RADIOACTIVE MATERIAL HANDLING SAFETY

Student Reference Guide

March 1997

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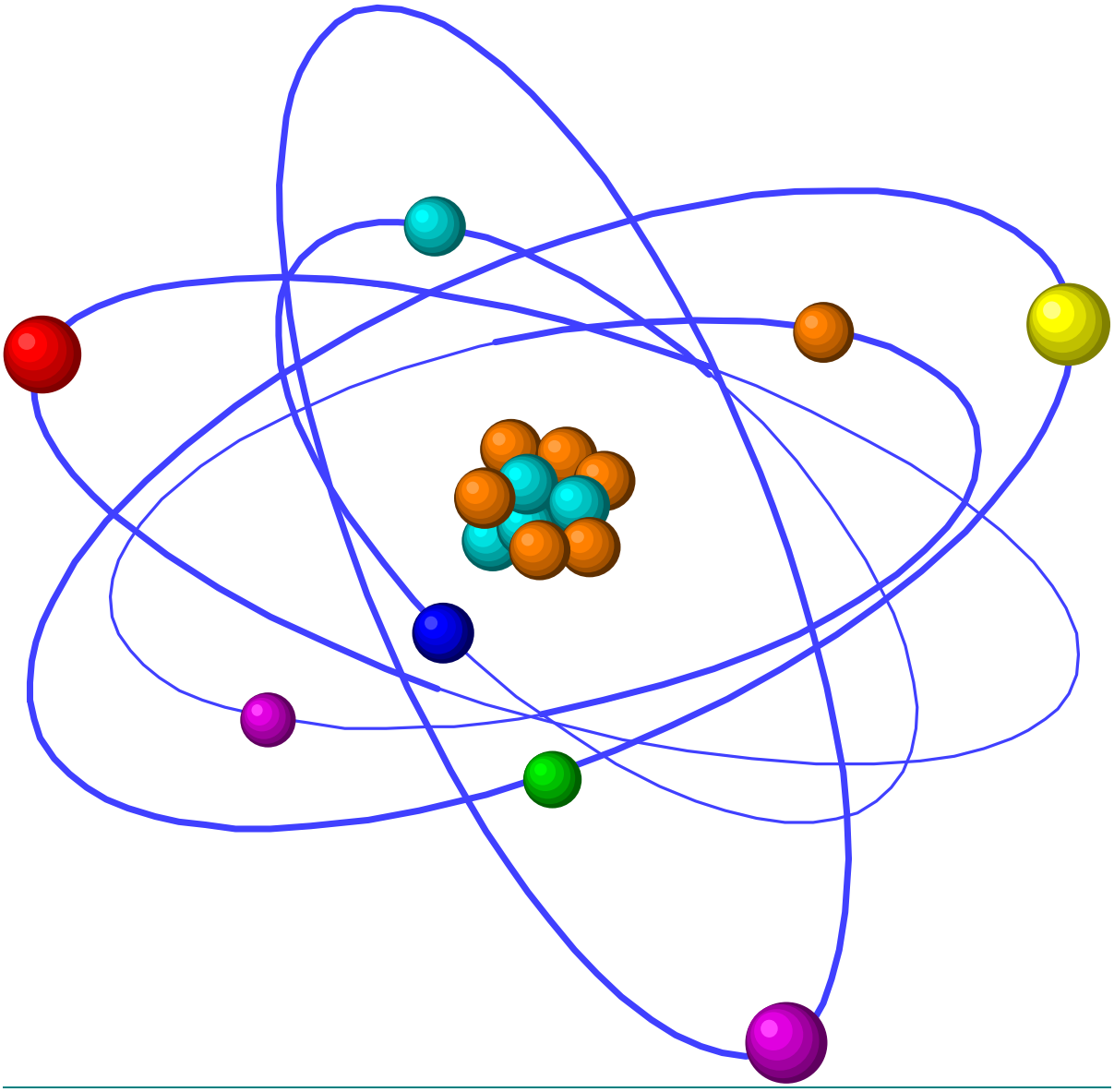

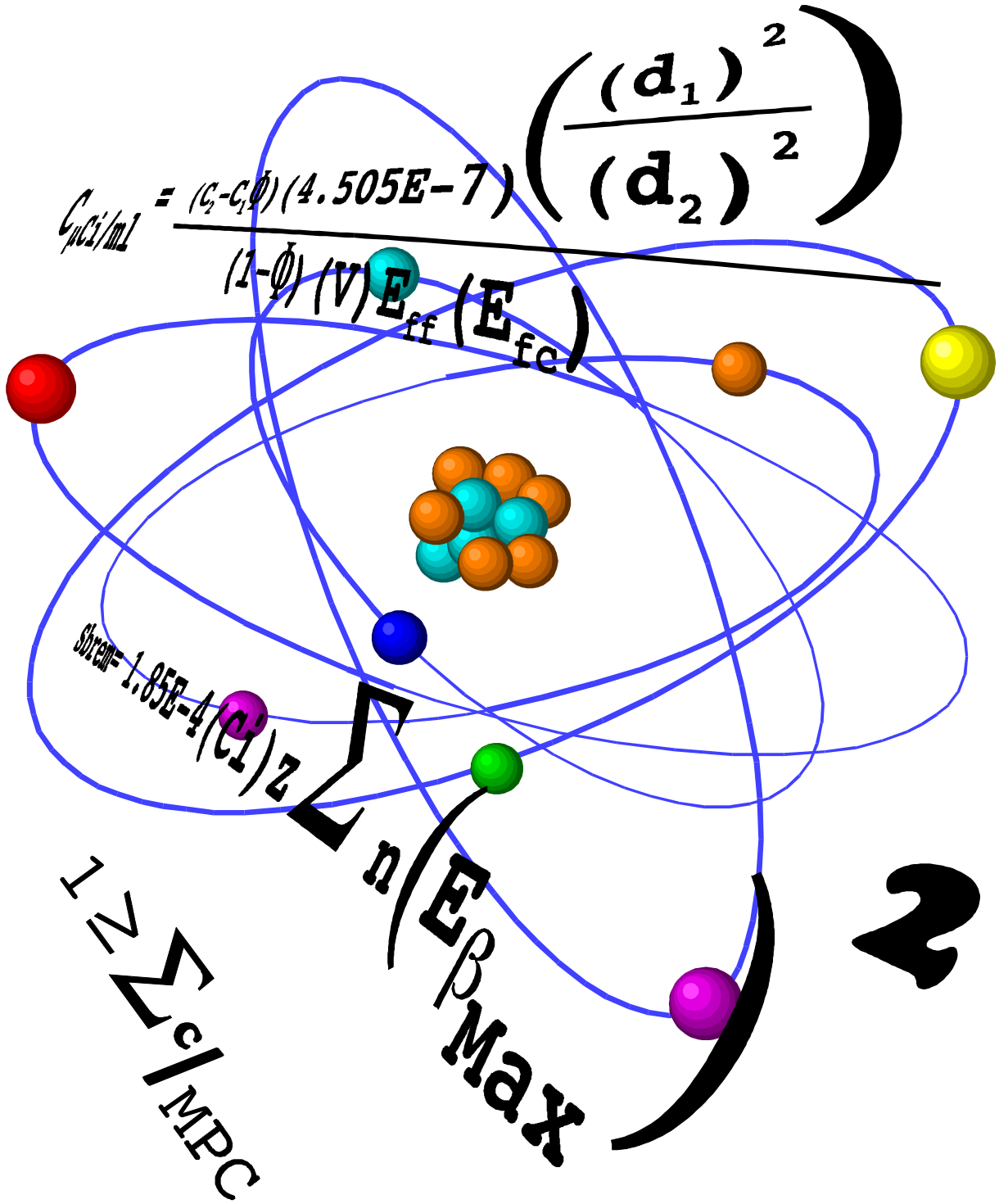
$C_{\mu Ci/ml} = \frac{(C_2 - C_1\phi)(4.505E-7)\left(\frac{(d_1)^2}{(d_2)^2}\right)}{(1-\phi)(V)E_{ff}(E_{fc})}$
$Strem = 1.85E-4(Ci)z\sum n\left(E_{\beta Max}\right)^2$
$1 \geq \sum c/_{MPC}$

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

Radioactive Material Handling Safety

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Radioactive Material Handling Safety

LP-RAD-01
Introduction to Radioactive Materials

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Radioactive Material Handling Safety

LP-RAD-02
Miscellaneous Radioactive Material

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Radioactive Material Handling Safety

LP RAD-03
Tritium

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LP-RAD-04
Depleted Uranium

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LP-RAD-05

The Nuclear Regulatory Commission Licenses and Other Regulations

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Radioactive Material Handling Safety

LP-RAD-06
Wipe Testing and DoDRATTS

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Radioactive Material Handling Safety

LP-RAD-07
Storage, Transportation, and Monitoring of Radioactive Materials

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Radioactive Material Handling Safety

LP-RAD-08
Emergency Procedures

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Radioactive Material Handling Safety

LP-RAD-09
Decontamination Procedures

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Radioactive Material Handling Safety

LP-RAD-10
Medical Evaluation and Monitoring

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Radioactive Material Handling Safety

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Radioactive Material Handling Safety

Student Reference Guide

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>>> ANNUAL REVIEW AND CERTIFICATION <<<

COURSE TITLE: Radioactive Material Handling Safety.

PURPOSE: To train selected individuals in the safe handling and hazards associated with radioactive materials used in military applications.

PREREQUISITES: None

LENGTH OF COURSE:

Administration	1.0
Conference	35.0
Final Review, Examination and Critique	4.0
Total	40.0

Radioactive Material Handling Safety
(33.0 Hours)

LESSON NO.	SUBJECT	HRS
LP-RAD-01	Introduction to Radioactive Materials	5.0
LP-RAD-02	Miscellaneous Radioactive Material	4.0
LP RAD-03	Tritium	5.0
LP-RAD-04	Depleted Uranium	5.0
LP-RAD-05	The Nuclear Regulatory Commission Licenses and Other Regulations	4.0
LP-RAD-06	Wipe Testing and DoDRATTS	5.0
LP-RAD-07	Storage, Transportation, and Monitoring of Radioactive Materials	3.0
LP-RAD-08	Emergency Procedures	2.0
LP-RAD-09	Decontamination Procedures	1.0
LP-RAD-10	Medical Evaluation and Monitoring	1.0
LP-RAD-12	Review, Examination and Critique	4.0
	Total Lesson Hours	39.0

Program of Instruction

LP-RAD-01 Introduction to Radioactive Materials

Hrs/Type: 5.0 C (U) 0.0 PE

Objective: Provide an overview of radioactive material and terminology

Conditions: Classroom

Standard: Student will understand the terminology associated with radioactive materials used in various military applications.

References: TB 9-1300-278
TM 3-261
AR 385-11
AR 700-64
Reference Guide: Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
10 CFR 20

LP-RAD-02 Miscellaneous Radioactive Material

Hrs/Type: 4.0 C (U) 0.0 PE

Objective: Provide an overview of miscellaneous radioactive materials used by the Army to include nickel-63, americium-241, thorium fluoride and other radioactive materials.

Conditions: Classroom

Standard: Student will understand what Thorium, nickel-63, americium-241 and other radioactive materials are, what they are used for, where they can expect to find them, and what some of the hazards are.

REFERENCES: TB 9-1300-278
TM 3-261
TM 5-6635-386-12&P
TM 11-6665-251-10
TM 11-6665-208-15
Reference Guide: Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
DARA 21-12-05
DARA A-21-12-04

LP-RAD-03 Tritium

Hrs/Type: 5.0 C (U) 0.0 PE

Objective: Provide an overview of tritium and tritium devices used in the military.

Conditions: Classroom

Standard: Student will understand what tritium is, what it is used for, where they can expect to find it, and what some of the hazards associated with it are.

REFERENCES: TB 9-1300-278
TM 3-261
McGraw-Hill Encyclopedia of Science and Technology
Reference Guide: Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
NRC License BLM 12-00722-06

LP-RAD-04 Depleted Uranium

Hrs/Type: 5.0 C (U) 0.0 PE

Objective: Provide an overview of depleted uranium materials used in the military

Conditions: Classroom

Standard: Student will understand what Depleted Uranium is, what it is used for, where they can expect to find it, and what some of the hazards associated with it are.

REFERENCES: TB 9-1300-278
TM 3-261
TM 9-2350-200-BD
Security Classification Guide for Abrams Tank System
Reference Guide: Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
10 CFR Part 20
10 CFR Part 40

LP-RAD-05 The Nuclear Regulatory Commission (NRC) Licenses and Various other Regulations.

Hrs/Type: 4.0 C (U) 0.0 PE

Objective: Provide information concerning the various licenses and regulations associated with radioactive materials.

Conditions: Classroom

Standard: Student will understand the requirements placed on the soldier and DoD personnel by NRC Licenses and other governing regulations.

REFERENCES: TB 9-1300-278
TM 3-261
Reference Guide: Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
10CFR20
NRC License 12-00722-06
NRC License 12-00722-13
NRC License 12-00722-14
NRC License 21-01222-05
AR 385-11

LP-RAD-06 Wipe Testing and DoDRATTS.

Hrs/Type: 2.0 C (U) 3.0 PE

Objective: Train students on proper wipe test procedures. Provide information on how to properly report wipe tests and other transactions that are monitored through the Department of Defense Radiation Testing and Tracking System.

Conditions: Classroom

Standard: Students will understand how to perform a proper wipe test on equipment and facilities suspected of radioactive contamination and how DoDRATTS functions.

REFERENCES: AR 710-3
AR 385-11
TM 3-261
ACALA SOUM 95-04
TM 3-6665-312-30&P
TM 3-6665-331-23&P

LP-RAD-07 Storage, Transportation, and Monitoring of Radioactive Material.

Hrs/Type: 3.0 C (U) 0.0 PE

Objective: Provide information about storage, transportation, and monitoring requirements associated with radioactive material

Conditions: Classroom

Standard: Student will understand the handling of radioactive material.

REFERENCES: TB 9-1300-278
TM 3-261
TM 11-6665-208-15
10 CFR Part 20
49 CFR
49 CFR 73
AR 385-11
AR 700-64
AMCCOM PAM 385-1

LP-RAD-08 Emergency Procedures

Hrs/Type: 2.0 C (U) 0.0 PE

Objective: Provide an overview of radioactive material emergency procedures.

Conditions: Classroom

Standard: Student will understand how to handle and who to notify in the event of various radioactive incidents.

REFERENCES: TB 9-1300-278
TM 3-261
10CFR20
10CFR40
AR 385-11
AR 385-40

LP-RAD-09 Decontamination Procedures

Hrs/Type: 1.0 C (U) 0.0 PE

Objective: Provide an overview of decontamination procedures that are most effective with the various types of radioactive material covered in this course.

Conditions: Classroom

Standard: Student will understand the various methods of decontamination used to help render safe and/or minimize potential spread of radioactive contaminants.

REFERENCES: TB 9-1300-278
TM 3-261

LP-RAD-10 Medical Evaluation and Monitoring

Hrs/Type: 1.0 C (U) 0.0 PE

Objective: Provide a basic understanding of the methods used to evaluate and monitor personnel for exposure to radioactive contaminants.

Conditions: Classroom

Standard: Student will understand the terminology and methods used to monitor and evaluate individuals who have possible radioactive contamination.

REFERENCES: TB 9-1300-278
TM 3-261
DARCOM HDBK 385-1.1-78
"BASIC RADIATION PROTECTION TECHNOLOGY" by D.A. Gollnick
10CFR20
Reference Guide Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
AR 40-5

Introduction and Definitions

Although our society has been concerned for some time with the potential radioactive contamination of the environment resulting from the technological exploitation of nuclear energy, the fact is that the universe is and always has been permeated with radiation, and at the present time there are about a billion rays traveling through space for every elementary particle of matter. This remarkable set of circumstances has been evolving for 10 billion years. The depth and scope of radiation safety is conservative; i.e., they over estimate the risk of harmful effects.

The development of radiation technology left its casualties -- physicists, radiologists, radiation chemists -- researchers who have investigated the properties and uses of radiation without appreciating their capacity for destructive effects in living matter.

It was very soon after the discovery of X-rays that it became apparent that these new rays had both beneficial and harmful effects. It wasn't until 1920 and the plight of radium dial painters that the US Government and scientists began to seriously contemplate setting up standards for protection against radiation injury.

During World War I, it was found that radium paint, a mixture of radium and phosphor, could be used to illuminate airplane instruments. Thus an industry grew up in the eastern US (mainly in New Jersey.) After the war the radium industry switched from military to civilian applications, painting watch and clock dials and faces. Young girls were employed in this industry. It was custom for them to form a fine point on their brush by shaping it between their lips, before dabbing the radium paint on the watch. Subsequently, from this procedure, they ingested small amounts of radium. During this period it was estimated that over four million watches had radium painted dials. Between 1921 and 1924 nine radium workers died of severe, unexplained cancer causes, accompanied by destructive lesions of the mouth and jawbones. The medical cause of death was eventually associated to the radium.

All the effects known to be caused by radiation exposures are duplicated by exposure to some other type of toxic agent and none that are uniquely tied to radiation have yet been discovered.

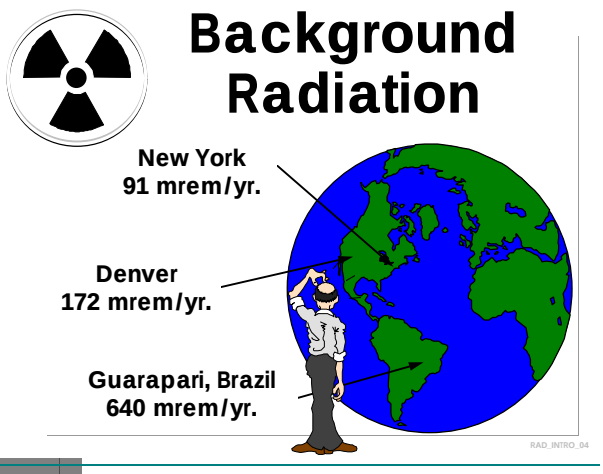
An estimate of the hazard associated with exposure to low levels of radiation likely to be encountered with routine use of radioisotope sources is complicated by the elusive nature of the possible effects. For the levels of exposure set by regulatory agencies no prompt or delayed consequences of any kind can be measured. Possible effects are sufficiently subtle so that they are lost in the normal variations which are inevitable when comparing one group of workers or subset of the population with another. Estimates of the hazard must then be made on limited data from exposures to much higher levels.

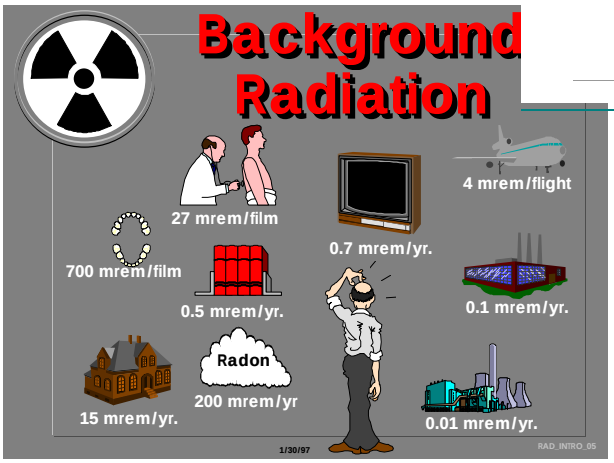
Student Notes

Ultimately, all of the standards for radiation are tied back to radiobiology data. In the earliest standards, this data was chiefly from animal experiments. As experience has grown, more and more human data has been obtained through the use of radiation in a variety of medical treatments, through data from occupational workers, from radiation accidents and from survivors of the Japanese atomic bombings. Unfortunately though, much of the data has been obtained at doses and dose rates well in excess of those encountered in the workplace so that some assumption must be made in extrapolating these observable effects to the lower dose.

Some recent studies suggest that radiation appears to be beneficial to health at low levels. This is a very controversial area of study and some say these reports are as much based on fact as Elvis sightings. More to the point is that the actual degree of harm of low levels of exposure to radiation is unknown. Therefore the NRC and health physicists take a conservative approach of minimizing any exposure to any radiation. Although the word "safe" is commonly used in referring to radiation exposure, it should be clearly understood that NO amount of radiation, regardless of the amount, can be considered 100% safe. "Biologically acceptable" is a more descriptive term in that no individual receiving up to that amount would be expected to develop manifestations of radiation injury.

It must be pointed out that exposure to radiation is nothing new. From the time we first appeared on this earth we have been receiving about 80 mrems per year from natural sources such as rocks, cosmic rays, air, food, and water. The amount of background radiation is not constant around the Earth, some areas are a lot higher than others.





Student Notes

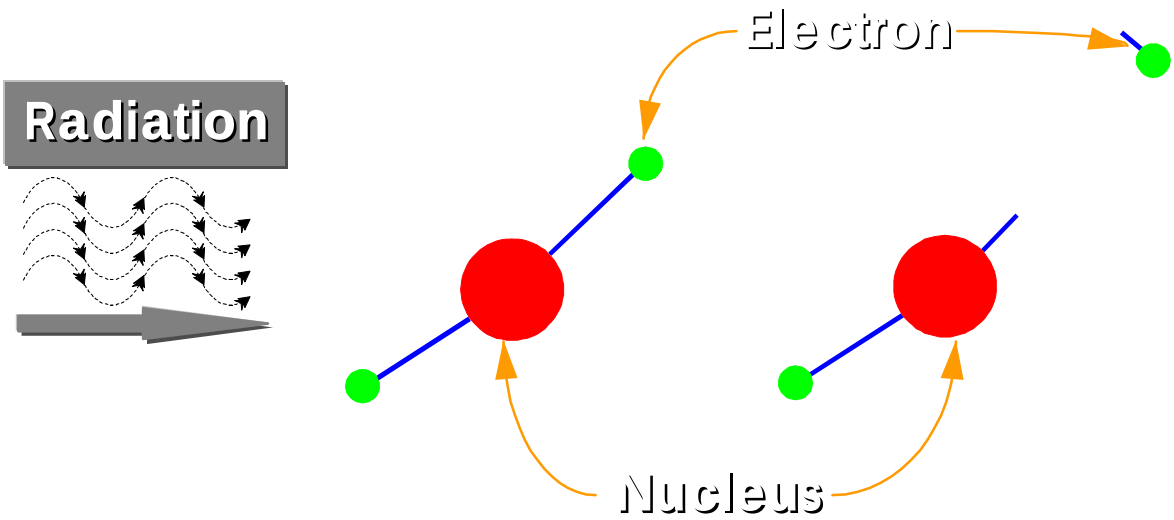
As technology advanced more radiation sources have become a part of daily life. But remember, the difference here is that these are doses due to things that we accept in the normal course of life. Exposure to radiation from Army equipment is mostly avoidable and as such must be minimized.

Radiation: The emission or propagation of energy or matter in the form of energy waves or particles.

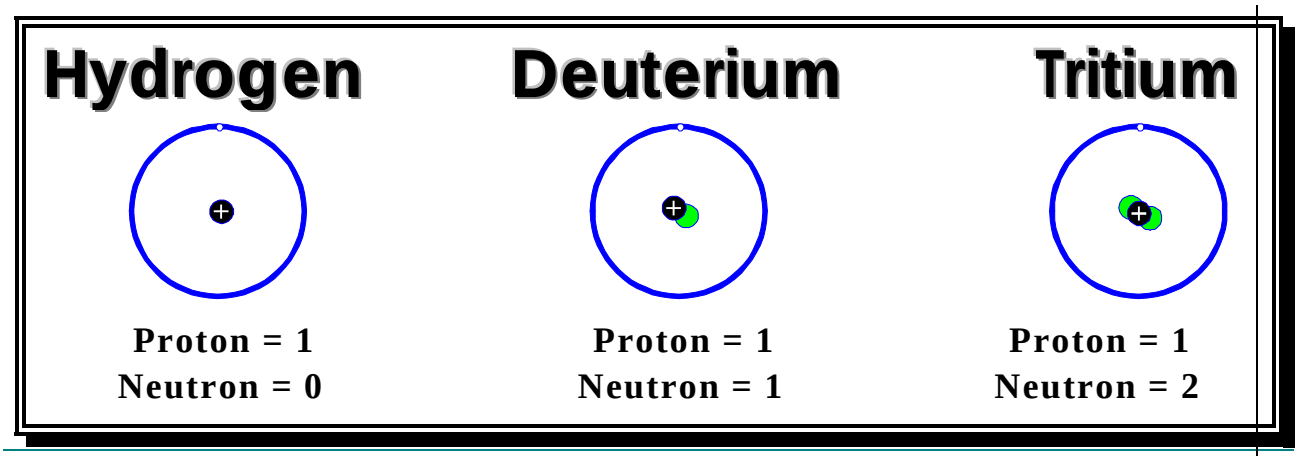
Radioactivity: The spontaneous decay of a material resulting in the release of ionizing radiation. For a substance to be considered *Radioactive Material* it must emit ionizing radiation as a result of nuclear disintegration. To be considered *Radioactive* the rate of nuclear disintegration must exceed 0.002 microcuries (μCi) per gram.

Student Notes

Ionization: The process by which electrons are added to or removed from an atom.



Isotope: Different forms of the same element having identical *chemical* properties but differing in *atomic mass*.



Student Notes

Background Radiation: Radiation from cosmic sources, naturally occurring radioactive materials, and global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials regulated by the NRC. Background radiation is not constant. It varies depending on many factors to include geographical location, altitude, mineral content of the soil, material content of surrounding structures, and industrial activity in the area.

Licensed Material: Source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the NRC.

Lost / Missing Licensed Material: Licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system. When licensed material is lost or stolen the loss or theft must be reported within 4 hours after discovery of the event.

Alpha Particles: Particles emitted from the nucleus of a radioactive atom. These particles travel at speeds from 9,000 to 20,000 miles per second and have 2 protons and 2 neutrons but no electrons. These particles have an extremely high **ionizing** ability because of their positive electrical charge that attracts electrons from other atoms. Because of their size though, they have very little penetrating ability and are easily shielded. They travel only a short distance in air, typically 2 - 8 cm, and can not penetrate the outer layer of dead skin. A single sheet of tissue paper can totally stop alpha particle radiation. Alpha particles are chiefly an internal radiation hazard.

Beta Particles: Generated inside the nucleus of a radioactive atom. These particles can be either negatively or positively charged and have a mass equal to an electron. The amount of energy carried by a beta particle can vary a great deal depending on the radionuclide it is emitted from. In air, beta particles can travel from a few millimeters to several feet depending on their energy levels. The ionizing ability of a beta particle is less than that of an alpha particle but it has a much higher penetrating capability. These factors normally make beta emitters a less serious internal hazard than alpha emitters. However, since higher energy beta particles can penetrate the skin and damage living cells, some beta emitters can be an external radiation hazard.

Student Notes

Gamma Rays: This type of radiation is not particulate. They are short wave length photons with no mass or charge that are emitted from the nucleus of a radioactive atom. Except for their origin they are very much like x-rays and are the most penetrating form of radiation. Compared to alpha and beta radiation, gamma rays travel great distances in air, typically about 25 feet, and require heavy shielding material such as lead or depleted uranium. Gamma radiation is primarily considered to be external radiation hazard.

Half-Life: The amount of time it takes for half of the mass of a material to disintegrate through radioactive decay. For example, the radiological half-life of tritium is 12.3 years. If you started with a 10 Ci source, after 12.3 years it would be a 5 Ci source. After another 12.3 years it would be only 2.5 Ci and so on. This is assuming of course that none of the tritium was able to leak through the container; a purely hypothetical situation for sure.

Activity: The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the *curie (Ci)* and the *becquerel (Bq)*.

Absorbed Dose: The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the *rad* and the *gray (Gy)*.

Dose Equivalent: The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the *rem* and *sievert (Sv)*.

Quality Factor: The modifying factor that is used to derive dose equivalent (rem) from absorbed dose (rad).

Student Notes

Units of Measure

Curie

The ***activity*** level of a radioactive material expressed in terms of the number of atoms that will disintegrate (decay) per second. One curie (Ci) is the amount of activity in which 37 billion (3.7×10^{10}) atoms disintegrate per second.

RAD

(*Roentgen Absorbed* Dose)

A unit of measure used to define the ***absorbed dose*** of ionizing radiation. One RAD equals the amount of energy of 100 *ergs* (a measure of energy) per gram of irradiated material.

REM

(*Roentgen Equivalent* Man)

A unit of measure adopted in 1968 used to express the ***dose equivalent*** and takes into account the damage done by various types of radiation on living tissue. It is defined as the amount of energy absorbed in the body and indicates the biological damage to human tissue. One rem equals the dose in rads times a quality factor.

To many people not accustomed to working around radioactive materials these terms can be confusing. To help sort these units of measure out it might be helpful to show an analogy with something a bit more familiar. As we all know, a common light bulb is generally designed to be used at a specific voltage level. Lets call this the ***CURIE*** rating of the light bulb. How much light a bulb is going to emit is commonly expressed as the wattage of the bulb (100 watt bulbs are much brighter than 50 watt bulbs). Since a watt is a measure of energy, it would be similar to the ***RAD*** unit of measure for radioactivity. Now, to continue this analogy, I must invent a new unit of measure. It is common knowledge that after a light bulb has been on for a while it can get quite hot; hot enough to damage human tissue. Lets call this the *owie* rating of the bulb. A 100 watt incandescent bulb might be rated at 100 *owies* whereas a 100 watt fluorescent bulb might only be 10 *owies*. Our new *owie* unit of measure is analogous to the ***REM***.

Student Notes

The international units used to express these values are the *becquerel*, *gray*, and *sievert* respectively. As to which units you are more likely to see in the field, 10CFR20.2101(a) states:

> **"Each licensee shall use the units: curie, rad, rem, including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by this part."**

This would seem to be a quite strong argument that the *curie*, *rad*, and *rem* are here to stay; but alas, that is not the case. In true bureaucratic fashion, the NRC's stance on this can best be seen in a response to a comment in the preamble to the new 10CFR20:

> **Response: Although both the "special units" and the SI units appear in the text of part 20 (to increase the familiarity of licensees with the SI units), the Commission has decided that adoption of the SI units at this time is not necessary. The Commission recognizes that the new terms and methodological approaches in the amendments to part 20 are complex and that imposition of the SI system of units on top of this complexity would further increase the potential for confusion. Consequently, at the present time, the record keeping, reporting, and notification requirements require the use of the "special units," the rad, the rem, and the curie. However, as the national move to metrication continues, as anticipated in section 5164 of the Omnibus Trade and Competitiveness Act of 1988 (Pub. L. 100-418), at some later time there may be amendments to part 20 that would require the use of SI units only (becquerels, grays, and sieverts).**

Student Notes

With this in mind, the following definitions of the international units are:

Becquerels	Gray	Sievert
The ***activity*** level of a radioactive material expressed in terms of the number of atoms that will disintegrate (decay) per second. One becquerel is equal to one disintegration per second.	A unit of measure used to define the ***absorbed dose*** of ionizing radiation. One gray is equal to an absorbed dose of 1 Joule per kilogram.	A unit of measure used to express the ***dose equivalent*** and takes into account the damage done by various types of radiation on living tissue. It is defined as the amount of energy absorbed in the body and indication the biological damage to human tissue. One sievert equals the absorbed dose in grays times a quality factor.

Basically, these definitions are quite similar to the curie, rad, and rem as far as what they are measuring. This makes conversions between the different units of measure fairly straight forward.

1 curie (Ci) = 3.7 X 10^{10} becquerels (Bq)	**1 Bq = 1 Ci / 3.7 X 10^{10}**
1 rad = 0.01 gray (Gy)	**1 Gy = 100 rad**
1 rem = 0.01 sievert (Sv)	**1 Sv = 100 rem**

External Dose: That portion of a radiation dose received from radiation sources outside the body.

Internal Dose: A radiation dose received from radioactive material taken into the body.

Student Notes

Somatic Effects: Health effects that occur in the individual after an exposure. These are effects to that individuals own body and can include reddening of the skin (beta burn), cancers, cataracts, etc.

Stochastic Effects: Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

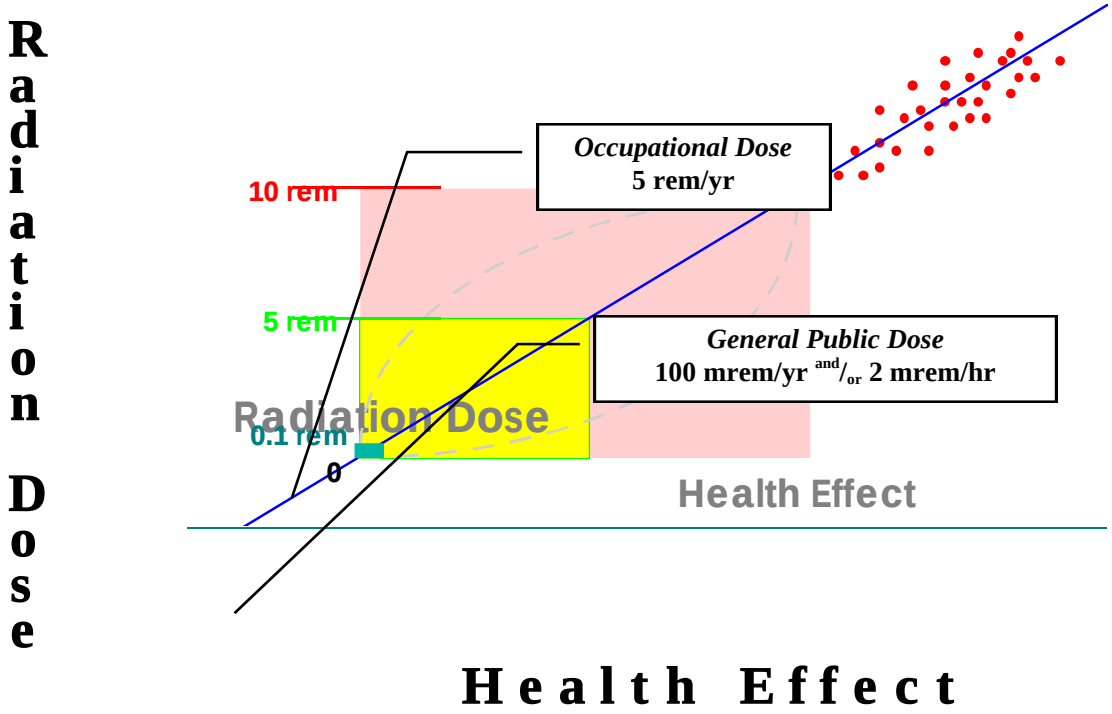
Nonstochastic Effects: Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation induced cataract formation is an example of nonstochastic effect (also called a deterministic effect).

Embryological Effects: These effects are caused by cell damage to a living fetus or embryo and can result in abnormalities such as stunted size, mental retardation, or other birth defects.

Genetic Damage: This type of effect may cause genetic mutations to appear in future generations. Typically these will not appear until the second or third generation.

Student Notes

Occupational Dose: The dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public. The occupational dose limit established by the NRC is a maximum of 5 rems per year for whole body exposure.



Student Notes

Public Dose: The dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

[1] The total effective dose equivalent to individual members of the public from any licensed operation cannot exceed 100 mrem per year.

[2] The dose in any unrestricted area to individual members of the public from external sources cannot exceed 2 mrem per hour.

Student Notes

ALARA

One of the most important changes to regulations issued by the NRC is the **requirement** to keep all exposures to radiation *as low as reasonably achievable*, (ALARA). 10CFR20.1101(b) states:

> **"The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)."**

In 10CFR20.1003 the NRC further defines ALARA as:

> **"...making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."**

The foundational basis of all radiation protection standards is that all exposures will be as low as **reasonably** achievable, with economic and social factors being taken into account. The permissible levels of exposure represent **upper** limits; not levels below which exposures are OK. Standards are all expressed in concrete numbers limiting radiation doses. Through constant usage, numbers of this type can be taken for granted. It is very easy to assume that there will be **no** problems or injuries in the limits are not exceeded. This may be true, but, NO ONE can be absolutely sure of this in light of *present* knowledge. Since the relationship between low level radiation exposure and biological damage is still uncertain and hotly debated, standards have been established on a very conservative basis. The International Commission on Radiological Protection (ICRP) and the NRC have nevertheless taken the reasonable stand that all unnecessary exposure should be avoided, even if it is within established limits.

