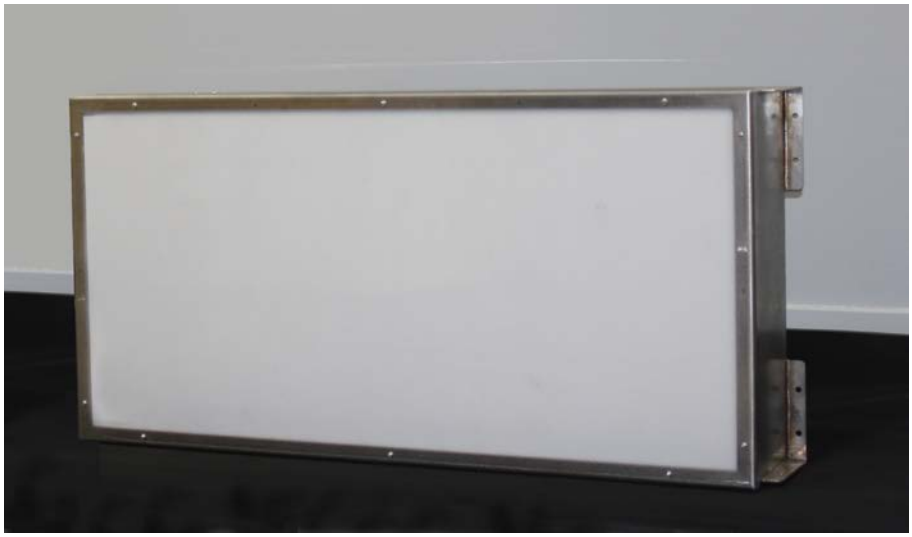

Figure 1. Gamma Radiation Detector Panel

3.2 Radiation Portal Monitor

A radiation portal monitor (RPM) is a collection of radiation detection panels mounted on a structure in a portal or archway configuration. The subject of the radiation inspection, such as a truck or car, is inspected as it moves through the portal. The RPM is designed so that the inspection field of view – the width and height – will inspect the largest vehicle. The design of the RPM depends on the specified performance, including the radioisotope type and activity (rate of decay), the distance from the radioactive material to the detector and the speed of motion through the RPM

A Rapiscan RPM with 7 radiation detection panels is shown in Figure 2. In this configuration, the panels are positioned on the vertical members, three on each side of the portal. If required to meet the specified performance, a panel is also mounted on the horizontal member of the portal, as shown in Figure 2.

The RPM also has an electrical panel, which houses the power supply and computing components, and combines signals from all the detectors. An optional module is also available that provides conformance to ANSI N42.42 data format and communication requirements.

The RPM has a monitoring station with a simple user interface for monitoring the output of the radiation detection inspection, including gamma and neutron alarms. The monitoring station can be installed in a nearby office. Optionally Rapiscan can supply a small inspection office with the RPM.

Figure 2. Radiation Portal Monitor

3.3 Integrated Radiation Detection and X-ray Scanning

Rapiscan Systems cargo and vehicle inspection products include high-energy X-ray imaging scanners and radiation detection monitors. Sometimes these products are deployed separately. In a standalone deployment, an RPM is installed at the entrance to a critical facility so that trucks are inspected for the presence of radioactive material. In other cases, the radiation detection occurs during X-ray scanning.

Figure 3 shows the Eagle M60 mobile scanner with a radiation detection panel, like the one shown in Figure 1, behind a door on the passenger (scanning) side of the vehicle. The panel is visible in Figure 4, where the access door is open. As the Eagle M60 drives past a stationary unoccupied vehicle, it uses the radiation detection panel to detect radiation while the vehicle moves through the X-ray beam. The linear accelerator X-ray generator and the radiation detection panel are integrated so that the presence of the X-ray beam does not produce an alarm. The output of the radiation detection inspection is conveniently superimposed on the X-ray image, so that the inspector can easily see the location of an alarm and evaluate potential radioactive sources visible in the image.

