5 Radiation Safety

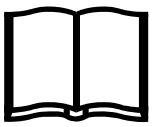
The purpose of this chapter is to provide radiation safety information for personnel who will operate and/or work near the **Vehicle Scanning System**.

Important Note:

This chapter is not intended to be a substitute for a radiation safety course, which is required to be reviewed or administered by the appropriate radiation protection regulatory authority or their approved designee, or by the system manufacturer.

5.1 Radiation Safety and the Vehicle Scanning System

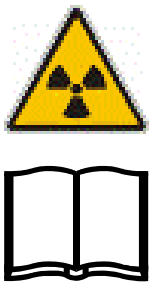
While all our company's security scanning equipment is designed for safe operation, the Vehicle Scanning System does emit **gamma rays**, and caution is advised when operating the System or performing maintenance.



DEFINITION: gamma rays

Very high energy electromagnetic radiation (interacting electric and magnetic field waves traveling at the speed of light or less if passing through matter).

Gamma rays interact with material by colliding with electrons around atoms. Depending on their initial energy, gamma rays can travel in air anywhere from 1 foot to hundreds of feet.



⚠ WARNING

All gamma-ray inspection systems have inherent risk and must be operated with safety in mind. Follow site radiation protection practices regarding the use of Gamma-Ray inspection systems such as the **Vehicle Scanning System**.

Only trained operators should handle the Vehicle Scanning System and equipment, and all the precautions in this manual must always be observed.

5.2 Standard Units of Radiation Measure

NOTICE

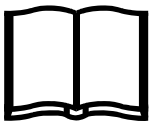
Throughout this Manual, there are numerous references to units of radiation measure, such as the following units of "**dose equivalent**":

- the **Sv** ("Sievert", from the International System of Units), and
- the **Rem** ("Roentgen Equivalent Man", a traditional unit of measure).

Definitions for units of radiation measurement are provided in **Appendix B**.

Note: In the original Product Manuals, the above Appendix is at the back of the Manual. In this excerpt, the content from the Appendix has been inserted after page **8**.

5.3 ALARA



DEFINITION: ALARA

As Low As Reasonably Achievable is a concept based on the assumption that any exposure to radiation involves some risk. Because the effects of chronic exposure to low levels of **ionizing radiation** (*) are not precisely known, there is an assumed risk from any exposure. (*) See definitions in Appendix B.

The goal of any ALARA Program is to keep individual radiation doses as far below the dose limits as is reasonably achievable.

The success of an ALARA Program is directly linked to a clear understanding and adherence to the policies and procedures provided for the protection of workers.

Keeping radiation doses ALARA is the responsibility of all workers, management, and the facility **Radiation Safety Officer (RSO)**.

NOTICE

There are three (3) common methods of dose reduction that you should apply every time you work with any source of radiation:

(1) minimize your time around a source of radiation,

(2) maximize your distance from a source of radiation, and

(3) always use available shielding between you and the source of radiation.

5.4 Operational Radiation Controlled Area

An operational Radiation Controlled Area must be set up prior to operating the Vehicle Scanning System. The actual dimensional boundaries of this Controlled Area may vary depending on customer site requirements and applicable local regulations.

For any cargo inspection system, including the Vehicle Scanning System, the dimensions of the Controlled Area depend on a number of factors, including:

1. The number of scans performed per hour (duty cycle);
2. The scan speed;
3. The length of objects scanned;
4. The intensity of the gamma-ray beam as represented by penetration; and
5. The dose limit at the controlled area boundary.

NOTICE

The dimensions of the Radiation Controlled Area are based on a maximum dose rate at the boundary of **20 µSv/hour** (2 mRem/hour), and an integrated dose of **0.5 µSv** (0.05 mRem) in one hour.

This may vary slightly in size for site characteristics, such as uneven/non-level surface and the type of materials used for pavement (concrete, asphalt, etc.).

The Radiation Beam is "OFF" when drivers pass through the inspection area and the Radiation Exclusion Zone (**5.5**). The beam does **not** turn "ON" until the driver has fully passed the region of the collimated primary beam.

Any radiation dose to the drivers of the inspected trucks will be less than **0.1 µSv** (0.01 mRem) per scan, and are in compliance with permissible doses as indicated in ANSI 43.17.