Controlling Exposure

The primary means for controlling exposure to external sources of radiation are:

DISTANCE

Radiation intensity from a point source rapidly decreases with distance from the source. Doubling the distance decreases the amount of radiation by a factor of four.

TIME

The actual radiation dose received is time dependent. Minimizing the time spent

Student Notes

around radioactive material minimizes the potential dose.

SHIELDING

Low levels of Beta Radiation can be stopped completely by 0.5 inches of water, even less thickness of plastic, or less than 0.25 inches of glass. Leather gloves can decrease the radiation dose to the hands by 50%.

Administrative, engineering controls, and personal attention to the principles of radiological protection are essential requirements that minimize individual exposure to ionizing radiation. The judicious use of time, the imposition of shielding, and the maximizing of distance between an individual and a source of ionizing radiation will minimize the dose equivalent to the individual.

Prompt completion of assigned duties in a radiation area minimizes exposure.

Never improvise when working around radioactive materials. Follow the procedures in the TM and never perform any maintenance that is beyond your level.

Isolation of radioactive materials shields the material and also maximizes the distance between an individual and the radioactive material.

Maintaining arms length between the radioactive source and the body can significantly reduce the exposure dose.

SAFETY RULES

The following rules are listed for all personnel who work with or use equipment containing radioactive material:

Smoking, eating, drinking, applying cosmetics, or chewing gum or tobacco within the area must be prohibited. This is to help minimize the potential ingestion of radioactive materials.

Always wash your hands after handling radioactive materials or sources with non-abrasive soap.

In the event of an accident or injury, injured personnel should be removed under the supervision of medical personnel. If injury occurs inside a

Student Notes

building or room with possible radioactive contamination, the injured person should be moved to limit exposure.

Local medical, police, and fire facilities should be informed of radiological handling operations.

Student Notes

Bioassay: The determination of kinds, quantities or concentrations, and, in some cases, the locations, of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

Airborne Radioactive Material: Radioactive material dispersed in the air in the form of dust, fumes, particulates, mists, vapors, or gases.

Airborne Radioactivity Area: A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations:

[1] In excess of the derived air concentrations (DACs) specified in appendix B to 10CFR20.1001 thru 2401

or

[2] To such a degree that an individual present in the area without respiratory equipment could exceed, during the hours an individual is present in a week, an intake of 0.6% of the annual limit on intake (ALI).

Student Notes

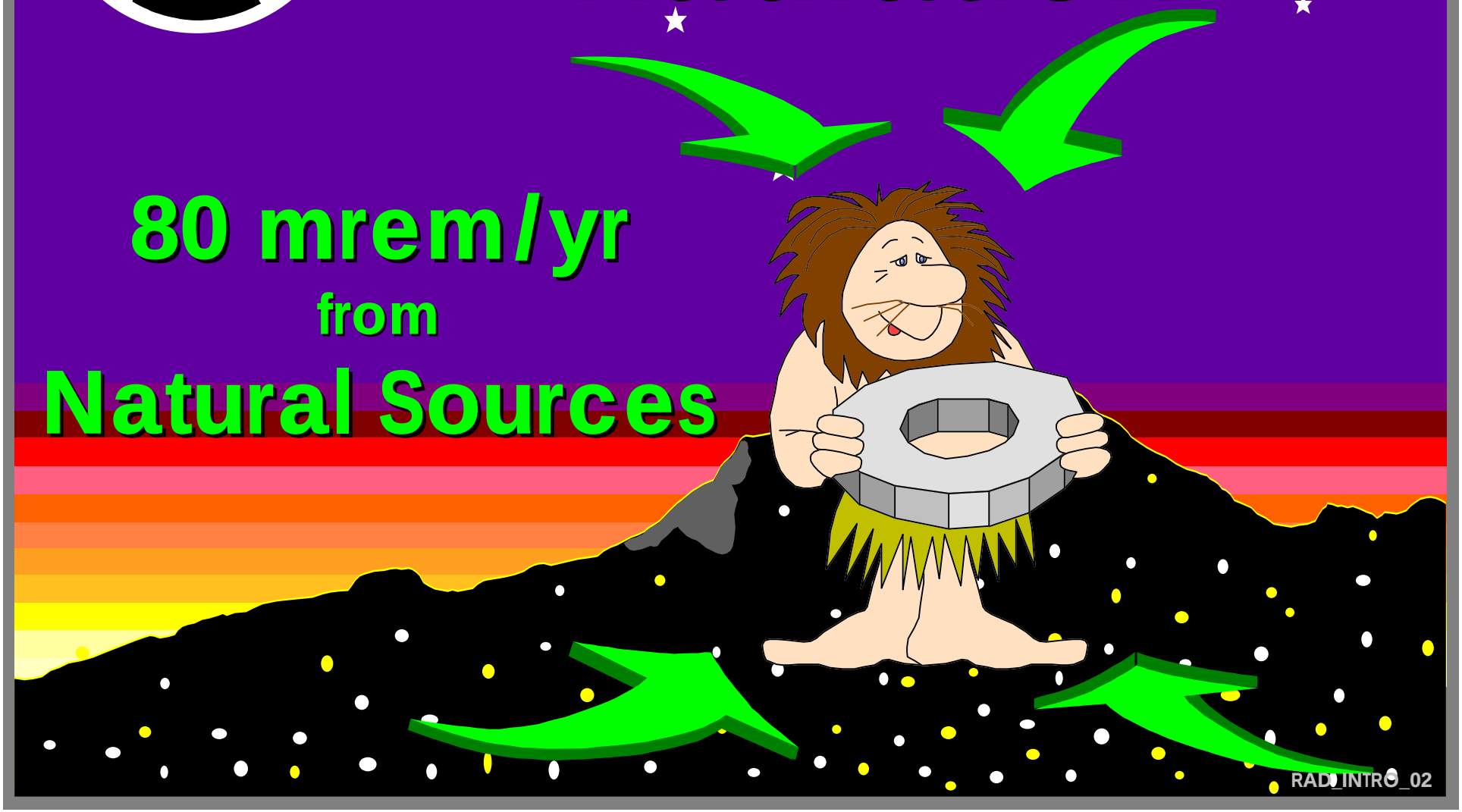
Radioactive Material

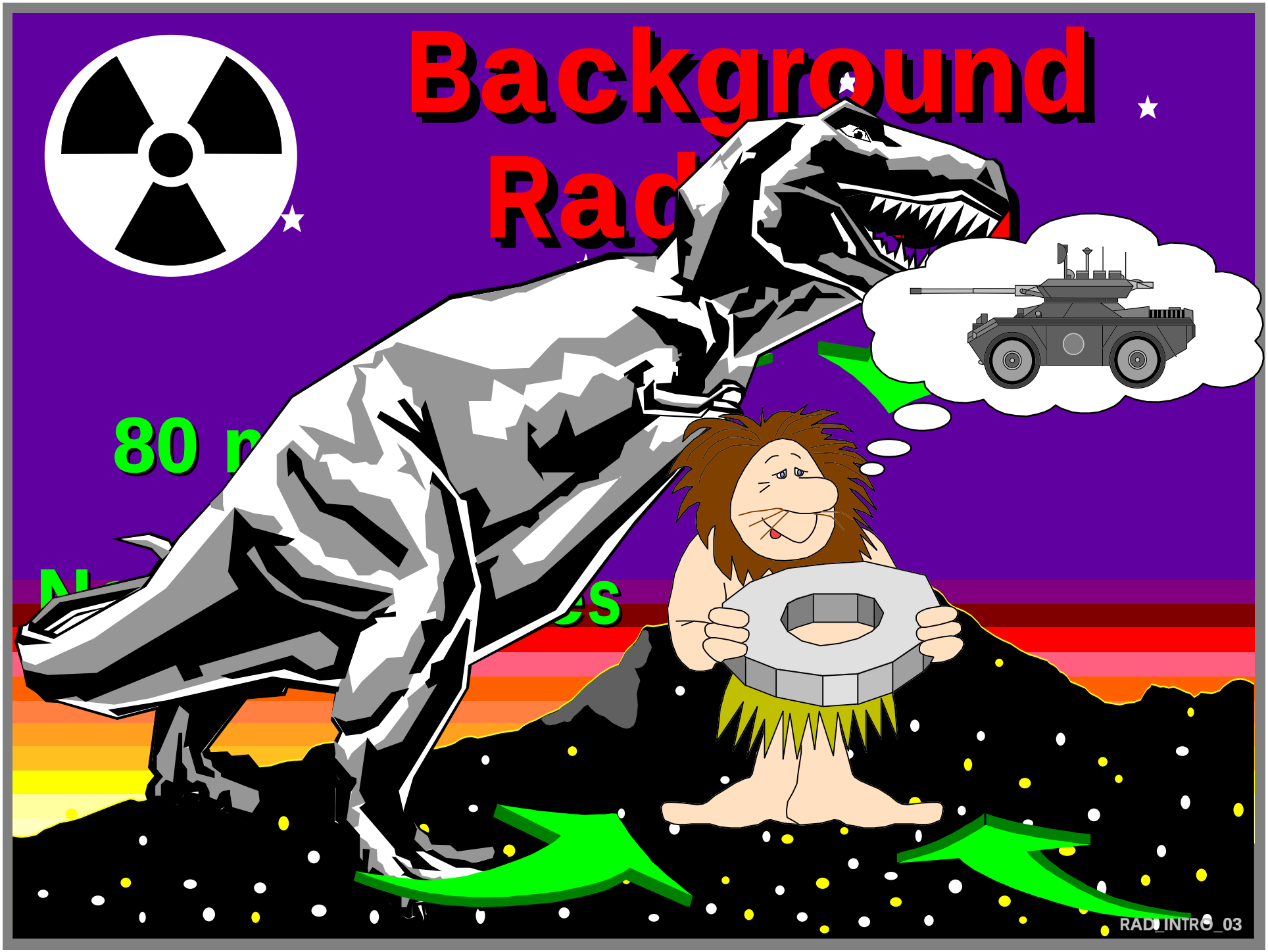
Background Radiation

80 mrem/yr

from

Natural Sources



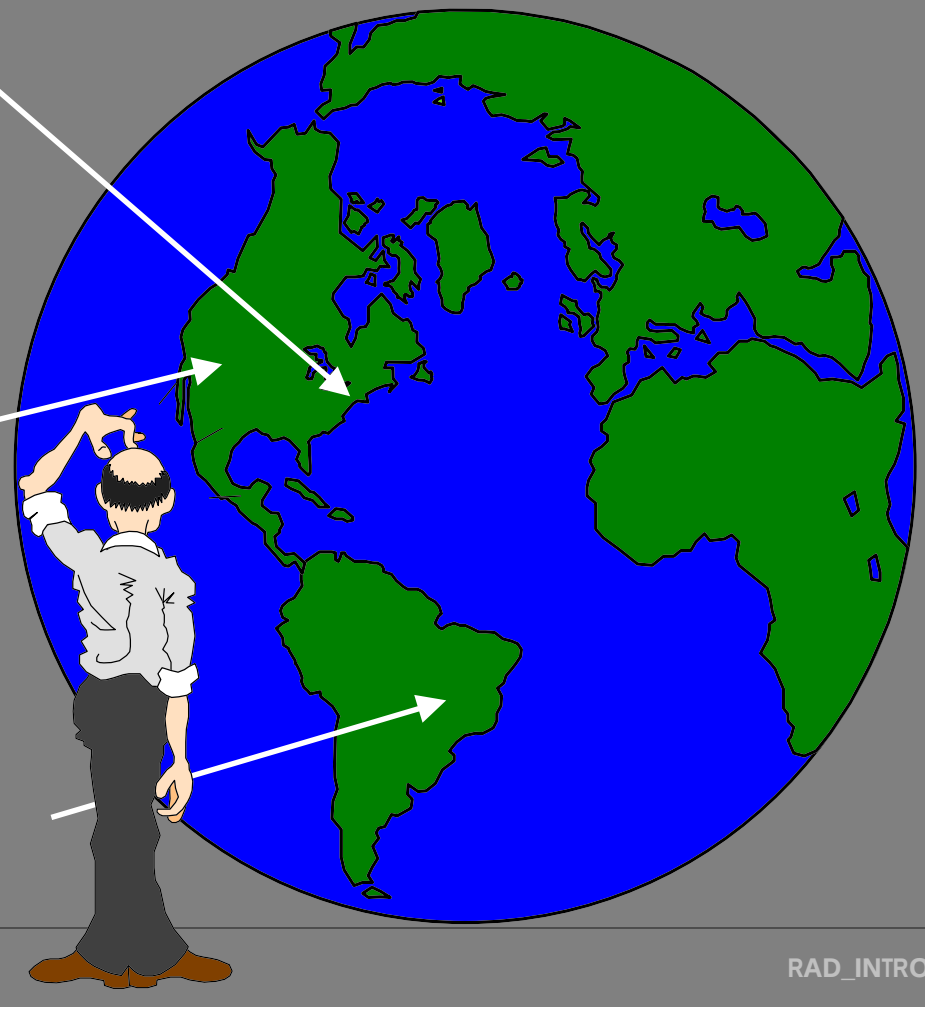

Background
Rad
80 m
RAD_INTRO_03

Background Radiation

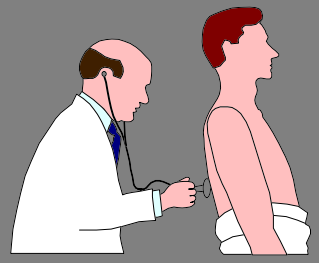
New York
91 mrem/yr.

Denver
172 mrem/yr.

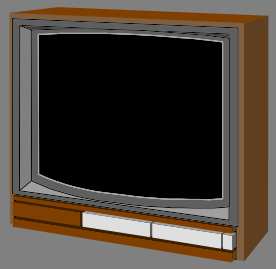
Guarapari, Brazil
640 mrem/yr.



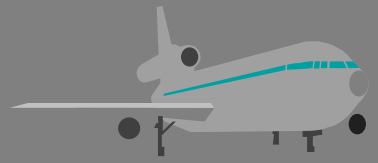
Background Radiation



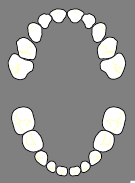
27 mrem/film



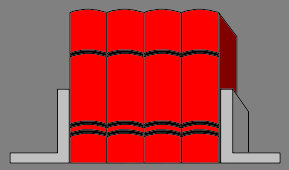
0.7 mrem/yr.



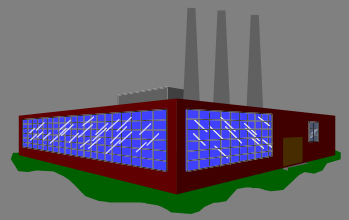
4 mrem/flight



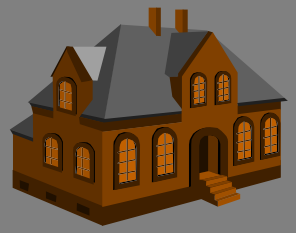
700 mrem/film



0.5 mrem/yr.

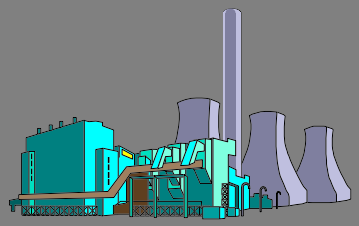


0.1 mrem/yr.



15 mrem/yr.

200 mrem/yr



0.01 mrem/yr.

Radiation

- The propagation or emission of energy or matter through space or a material medium in the form of waves or particles.
  - Light
  - Heat
  - Radio Waves
  - Micro Waves
  - Electrons
  - Protons

Radioactivity

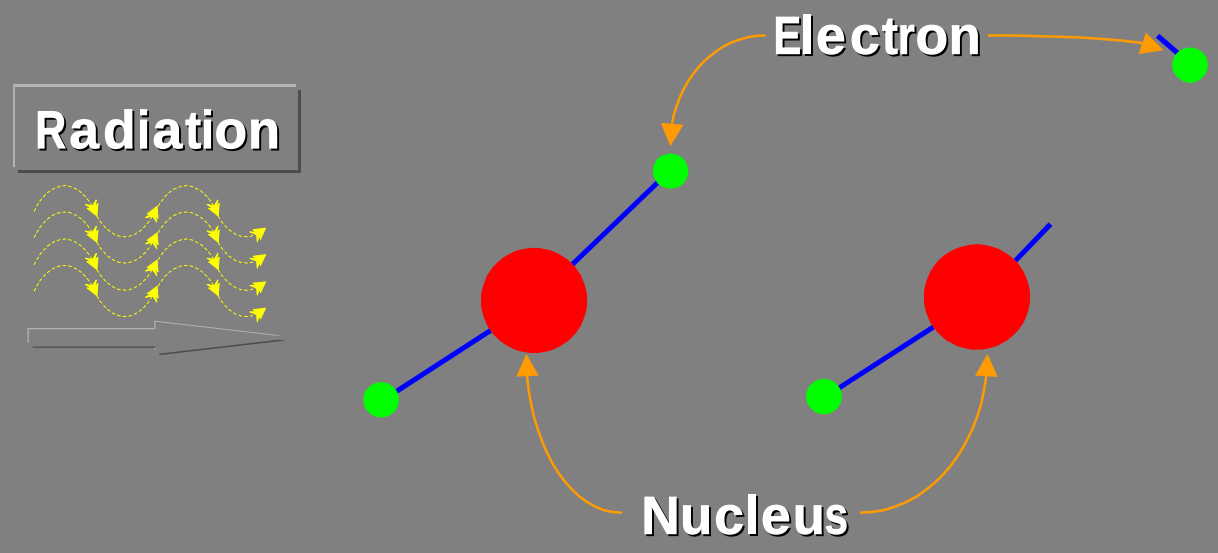
- The spontaneous decay of a material which results in the release of ionizing radiation.

Ionization

- The process by which electrons are added or removed causing an electrical imbalance to the atom.

Ionizing Radiation

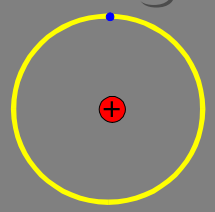
- Radiation with sufficient energy to cause Ionization.



Isotope

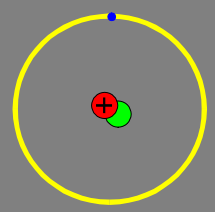
- **An atom of a chemical element with:**
  - **Same atomic number and position in the periodic table**
  - **Nearly identical *chemical* behavior**
  - **Different atomic mass**
  - **Different physical properties**

Hydrogen



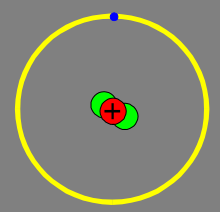
Proton = 1
Neutron = 0

Deuterium



Proton = 1
Neutron = 1

Tritium



Proton = 1
Neutron = 2

Background Radiation

Radiation from cosmic sources, naturally occurring radioactive materials, and global fallout as it exists in the environment from the testing of nuclear explosive devices.

Does not include radiation from source, byproduct, or special nuclear materials regulated by the NRC

Licensed Material

Source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the NRC.

Lost or Missing Licensed Material

Licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

Requires immediate notification.
(within 4 hours of discovery of the loss)

Alpha Particles

- Mass equal to the nucleus of a helium atom
  - Two neutrons / Two protons / NO electrons
- Positively (+) charged particles
- Travel very short distances in air
- Easily shielded
- Very little penetrating ability
  - Chiefly considered internal radiation hazard

Beta Particles

- Negative (-) or positive (+) charged particles emitted from the nucleus
- Mass equal to that of an electron
- Travel greater distances in air
  - Intermediate penetrating ability
- Easily shielded with common materials

Gamma Rays

- Not Particulate
- Short wave length electromagnetic radiation emitted from the nucleus
- Most penetrating form of radiation
- Travel great distances in air
  - Typically about 25 feet
- Require heavy shielding materials
  - Lead

Half-Life

- Time it takes for half of the atoms of a radioactive material to release excess energy.

^{238}U	^{3}H
4,500,000,000 Yrs	12.3 Yrs

Activity

The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the *curie (Ci)* and the *becquerel (Bq)*.

Curie

- The quality of radioactive material in terms of the number atoms which decay per second
- 1 curie = 37,000,000,000 atoms per second
  - 1 millicurie (mCi) = .001 curie
  - 1 microcurie (uCi) = .000001 curie
- 1 becquerel = 1 atom per second

Absorbed Dose

The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the *rad* and the *gray (Gy)*.

RAD

- A unit of measure used to define the absorbed dose of ionizing radiation.
- One RAD equals the amount of energy of 100 ergs (a measure of energy) per gram of irradiated material.
- 1 gray = 100 RAD

Dose Equivalent (DE)

The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the *rem* and *sievert (Sv)*.

REM

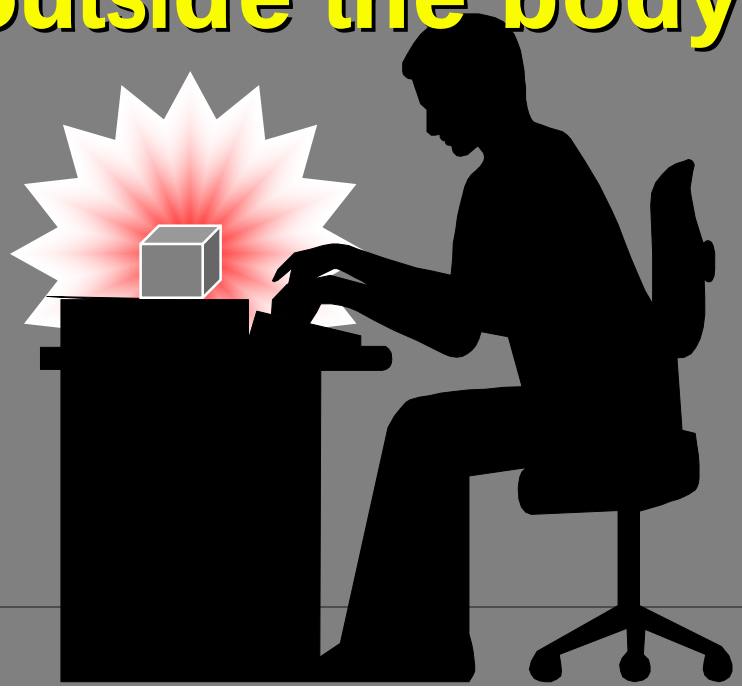
- **R**oentgen **E**quivalent **M**an
- A unit of measure used to express radiation doses.
- Measures the amount of energy absorbed by living tissue.
- Gives an indication of biological damage to human tissue.
- For *beta* and *gamma* radiation
  - 1 RAD = 1 REM
- For *alpha* radiation
  - 1 RAD = 10 - 20 REM
  - Depending on energy level of the alpha particle
- 1 sievert = 100 REM

Types of Exposure

- **Chronic Exposure**
  - Low level radiation received over a long period of time
  - Allows normal bodily repair of damage
- **Acute Exposure**
  - Accumulation over a short period of time
  - Greater chance of causing radiation damage
  - Body does NOT have time to repair itself before the effect is seen.

External Dose

That portion of a radiation dose received from radiation sources outside the body.



Internal Dose

That portion of a radiation dose received from radioactive material taken into the body.

Stochastic Effects

Health effects that occur randomly and for which the probability of the effect occurnng, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Nonstochastic Effects

Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation induced cataract formation is an example of nonstochastic effect (also called a deterministic effect).

Effects of radiation exposure

- **Somatic:** Effects which occur in the individual after exposure.

Nonstochastic

Health effects, the severity of which varies with the dose and for which a threshold is believed to exist.

(Reddening of skin / Radiation induced Cateracts)

Stochastic

Health effects that occur randomly and for which the probability of the effect occurnng, rather than its severity, is assumed to be a linear function of dose without threshold.

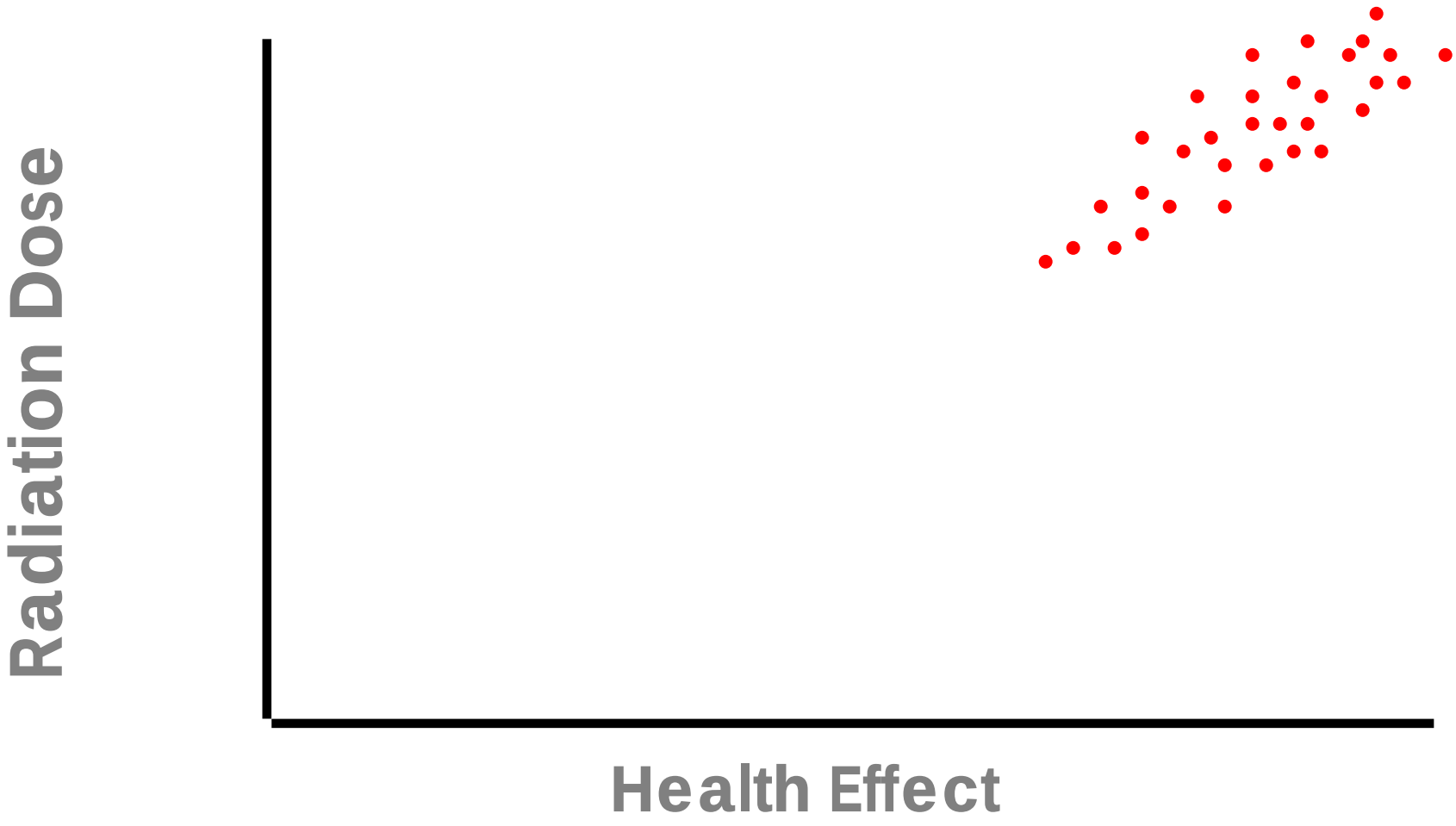
(Cancer)

Effects of radiation exposure

- **Somatic:** Effects which occur in the individual after exposure.
- **Embryological:** Cell damage to a fetus or reproductive organs.
  - Stunted size
  - Mental retardation
- **Genetic:** Mutations which may appear in future generations.

Linear Non-threshold Hypothesis

Linear Non-threshold Hypothesis



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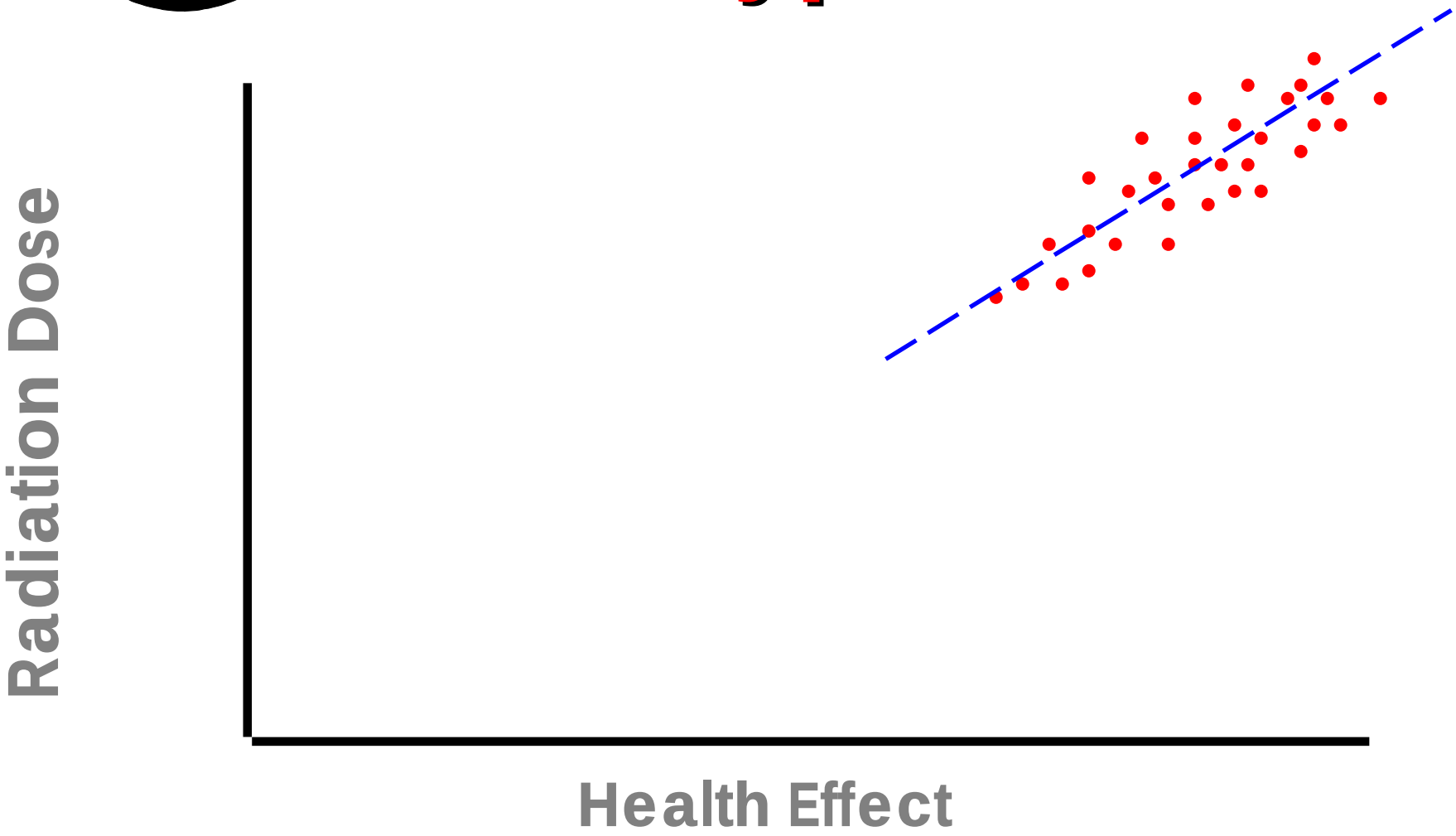

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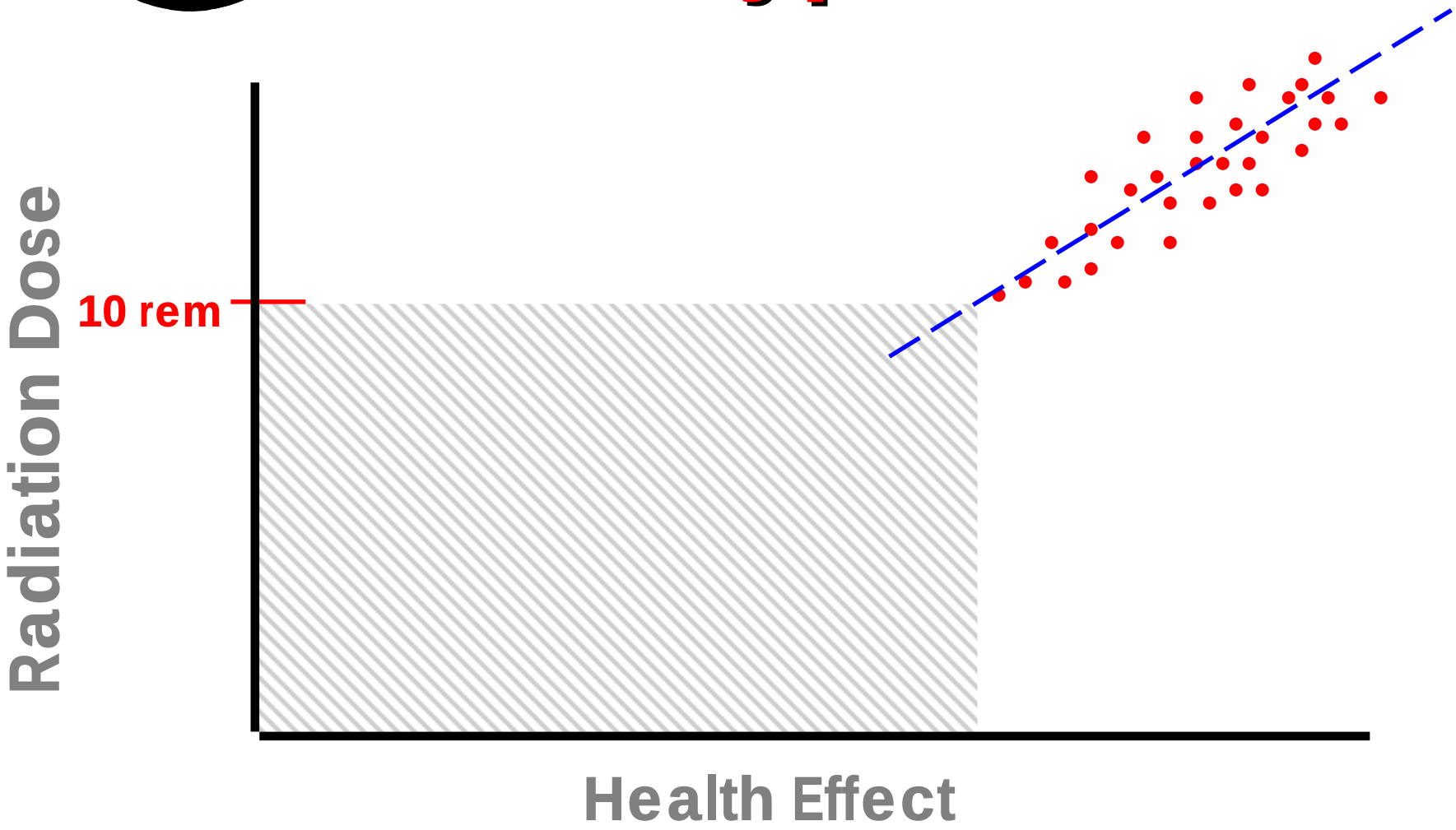