Figure 2. Eagle M60 with Boom Deployed for Scanning

Figure 3. Radiation Detection Panel Installed on Side of Eagle M60

4 Operation

The RPM supports a continuous flow of vehicles to ensure high scanning throughput. Inspection of a vehicle with the standalone RPM typically consists of the following sequence of events:

1. When a vehicle is detected approaching the RPM inspection zone, the system automatically stores the natural background radiation count rate.
2. As the vehicle approaches the RPM, a snapshot photograph of the vehicle and driver is taken, if this optional capability is installed. The license plate number can also be automatically captured using the optional automatic number plate recognition capability.
3. The vehicle is inspected as it passes through the RPM. The cargo container number is automatically captured using the optional automated container code recognition capability, if this capability is installed.
4. The vehicle inspection data is transmitted to the control station computer. Inspection data consists of the inspection date and time and the gamma and optional neutron radiation count data. Other optional inspection data include the vehicle license plate, the container number, the vehicle photograph and the container photograph.
5. Each new package of data forms a new database record which inspectors can review. Inspectors can sort this database by features, such as date, time, vehicle license plate number or container number.
6. The result of the inspection is also stored in the database.

Optionally, the Inspector/Operator can be provided with one or more CCTV screens on which he can monitor the site around the RPM.

Crew. The RPM is designed for highly automated operation and does not require any dedicated staff for normal operation. An Inspector/Operator will typically be available to deal with vehicles that alarm.

Maintenance. With no moving parts, the RPM requires minimal maintenance. Nonetheless, the system is designed to allow easy access to the electronic and electrical equipment for service personnel.

Environment. The CVI radiation detection products are designed to operate in a wide-range of weather conditions.

- Operating Temperature range: -10ºC to 40ºC
- Optional Cold Weather Kit extends the low temperature range to -40°C when cold weather operating requirements are followed (see below)
- Optional Hot Weather Kit extends the high temperature range to 55ºC.
- Humidity 5% to 95% non-condensing

The design draws on Rapiscan Systems' experience deploying cargo inspection systems at a wide variety of locations. The CVI radiation detection products are designed to perform in all deployment environments, including seaside, dusty and sandy sites and tropical conditions and various weather conditions, including rain and snow. The unit must be operated in accordance with the Operator Manual and maintained in accordance with the Maintenance Manual.

5 Safety

The Rapiscan radiation detection panel and RPM are designed and manufactured in accordance with the Rapiscan Systems quality management system and is CE marked. These passive radiation detectors do not emit radiation, so they pose no radiation hazard during operation.

6 Performance

There are a number of standards that address radiation detection for security applications, including:

- ANSI N42.35, American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security – This standard addresses performance requirements for conventional portal monitor instruments used in support of efforts associated with the US DHS.
- ASTM C1236-99, Standard Guide for In-Plant Performance Evaluation of Automatic Vehicle SNM Monitors – This guide is designed to verify whether an SNM monitor performs as expected for detecting SNM or an alternative test source.
- IAEA 1240, Technical and Functional Specifications for Border Monitoring Equipment – This standard addresses performance, testing and deployment of radiation monitors used to detect and characterize radioactive material at borders or inside countries.

Standards, such as ANSI N42.35, specify the performance of an RPM under defined test conditions, including

- Type of radioisotope
- Activity of radioisotope
- Separation between RPM pillars
- Speed of motion through the RPM

Test conditions specified in ANSI N42.35 include:

- Distance between vertical monitors – 5m (16.4 ft)
- Vehicle speed – 8km/h (5 mph)
- Minimum height of “detection zone” – 0.2m to 4.5m (0.6 ft to 14.8 ft) above ground

Under these conditions, Rapiscan RPMs will detect the isotopes and neutron source with the activities specified in ANSI N42.35 and listed in Table 1 when tested according to the ANSI N42.35 test procedures.

Table 1. Radiation Detection Performance

Radioisotope	Test Source Activity, µCi
Co-57	5 µCi
Ba-133	14 µCi
Cs-137	16 µCi
Co-60	7 µCi
Th-232	14 µCi
Am-241	47 µCi
Cf-252 (neutrons)	2×10^4 n/s ± 20%

Rapiscan radiation detection products, in particular the RPM, are designed to meet the requirements of ANSI N42.35, which is typically relevant to most vehicle inspection applications.