⚠ WARNING

The Radiation Safety Officer (**RSO**) must confirm the actual radiation dose readings (which are dependent upon the age of the source), and is responsible for establishing the actual dimensions of the Radiation Controlled Area employed.

The recommended operational **Radiation Controlled Area** for a Vehicle Scanning System that employs a **Cobalt-60** gamma source is illustrated in **Figure 1** below.

Notes:

- The depicted Radiation Controlled Area is based upon conducting 20 scans in one hour at a minimum speed of 3 kilometers per hour (2 miles per hour), assuming an average length of 12 meters (40 feet) for each cargo vehicle scanned.
- The maximum dose rate at the boundary is **20 µSv/hour** (2 mRem/hour), and an integrated dose of **0.5 µSv** (0.05 mRem) in one hour.
- The size of the Radiation Controlled Area may be reduced with the addition of concrete or similar shielding materials. (See **Figure 2**.)
- All radiation measurements were taken 92 cm (3 feet) above ground level.

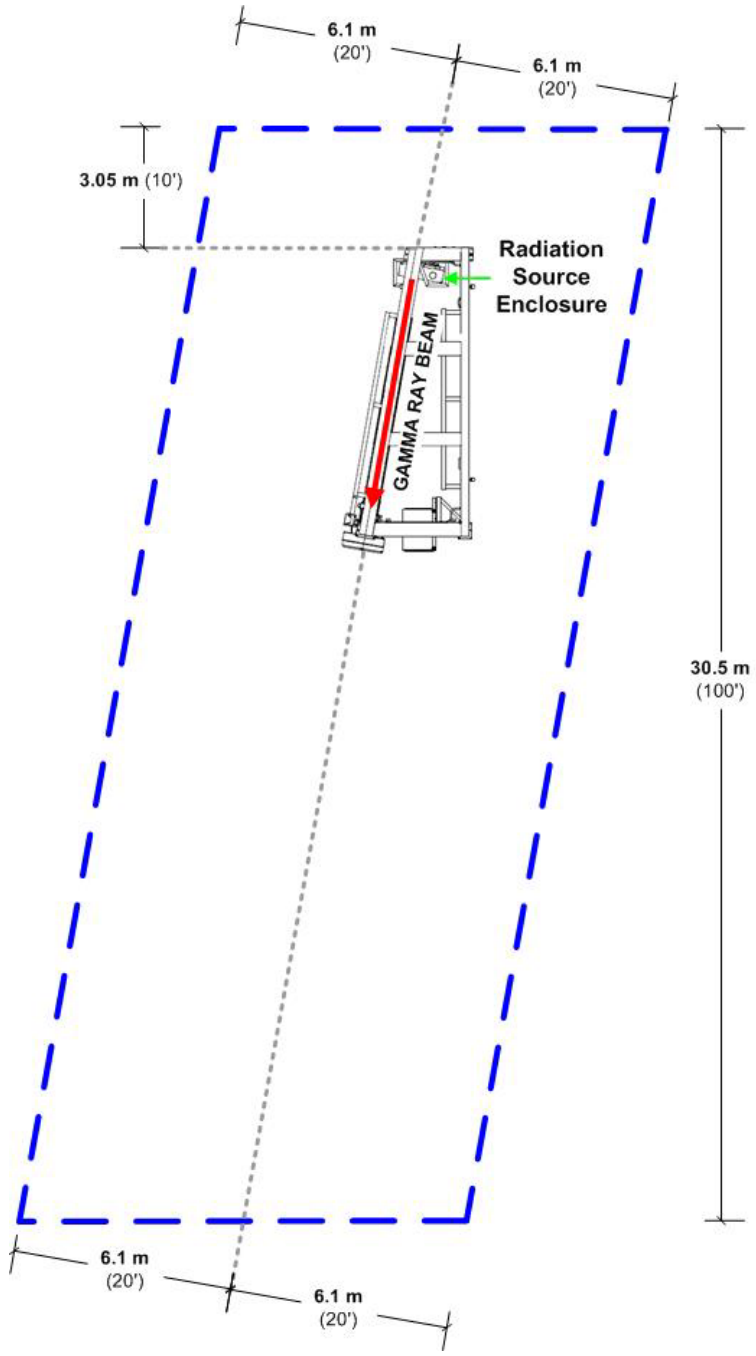


Figure 1: Radiation Controlled Area (without Shield Material)