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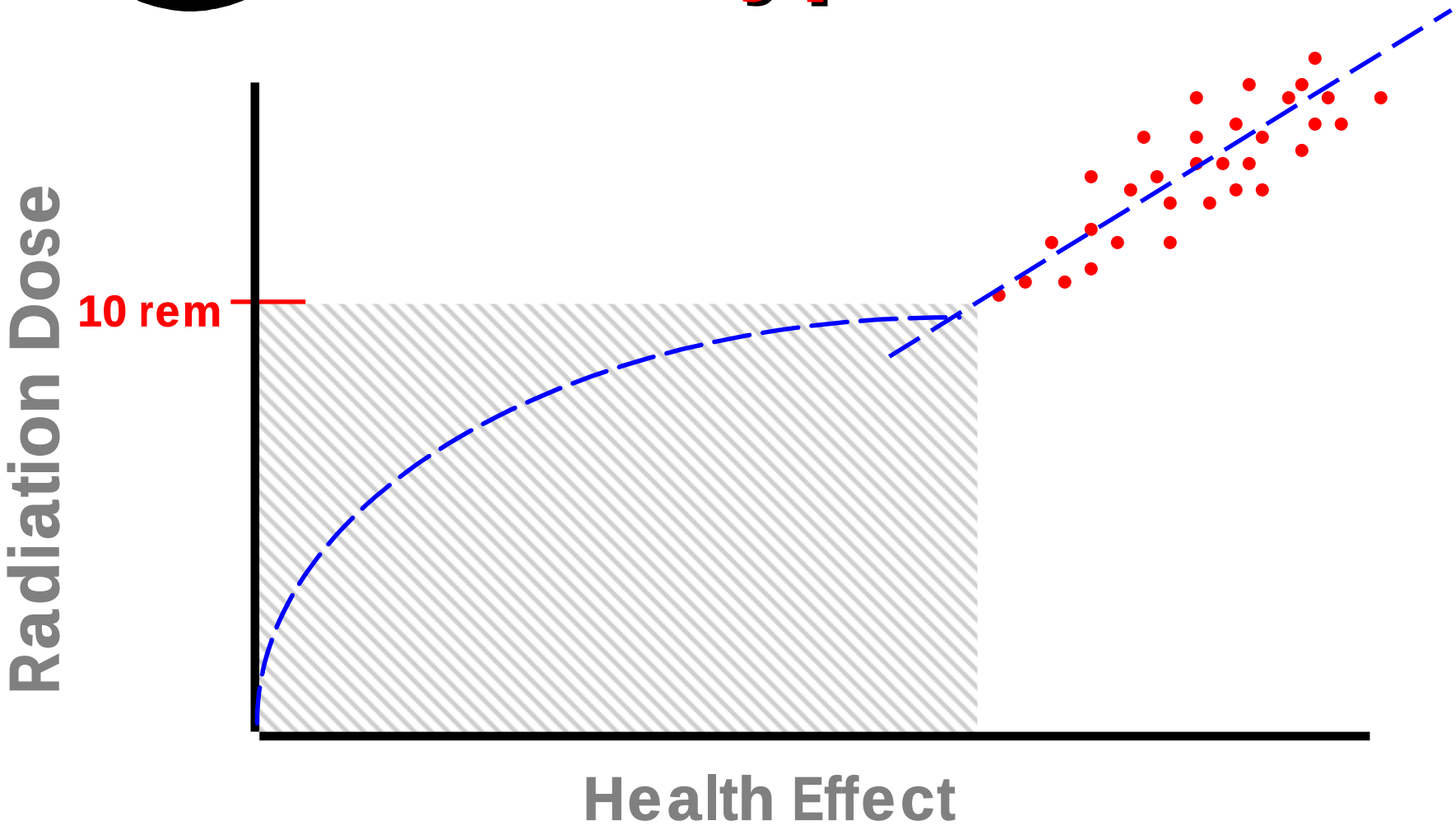

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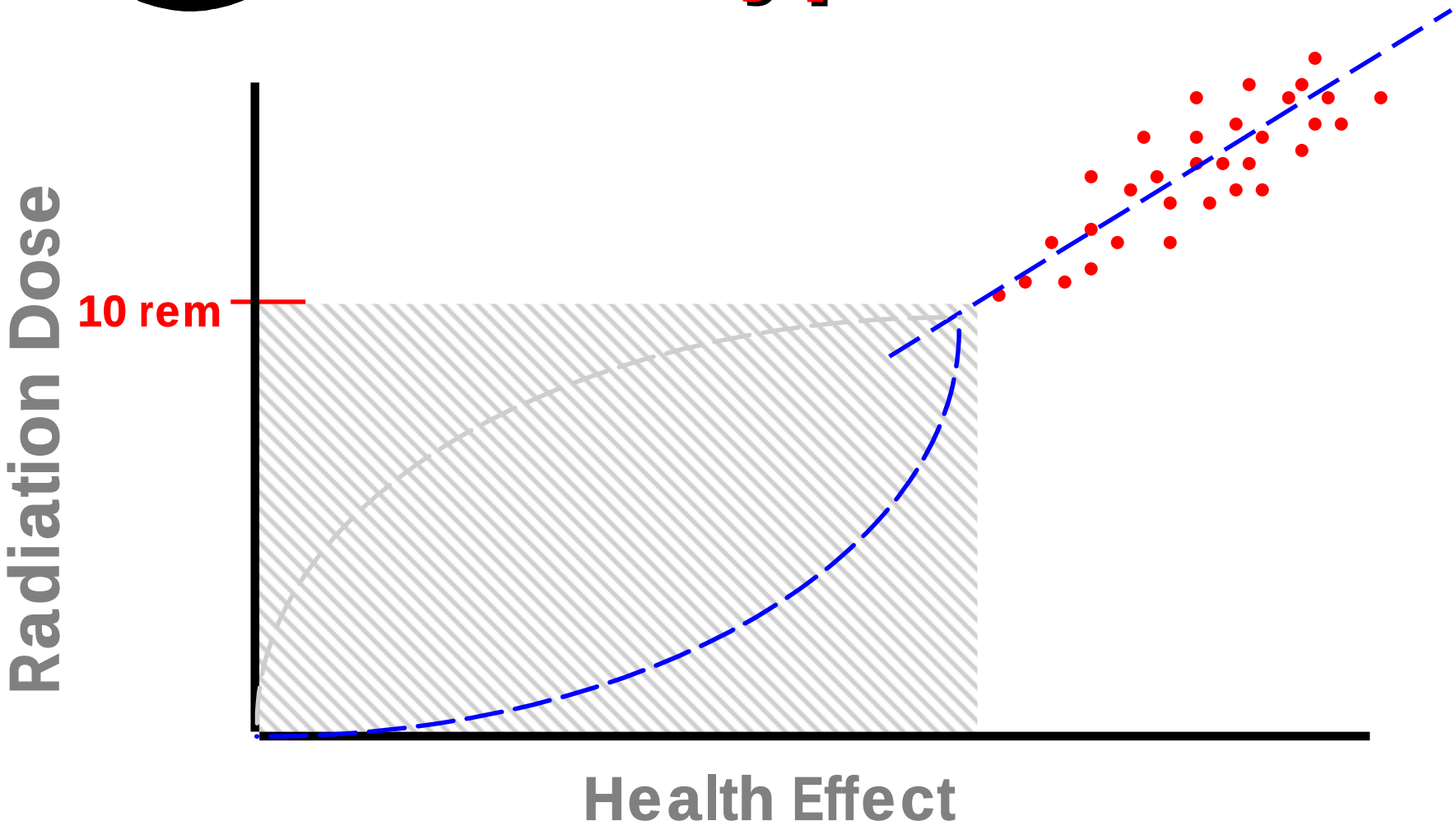

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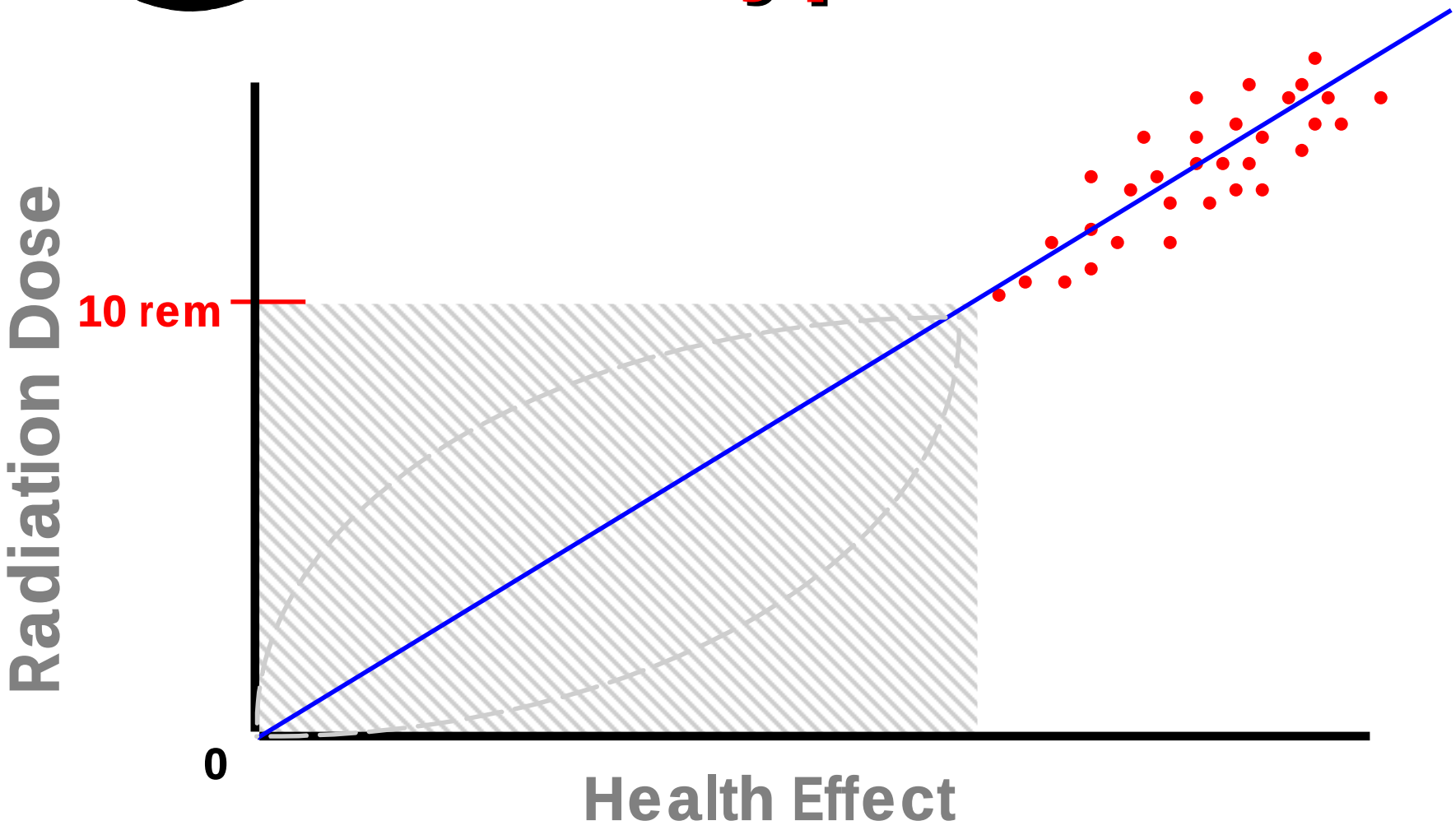

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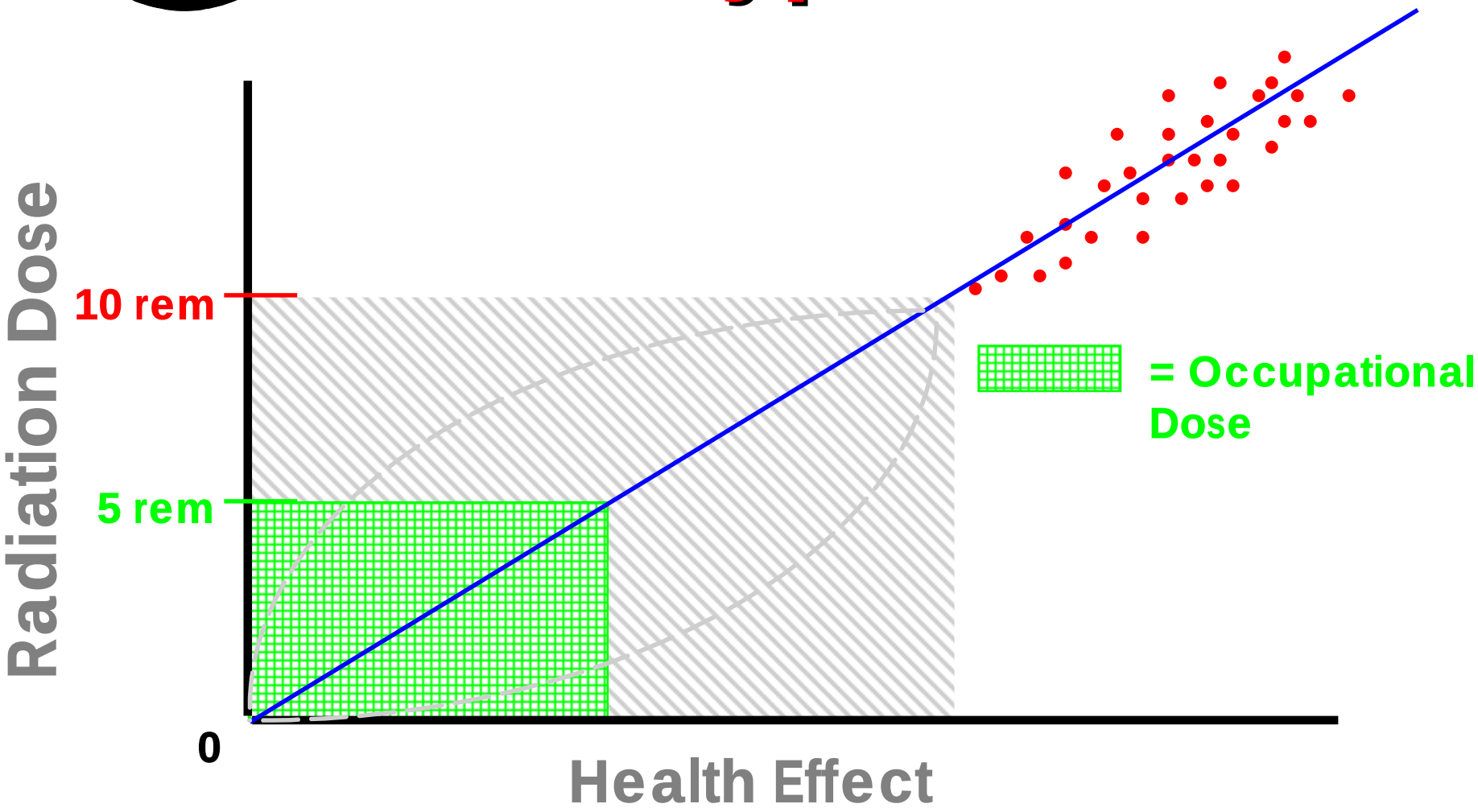
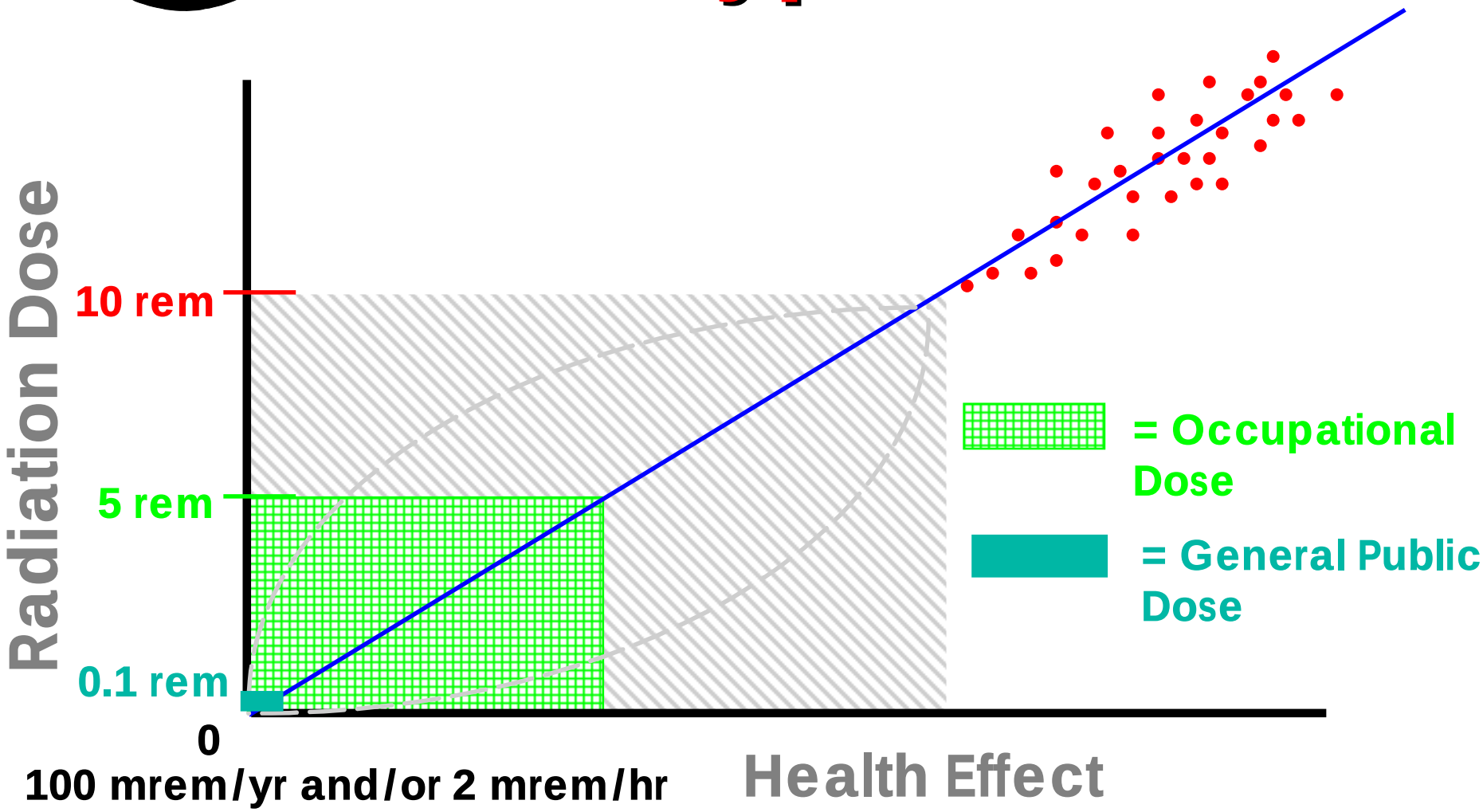


Linear Non-threshold Hypothesis



Occupational Dose

The dose received in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

5 REM/YEAR - 10CFR20

5 REM/YEAR and/or 1.25 REM/QTR : AR 40-14

Public Dose

The dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

- The total effective dose equivalent cannot exceed 100 mrem per year.
- The dose in any unrestricted area cannot exceed 2 mrem per hour.

Exposure Standard

ALARA

As
Low
As
Reasonably
Achievable

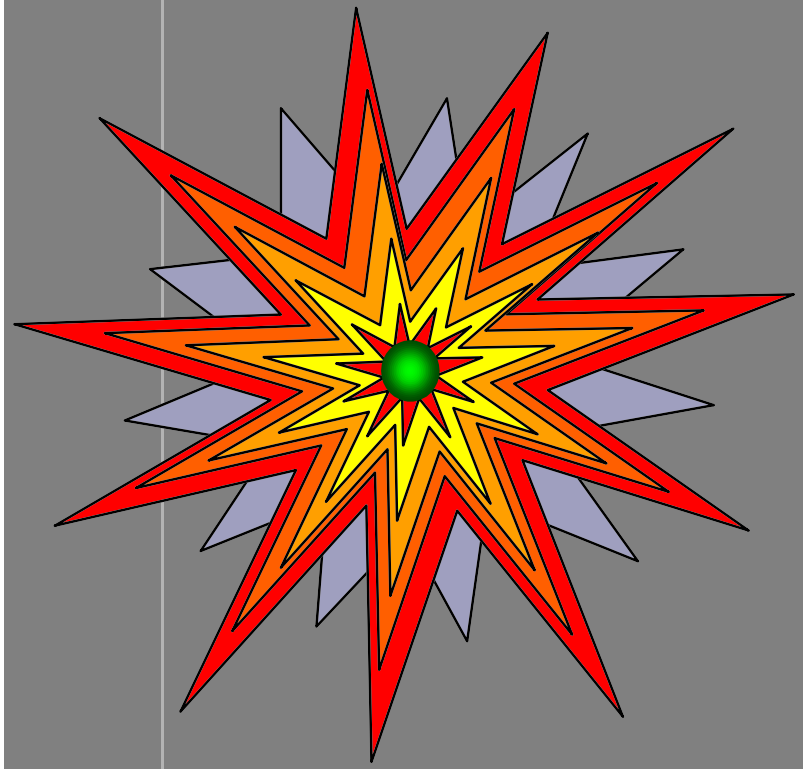
Permissible levels represent <u>upper limits</u> rather than a goal to be achieved. These <u>upper limits</u> represent a dose which "in the light of current knowledge, carries negligible probability of severe *somatic, embryological* effects, or *genetic* injury."

Controlling Exposure

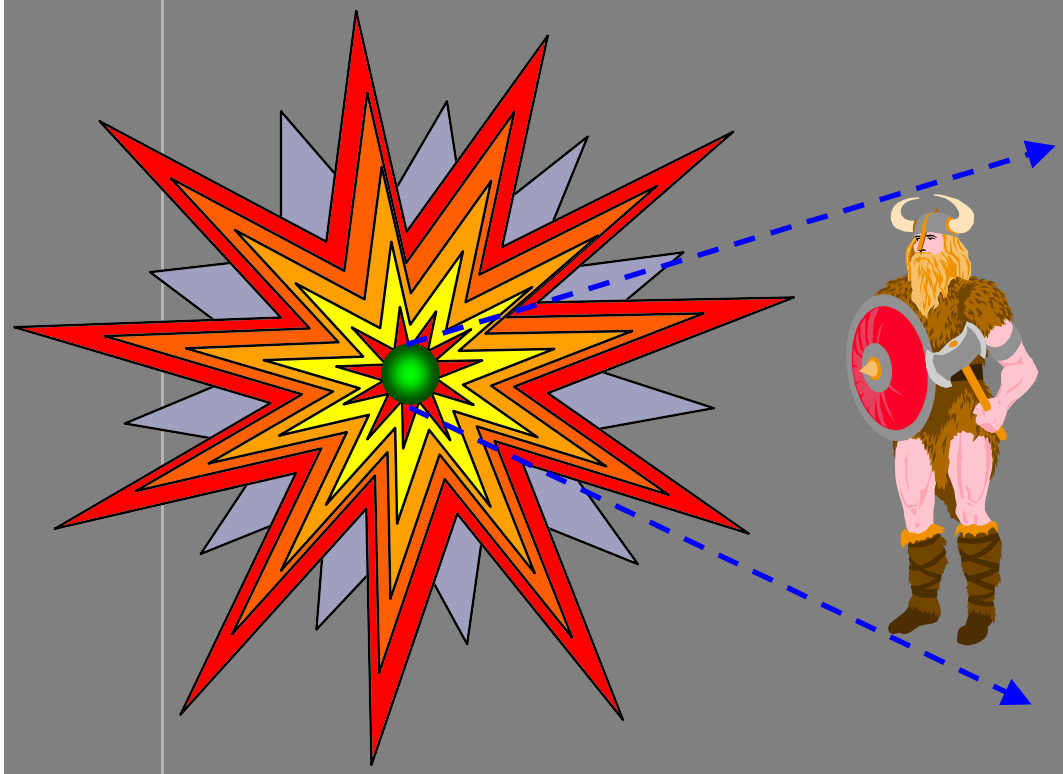
- **Shielding**
  - Low level beta radiation can be completely stopped by:
    - 0.5 inches of water
    - 0.25 inches of glass
  - Leather gloves reduce radiation dose to the hands by 50%
- **Time** - The amount of time a person is exposed to radiation is directly proportional to the radiation dose.
- **Distance** - Radiation intensity decreases rapidly with distance.
  - Doubling the distance from the source decreases the intensity by a factor of four.

Controlling Exposure

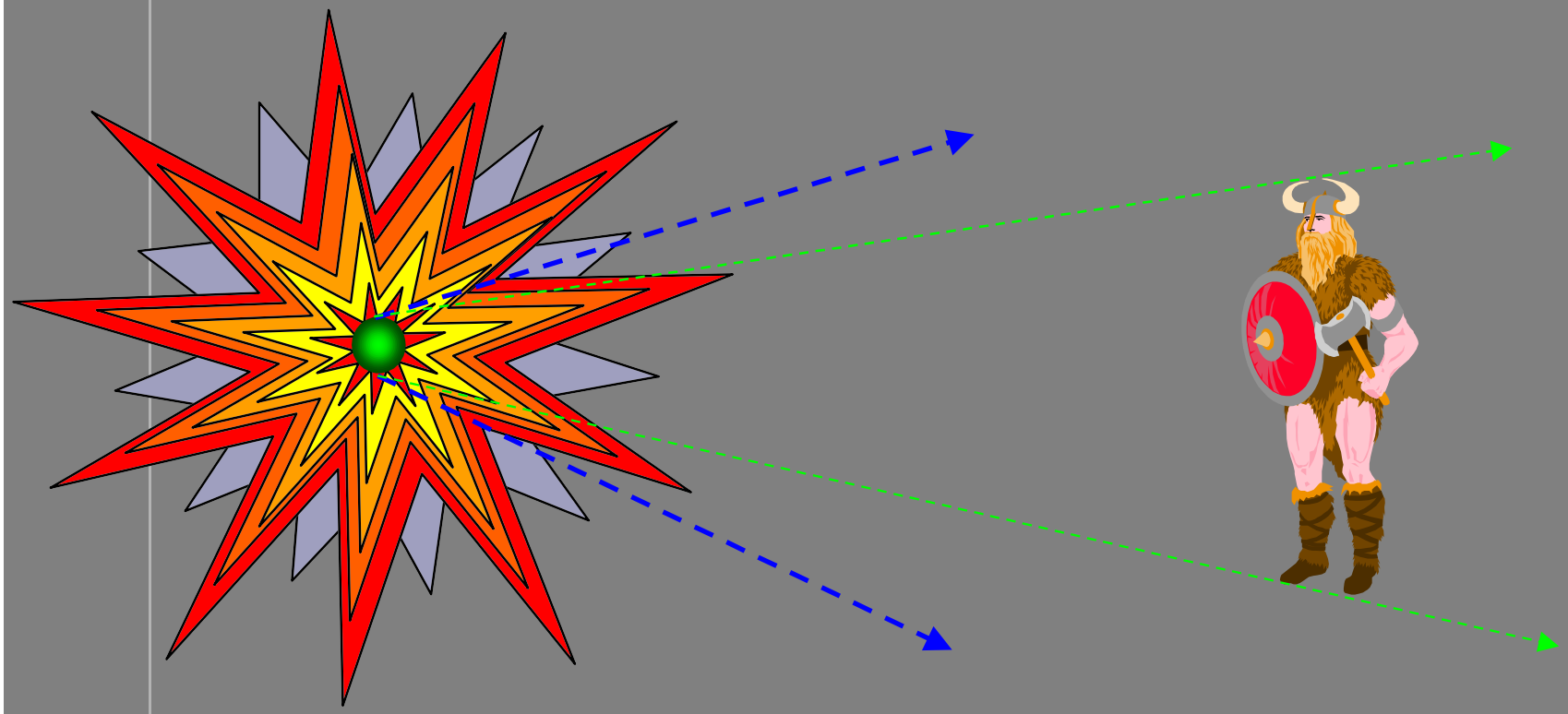
Controlling Exposure



Controlling Exposure



Controlling Exposure



Safety Rules

- Smoking, eating, drinking, chewing gum or tobacco, or applying cosmetics are prohibited.
  - This is to help minimize the potential ingestion of radioactive materials.
- Always wash your hands after handling radioactive materials with non-abrasive soap.
- Injured personnel should be removed under the supervision of medical personnel.
  - But as soon as possible to limit exposure
- Police, fire, and emergency medical personnel should be knowledgeable of the location and type of radiological handling operations and storage locations.

Bioassay

The determination of kinds, quantities or concentrations, and, in some cases, the locations, of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-01

DATE: Oct 96

TITLE: Introduction to Radioactive Materials.

APPROVED:

COURSE: Radioactive Material Handling Safety.

HOURS AND TYPE: 5.0 C (U) FACILITY REQ: Classroom
0.0 PE

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty TRANSPORTATION: None

ISSUED TO STUDENTS: Student Reference Guide - “Radioactive Material Handling Safety”

AIDS AND EQUIPMENT:

a. Overhead Projector
b. Computer Display Device
c. Computer capable of 256 color VGA
d. Video Cassette Player
e. Television
f. Display Screen
g. Chalk Board
h. Video “Radiation Naturally”
i. RADINTRO.PPT file

REFERENCES:	TB 9-1300-278	"Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
	TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
	Reference Guide	Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
	AR 385-11	Ionizing Radiation Protection
	AR 700-64	Radioactive Commodities in the DoD Supply Systems
	10 CFR 20	Title 10 Code of Federal Regulations, Part 20; "Standards for Protection Against Radiation"

COURSE TITLE: Radioactive Material Handling Safety.

LESSON TITLE: Introduction to Radioactive Materials.

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

a. Introduction:

NOTE: *SHOW SLIDE RAD_INTRO_01*

(1) **Objective:** Provide an overview of radioactive material and terminology.

(2) **Reason and Tie-In:** Prior to presenting the bulk of information provided in this course it is important to expose the student to background material and definitions of terms used throughout the course. This will help ensure that all students are starting the course with a common knowledge base.

b. Explanation:

NOTE: *SHOW VIDEO - "Radiation Naturally"*

NOTE: *SHOW SLIDE RAD_INTRO_01*

(1) Although our society has been concerned for some time with the potential radioactive contamination of the environment resulting from the technological exploitation of nuclear energy, the fact is that the universe is and always has been permeated with radiation, and at the present time there are about a billion rays traveling through space for every elementary particle of matter. This remarkable set of circumstances has been evolving for 10 billion years. The depth and scope of radiation safety is conservative; i.e., they over estimate the risk of harmful effects.

(2) The development of radiation technology left its

casualties -- physicists, radiologists, radiation chemists -- researchers who have investigated the properties and uses of radiation without appreciating their capacity for destructive effects in living matter.

(3) It was very soon after the discovery of X-rays that it became apparent that these new rays had both beneficial and harmful effects. It wasn't until 1920 and the plight of radium dial painters that the US Government and scientists began to seriously contemplate setting up standards for protection against radiation injury.

(4) During World War I, it was found that radium paint, a mixture of radium and phosphor, could be used to illuminate airplane instruments. Thus an industry grew up in the eastern US (mainly in New Jersey.) After the war the radium industry switched from military to civilian applications, painting watch and clock dials and faces. Young girls were employed in this industry. It was custom for them to form a fine point on their brush by shaping it between their lips, before dabbing the radium paint on the watch. Subsequently, from this procedure, they ingested small amounts of radium. During this period it was estimated that over four million watches had radium painted dials. Between 1921 and 1924 nine radium workers died of severe, unexplained cancer causes, accompanied by destructive lesions of the mouth and jawbones. The medical cause of death was eventually associated to the radium.

(5) All the effects known to be caused by radiation exposures are duplicated by exposure to some other type of toxic agent and none that are uniquely tied to radiation have yet been discovered.

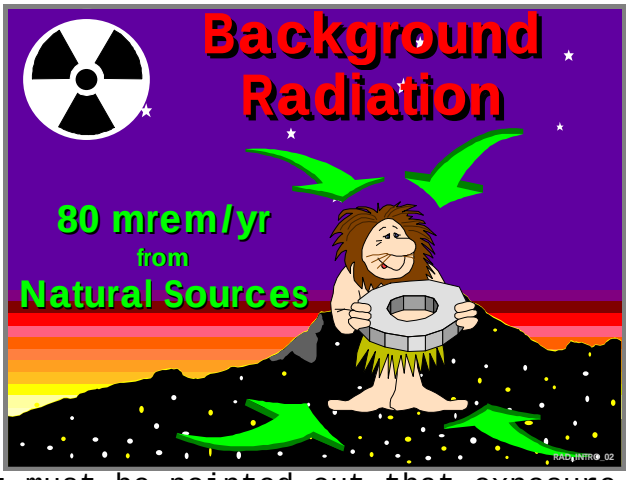
(6) An estimate of the hazard associated with exposure to low levels of radiation likely to be encountered with routine use of radioisotope sources is complicated by the elusive nature of the possible effects. For the levels of exposure set by regulatory agencies no prompt or delayed consequences of any kind can be measured. Possible effects are sufficiently subtle so that they are lost in the normal variations which are inevitable when comparing one group of workers or subset of the population with another. Estimates of the hazard must then be made on limited data from exposures to much higher levels.

(7) Ultimately, all of the standards for radiation are tied back to radiobiology data. In the earliest standards, this data was chiefly from animal experiments. As experience has grown, more and more human data has been obtained through the use of radiation in a variety of medical treatments, through data from occupational workers, from radiation accidents and from survivors of the Japanese atomic bombings. Unfortunately though, much of the data has been obtained at doses and dose rates *well in excess of those encountered in*

the workplace so that some assumption must be made in extrapolating these observable effects to the lower dose.

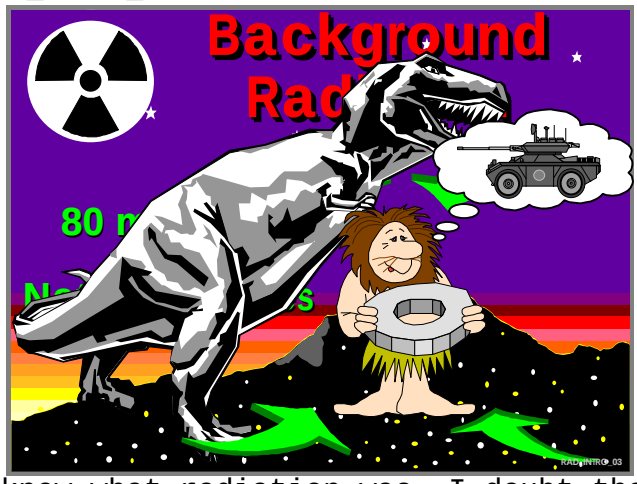
(8) Some recent studies suggest that radiation appears to be beneficial to health at low levels. This is a very controversial area of study and some say these reports are as much based on fact as Elvis sightings. More to the point is that the actual degree of harm of low levels of exposure to radiation is unknown. Therefore the NRC and health physicists take a conservative approach of minimizing any exposure to any radiation. Although the word "safe" is commonly used in referring to radiation exposure, it should be clearly understood that NO amount of radiation, regardless of the amount, can be considered 100% safe. "*Biologically acceptable*" is a more descriptive term in that no individual receiving up to that amount would be expected to develop manifestations of radiation injury.

NOTE: *SHOW SLIDE RAD_INTRO_02*



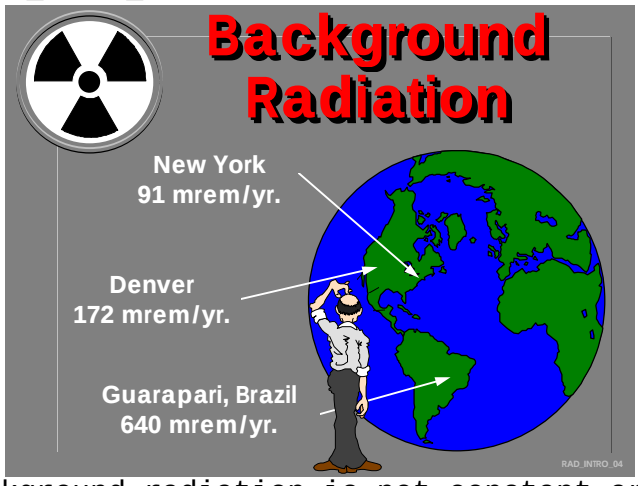
(9) It must be pointed out that exposure to radiation is nothing new. From the time we first appeared on this earth we have been receiving about 80 mrems per year from natural sources such as rocks, cosmic rays, air, food, and water.

NOTE: *SHOW SLIDE RAD_INTRO_03*



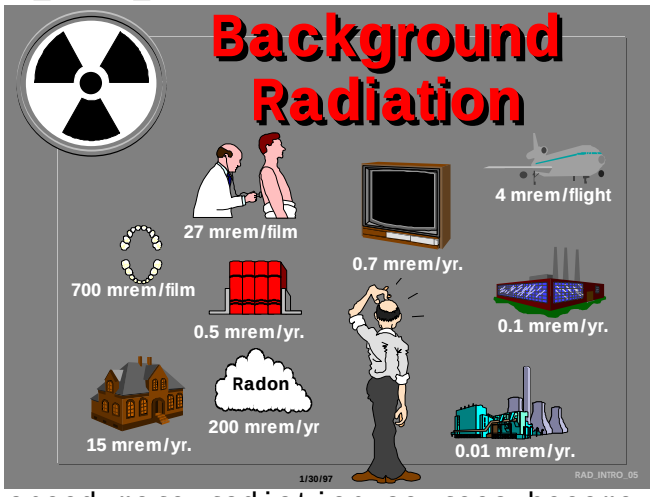
Even if this guy knew what radiation was, I doubt that it would have been high on his list of priorities - He had other things to worry about that presented more immediate danger.

NOTE: *SHOW SLIDE RAD_INTRO_04*



The amount of background radiation is not constant around the Earth. As you can see from this slide, some areas are a lot higher than others.

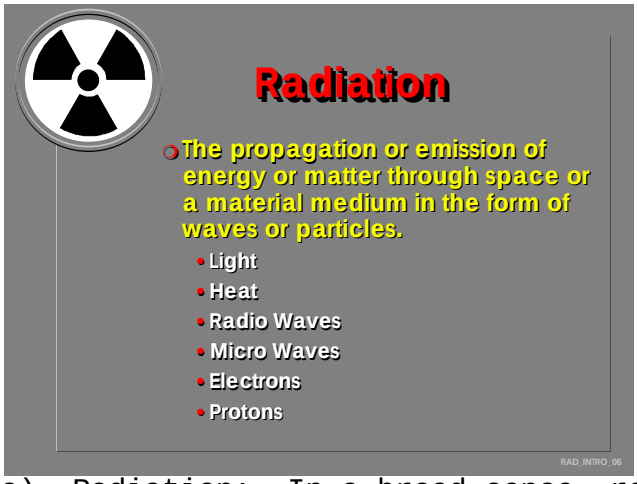
NOTE: *SHOW SLIDE RAD_INTRO_05*



As technology advanced more radiation sources become a part of daily life. But remember, the difference here is that these are doses due to things that we accept in the normal course of life. Exposure to radiation from Army equipment is mostly avoidable and as such must be minimized.

(10) Common Terminology:

NOTE: *SHOW SLIDE RAD_INTRO_06*



(a) <u>Radiation</u>: In a broad sense, radiation can be defined as the emission or propagation of energy or matter through space or a material medium in the form of waves. This could include light, heat, radio waves, micro waves, electrons, protons, or other particles. During this course, the discussion will be limited to the examination of **ionizing radiation**.

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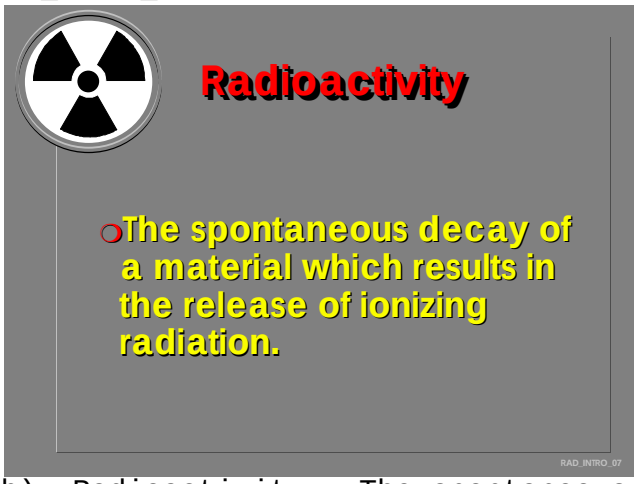
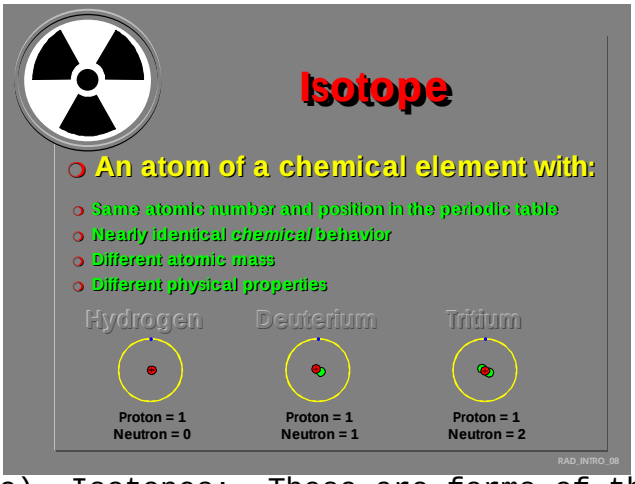


(b) Radioactivity: The spontaneous decay of a material resulting in the release of ionizing radiation. In order for a substance to be considered "Radioactive Material", it must emit ionizing radiation as a result of nuclear disintegration. To be considered "Radioactive" by the Department of Transportation, the rate of nuclear disintegration (radioactivity) must exceed 0.002 microcurie (µCi) per gram.

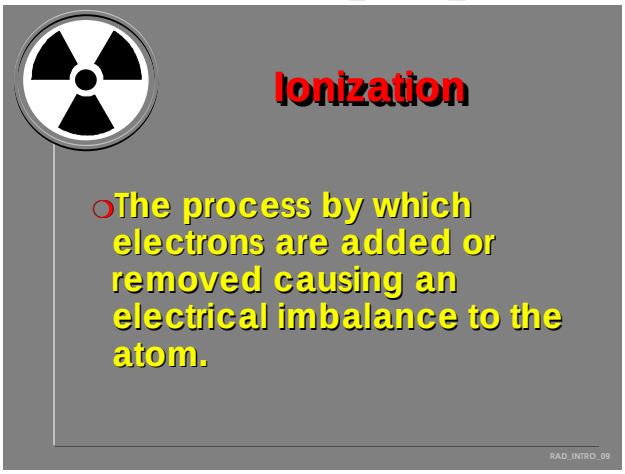
NOTE: *SHOW SLIDE RAD_INTRO_08*

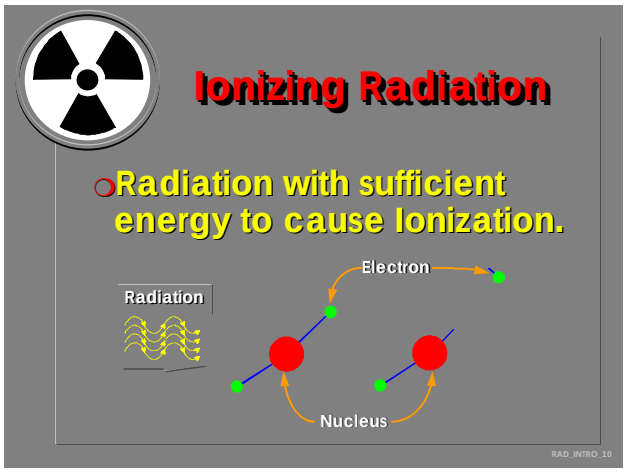


(c) Isotopes: These are forms of the same element having identical *chemical* properties but differing in their *atomic mass*. For example, hydrogen has three isotopes: ^{1}H, ^{2}H, and ^{3}H. The common name for ^{2}H is "Deuterium" and ^{3}H has the distinction of being known as "Tritium".

(d) Radioisotope and radionuclide: These are synonymous with "Radioactive Materials" and identify specific isotopes of chemical elements that have radioactive properties.

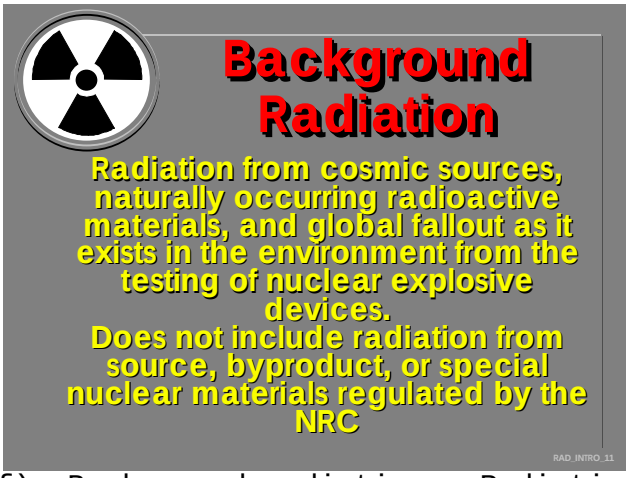
NOTE: *SHOW SLIDE RAD_INTRO_09/10*





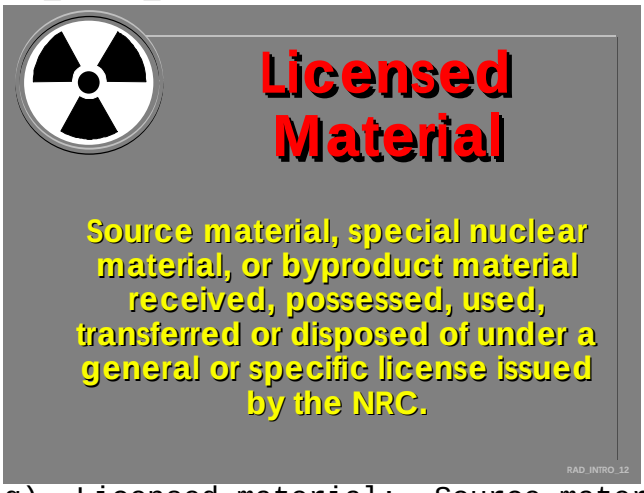
(e) Ionizing radiation or Ionization: Basically, ionization is the process by which electrons are added to or removed from an atom.

NOTE: *SHOW SLIDE RAD_INTRO_11*



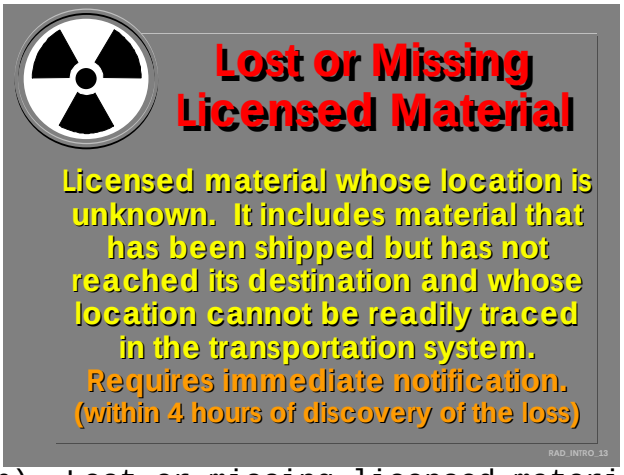
(f) Background radiation: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials regulated by the NRC.

NOTE: *SHOW SLIDE RAD_INTRO_12*



(g) Licensed material: Source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the NRC.

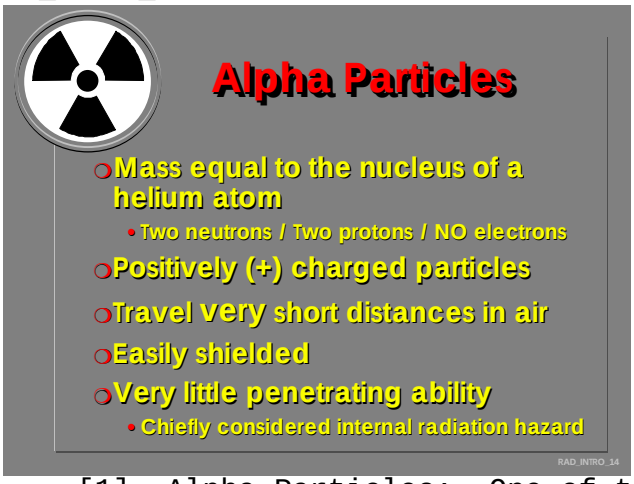
NOTE: *SHOW SLIDE RAD_INTRO_13*



(h) Lost or missing licensed material: Licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system. Immediate notification (within 4 hours after the discovery of the loss) is required for lost, missing, or stolen licensed material.

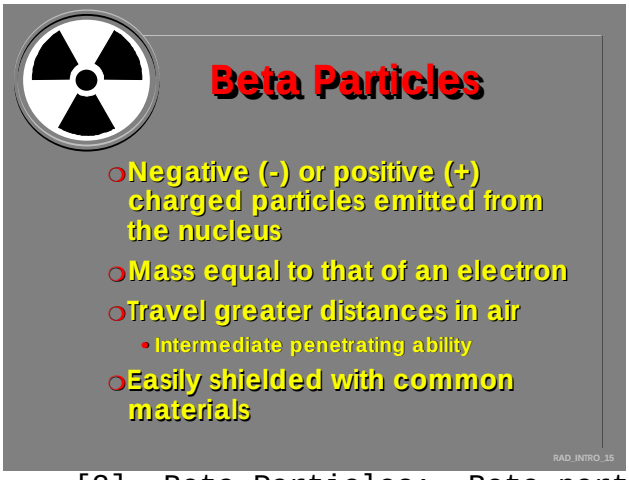
(i) In the process of radioactive decay, there are three different types of radiation given off:

NOTE: *SHOW SLIDE RAD_INTRO_14*



[1] Alpha Particles: One of the three primary forms of radioactive emissions. Alpha particles are emitted from the nucleus of a radioactive atom at speeds of 9,000 to 20,000 miles per second and have a mass equal to the nucleus of a helium atom (2 protons and 2 neutrons). These particles however, have no electrons and therefore have a positive electrical charge of two. These particles are very heavy compared to other types of radiation and therefore move much more slowly. As a result of this and of having a high positive charge (remember they have two protons and no electrons so they have a positive charge of "2") alpha particles produce very dense **ionization** along their path. This causes them to rapidly loose kinetic energy and so they have little penetrating ability and are easily shielded. They travel very short distances in air (2 to 8 cm) and are easily shielded. An alpha particle can not even penetrate the outer dead layer of skin of the body, however, internally it is the most dangerous type of radiation.

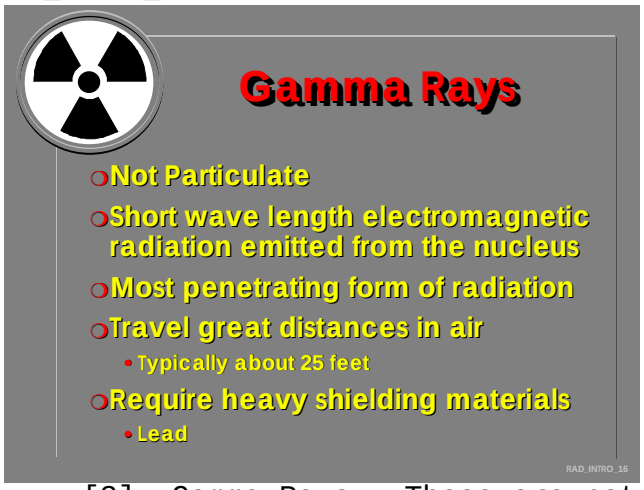
NOTE: *SHOW SLIDE RAD_INTRO_15*



[2] Beta Particles: Beta particles are

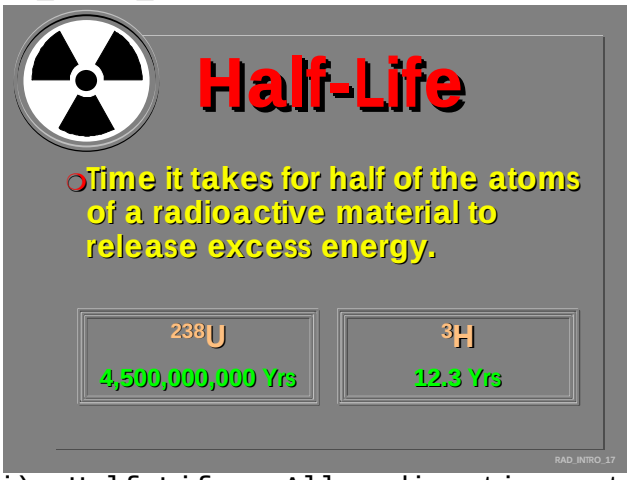
generated inside the nucleus of an atom when a proton is converted to a neutron or when a neutron is converted to a proton. During this transition, two types of particles are ejected from the nucleus: a neutrino and a beta particle. A neutrino has no charge, essentially no mass, and travels at the speed of light. The neutrino does not easily interact with matter and presents no radiation hazard. The beta particle can be negatively (-) or positively (+) charged and has a mass equal to that of an electron. The beta particle and the neutrino are emitted from the nucleus and share a given amount of energy, but the sharing is not a constant ratio. The beta particle may therefore be ejected from the nucleus with essentially no kinetic energy, or with a high kinetic energy depending on how much energy is carried by the neutrino. Compared to the alpha particle, the beta particle has a much smaller mass. Because of this, a beta particle's ionizing ability is less than that of an alpha particle, though its range is greater. These factors normally make beta emitters a less serious internal hazard than alpha emitters. However, since higher energy beta particles can penetrate the skin and damage living cells, the beta emitter can be an external hazard.

NOTE: *SHOW SLIDE RAD_INTRO_16*



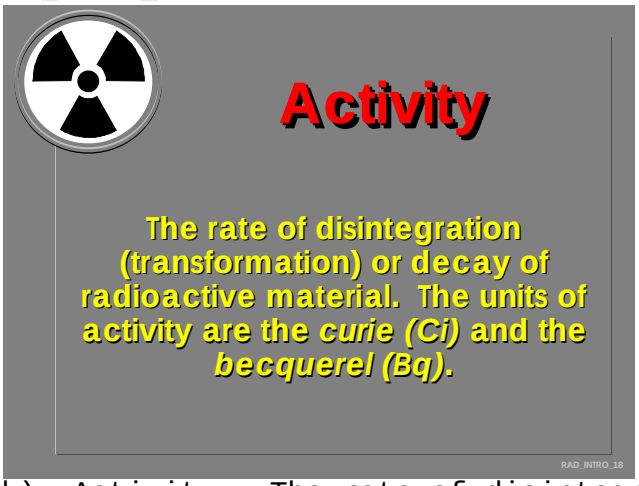
[3] Gamma Rays: These are not particulate (as opposed to alpha or beta particles) but are short wave length photons with no mass or charge emitted from the nucleus of radioactive atoms. Except for their origin, they are similar to X-rays. Gamma rays are the most penetrating form of radiation and can travel great distances in air (typically about 25 feet) before absorption. This makes gamma radiation primarily an external hazard. They require heavy shielding materials such as lead to reduce the radiation.

NOTE: *SHOW SLIDE RAD_INTRO_17*



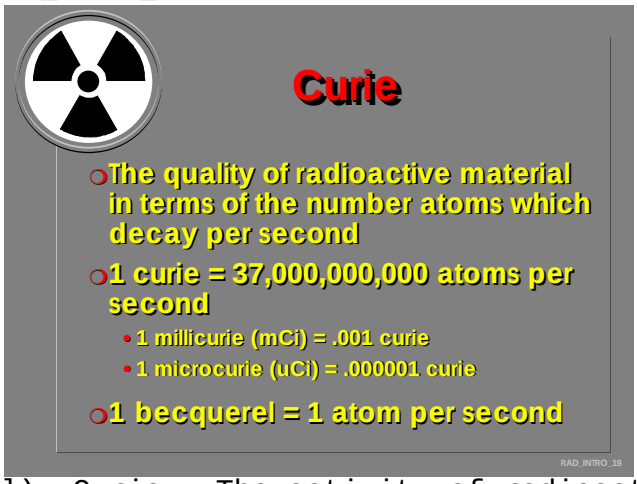
(j) Half-Life: All radioactive materials have a unique **half-life**, the time which it takes for half of the mass of the material to disintegrate through radioactive decay. For example, in the case of uranium ^{238}U which accounts for over 99% of the material makeup of "depleted uranium", the **half-life** is about 4.5 billion years (which is comparable to the age of the universe as we know it). In comparison, the half-life of tritium is only 12.3 years.

NOTE: *SHOW SLIDE RAD_INTRO_18*



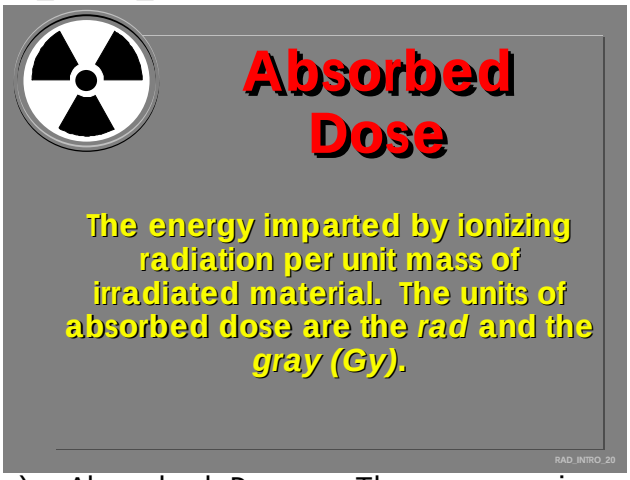
(k) Activity: The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the *curie (Ci)* or the *becquerel (Bq).*

NOTE: *SHOW SLIDE RAD_INTRO_19*



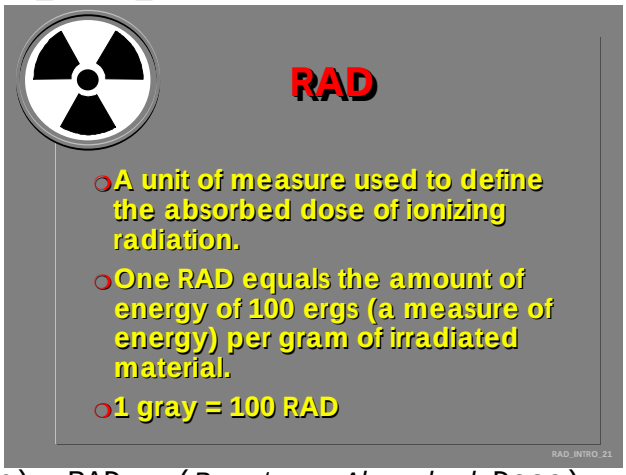
(l) Curie: The activity of radioactive material expressed in terms of the number of atoms which disintegrate (decay) per second. One curie is that activity of a radioactive isotope in which 37 billion (3.7×10^{10}) atoms disintegrate per second. Each disintegration, results in the emission of alpha, beta, and/or gamma ray radiation, depending on the isotope involved. Curie is further divided into millicurie (mCi),one thousandth (.001) of a curie; and microcurie (µCi), one millionth (.000001) of a curie. **The activity alone is not a direct measure of the hazard of a radioactive sample**. As an example, working 1 meter away from a 100 Ci source of cobalt-60 for 8 hours would deliver a whole body dose of about 1050 rem of high energy gamma radiation to an individual; a lethal dose. Work performed under the same conditions with a 100 Ci Tritium source would produce no effect at all. In this case the low energy beta emissions of the tritium would be totally absorbed by the one meter of air between the worker and the source.

NOTE: *SHOW SLIDE RAD_INTRO_20*



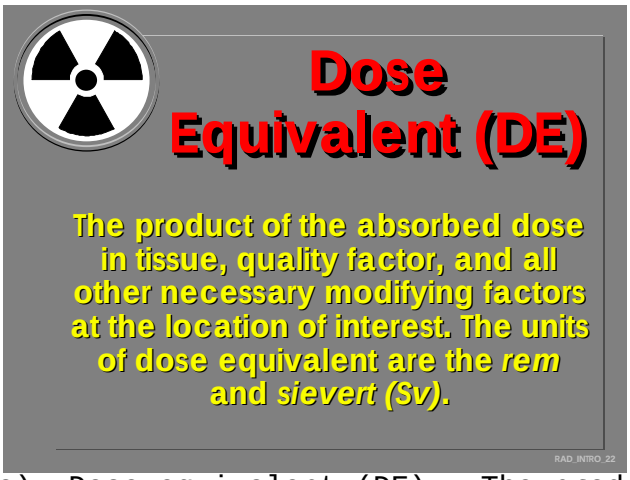
(m) Absorbed Dose: The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the *rad* or the *gray (Gy)*.

NOTE: *SHOW SLIDE RAD_INTRO_21*



(n) RAD: (*Roentgen Absorbed* Dose) - A unit of measure used to define the absorbed dose of ionizing radiation. One RAD equals the amount of energy of 100 *ergs* (a measure of energy) per gram of irradiated material. This also is an imperfect measure for determining the hazards and degree of protection required in dealing with radioactive material since the relative amount of injury to irradiated persons depends both on the energy deposited (measured in rads) and the type of radiation.

NOTE: *SHOW SLIDE RAD_INTRO_22*

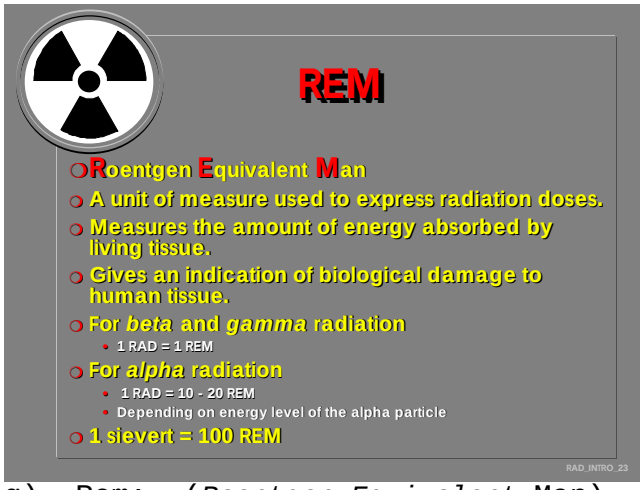


(o) Dose equivalent (DE): The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem or sievert (Sv).

(p) Fundamentally, harmful consequences of ionizing radiation to a living organism are due to the energy absorbed by cell and tissues that form the organism. This absorbed energy (or dose) produces chemical decomposition of molecules present in living cells.

The mechanism of the decomposition appears to be related to ionization and excitation interactions between the radiation and atoms within the tissue. The amount of ionization or number of ion pairs produced by ionizing radiation in cells or tissues provides some measure of the amount of physiological damage that might be expected from a given quantity or dose.

NOTE: *SHOW SLIDE RAD_INTRO_23*



(q) Rem: (*Roentgen Equivalent* Man) - A unit of measure adopted in 1968 used to express the dose equivalent and takes into account the damage done by various types of radiation on living tissue. It is defined as the amount of energy absorbed in the body and gives an indication of biological damage to human tissue. A millirem is one thousandth (.001) of a rem.

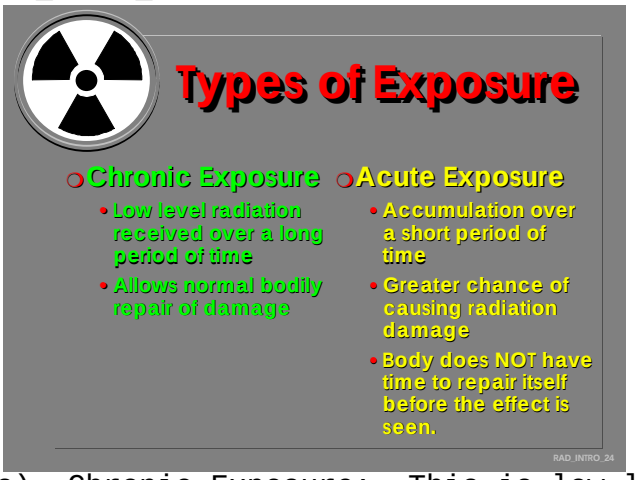
(r) There is a new International system of units for expressing dose being introduced. Eventually, the curie will be replaced by the becquerel, the rad will be replaced by the gray, and rem will be replaced by sievert.

[1] Becquerel: One becquerel equals 1 Ci divided by 3.7×10^{10}.

[2] Gray: One gray equals 100 RAD.

[3] Sievert: One sievert equals 100 REM.

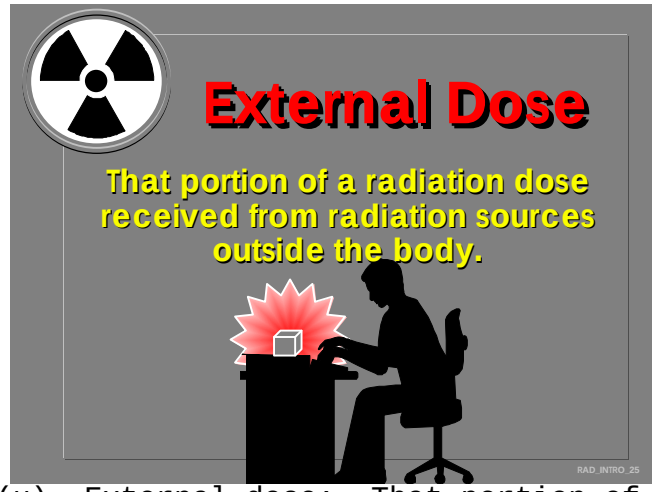
NOTE: *SHOW SLIDE RAD_INTRO_24*



(s) Chronic Exposure: This is low level exposure received over a long period of time. Chronic exposure allows for the normal bodily repair of damage before reaching the level that would result in an effect.

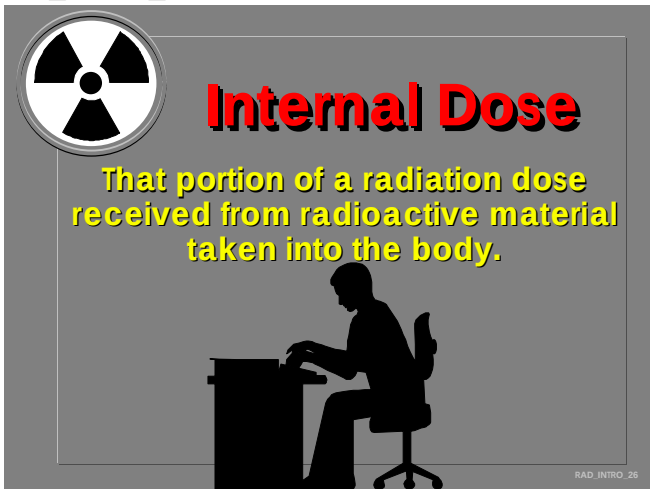
(t) Acute Exposure: This is an accumulation of exposure over a short period of time. Acute exposure has a greater chance of causing radiation damage because the body does not have time to repair itself before the effect is seen.

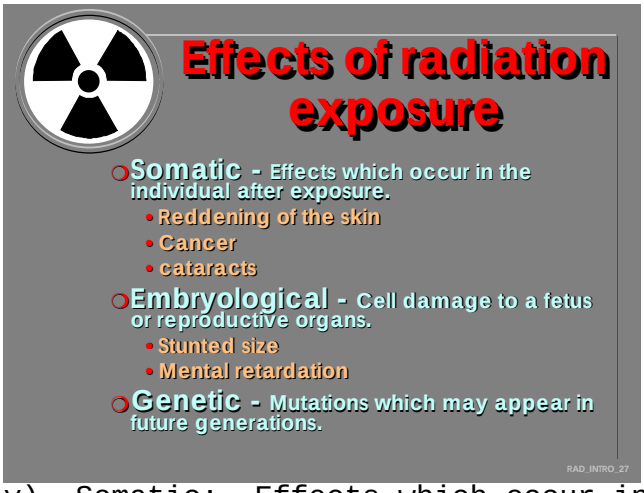
NOTE: *SHOW SLIDE RAD_INTRO_25*



(u) External dose: That portion of a radiation dose received from radiation sources outside the body.

NOTE: *SHOW SLIDE RAD_INTRO_26*



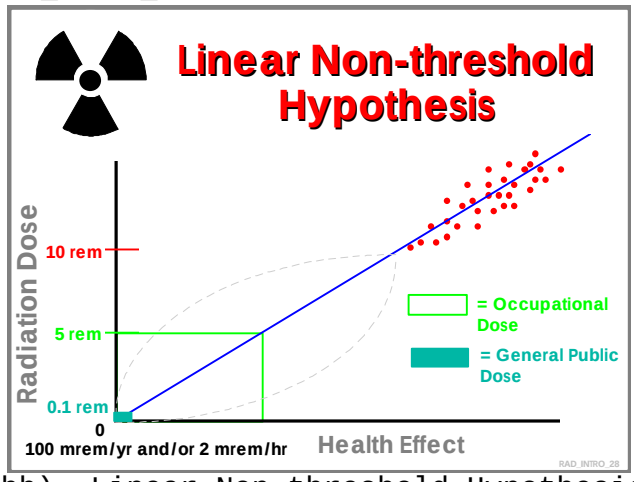


(y) Somatic: Effects which occur in the individual after exposure to radiation, such as reddening of the skin, cancer, or cataracts.

(z) Embryological: Cell damage to a fetus which may surface as such things as stunted size or mental retardation.

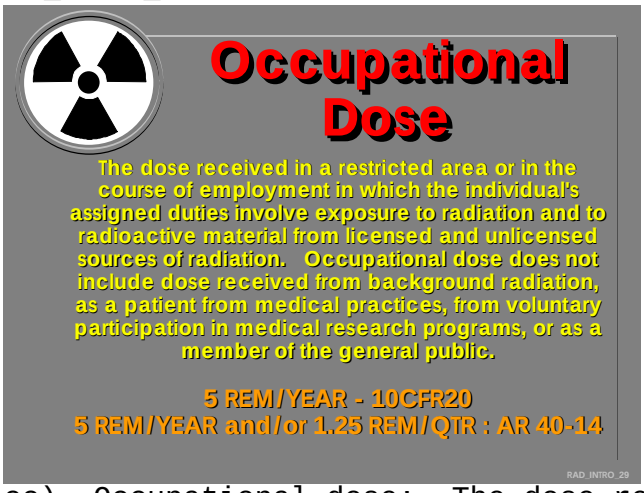
(aa) Genetic Injury: Cell damage to reproductive organs which may appear as mutations in future generations.