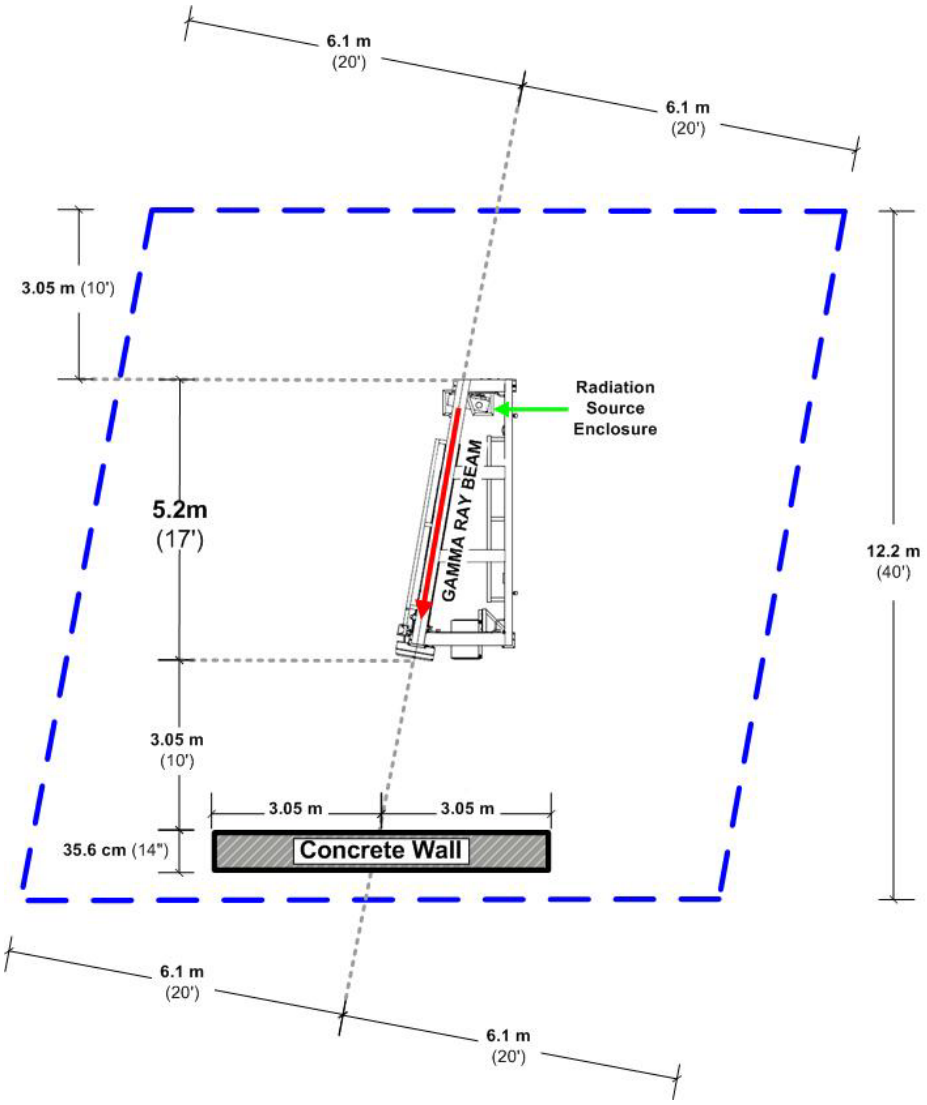


Figure 2: Radiation Controlled Area <u>with</u> Shield Material

⚠ WARNING

The Vehicle Scanning System Operator Workstation must always be located <u>outside</u> the boundary of the **Radiation Conrolled Area**.

This ensures that the annual effective dose to the Operator(s) at the Workstation does not exceed **1,000 µSv per year** (100 mRem per year), and assures the dose will be within the limits established for members of the general public.

5.5 Operational Radiation Exclusion Zone

The operational Radiation Exclusion Zone for the Vehicle Scanning System is the area within which **no persons should be present** when the radiation source is "ON".