NOTE: *SHOW SLIDE RAD_INTRO_28*



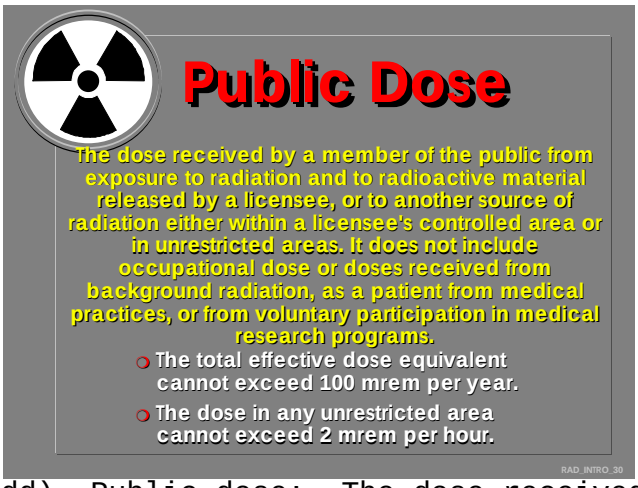
(bb) Linear Non-threshold Hypothesis: When the known health effects of annual exposures to radiation are plotted on a graph, the points appear to be linear. Exposures below 10 Rem per year appear to have no statistical correlation to provable health effects. Some studies indicate that exposures slightly below 10 Rem/Year indicate significant decreases in health effects. Other studies indicate that annual doses must be reduced substantially to reduce health effects. The NRC takes the conservative approach by disregarding this 10 Rem/year threshold and continues the linear aspects of the graph to the zero point; in effect saying that any exposure to radiation can be directly correlated to health hazards.

NOTE: *SHOW SLIDE RAD_INTRO_29*



(cc) Occupational dose: The dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public. By NRC regulations the maximum allowable dose to a major portion of the body is 5 rem per year. Army regulations further restrict this type of dose to not only 5 rem per year but also not more than 1.25 rem per quarter.

NOTE: *SHOW SLIDE RAD_INTRO_30*



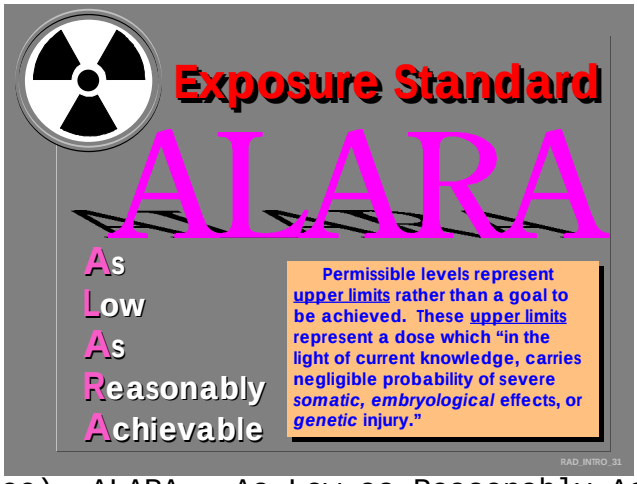
(dd) Public dose: The dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background

radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

[1] The total effective dose equivalent to individual members of the public from any licensed operation cannot exceed 100 mrem per year.

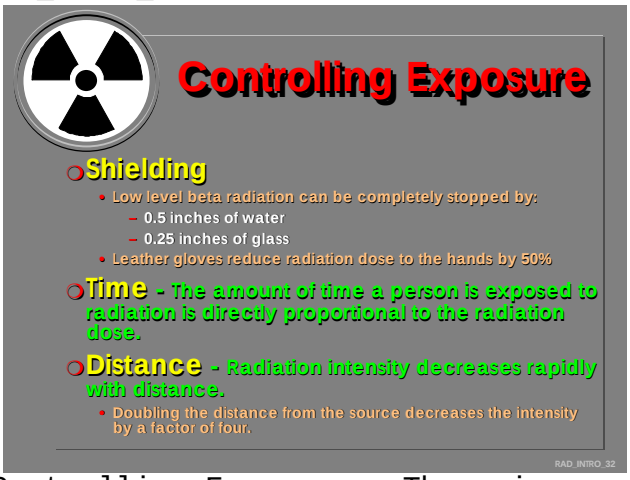
[2] The dose in any unrestricted area to individual members of the public from external sources cannot exceed 2 mrem per hour.

NOTE: *SHOW SLIDE RAD_INTRO_31*



(ee) ALARA - As Low as Reasonably Achievable: The fundamental basis of all protection standards is that all exposure should be AS LOW AS REASONABLY ACHIEVABLE, with economic and social factors being taken into account. Thus the permissible levels represent **upper** limits rather than a goal to be achieved. These conservative upper limits represent a dose to the individual which "in the light of current knowledge, carries negligible probability of severe *somatic*, *embryological* effects, or *genetic* injury. The principles of ALARA shall be incorporated into each and every daily activity such as decontamination, disposal, receipt, storage, maintenance, survey and/or transportation of any radioactive source or material.

NOTE: *SHOW SLIDE RAD_INTRO_32*

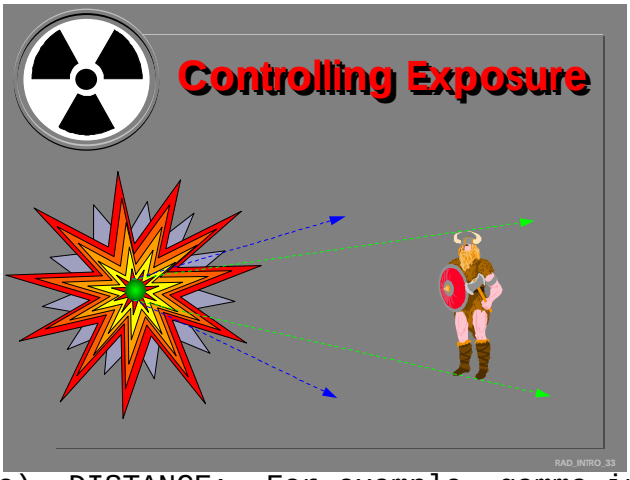


(11) Controlling Exposure: The primary means for controlling exposure to external sources of radiation are:

(a) SHIELDING: Low levels of Beta Radiation can be stopped completely by 0.5 inches of water, even less thickness of plastic, or less than 0.25 inches of glass. Leather gloves can decrease the radiation dose to the hands by 50%.

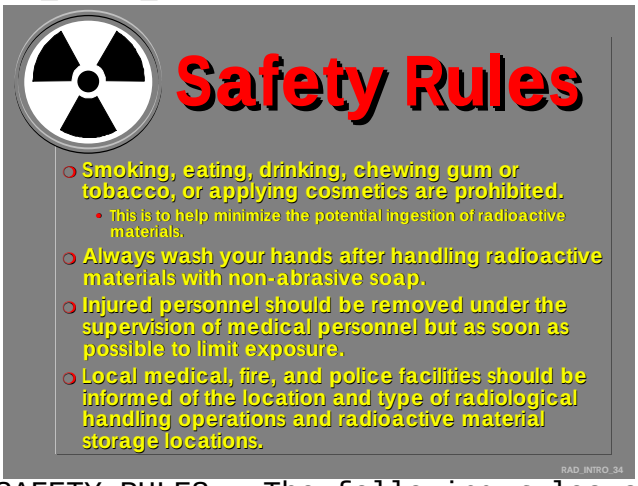
(b) TIME: The actual radiation dose received is time dependent. Minimizing the time spent around radioactive material minimizes the potential dose.

NOTE: *SHOW SLIDE RAD_INTRO_33*



(c) DISTANCE: For example, gamma intensity from a point source rapidly decreases with distance from the source.

NOTE: *SHOW SLIDE RAD_INTRO_34*



(12) SAFETY RULES: The following rules are listed for all personnel who are exposed to radiation or radioactive material:

(a) Smoking, eating, drinking, applying cosmetics, or chewing gum or tobacco within the area are prohibited. This is to help minimize the potential ingestion of radioactive materials.

(b) Always wash your hands after handling radioactive materials or sources with non-abrasive soap.

(c) In the event of an accident or injury, injured personnel should be removed under the supervision of medical personnel. If injury occurs inside a building or room with possible radioactive contamination, the injured person should be moved to limit exposure.

(d) Local medical facilities should be informed of radiological handling operations.

c. Summary:

(1) This block of instruction has covered many of the terms and concepts used in association with handling radioactive materials. Everyone should now have an understanding of what radiation is, the types of radiation, the units of measure, and how radiation affects the human body. Some of these concepts will be discussed in more detail during the remainder of this course.

(2) Administrative, engineering controls, and personal attention to the principles of radiological protection are essential requirements that minimize individual exposure to ionizing radiation. The judicious use of time, the imposition of shielding, and the maximizing of distance between an individual and a source of ionizing radiation will minimize the dose equivalent to the individual.

(a) Prompt completion of assigned duties in a radiation area minimizes exposure.

(b) Never improvise when working around radioactive materials. Follow the procedures in the TM and never perform any maintenance that is beyond your level.

(c) Isolation of radioactive materials shields the material and also maximizes the distance between an individual and the radioactive material.

(d) Maintaining arms length between the radioactive source and the body can significantly reduce the exposure dose.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

Miscellaneous Radioactive Material

Thorium-232

Americium-241

Nickel-63

Promethium-147

Radium-226

Cesium-137

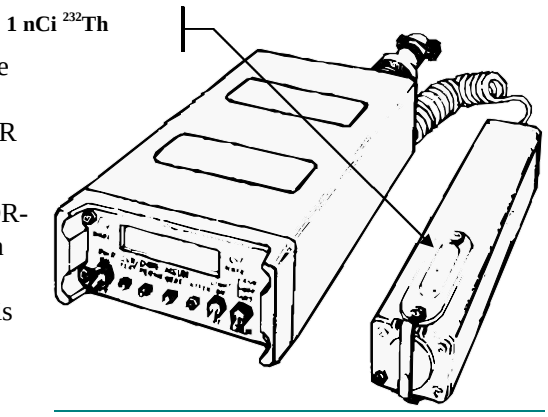
Student Notes

Thorium-232

There are 13 radioactive isotopes of thorium of which only one, ^{232}Th, occurs naturally. As Thorium decays, other elements are formed and radioactive emissions, chiefly alpha particles, are generated. These other elements are known as *daughter* elements and most of them have short half-lifes as they in term decay to other daughter elements. Consequently, relatively large amounts of ionizing radiation are generated.

An interesting property of thorium is that when it is heated in air it glows with a dazzling white light. Because of this, one of the major uses of thorium has been the *Welsback* lantern mantle used in portable gas lanterns.

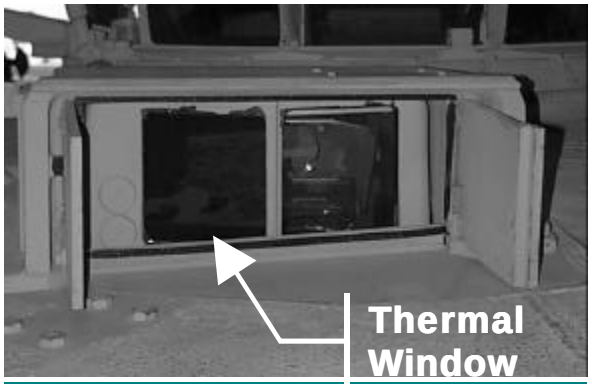
Thorium-232



This isotope of thorium is used in conjunction with the high range detector of the AN/VDR-2 Radiac Set. This item contains a 1 nanocurie source that must be disposed of IAW AR 385-11 and TM 3-261.

The check sources of the AN/PDR-54 and the AN/PDR-77 Radiac Sets contain 0.1 microcuries of thorium-232 with an emission rate of 14,000 counts per minute (cpm). Care should be taken while handling the check sources as the thorium-232 is exposed to allow alpha particle emissions.

Thorium Fluoride



The material that lenses in thermal systems are made of is germanium which is not radioactive. Thermal optics use germanium instead of glass because of the wavelengths of the electromagnetic energy (between 7 and 14 microns) that the thermal system is “looking” at. Germanium behaves just like glass to this range of energy with the added benefit of totally blocking visible light. In general, a very thin coating material (typically magnesium-fluoride) is used on all optic lenses to make the highly polished outer surface of the lens less reflective. This is so that more of the light continues through the optical train and less is reflected causing *ghost* images.

Thermal optics possess a multi-layered infrared anti-reflective coating that contains radioactive thorium as a fluoride compound (thorium tetrafluoride). This hard coating is covered with a protective layer of a non-radioactive compound, which prevents direct contact with the thorium surface.

Care should be taken in the handling of these optical components to avoid inhalation and/or ingestion of any particles inadvertently chipped or scratched. Prompt first aid attention should be given to anyone receiving a

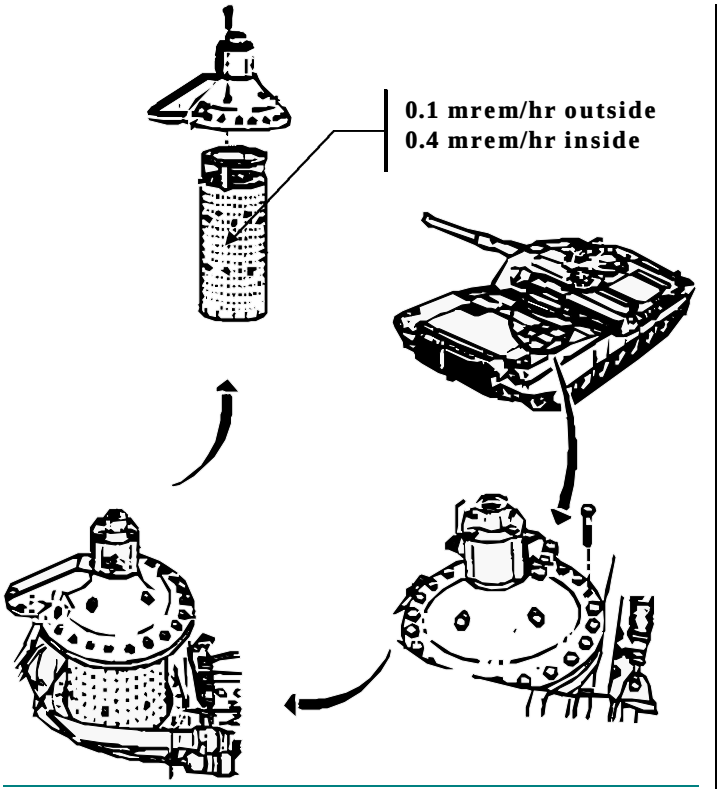
Student Notes

cut caused by broken and/or chipped thorium fluoride coated lenses. Prompt cleansing of the wound to minimize entrance of thorium particles into the body is extremely important and the RPO or Safety Officer must be notified at once. Wearing rubber gloves to handle lenses provides protection from contaminated dust on chipped or broken thermal optics. Maintenance personnel should also wash their hands with mild soap and water after handling thermal lenses or windows.

Thorium Nickel Alloy

Due to the low activity level of the thorium-nickel alloy, no NRC license is required for this item. Its use is authorized by Department of the Army Radiation Authorization (DARA) 21-12-05 which has been issued to TACOM.

Natural thorium oxide evenly dispersed in simple nickel thorium alloy is used in the combustor liner, NSN 2835-01-076-6092, for the M1 Abrams series tank turbine engines. thorium-232 is used because the alloy can withstand a great amount of heat without physical change.



Student Notes

The combustor is a non-repairable component. The only maintenance function allowed on the combustor is to replace the combustor with a new one. Unserviceable combustors must be disposed of IAW AR 385-11, and TM 3-261 or sent to a licensed thorium rework facility in the Army. Combustor liners separated from vehicle engines must be tagged or labeled with the words “RADIOACTIVE MATERIAL - TH 232” and otherwise labeled IAW MIL-STD-129.

Surveys of the combustor indicates that the radiation exposure rates are 0.1 mrem/hr on the outside surface and 0.4 mrem/hr on the inside surface. No regular monitoring of the item in the turbine engine is required. The Thorium-Nickel alloy presents no external radiation hazard when handling and installing the combustor liner.

Student Notes

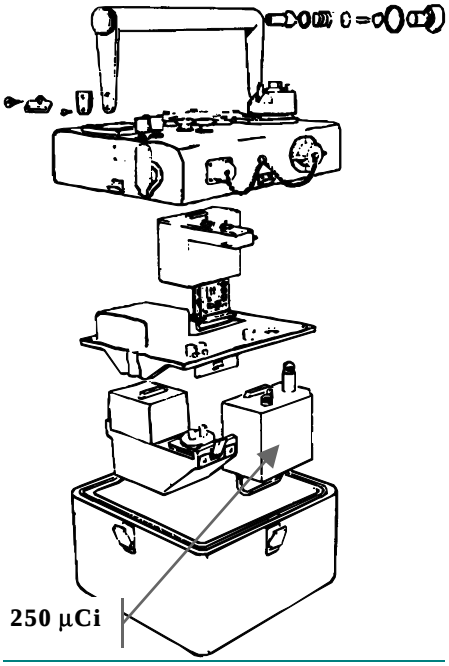
AMERICIUM-241

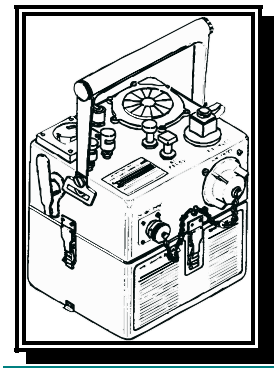
Americium-241 does not occur in nature. It is a daughter product of the decay process of plutonium-241 with a half-life of 458 years and is primarily an alpha and gamma emitter. The gamma radiation for this isotope is very low, so an external dose could not be received unless large amounts of Am-241 are stored in one area and a person is in close contact with the material for most of the work day.

The high energy alpha emission can present an internal radiation hazard if it is ingested. Americium-241 is chemically analogous to calcium and can replace calcium in the body, especially in bone material. For this reason it is often referred to as a “bone seeker”. Once incorporated in the bone, the bone and surrounding tissue are constantly irradiated, which can result in leukemia and malignancies.

Since ^{241}Am primarily emits alpha radiation, alpha detection equipment must be used to accurately assess contamination levels. Personal gamma dosimetry is not usually required unless a person is in close contact with the material throughout most of the day.

M43A1 Chemical Agent Detector



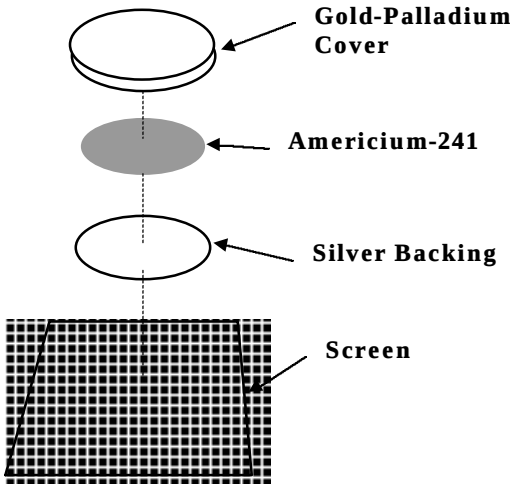


This isotope is used as a sealed source in the M43A1 Chemical Agent Detector which is a component of the M8A1 alarm. A component of the M43A1 is a cell module that contains a radioactive source of 250 µCi of ^{241}Am.

The M43A1 Detector operates on the principle of molecular ion clustering. An air sample is drawn over the radiation source which causes clustering of molecules with water and air. The air sample is drawn through a sensor cell which is geometrically configured to allow passage only to clusters below a certain mass. The nerve agents cluster very rapidly whereas atmospheric agents do not. The molecules are impacted on a collector and an electrical signal is obtained when nerve agents are present.

Student Notes

The source is located in the cell module of the detector. It consists of a foil disc made of 250 μCi of americium-241 oxide in a gold matrix contained between a gold-palladium alloy face and a silver backing. The disc is affixed onto a metal screen which is secured by a retaining ring within the sensing housing. This source is considered a "special form" source.



The ^{241}Am source has passed rigorous environmental and accident situations without damage or leakage and is expected to remain intact throughout its life cycle. Small amounts of radioactive contamination have been detected in some M43A1 Chemical Agent Detectors. Constant bombardment from the alpha particles emitted by the ^{241}Am has caused the gold-palladium cover in some of the detector modules to deteriorate. This deterioration is in the form of small cracks similar to "heat checking". In the most severe cases these cracks may penetrate the cover allowing moisture from the air to contact the Americium oxide causing it to plate out onto the outer surface of the cover. Continued use of the device will cause this contamination to migrate through the air path. The contamination is in the form of a powder found in the plastic tubing between the pump module and the cell module. Owners and maintenance personnel of this equipment have been alerted to take the following actions:

[1] Ensure all users are reminded that use of the outlet filter is mandatory when the M43A1 is used indoors.

[2] Ensure strict adherence to the procedures in the technical manuals regarding wearing gloves, use of Kraft paper on work benches, and monitoring the area with an alpha meter when maintenance is being performed.

Student Notes

[3] If you see any powder in the pump tubing immediately place the device in double bags, seal and store. **DO NOT PERFORM ANY MAINTENANCE ON THE DEVICE**. Contact your installation RPO for further instructions.

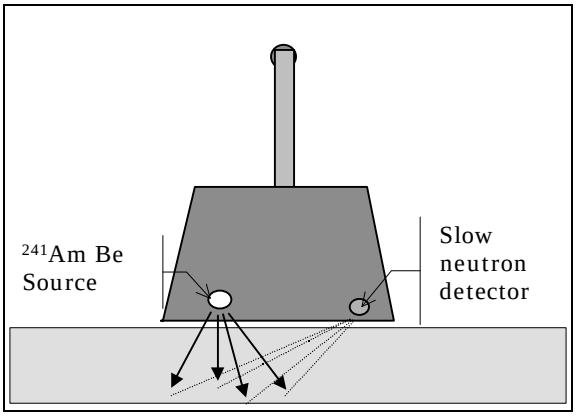
Density and Moisture Tester
Campbell Pacific Model MC-1

A 50 mCi mixture of americium-241 and Beryllium is located within the base of the MC-1 (about 200 times more ^{241}Am than is used in the M43A1 Chemical Agent Detector). Neutron emission occurs when an alpha particle emitter such as ^{241}Am is mixed with Beryllium (Be) powder in a tightly compressed pellet. The alpha particles strike the Beryllium atoms to produce "fast" neutrons with an average energy of 5 MeV. This *neutron* radiation consists of noncharged particles emitted from the source.

Typical neutron detectors "see" only slow, or "thermal" neutrons. Therefore, the fast neutrons must slow down or they are ignored by the detector. Neutrons slow down by colliding with other atomic particles. Collision of fast neutrons with the nuclei of large atoms results in rebounding of the neutrons with little loss of energy. Collision with the orbiting electrons (approximately $^{1}/_{1840}{}^{th}$ the weight of a neutron) produces little loss of energy.

A simple analogy would be that of a billiard ball colliding with a bowling ball. The billiard ball would bounce off with little change in energy (however the **direction** of the billiard ball would probably change drastically). When a billiard ball goes crashing through a bunch of BBs, the BBs will fly off in all directions but the billiard ball would continue in much the same direction with nearly all of its original energy.

Student Notes



The only atom which can markedly slow down a fast neutron, and which would likely be found in soil, is hydrogen. The hydrogen atom consists of one proton (about the same mass as a neutron) and one electron. When the fast neutron collides with a hydrogen atom it is much the same as when a billiard ball hits another billiard ball. One slows down a lot, the other starts moving (or speeds up), and they both change direction. The only form of hydrogen normally found in a typical construction sight is water (H_2O). So if we "pump" in fast neutrons and "read" the amount of slow ones that result, we can determine the amount of moisture in the soil.

Student Notes

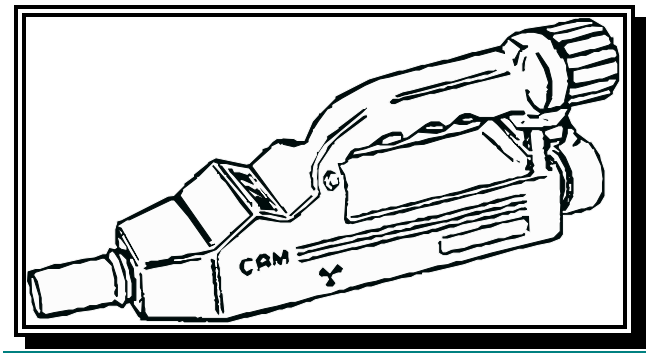
NICKEL-63

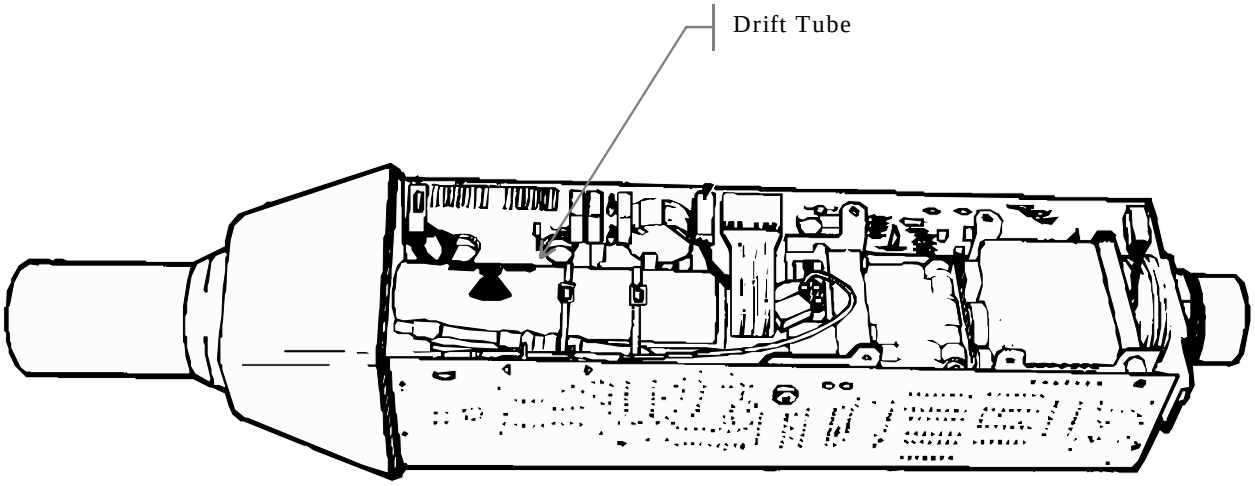
With a radiological half life of 96 years, nickel-63 is a beta emitter with a short decay chain and no gamma radiation.

The beta energy level of ^{63}Ni is too low to penetrate the dead layer of skin. Efforts should be taken to prevent ingestion, inhalation, or absorption through broken skin.

The Chemical Agent Monitor (CAM) uses this isotope. The nickel-63 is used to ionize air molecules as they pass through the detector. The drift tube module consists of 10 millicuries of ^{63}Ni plated on a brass foil cylinder inside a Teflon housing that is installed in a larger aluminum alloy cylinder.

The CAM is used by ground forces and responds to nerve and blister agent vapor down to the lowest concentrations that could affect personnel over a short period of time.





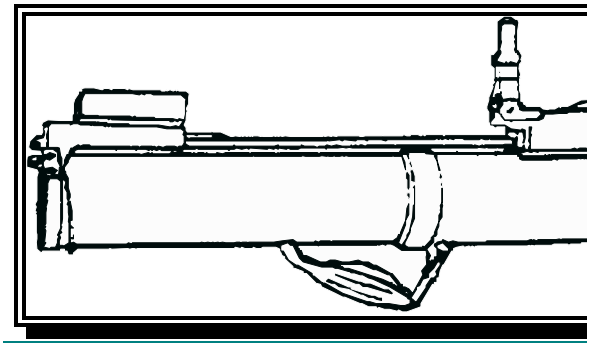
Student Notes

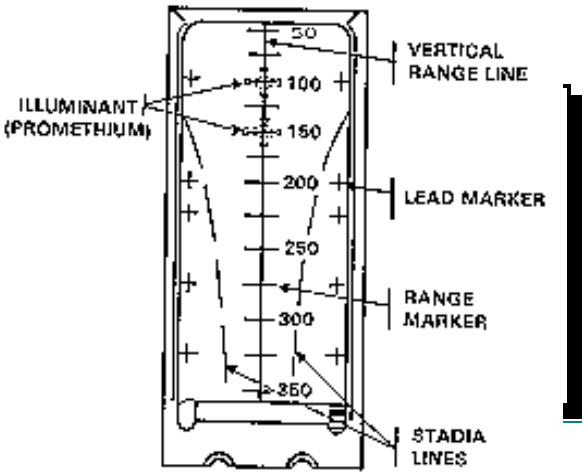
PROMETHIUM-147

Promethium-147 has a half life of 2.64 years and is a beta and alpha particle emitter used in luminous paints.

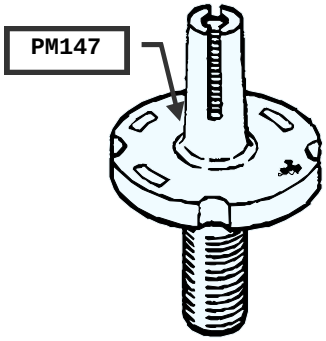
The only weapon system that used this element was the M72 series, 66mm, Light Antitank Weapon (LAW). For 20 years the LAW was manufactured with ^{147}Pm is just located in two spots that are located at the 100 and 150 range markers on the sight. In the early 80's the "E" version of the LAW changed the sight to an adjustable rifle type there by eliminating the need for ^{147}Pm. However, the older models, M72, M72A1, and M72A2 still remain in use for training and in storage.

M16A1 Rifle Front Sight Post

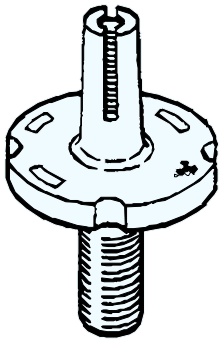




No longer in use.



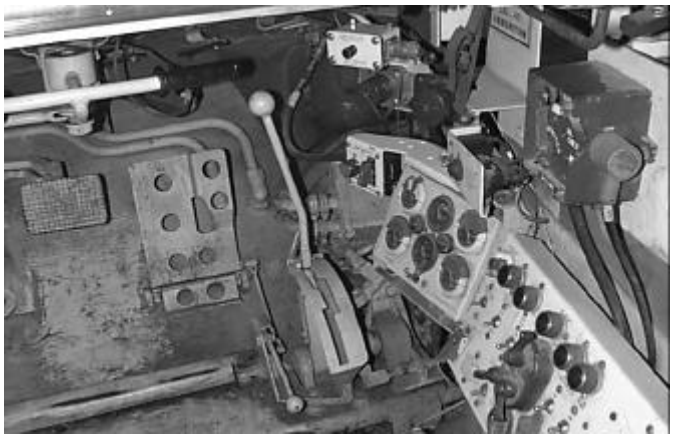
Student Notes



Student Notes

RADIUM-226

Though primarily an alpha emitter ^{226}Ra also emits some low energy beta and gamma radiation.



Radium-226 was used on the faces and pointers of dials and gauges of instrument panels in tactical and combat vehicles. These items are no longer in DoD storage depots and have not been procured since 1969. Non-radioactive replacements are available in the supply system for all of the radioactive items.

According to Department of the Army Radiation Authorization (DARA) A21-12-04 and TB 43-0216 all fielded TACOM managed vehicles containing radioactive dials and gauges will have the instrument panel labeled "*CAUTION RADIOACTIVE. THE GAUGES IN THIS VEHICLE MAY CONTAIN RADIUM-226. REMOVE RADIOACTIVE GAUGES PRIOR TO EXCESS OR DISPOSAL OF THIS VEHICLE IAW AR 385-11, and TM 3-261. REFER TO TB43-0216 FOR ADDITIONAL GUIDANCE.*" Information from the TACOM Safety office indicates that as of September 1994 these vehicles have not yet been labeled. The gauges and dials themselves are not marked or labeled in any way that would indicate that they are radioactive.

Radium dials and gauges are not sold to the public. Users are required to remove dials and gauges containing radium from the vehicles when the dials/gauges are defective, when the vehicles are used for other than its intended purpose and prior to turning the vehicles into property disposal offices. Radioactive dials and gauges must be removed as complete units and under no circumstances are any of the radioactive dials/gauges to be taken apart for disposal or repair.

Now, if you have read the preceding three paragraphs, one small question may have come to mind. How do I tell whether a dial or gauge is radioactive since they are not marked in any way? Good question! The easiest way to tell for sure if a gauge or dial might contain radium or some other radioactive material is to check it with a radiac meter (but remember that fielded radiac instruments cannot detect tritium).

Student Notes

Cesium-137

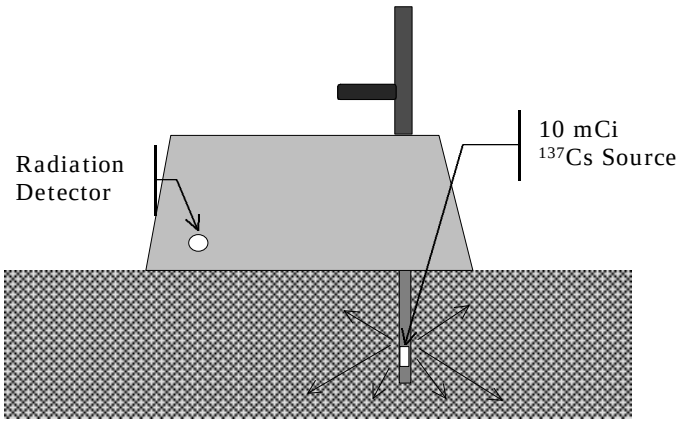
Density and Moisture Tester
Campbell Pacific Model MC-1

The MC-1 has a 10 mCi cesium-137 source located in a probe tip used to determine the density of the soil at a construction site. This source is classified as a "special form" source and is double-encapsulated in stainless steel. Cesium-137 emits a negative beta particle (which is vertually totally shielded by the stainless steel) and becomes barium-137 which in turn decays by emitting x-rays of a single energy level of 0.662 MeV. This fixed spectrum emission requires less shielding and is ideal for soil density determination purposes.

The density of soil is measured by *backscatter* or *transmission*.

BACKSCATTER is the technique of placing the source on the surface of a flat material. This technique measures only the top 2 inches of soil and is very sensitive to surface roughness or quality of site preparation.

TRANSMISSION is the technique of pre-drilling a small hole in the ground and then inserting the radioactive source in the ground via the movable source rod. This permits measurement to specific depths to 12 inches and is not sensitive to surface roughness. It is very accurate and is the preferred method of density measurement for soils.



Radiation detectors in the MC-1 measure the amount of radiation that penetrates the soil. Dense soil will block more of the radiation than lighter soil. The measurement taken by the detector is displayed electronically as an indication of the soil density.

TACOM is the NRC license holder for the MC-1 and is responsible for item management. Problems occur when field units fail to properly handle, transport, or store the device.