NOTICE

The Radiation Beam is "OFF" when drivers pass through the inspection area and the **Radiation Exclusion Zone**. The beam does **not** turn "ON" until the driver has fully passed the region of the collimated primary beam.

Any radiation dose to the drivers of the inspected trucks will be less than **0.02 µSv** (0.002 mRem) per scan, and are in compliance with permissible doses as indicated in ANSI 43.17.

⚠ WARNING

The Radiation Safety Officer (**RSO**) must confirm the actual radiation dose readings (which are dependent upon the age of the source), and is responsible for establishing the actual dimensions of the **Radiation Exclusion Zone** employed.

The operational **Radiation Exclusion Zone** for a Vehicle Scanning System that employs a **Cobalt-60** gamma source is illustrated in **Figure 3** on the following page. The dimensions shown on this diagram assume that the site has no external shielding walls.

Figure 4 (on page 8) shows the operational **Radiation Exclusion Zone** for a Vehicle Scanning System with a **Cobalt-60** gamma source at a site that does employ external shielding walls.

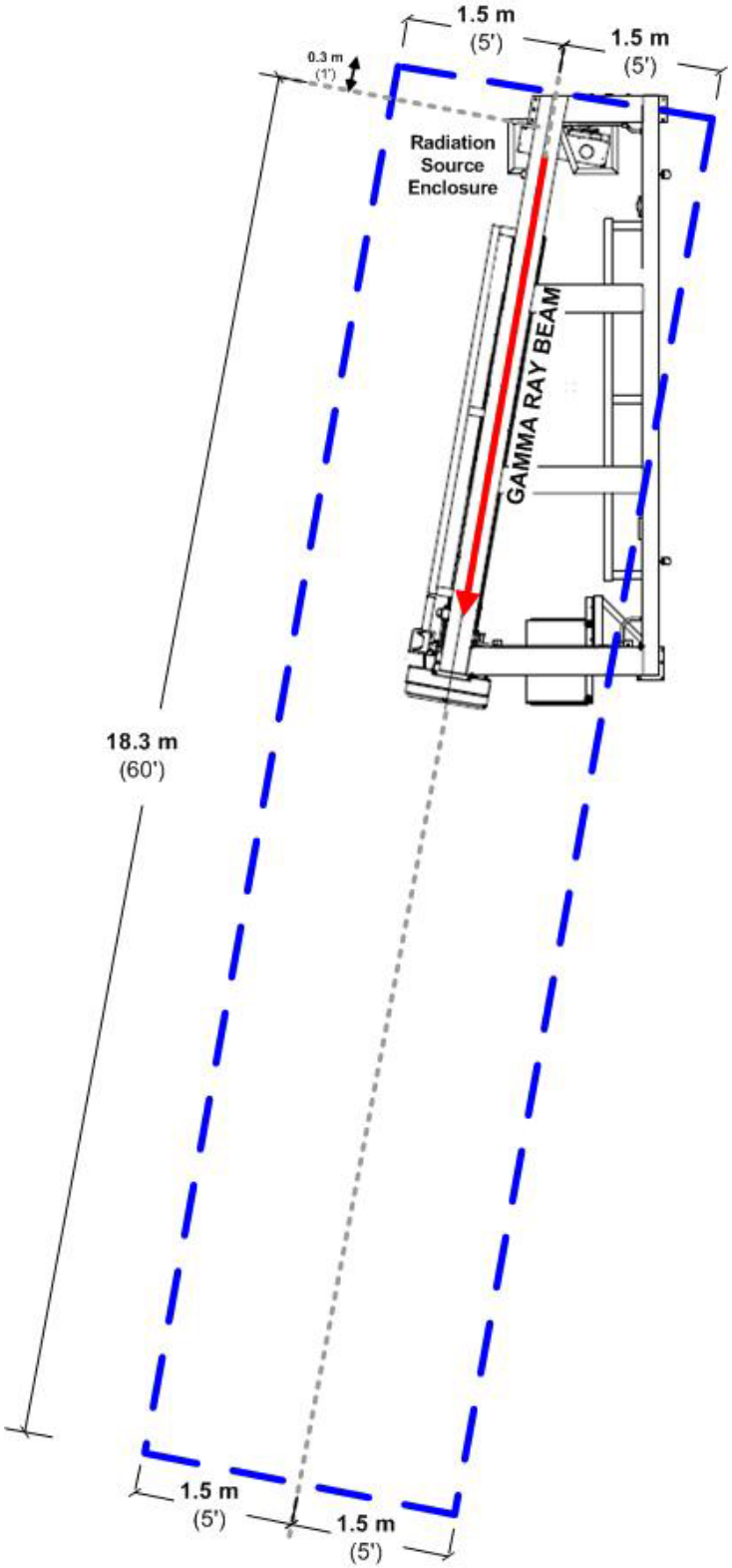


Figure 3: Radiation Exclusion Zone (without Shield Material)