Student Notes

Radioactive Materials

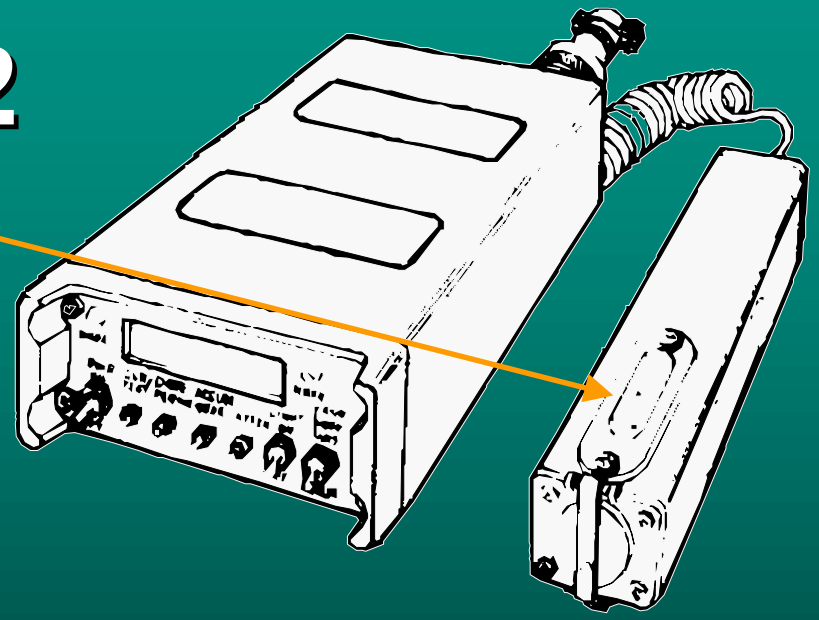
- Thorium-232
- Americium-241
- Nickel-63
- Promethium-147
- Cesium-137
- Radium-226

Thorium-232

- Abundant as Lead
- Half-Life = 14,100,000,000 yrs
- Daughter Elements have Short Half-Life
- Large amounts of Ionizing Radiation
- Alpha Particle Emitter

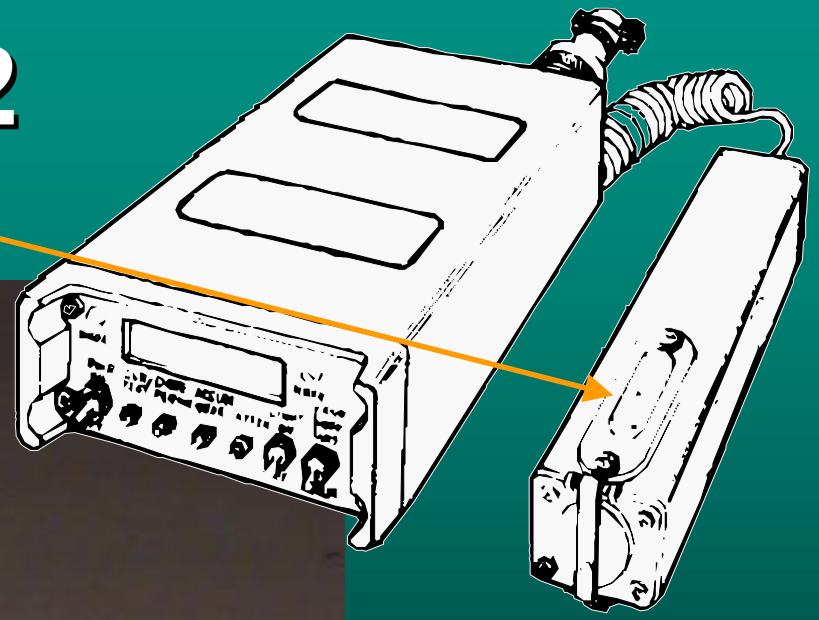
Thorium-232

- Thorium-232
  - AN/VDR-2



Thorium-232

- Thorium-232
  - AN/VDR-2



Thorium-232

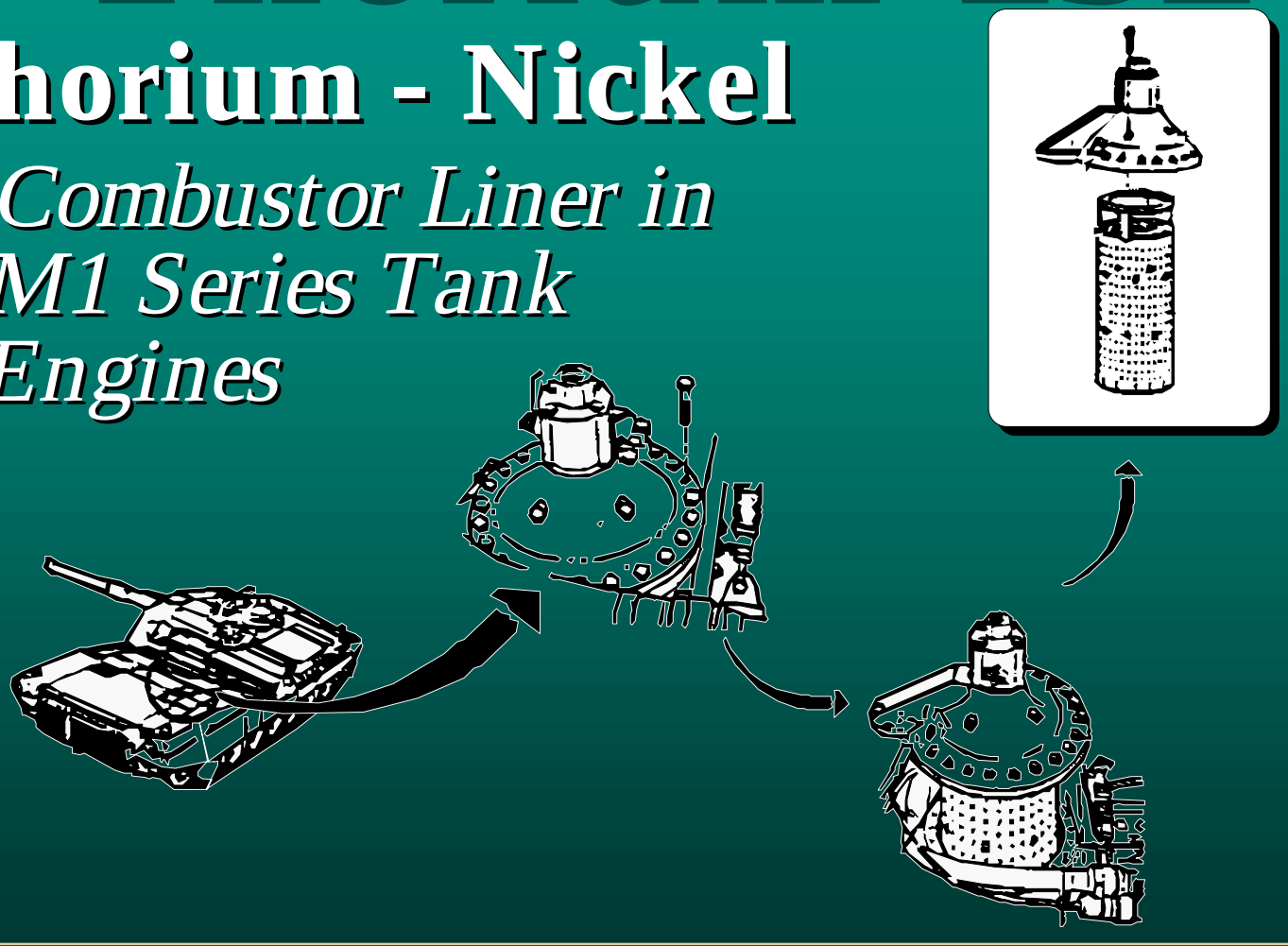
- Check Sources
  - AN/PDR-54
  - AN/PDR-56F
  - AN/PDR-77

Thorium-232

- Thorium Fluoride
  - Thermal Optics

Thorium-232

- **Thorium - Nickel**
  - *Combustor Liner in M1 Series Tank Engines*

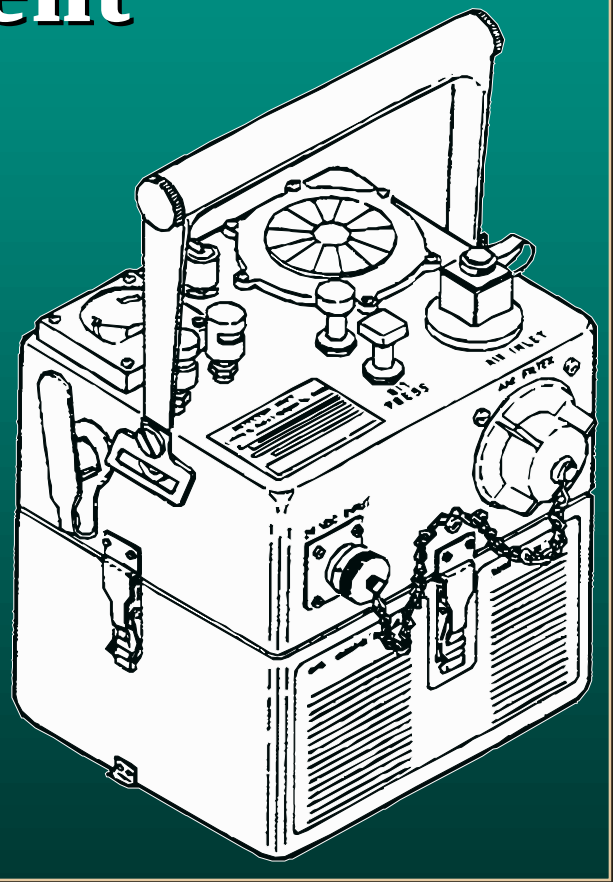


Americium-241

- Does not occur in nature
  - Daughter product of Plutonium
- Half Life = 458 yrs
- Alpha emitter
  - Some Beta & Gamma
- “Bone Seeker”

Americium-241

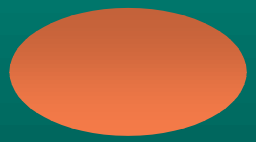
- M43A1 Chemical Agent Detector



Americium-241

- M43A1 Chemical Agent Detector

Americium oxide →

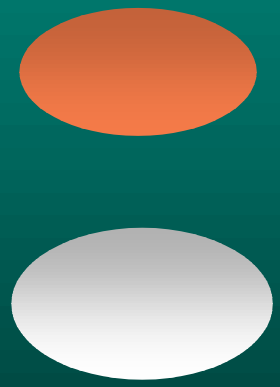


Americium-241

- **M43A1 Chemical Agent Detector**

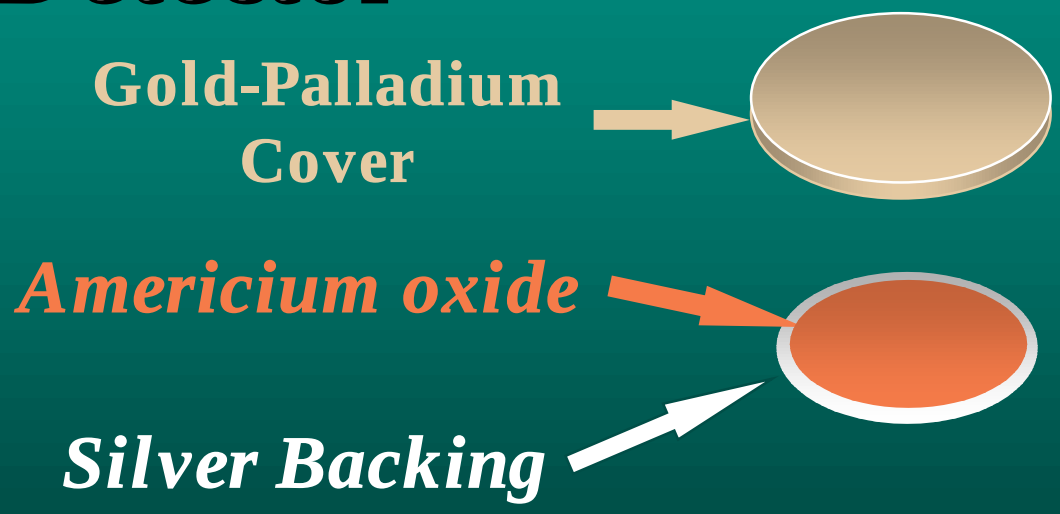
Americium oxide →

Silver Backing →



Americium-241

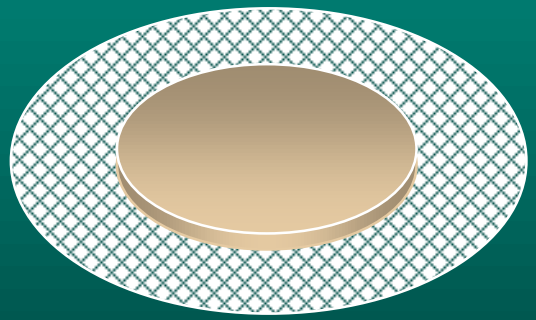
- **M43A1 Chemical Agent Detector**



Americium-241

- M43A1 Chemical Agent Detector

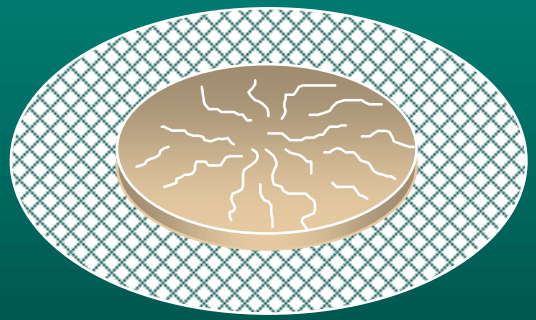
"Special Form" Source



Americium-241

- M43A1 Chemical Agent Detector

"Special Form" Source

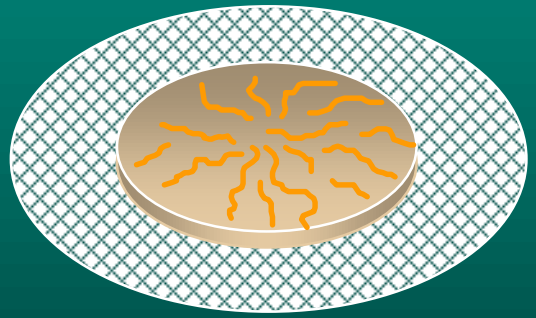


Source Deterioration

Americium-241

- M43A1 Chemical Agent Detector

"Special Form" Source



Americium Contamination

Americium-241

MC-1

Density

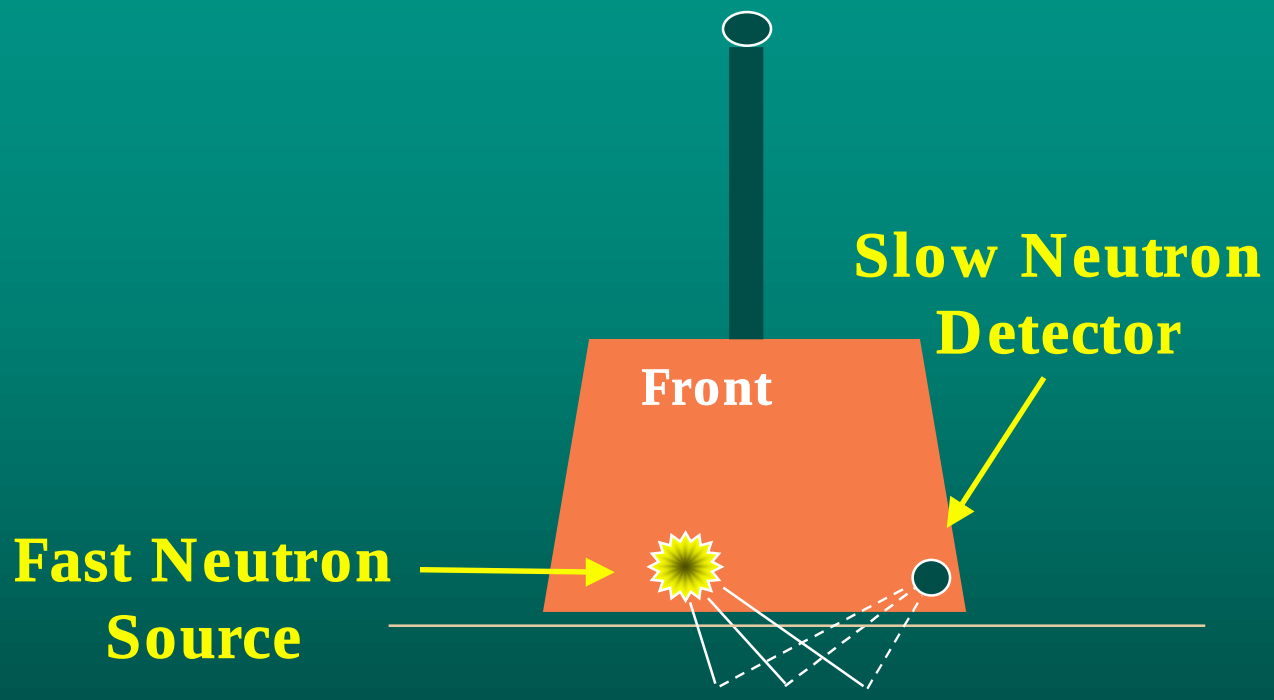
&

Moisture

Tester

RAD_02_12

Americium-241



- **Density & Moisture Tester**

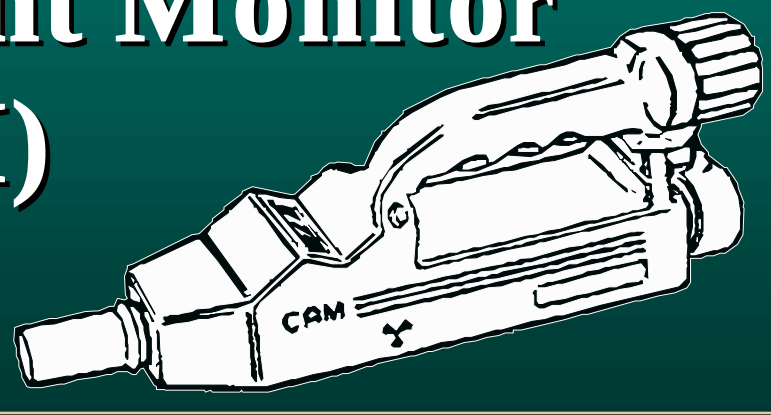
Campbell Pacific Model MC-1

Nickel-63

- Half Life = 96 yrs
- Beta emitter
  - Too low to penetrate dead skin

Nickel-63

- Half Life = 96 yrs
- Beta emitter
  - Too low to penetrate dead skin
- Chemical Agent Monitor (CAM)

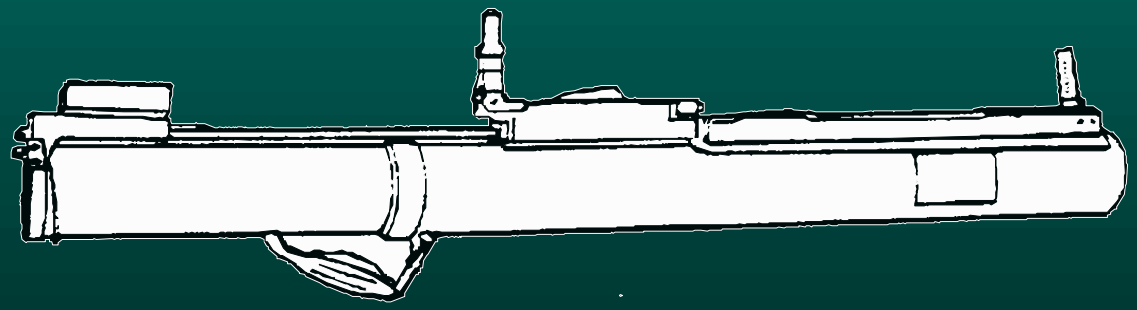


Promethium-147

- Half Life = 2.64 yrs
- Alpha & Beta particle emitter
- Used in Luminous Paint

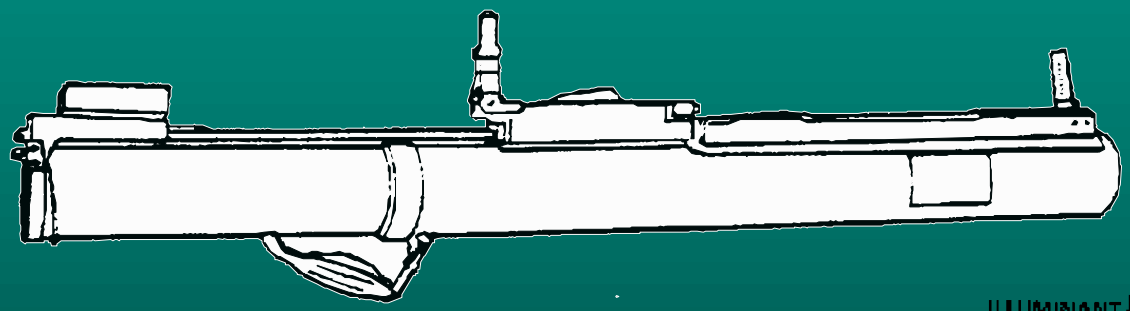
Promethium-147

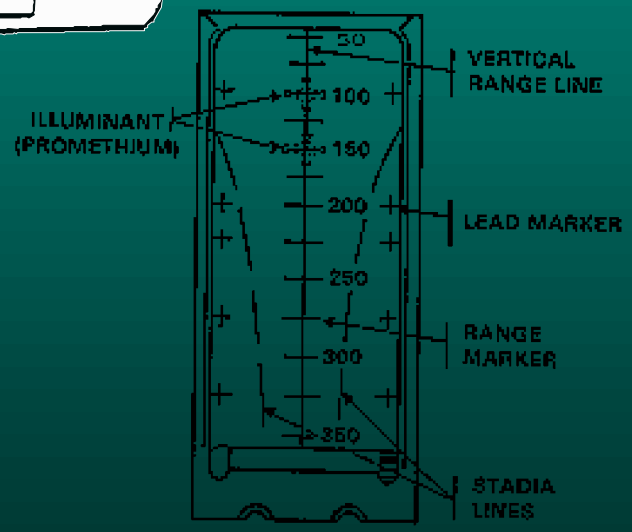
- Half Life = 2.64 yrs
- Alpha & Beta particle emitter
- Used in Luminous Paint
  - M72 Series
    Light Antitank Weapon (LAW)



Promethium-147

- M72 Series
  Light Antitank Weapon (LAW)

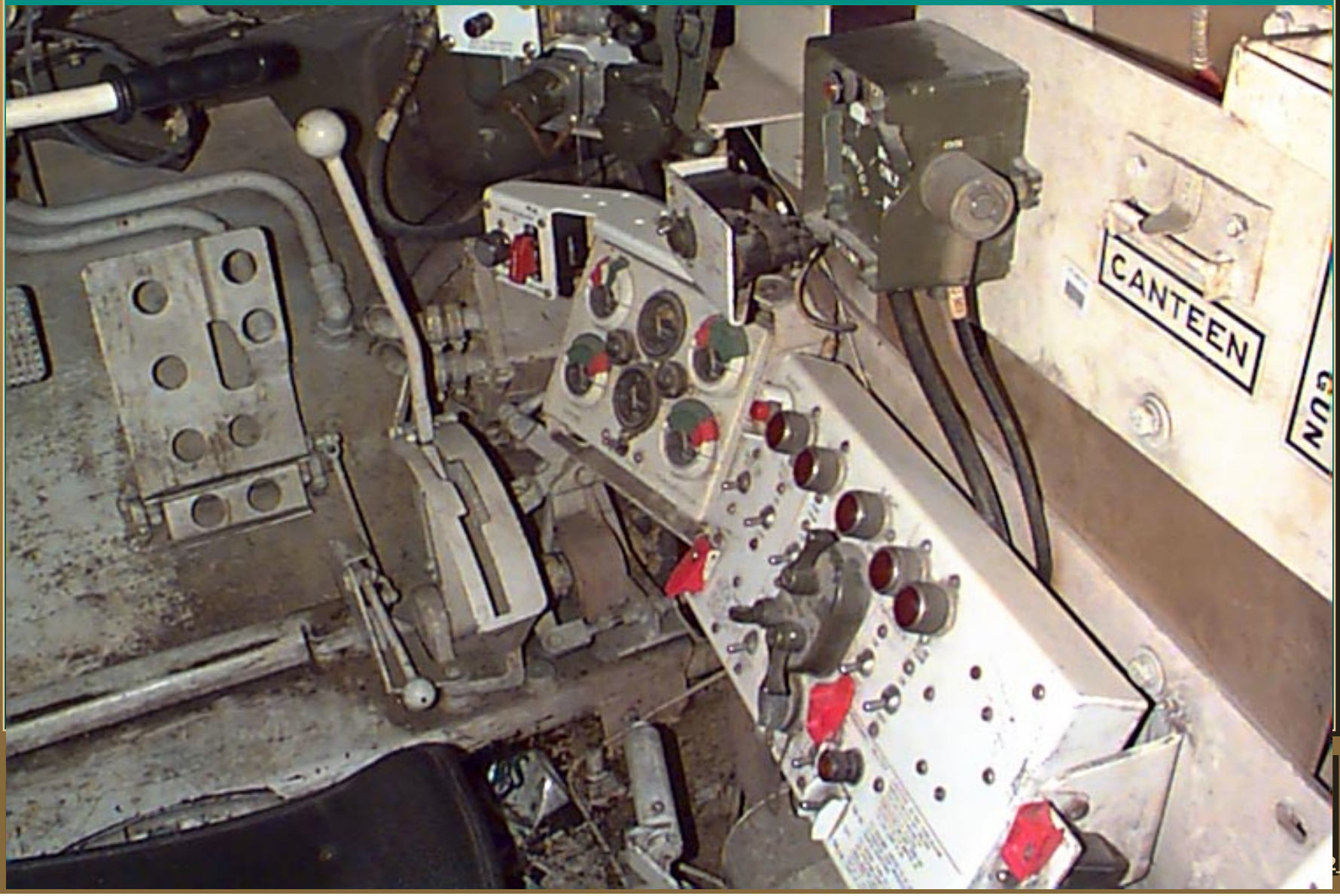




Radium-226

- **Half-Life = 1,602 yrs**
- **Alpha Emitter**
  - *Some Beta and Gamma*
- **Gauges & Dials**
- **DARA A21-12-04**

Radium-226

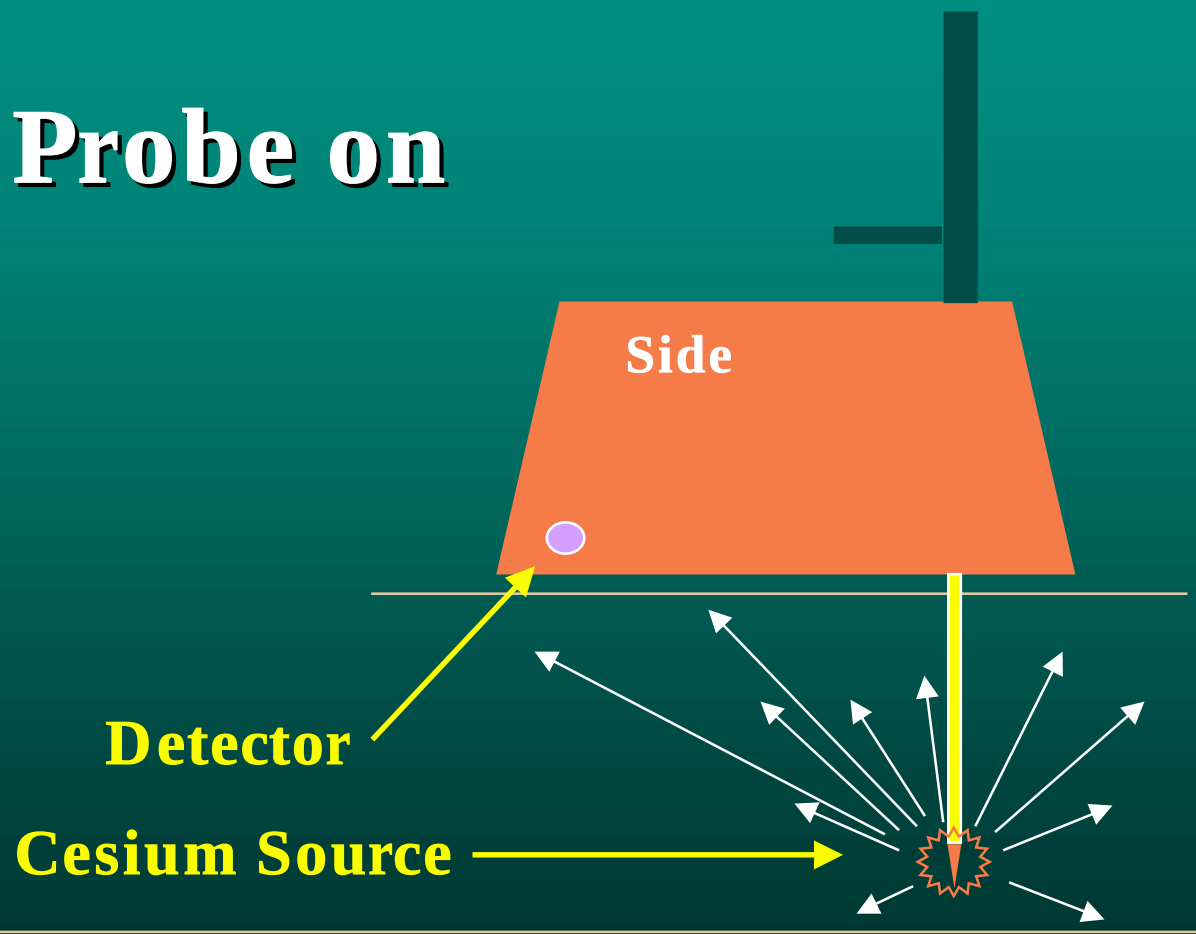


Cesium-137

- **Half-life = 30 yrs**
- **Beta emitter**
  - *Some x-rays from barium daughter element*

Cesium-137

- Density Probe on MC-1

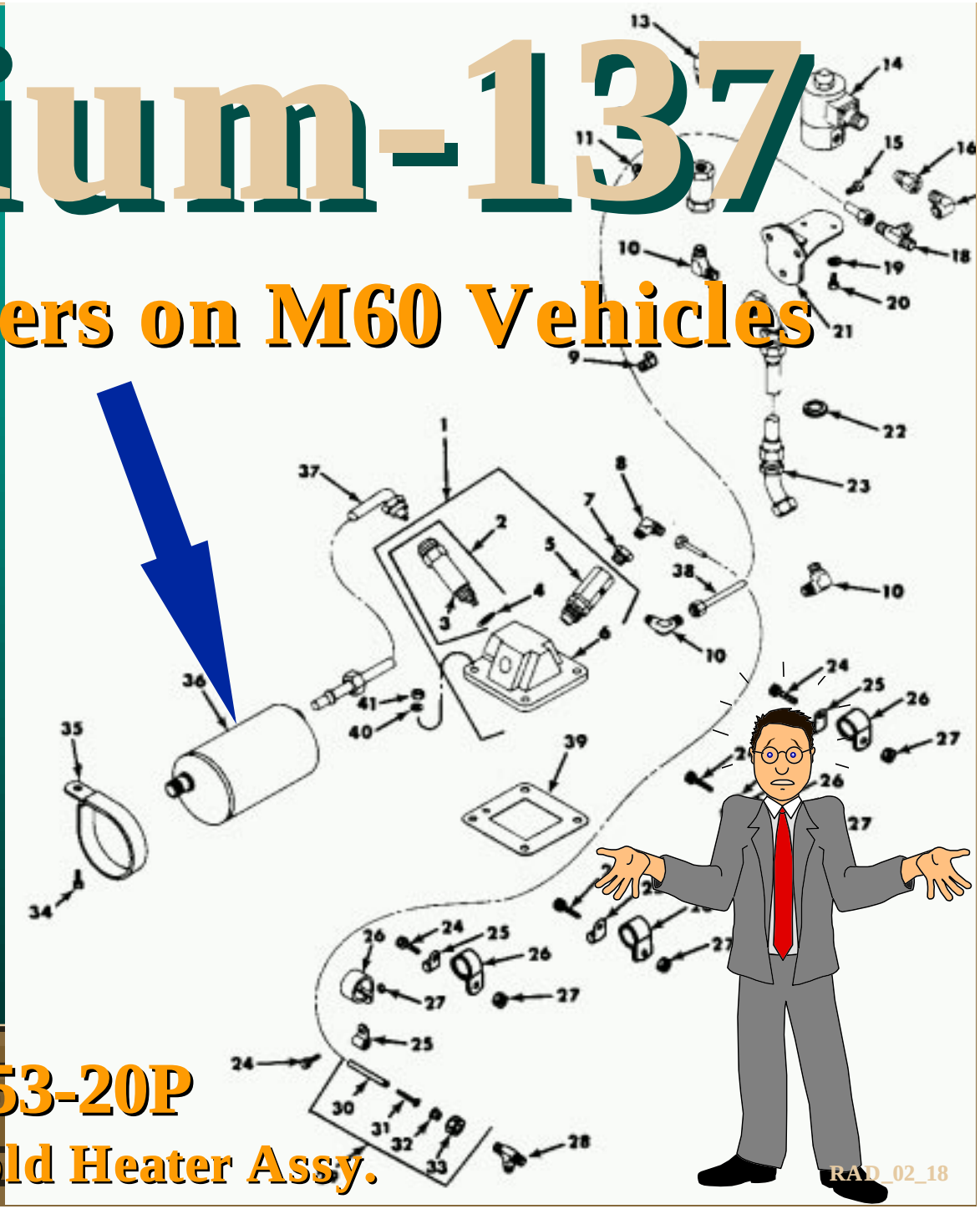


Cesium-137

- **Spark Igniters on M60 Vehicles**

NSN
2920-00-009-9340
Replaced by:
2920-00-770-1641

SMR Code
PAOZZ



TM 9-2350-253-20P
Fig 42. Left Bank Manifold Heater Assy.

Cesium-137

- Spark Igniters on M60 Vehicles

NSN
2920-00-711-5829
Replaced by:
2920-00-770-1641

SMR Code
PAOZZ

TM 9-2350-256-24P-1
Fig 42. Manifold Heater Assy. (Right Bank)

RAD_02_19

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-02

DATE: Oct 96

TITLE: Miscellaneous Radioactive Material.

APPROVED:

COURSE: Radioactive Material Handling Safety .

HOURS AND TYPE: 4.0 C (U) FACILITY REQ: Classroom
0.0 PE

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty TRANSPORTATION: None

ISSUED TO STUDENTS: Student Reference Guide “Radioactive Material Handling Safety”

AIDS AND EQUIPMENT:
a. Overhead Projector
b. Computer Display Device
c. Computer
d. Screen
e. Photographs (Pass around)
f. M43A1 Chemical Agent Detector
Chemical Agent Monitor
AN/VDR-2 Radiac Set
AN/PDR-77 Radiac Set
g. RAD_02.PPT File

REFERENCES:	TB 9-1300-278	"Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
	TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
	TM 5-6635-386-12&P	"Unit Maintenance Manual for Tester, Density and Moisture, (Soil and Asphalt), Nuclear Method, Campbell Pacific Model MC-1 (CCE)"
	TM 11-6665-251-10	Operators Manual, Radiac Set, AN/VDR-2
	TM 11-6665-208-15	"Operator's, Organizational, Direct Support, General Support, and Depot Maintenance Manual; RADIAC SET AN/PDR-54
	Reference Guide	Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
	DARA 21-12-05	Department of the Army Radiation Authorization for the use of thorium-232 in the combustor liner in M1 series tank engines.
	DARA A-21-12-04	Department of the Army Radiation Authorization for the use of Radium Dials and Gauges and Instrument Panels.

COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: Miscellaneous Radioactive Material.

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

a. Introduction:

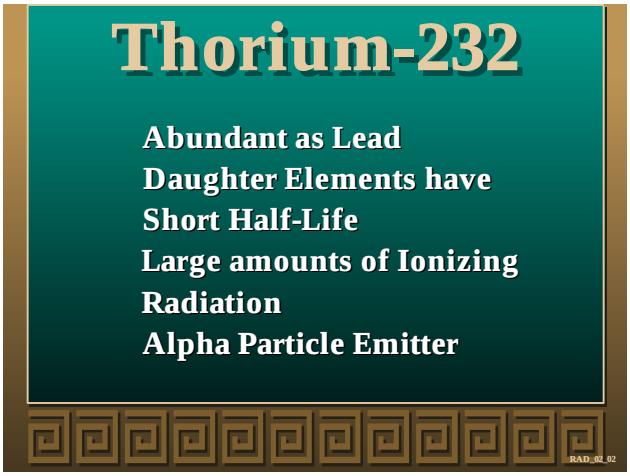
(1) Objective: Provide an overview of miscellaneous radioactive materials used by the Army to include nickel-63, americium-241, thorium fluoride and other radioactive materials.

NOTE: *SHOW SLIDE RAD_02_01*

(2) Reason and Tie-In: There are many different radioactive isotopes used by the Army in a variety of applications. Each of these present their own hazard and should be treated with respect.

b. Explanation:

NOTE: *SHOW SLIDE RAD_02_02*

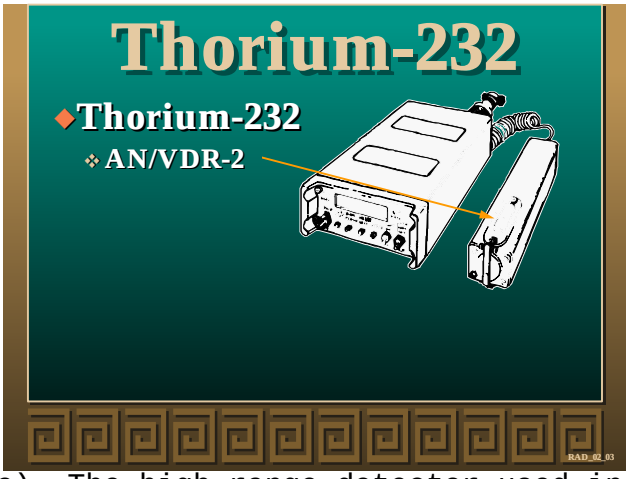


(1) **<u>THORIUM:</u>**

(a) There are 13 radioactive isotopes of thorium of which only one, ^{232}Th, occurs naturally. It is about as abundant as lead. The decay series of ^{232}Th is analogous to that of ^{238}U except that the daughter elements have short half lives, with two exceptions (^{228}Ra - 6.5 yrs and ^{228}Th - 1.9 yrs). Consequently, relatively large amounts of ionizing radiation are delivered to the tissue surrounding a particle. The radiation hazard stems from alpha particle emissions.

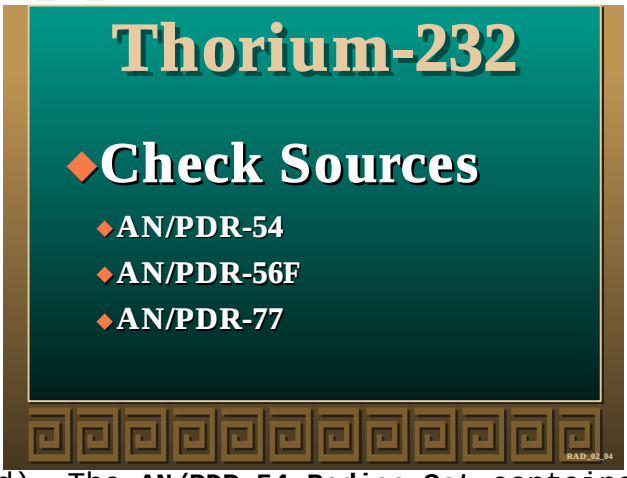
(b) An interesting property of thorium is that, when heated in air, it glows with a dazzling white light. Because of this, one of the major uses of thorium has been the Welsback lantern mantle used in portable gas lanterns. An unburned mantle will provide an alpha indication of about 15,000 CPM on standard alpha survey instruments. Mantle ash from a single mantle will provide even higher readings.

NOTE: *SHOW SLIDE RAD_02_03*



(c) The high range detector used in conjunction with **Radiac Set, AN/VDR-2** contains 1 nanocurie of ^{232}Th. This item must be disposed of in accordance with AR 385-11, and TM 3-261.

NOTE: *SHOW SLIDE RAD_02_04*



(d) The **AN/PDR-54 Radiac Set** contains a check source which contains 0.1 microcuries of thorium-232 and has an emission rate of 14,000 counts per minute (cpm).

(e) The **AN/PDR-56F Radiac Set** contains a thorium check source located on the bottom of the main unit.

(f) The **AN/PDR-77 Radiac Set** contains a thorium check source located in a plastic encased container that is stored in the case.

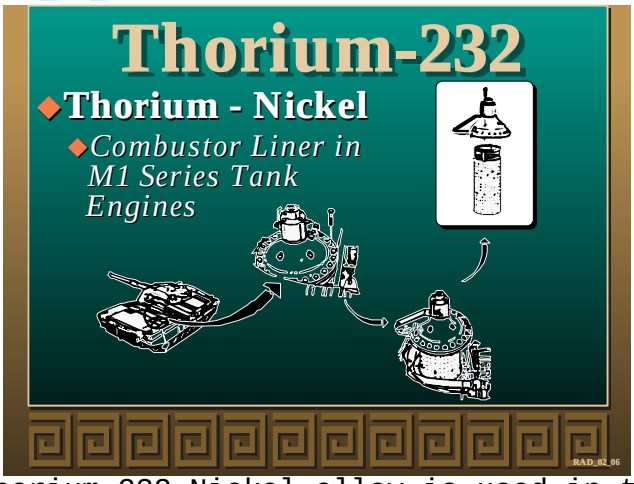
NOTE: *SHOW SLIDE RAD_02_05*

(2) **THORIUM-FLUORIDE:**

(a) The anti-reflective coating used on all thermal optics contains a small amount of thorium fluoride and is slightly radioactive. The only potential hazard involves ingesting (swallowing or inhaling) large quantities of broken lens material. Let’s all agree that doing that would be quite uncomfortable in the first place.

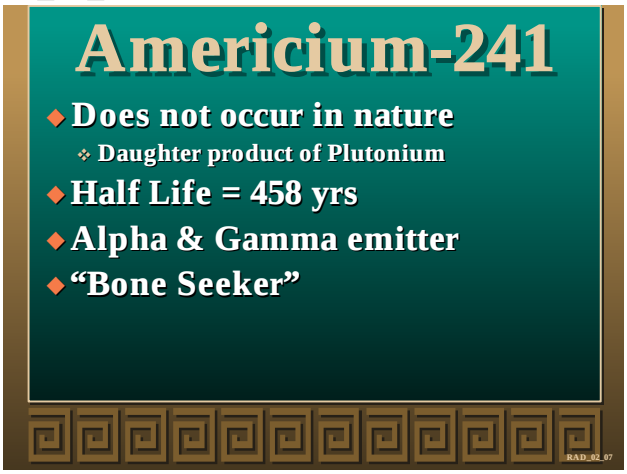
(b) The main thing to remember here is to wash your hands after handling any of this material. Though the quantity of radioactive thorium is extremely low, it is always best to minimize any exposure. Remember - ALARA.

NOTE: *SHOW SLIDE RAD_02_06*



(3) Thorium-232-Nickel alloy is used in the combustor, NSN 2835-01-076-6092, of the M1 series tank turbine engine. Thorium-232 is used because the alloy can withstand a great amount of heat without physical change. The combustor is a non-repairable component and the only maintenance allowed is to replace the combustor assembly with a new one. Unserviceable combustors will be disposed of IAW AR 385-11 and TM 3-261.
Radiation exposure rates on the combustor is 0.1 mrem/hour on the outer surface and 0.4 mrem/hour on the inner surface. No regular monitoring of the liner combustor is required.

NOTE: *SHOW SLIDE RAD_02_07*



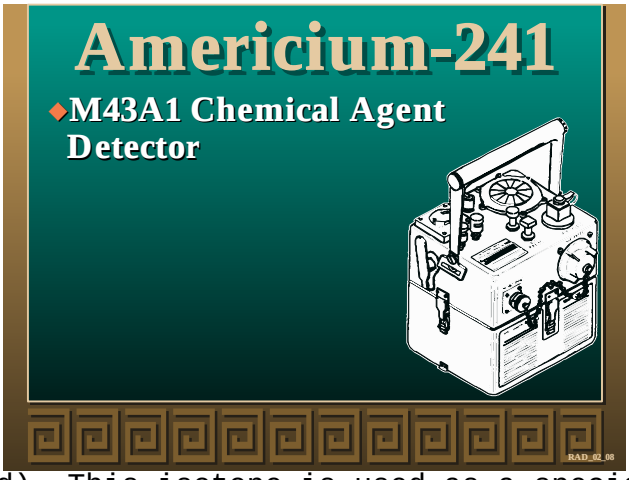
(4) **<u>AMERICIUM-241:</u>**

(a) This element does not occur in nature and is a daughter product of plutonium-241. The radiological half life of this material is 458 years. Decay of americium-241 produces alpha radiation and a small amount of low energy gamma radiation. The gamma radiation for this isotope is low, so an external dose could not be received unless large amounts of ^{241}Am (i.e. 500 M43A1 Chemical Agent Detectors) are stored in one area and a person is in close contact with the material for most of the work day.

(b) The high energy alpha emission can present an internal radiation hazard if ingested. ^{241}Am is a chemical analog of calcium. This means the ^{241}Am can replace calcium in the body, especially in the bone. For this reason, it is often referred to as a “bone seeker”. Once incorporated in the bone, the bone and surrounding tissue are constantly irradiated, which may result in leukemia and malignancies.

(c) Since ^{241}Am primarily emits alpha radiation, alpha detection equipment must be used to accurately assess contamination levels. Personal gamma dosimetry is not usually required unless a person is in close contact with the material throughout most of the day.

NOTE: *SHOW SLIDE RAD_02_08*



(d) This isotope is used as a special form source in the M43A1 Chemical Agent Detector which is a component of the M8A1 alarm. A component of the M43A1 is a cell module which contains the radioactive source.

NOTE: *SHOW SLIDE RAD_02_09*

(e) It consists of a foil disc made of 250 µCi of **americium-241** oxide in a gold matrix contained between a gold-palladium alloy face and a silver backing. The disc is affixed onto a metal screen which is secured by a retaining ring within the sensing housing. This source is considered a "special form" source. The M43A1 Detector operates on the principle of molecular ion clustering. An air sample is drawn over the radiation source which causes clustering of molecules with water and air. The air sample in drawn through a sensor cell which is geometrically configured to allow passage only to clusters below a certain mass. The nerve agents cluster very rapidly whereas atmospheric agents do not. The molecules are impacted on a collector and an electrical signal is obtained when nerve agents are present.

NOTE: *SHOW SLIDE RAD_02_10/11*

(f) Small amounts of radioactive contamination have been detected in some M43A1 Chemical Agent Detectors. The contamination is in the form of a yellow/gold powder found in the plastic tubing between the pump module and the cell module. The ^{241}Am source has passed rigorous environmental and accident situations

without damage or leakage and is expected to remain intact throughout its life cycle. Owners and maintenance personnel of this equipment have been alerted to take the following actions:

[1] Ensure all users are reminded that use of the outlet filter is mandatory when the M43A1 is used indoors.

[2] Ensure strict adherence to the procedures in the technical manuals regarding wearing gloves, use of Kraft paper on work benches, and monitoring the area with an alpha meter when maintenance is being performed.

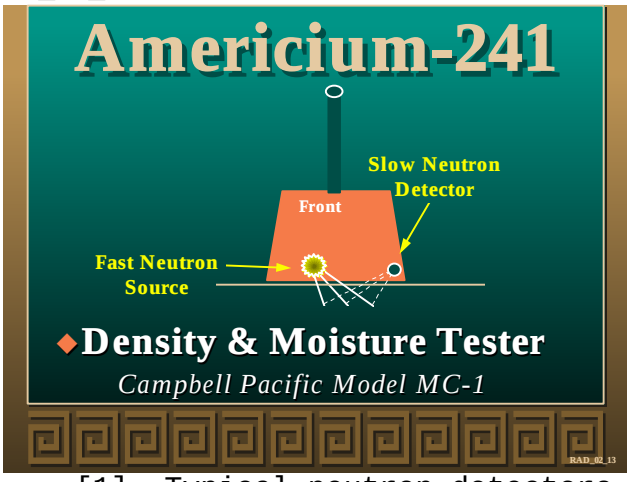
[3] If you see any yellow or gold colored powder in the pump tubing immediately place the device in double bags, seal and store. **DO NOT PERFORM ANY MAINTENANCE ON THE DEVICE.** Contact the item manager at DSN 793-3212 for shipping and turn-in instructions.

(g) Maintenance on the M43A1 can only be performed by qualified and trained personnel.

NOTE: *SHOW SLIDE RAD_02_12*

(h) **Density and Moisture Tester - Campbell Pacific Model MC-1**: A 50 mCi mixture of americium-241 and Beryllium is located within the base of the MC-1 (about 200 times more ^{241}Am than is used in the M43A1 Chemical Agent Detector). Neutron emission occurs when an alpha particle emitter such as ^{241}Am is mixed with Beryllium (Be) powder in a tightly compressed pellet. The alpha particles strike the Beryllium atoms to produce “fast” neutrons with an average energy of 5 MeV. This neutron radiation consists of noncharged particles emitted from the source.

NOTE: *SHOW SLIDE RAD_02_13*

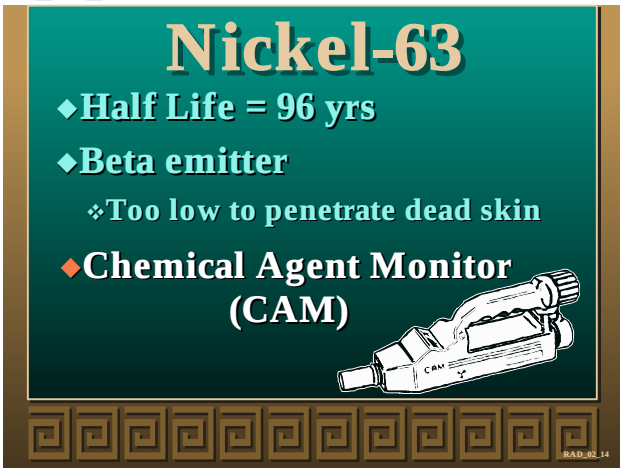


[1] Typical neutron detectors “see” only slow, or “thermal” neutrons. Therefore, the fast neutrons must slow down or they are ignored by the detector. Neutrons slow down by colliding with other atomic particles. Collision of fast neutrons with the nuclei of large atoms results in rebounding of the neutrons with little loss of energy. Collision with the orbiting electrons (approximately 1/1840th the weight of a neutron) produces little loss of energy.

[2] A simple analogy would be that of a billiard ball colliding with a bowling ball. The billiard ball would bounce off with little change in energy (however the direction of the billiard ball would probably change drastically). When a billiard ball goes crashing through a bunch of BBs, the BBs will fly off in all directions but the billiard ball would continue in much the same direction with nearly all of its original energy.

[3] The only atom which can markedly slow down a fast neutron, and which would likely be found in soil, is hydrogen. The hydrogen atom consists of one proton (about the same mass as a neutron) and one electron. When the fast neutron collides with a hydrogen atom it is much the same as when a billiard ball hits another billiard ball. One slows down a lot, the other starts moving (or speeds up), and they both change direction. The only form of hydrogen normally found in a typical construction sight is water (H_2O). So if we “pump” in fast neutrons and “read” the amount of slow ones that result, we can determine the amount of moisture in the soil.

NOTE: *SHOW SLIDE RAD_02_14*



(5) **NICKEL-63:**

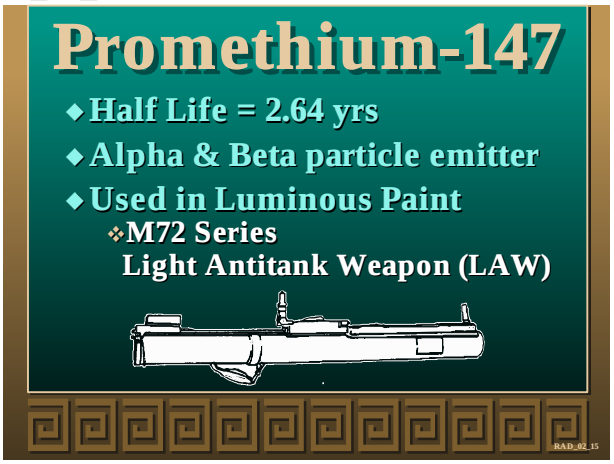
(a) With a radiological half life of 96 years, nickel-63 is a beta emitter with a short decay chain and no gamma radiation.

(b) The beta energy level of ^{63}Ni is too low to penetrate the dead layer of skin. Efforts should be taken to prevent ingestion, inhalation, or absorption through broken skin.

(c) The Chemical Agent Monitor (CAM) is the only Army instrument which uses this isotope. The nickel-63 is used to ionize air molecules as they pass through the detector. The drift tube module consists of 10 millicuries of ^{63}Ni plated on a brass foil cylinder inside a Teflon housing which is installed in a larger aluminum alloy cylinder.

(d) The CAM is used by ground forces and responds to nerve and blister agent vapor down to the lowest concentrations that could affect personnel over a short period of time.

NOTE: *SHOW SLIDE RAD_02_15*



(6) **PROMETHIUM-147:**

(a) ^{147}Pm has a half life of 2.64 years and is a beta and alpha particle emitter and is used in luminous paint.

(b) This element was used in the M72 series, 66mm, Light Antitank Weapon (LAW). For 20 years the LAW was manufactured with ^{147}Pm in the front sight. In the early 80's the "E" version of the LAW changed the sight to an adjustable rifle type there by eliminating the need for ^{147}Pm. However, the older models, M72, M72A1, and M72A2 still remain in use for training and in storage.

(c) Some of the older low light front sights for M16 series rifles also contained ^{147}Pm. These sights have a small **"^{147}Pm"** stamped across from the trifoil.

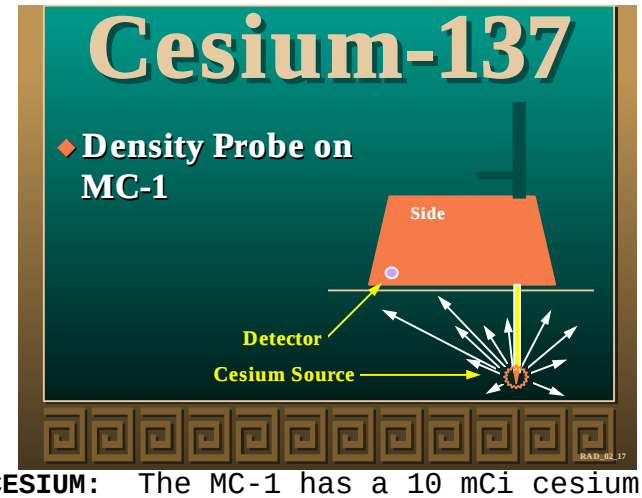
NOTE: *SHOW SLIDE RAD_02_16*

The promethium-147 is just located in two spots that are located at the 100 and 150 range markers on the sight.

NOTE: *SHOW SLIDE RAD_02_17*

(7) **RADIUM:** Used on some older tracked and wheeled vehicles for illuminating gages on the instrument panel. Vehicles with these gages are not labeled with any radiation warning labels and it is not possible to visually distinguish gages containing radium from those that do not. The only sure way to determine whether a particular gage contains radium is to check it with a radiac meter. ^{226}Ra is primarily an alpha particle emitter but also emits some beta and gamma radiation. Radioactive gages containing radium must be removed prior to vehicle disposal, transfer to non-government personnel, or placed on static display. These dials and gages are also listed in TB 43-0216 and TB 43-0116.

NOTE: *SHOW SLIDE RAD_02_18*



(8) **CESIUM:** The MC-1 has a 10 mCi cesium-137 source located in a probe tip used to determine the density of the soil at a construction site. This source is classified as a "special form" source and is double-encapsulated in stainless steel. Gamma radiation is emitted from the ^{137}Cs in a single energy level of 0.66 MeV. This fixed spectrum emission requires less shielding and is ideal for soil density determination purposes.

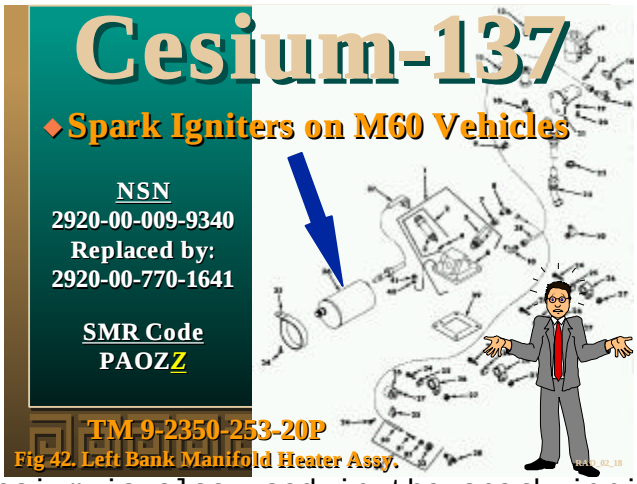
(a) The density of soil is measured by backscatter or transmission.

[1] BACKSCATTER is the technique of placing the source on the surface of a flat material. This technique measures only the top 2 inches of soil and is very sensitive to surface roughness or quality of site preparation.

[2] TRANSMISSION is the technique of pre-drilling a small hole in the ground and then inserting the radioactive source in the ground via the movable source rod. This permits measurement to specific depths to 12 inches and is not sensitive to surface roughness. It is very accurate and is the preferred method of density measurement for soils.

(b) Gamma radiation detectors in the MC-1 measure the amount of radiation that penetrates the soil. Dense soil will block more of the gamma radiation than lighter soil. The measurement taken by the gamma detector is displayed electronically as an indication of the soil density.
TACOM is the NRC license holder for the MC-1 and is responsible for item management. Problems occur when field units fail to properly handle, transport, or store the device.

NOTE: *SHOW SLIDE RAD_02_19*



(9) Cesium is also used in the spark ignitors on M60 series tanks engines.

c. Summary: This lesson covered many radioactive materials found in Army applications.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

Tritium
^{3}H

Currently the Army's greatest problem with radioactive devices resulted from a series of accidents involving tritium ^{3}H devices.

Many of these accidents involved the M1A1 Collimator. It is suspected that some of the tritium sources on these items were damaged by attempting to purge them using a *HIGH PRESSURE PURGING KIT*. Also some maintenance shops did not have SOPs informing personnel of how to handle tritium devices and what to do if one is broken. Some of the results from this has been personnel exposures in excess of 1500 mrem and very costly decontamination operations of entire shop areas and removal of very costly shop equipment for disposal as radioactive waste.

Tritium is the heaviest isotope of the element hydrogen and is the only one that is radioactive. Both molecular tritium and hydrogen are gases under ordinary conditions. Because of the great difference in mass however, many of the properties of tritium differ substantially from those of ordinary hydrogen.

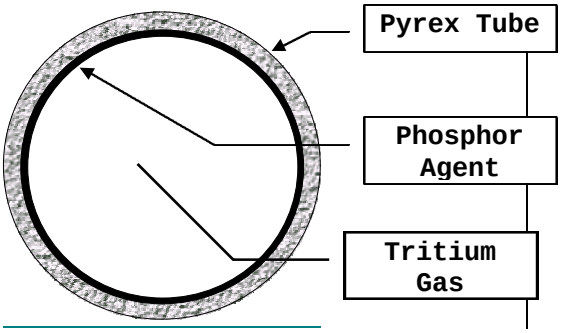
The nucleus of the tritium atom consists of one proton and two neutrons. It undergoes radioactive decay by emission of a beta particle. No gamma rays are emitted in this process. The most energetic of the beta particle emitted by tritium have comparatively low energy and are completely stopped by 7 mm of air or 0.01 mm of paper. Tritium possesses a half-life of only 12.3 years.

Tritium was discovered in 1939. It has been allowed to release into the environment in fairly large quantities.

Some non-military uses of tritium include hydrological studies since it is an ideal tracer for water movement. In some cases, large amounts of tritium are deliberately added to track the distribution of ground water in oil fields, the tracing of springs, rivers and lakes, water loss and seepage from reservoirs, and the movement of glaciers. Tritium has also been used in an admixture with zinc-sulfide in the production of luminous paints, which have largely replaced radium.

The most wide spread use of tritium has probably been in biological research. In particular, tritiated thymidine has been extensively used in studies of the formation of DNA and RNA.

In military applications the tritium is contained in a Pyrex glass tube that has been lined with phosphor. The interaction between the phosphor and the beta particles emitted by the tritium gas produces visible light. The amount of light and the size of the light source determines how much tritium activity the light will contain during manufacture.



Watches, compasses and other small items viewed at only a few inches do not require significant amounts of tritium. The fire control devices used with mortars, howitzers, and tanks use tritium sources to illuminate them in low light conditions. A single howitzer can have 6 or more fire control devices, each of which can contain several tritium light sources. The fire control devices that contain the most tritium are collimators and aiming lights. These items must be visible from a distance of several meters. In all cases the equipment and its carrying case should have warning labels attached.

Student Notes

Tritium is a low energy beta emitter. This low energy beta particle can not penetrate the intact Pyrex tube. However, if the tube is broken, the tritium gas will dissipate, and outer surfaces of the device and surfaces in the near vicinity of the break may become contaminated. Because of the weak beta radiation, tritium is NOT readily measured by the Geiger-Mueller counter used with most fielded radiac instruments and requires wipe testing to determine the level of contamination.

In its gaseous state, tritium is not absorbed by the skin to any significant degree. The hazardous nature of tritium is due to its ability to combine with other materials. Tritium water vapor is readily absorbed by the body, both through inhalation and absorption through the skin. The radioactive water that enters the body is chemically identical to ordinary water and is distributed throughout the body tissue. In addition, tritium that has plated out on a surface or combined chemically with solid materials is a contact hazard.

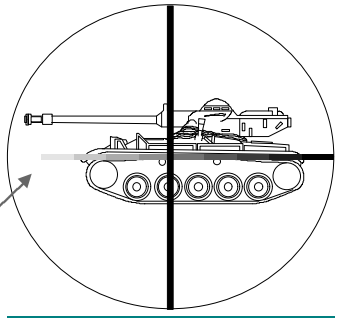
ILLUMINATION TEST FOR TRITIUM DEVICES

No maintenance action can be performed on devices that contain tritium if it is suspected that the Pyrex tube containing the tritium gas has been broken or is leaking. Lack of illumination is an indication that the source may be damaged.

To test for illumination of the light source, place the device in a dark place for a long enough time to ensure that the phosphor agent is not being activated by an outside light source. View the device in low light after your eyes have become accustomed to the dark. If there is no evidence of illumination, consider the light source to be broken.

While performing the illumination test, make sure that all light sources are illuminated. Some reticles have more than one tritium light sources. If one of the light sources for a reticle are damaged, the reticle pattern may appear to be dim in only that region.

The Tritium light source for this portion of the reticle may be damaged.



Student Notes

HANDLING DAMAGED DEVICES

General Information

If a Tritium source is broken during handling, inform all personnel to vacate the area and move up wind from the device.

When a tritium source breaks or is no longer illuminated, the local RPO must be notified, and the following actions must be taken under the direction of the RPO:

[1] Anyone who may have touched or handled the broken Pyrex tube should wash as soon as possible with non-abrasive soap and luke warm water.

[2] Personnel handling the device should wear rubber or latex gloves.

[3] The device must be immediately double wrapped in plastic. The outside container **must be labeled** "BROKEN TRITIUM DEVICE -- DO NOT OPEN". Store the broken device outside in a secured container. Contact the supply item manager of the damaged equipment for disposition instructions. Dispose of used gloves as radioactive waste per direction of the local RPO, and then wash hands well.

[4] Personnel who may have handled the broken tritium device should report to the health clinic for a tritium bioassay. The optimum bioassay sample time is approximately four hours after the exposure. A minimum of four hours is necessary for tritium to reach an equilibrium in the human body. Only after this minimum time should a urine sample be taken. For information on bioassay procedures and to receive bioassay kits, contact the US Army Center for Health Promotion and Preventive Medicine at DSN 584-2619 or Commercial (410) 671-2619.

[5] Broken tritium devices indoors may result in tritium contamination of the work bench, table or the surrounding area. The area must be cordoned off and restricted until wipe test in the area indicates that no contamination remains on the surface.

Student Notes

[6] Due to tritium's low energy level, there is no portable detection equipment that will detect its presence. The only method of detecting tritium is by performing wipe tests and evaluating the wipe test on a liquid scintillation counter.

[7] No maintenance will be performed on tritium devices that are not illuminated except by trained personnel at authorized depot facilities. Federal Law prohibits unauthorized tampering with any tritium light source.

[8] Dispose of used gloves as radioactive waste per instructions from the local RPO.

Damaged MRS/M1 Series Tank Gun Tube

In the event that an M1 series tank gun tube sustains damage to the main gun tube (i.e. blown gun tube or significant impact to the tube) and the MRS could have been damaged, treat the MRS and end of the main gun tube (even if the MRS is no longer attached) as if contaminated and take the following actions.

[1] Whether the MRS is attached or not, double bag the end of the gun tube in plastic. If this is not possible, avoid any contact with the end of the gun tube.

[2] If the MRS has separated from the gun tube, collect and double bag all the pieces and label as previously indicated. Use the bag to pick up the pieces so as to minimize contact with any contaminated parts. Wash hands after picking up the pieces with non-abrasive soap.

[3] Notify the Installation RPO

[4] In coordination with the RPO, have the proper level maintenance personnel remove the MRS from the gun tube and double bag the MRS. Label the outer bag as DAMAGED TRITIUM DEVICE - DO NOT OPEN.

Student Notes

[5] Wipe tests should be taken on the gun tube after the MRS has been removed to determine the extent of any possible contamination. A copy of the wipe test results should be forwarded with the bagged MRS.

[6] Notify the item manager, DSN 793-6776, as to the condition of the MRS and receive disposition instructions to forward to:

Commander, Anniston Army Depot
ATTN: SDSAN-SF (Mr. R. Curry)
Anniston, AL 36201-5046

MAINTENANCE OF FIRE CONTROL DEVICES CONTAINING TRITIUM:

Maintenance on devices containing radioactive material can not be performed with a "shade tree mechanic" attitude. Maintenance personnel must be familiar with the TM for the equipment and must follow the instructions precisely.

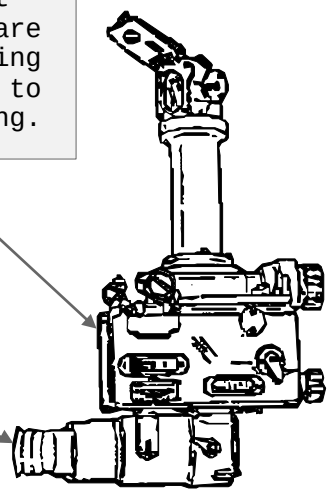
If a fire control device requires maintenance in the areas of the device that contain tritium check the TM to see if you are authorized to perform the maintenance. Opening the components that contain tritium sources that are broken or damaged will release tritium oxide and the work area will be contaminated.

Over 99% of the tritium in light sources used by the Army is tritium gas. The remaining 1% may be tritium oxide. Tritium oxide is formed when the hydrogen isotope ^{3}H interacts and combines chemically with oxygen. This 1% tritium oxide can be readily absorbed by the body but poses no health threat as long as it is contained within the Pyrex tube.

If a tritium light source is broken or damaged while it is still contained in the fire control device the tritium gas is released into the interior of the device. In this confined space the gas does not dissipate into the atmosphere but has a tendency to combine with the available oxygen molecules to form significantly more tritium oxide. When contained like this, tritium, being a very small molecule, will leach into the metal and other materials it contacts in the interior of the device creating an additional contact hazard.

Student Notes

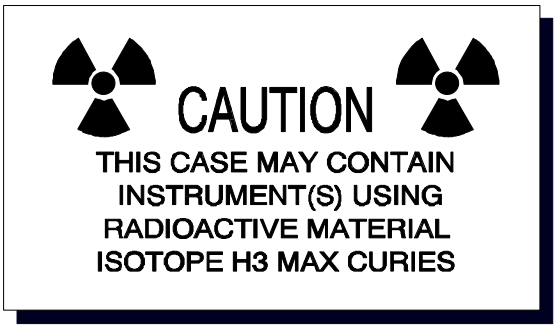
For example, make sure that **all** tritium light sources are illuminated before performing **any** maintenance procedure, to include purging and charging.

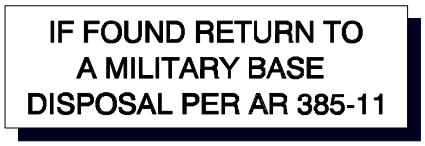


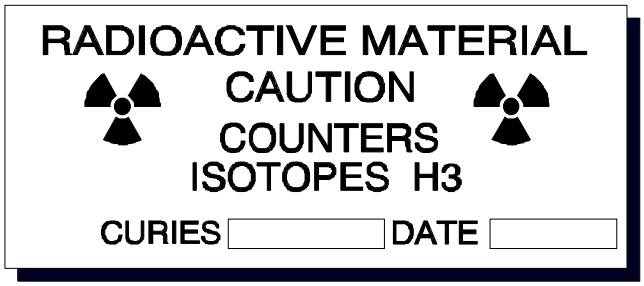
Before performing ANY maintenance procedures on devices that contain tritium light sources, perform an illumination test to determine whether **all** tritium sources contained in the device are illuminated. If **any** light source is not illuminated, it must be considered broken and **NO FURTHER MAINTENANCE CAN BE PERFORMED BY FIELD LEVEL PERSONNEL**. Immediately double bag the device, contact your local RPO, and consult the appropriate TM for proper disposition instructions.

Repair facilities that routinely perform maintenance on devices that contain tritium light sources must have quarterly wipe test of all work benches and tables used when working with these devices. All work benches and tables must be covered with Kraft paper during maintenance procedures. In addition, all personnel that work in these facilities will have baseline tritium bioassays.

Typical Radioactive Material Data Plates





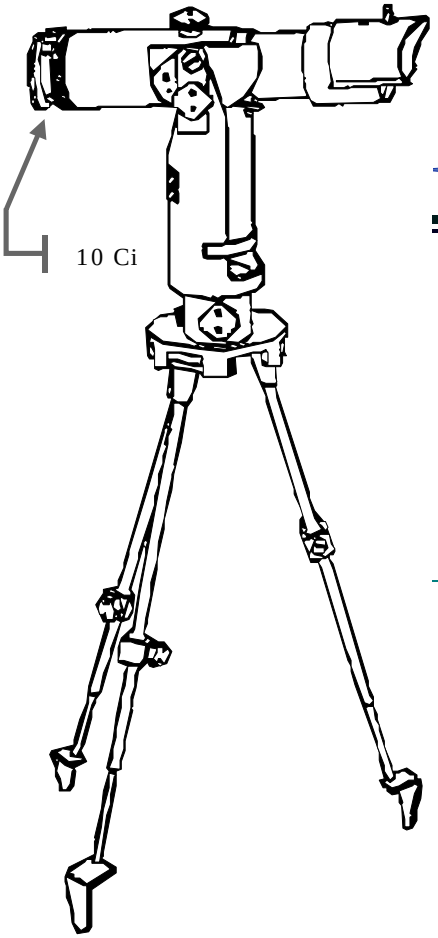


Location of Tritium Devices

		Activity (in Curies)
M1 Series Tank		
MRS	Muzzle Reference Sensor	10.0
M1A2	Gunner's Quadrant	0.075
M119A1 Howitzer		
M137A1	Panoramic Telescope	5.1
M187	Telescope Mount & Quadrant	2.65
M90A2	Straight Telescope	1.6
M140	Alignment Device	3.0
M1A1	Collimator	10.0
M1A2	Gunner's Quadrant	0.075
M102 Howitzer		
M113A1	Panoramic Telescope	4.0
M134A1	Telescope Mount	0.15
M114A1	Elbow Telescope	5.6
M14A1	Fire Control Quadrant	2.15
M140	Alignment Device	3.0
M1A1	Collimator	10.0
M1A2	Gunner's Quadrant	0.075
M198 Howitzer		
M137	Panoramic Telescope	5.1
M171	Telescope Mount	0.15
M17	Fire Control Quadrant	1.875
M18	Fire Control Quadrant	1.95
M139	Alignment Device	3.0
M1A1	Collimator	10.0
M1A2	Gunner's Quadrant	0.075
M110 & M109 Series Self-Propelled Howitzer		
M140	Alignment Device	3.0
M1A1	Collimator	10.0
M1A2	Gunner's Quadrant	0.075
M224 Mortar		
M58 & M59	Aiming Post Light	9.0
M64A1	Sight Unit w/ M9 Elbow Telescope	6.69
Range Indicator		3.2
M1A2	Gunner's Quadrant	0.075
M252 Mortar		
M58 & M59	Aiming Post Light	9.0
M64A1	Sight Unit w/ M9 Elbow Telescope	6.69
M1A2	Gunner's Quadrant	0.075
M120 Mortar		
M58 & M59	Aiming Post Light	9.0
M67A1	Sight Unit w/ M9 Elbow Telescope	5.79
M1A2	Gunner's Quadrant	0.075
M16A1 Rifle		
Front Sight Post		0.009
M11 Pistol, 9mm		
Front Sight Post		0.018
Rear Sight Assembly (2 light sources w/ 0.018 Ci each)		0.036

M1A1 Collimator

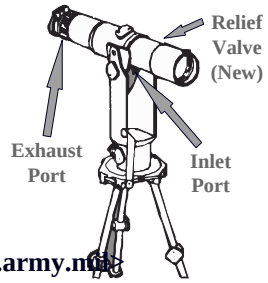
Used with field artillery and contains a 10 Curie Tritium Source, PN 10556135. Before performing **any** maintenance actions on the M1A1 Collimator, check to see if the light source is illuminated. If the light source is not illuminated, immediately double bag the entire collimator. This device has a field maintenance procedure that requires purging and charging with dry nitrogen. The procedure (TM 750-116) is performed using a nitrogen gas regulator set at 3 psi or less. **Do not** purge the collimator if you do not have the proper regulator. Failure of maintenance personnel to read and follow TM instructions has resulted in broken tritium sources on several occasions. **Do not** attempt to perform any maintenance if it is suspected that the Tritium light source is leaking (no illumination).