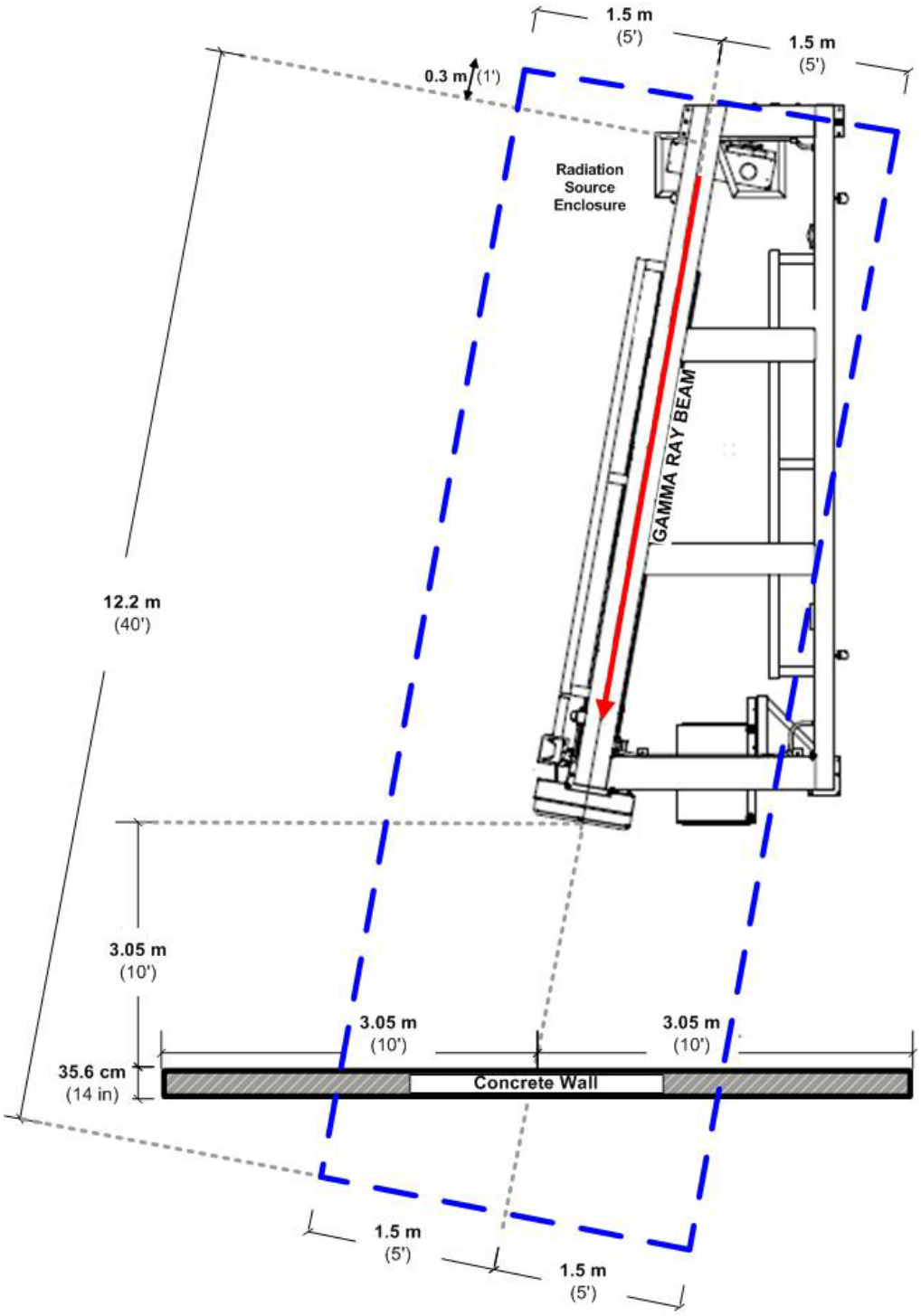


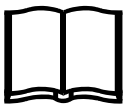
Figure 4: Radiation Exclusion Zone <u>with</u> Shield Material

<u>Note</u>: In the original Product Manuals, this chapter includes additional content that contains proprietary information, and so has been excluded from this brief excerpt.

Appendix B: Units Of Radiation Measure

When radiation is measured, different terms are used based on whether we are:

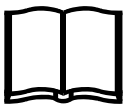
- measuring radiation emitted from a radioactive source,
- measuring the radiation dose absorbed by an individual, or
- measuring the risk an individual may suffer biological effects from exposure to radiation.



DEFINITION: radioisotope

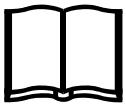
An isotope (one form of a chemical element) that is unstable and prone to break up (**decay**). Decay releases small fragments of atoms and energy in the form of **radiation**.

Also referred to as a radioactive isotope.



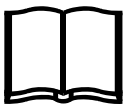
DEFINITION: SI (International System of Units)

Système International d'Unités (International System of Units) is the international standard set of units of measurement set by the 11th General Conference on Weights and Measures in 1960.



DEFINITION: Becquerel (Bq)

A unit of radioactivity, in the **SI** system, equal to the amount of radiation from a radioactive isotope that **decays** at the rate of **1 disintegration per second**.

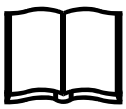


DEFINITION: Curie (Ci)

A unit of radioactivity, equal to the amount of radiation from a radioactive isotope that **decays** at the rate of 37,000,000,000 disintegrations per second.

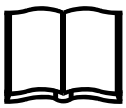
1 Curie (Ci) = 37 Giga-Becquerels (37 GBq)

(37,000,000,000 Becquerels)



DEFINITION: ionizing radiation

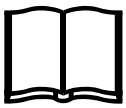
Types of radiation which have enough energy to cause the tiny atoms that make up a material to become "**ionized**" – having a positive (+) or negative (–) electrical charge – after the radiation passes through the material.



DEFINITION: exposure

Exposure is a measure of the ability of electromagnetic radiation, such as gamma-rays, to produce ionization in air.

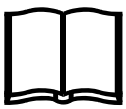
Traditionally, the unit of exposure is the **Roentgen (R)**.



DEFINITION: absorbed dose

A measure of the amount of energy absorbed or deposited per unit of mass.

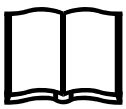
The unit **Rad (R)** can be applied to all types of radiation and is defined as the deposition of 100 ergs of energy in one gram (mass) of any material.



DEFINITION: dose equivalent

A measurement that expresses, on a common scale for all ionizing radiations, the magnitude of radiation effects likely to be incurred by exposed persons.

Dose equivalent is computed multiplying the absorbed dose in **Rad** by a **Quality Factor** (**QF**)



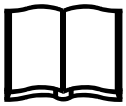
DEFINITION: Quality Factor (QF)

An energy dependent factor which relates:

(a) the amount of radiation effects likely to be incurred by exposed persons from the type of radiation absorbed, to

(b) the amount of radiation effects from the same dose of gamma rays.

The **QF** is **1** for gamma rays.



DEFINITION: Roentgen Equivalent Man (Rem)

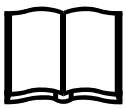
A unit of measurement for dose equivalent, computed as:

1 Rem = 1 Rad × QF

For X-rays and gamma rays (where the QF is 1), 1 Rad of exposure results in 1 Rem of dosage.

A Rem is a large amount of radiation, so the milli-Rem (**mRem**), which is one thousandth of a Rem, is often used for the dosages commonly encountered, such as that from medical X-rays or background sources.

A micro-Rem (**µRem**) is one millionth of a Rem.



DEFINITION: Sievert (Sv)

The SI unit of dose equivalent, defined as:

1 Sv = 100 Rem

In security equipment, a more applicable unit is the micro Sievert (**µSv**), which is one millionth of a Sievert (Sv).

1 µSv = 100 µRem

[End of Sample]