M1A1
Infinity Collimator

- **Pressure Relief Valve**
  - **PN 9356010**
  - **NSN 4820-01-343-0401**
  - **GS level modification**

☞ **John Johnson**
AMSTA-AC-FASF
DSN 793-0126
COM (309) 782-0126
<jjohns02@ria-emh2.army.mil>



Infinity Collimator (MRS)

The **Muzzle Reference Sensor (MRS)** located on the end of the main gun tube of all M1 Series tanks have a beamsplitter assembly which contains a 10 curie tritium light source. This light source is completely contain within the beamsplitter and poses no external radiation threat unless the Pyrex vial is broken. If there is no apparent illumination when viewed in subdued light the source may be leaking. If the beamsplitter is still mounted in the MRS, the entire MRS should be double bagged. Do not remove the beamsplitter assembly from the MRS if there is no illumination.

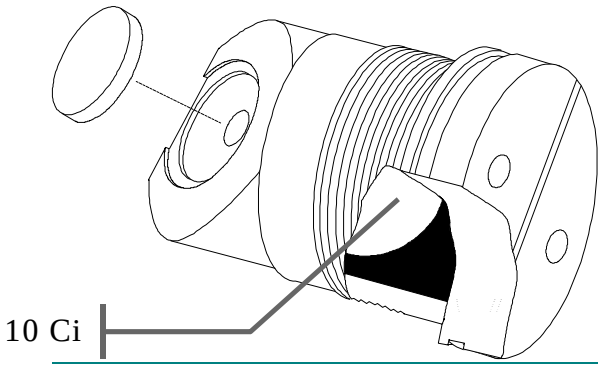
M1 / IPM1 Tank
Muzzle Reference Sensor
NSN: 1240-01-324-2217

M1A1 Tank NSN: 2350-01-087-1095
Muzzle Reference Sensor
NSN: 1240-01-313-8932

M1A2 Tank NSN: 2350-01-328-5964
Muzzle Reference Sensor
NSN: 1240-01-356-5887

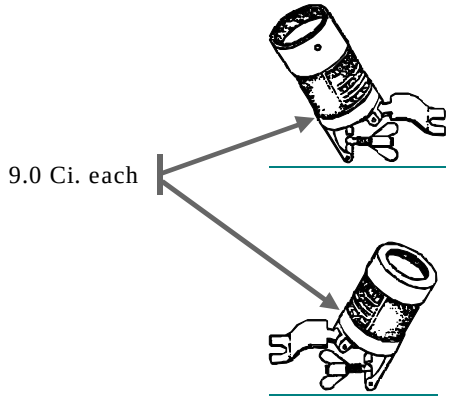
Beamsplitter		KFFFA	B14	1
Kit	1240-01-319-3983	PAFZA	B14	1

The beamsplitter is part of kit NSN 1240-01-319-3983 and the kit is the same for all three MRS.



M58 and **M59 Aiming post lights**

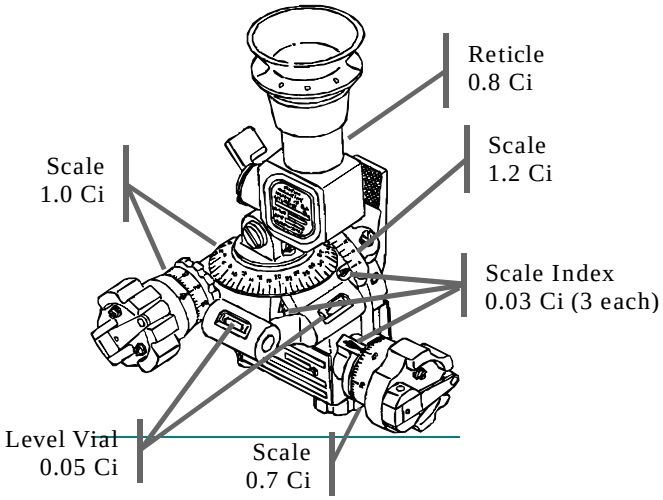
Each contain a 9.0 curie tritium light source, PN 11739179-1 and PN 11739179-2.



M64A1 Sight Unit w/ M9 Elbow Telescope

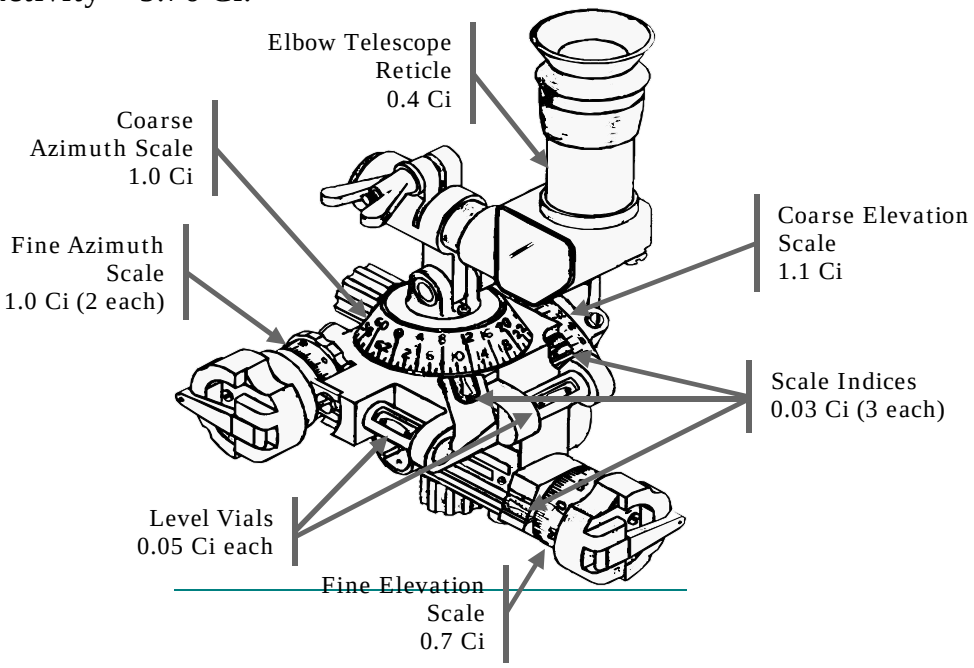
Total activity of 6.69 Ci:

Source Location	**Part Number**	**Activity**
Reticle	11739555	0.8 Ci
Scale	11733744-2	1.0 Ci
Scale	11733744-1	0.7 Ci
Scale	11733737	1.2 Ci
Scale	11733736	1.0 Ci
Scale Indices	11733738	0.03 Ci
Level Vial	11729510-0	0.05 Ci



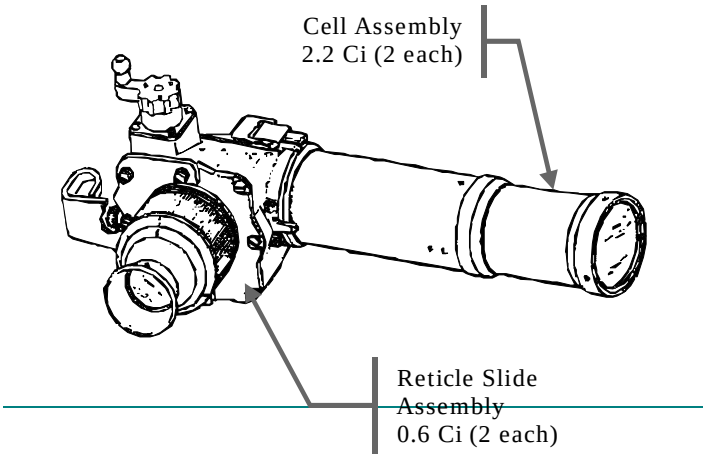
M67 Sight Unit

Total activity = 5.76 Ci.



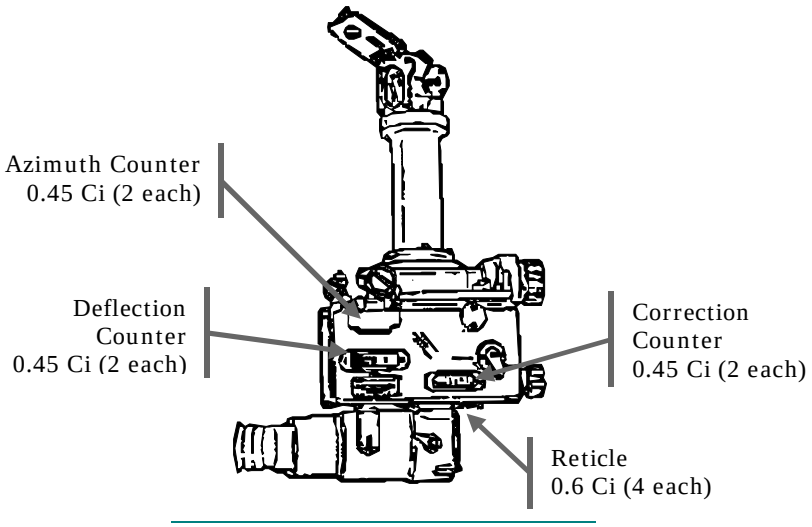
M114A1 Elbow Telescope

Total activity of 5.6 Ci, one ballistic reticle light source, PN 11729519, containing 0.6 Ci and two light sources, PN 11729517, for the sliding reticle each of which contains 2.2 Ci.



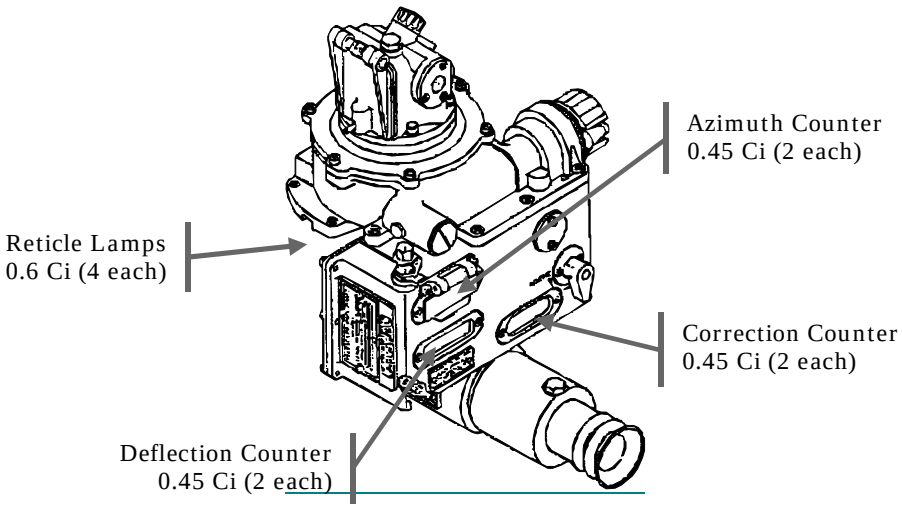
M137 Panoramic Telescope

Total activity 5.1 Ci, six light sources, PN 11730922-2, with 0.45 Ci each for the azimuth, deflection, and correction counters, and four light sources, PN 11729514, with 0.6 Ci each to illuminate the reticle.



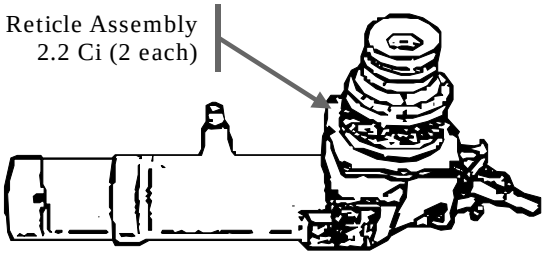
M137A1 Panoramic Telescope

Total activity 5.1 Ci, six light sources, PN 11730922-2, with 0.45 Ci each for the azimuth, deflection, and correction counters, and four light sources, PN 11729514, with 0.6 Ci each to illuminate the reticle.



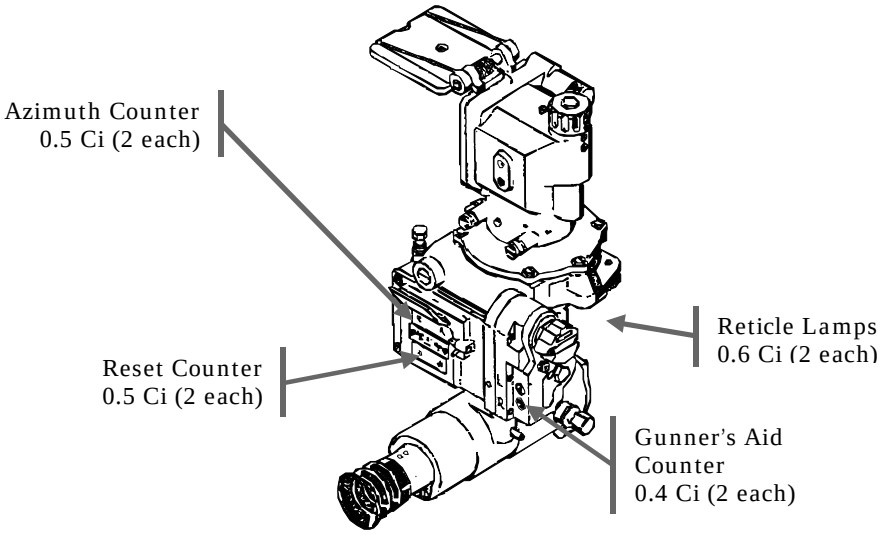
M138 Elbow Telescope

Total activity 4.4 Ci, two light sources, PN 11748012, with 2.2 Ci each to illuminate the reticle.



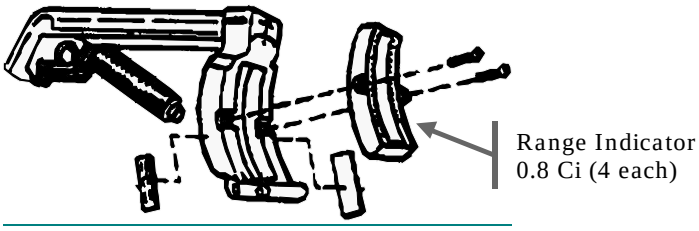
M113A1 Panoramic Telescope

Total activity 4.60 Ci, four light sources, PN 11730922-3, each with 0.5 Ci for the azimuth and reset dials, two sources, PN 10556228, with 0.6 Ci each, and two light sources, PN 11730273, with 0.4 Ci each for the correction counter dials.



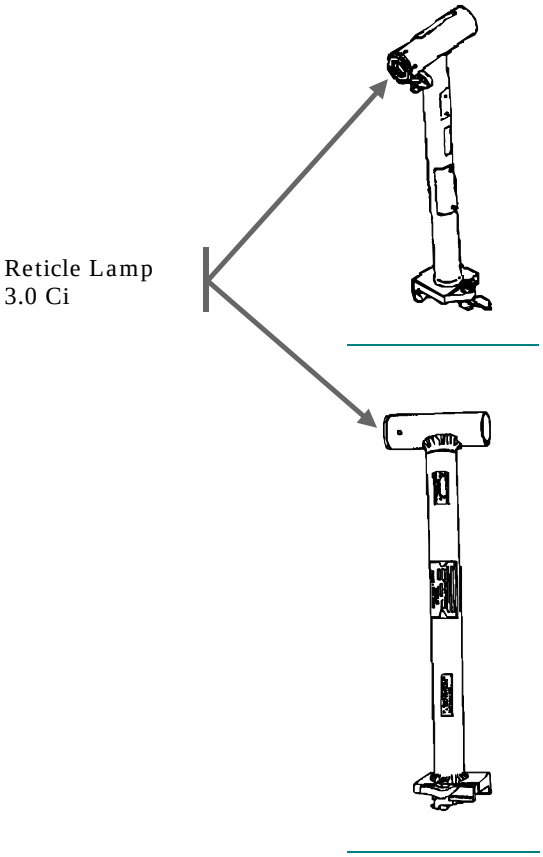
M224 Mortar, 60mm, Range Indicator

Total Activity = 3.2 Ci. Used to determine rough range estimates for the light weight mortar. This device contains four tritium lamps with 0.8 Ci each.



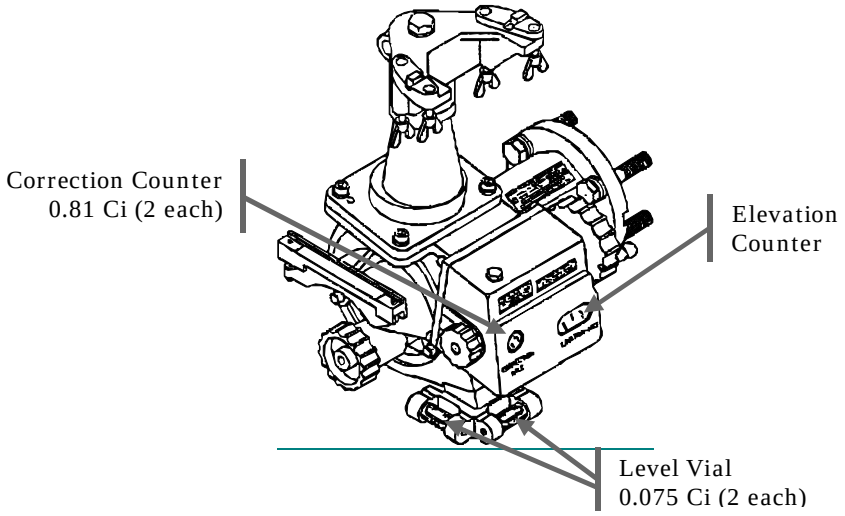
M139/M140 Alignment Devices

Contains a light source, PN 10544163, which has 3.0 Ci tritium. The Alignment Device is used to align the sights with the gun tube. It is considered support equipment for the howitzer and is not mounted except while performing alignment procedures.



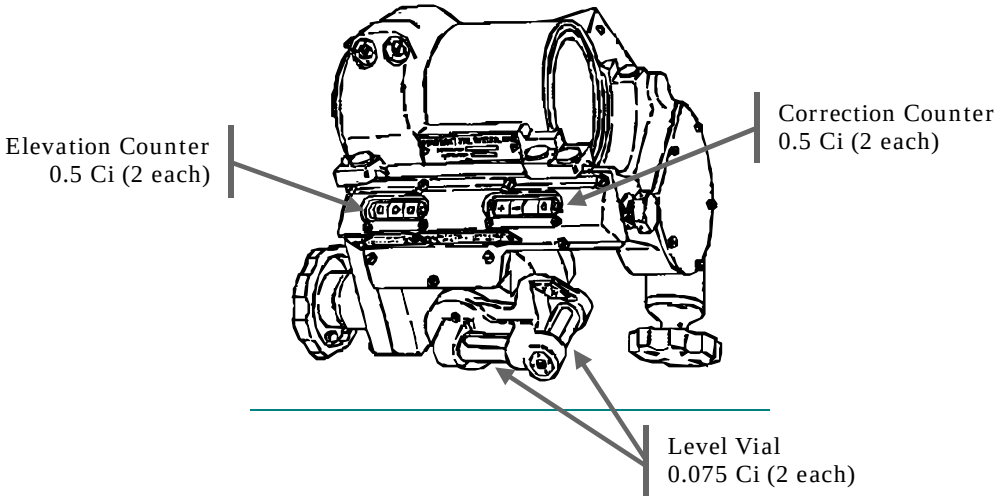
M187 Telescope Mount and Quadrant

Total activity 2.65 Ci, two light sources, PN 11730922-2, with 0.45 Ci each, two light sources, PN 10556228, with 0.80 Ci each and two level vials, PN 11729510-2, with 0.075 Ci each.



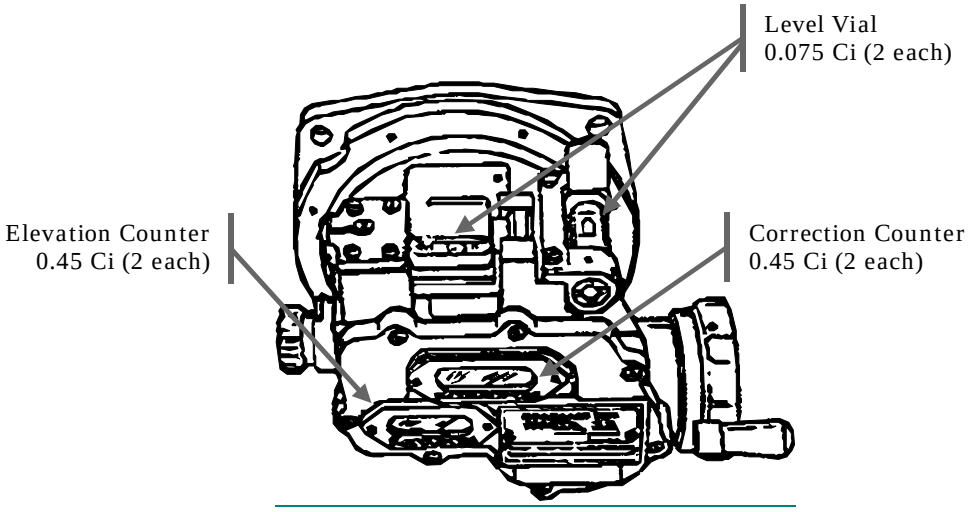
M14A1 Fire Control Quadrant

Total activity of 2.15 Ci, Two level vials, PN 11729510-2, with 0.075 Ci and four light sources, PN 11730922-3, with 0.5 Ci each for the elevation and correction counters.



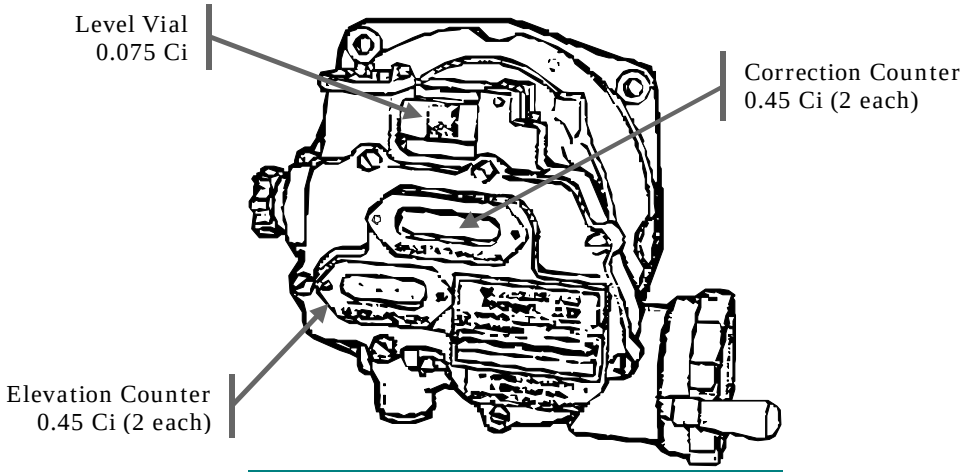
M18 Fire Control Quadrant

Total activity of 1.95 Ci, two level vials, PN 11729510-2, with 0.075 Ci each and four light sources, PN 11730922-2, each with 0.45 Ci for the elevation and correction counters.



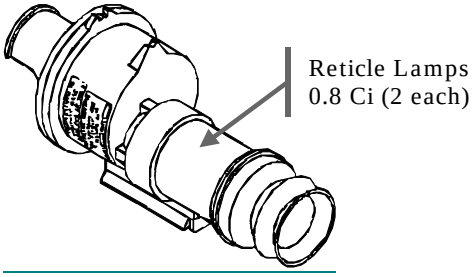
M17 Fire Control Quadrant

Total activity of 1.875 Ci, one level vial, PN 11729510-2, with 0.075 Ci and four light sources, PN 11730922-2, each with 0.45 Ci for the elevation and correction counters.



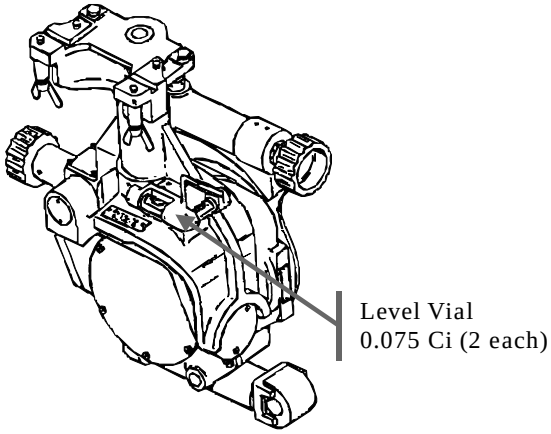
M90A2 Straight Telescope

Total activity 1.60 Ci, two light sources, PN 10556228, with 0.80 Ci each.



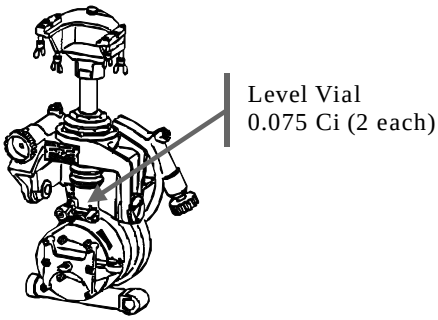
M134A1 Telescope Mount

Total activity level of 0.15 Ci contained in two level vials with 0.075 Ci each.

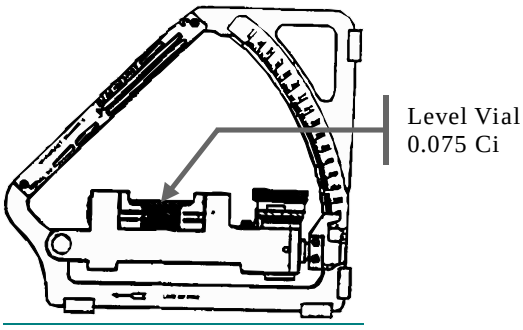


M171 Telescope Mount

Total Activity 0.15 Ci, Two level vials, PN 11729510-2, with 0.075 Ci each.

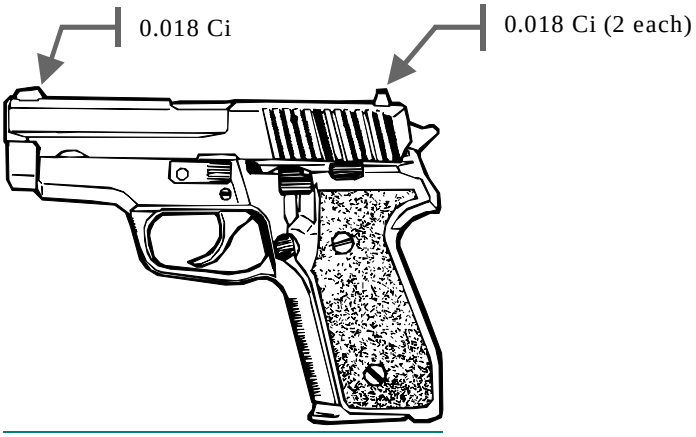


M1A2 Gunner's Quadrant



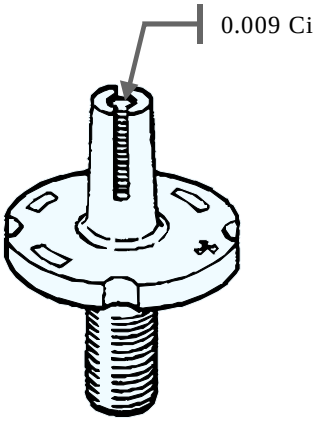
M11 Pistol, 9mm - DARA 12-93-01

Total Activity - 0.054



M16A1 Rifle Front Sight Post

No longer in use.



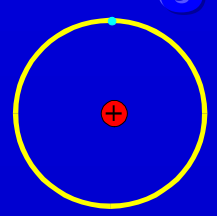
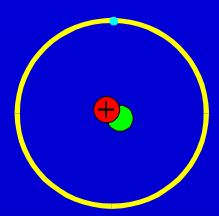
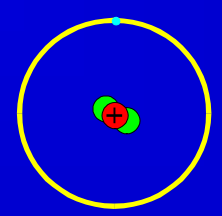
Tritium

^{3}H

Tritium - ^{3}H

Tritium - ^{3}H

- Heaviest isotope of hydrogen
- Gas under ordinary conditions
- Low energy beta emitter
- Half Life = 12.3 years

Hydrogen	Deuterium	Tritium
		
Proton = 1	*Proton = 1*	*Proton = 1*
Neutron = 0	*Neutron = 1*	*Neutron = 2*

What is it used for?

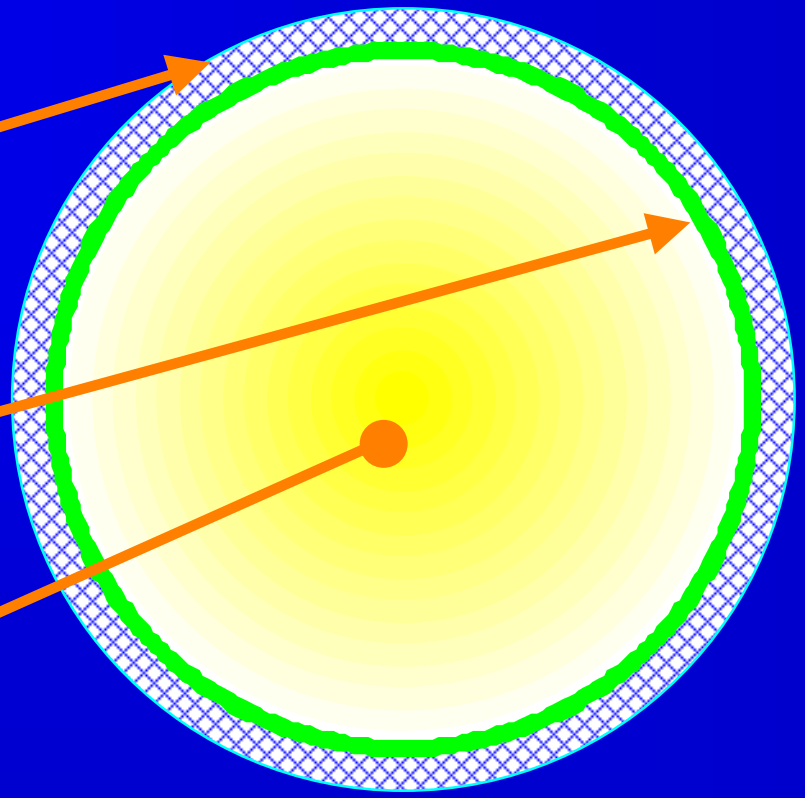
- Hydrological Studies
- Tracer for Biological Research
- Luminous Paints
- Activator in Phosphor Light Sources

Tritium Light Source

Pyrex Container

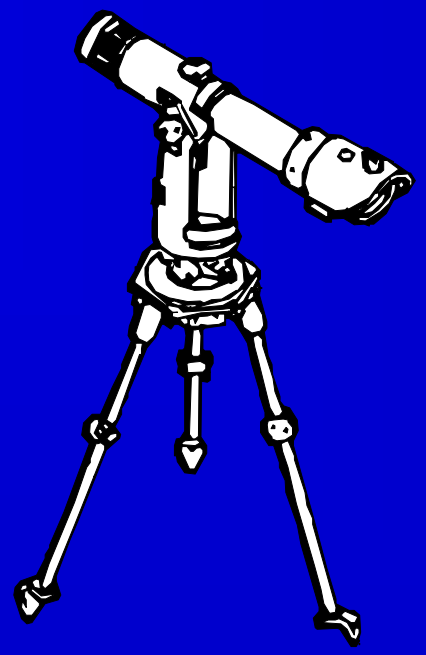
Phosphor Agent

Tritium Gas



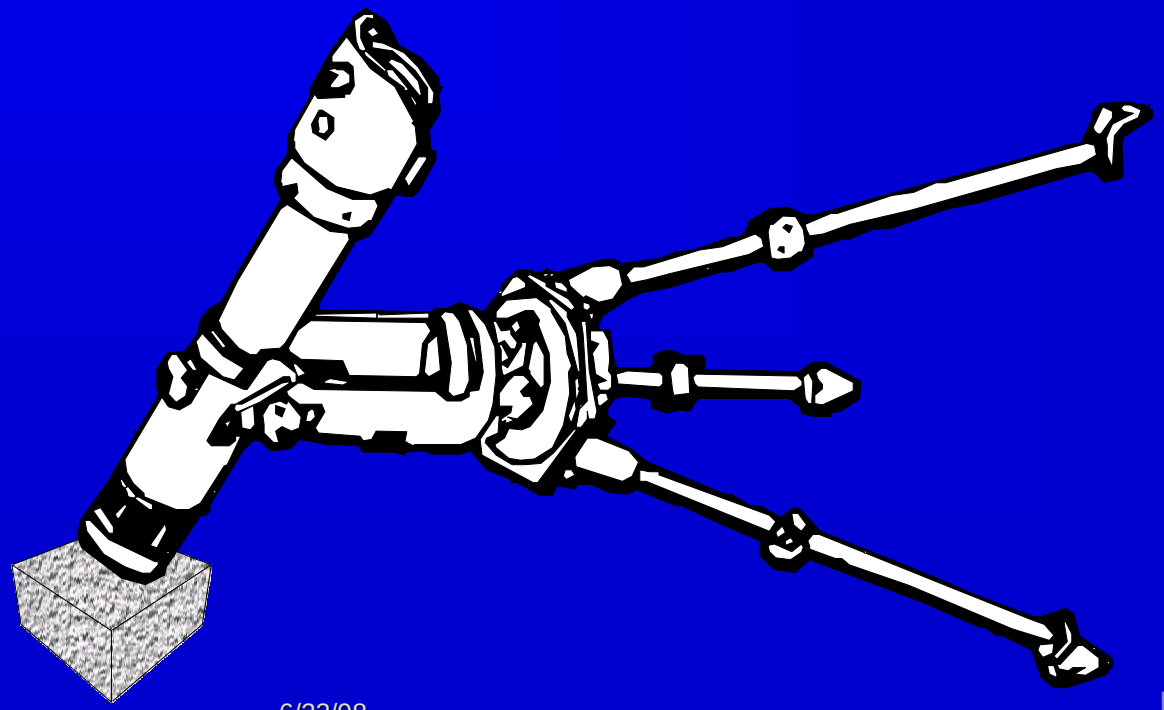
Tritium Hazards

- Tritium gas poses little hazard
  - Dissipates Quickly into the Atmosphere



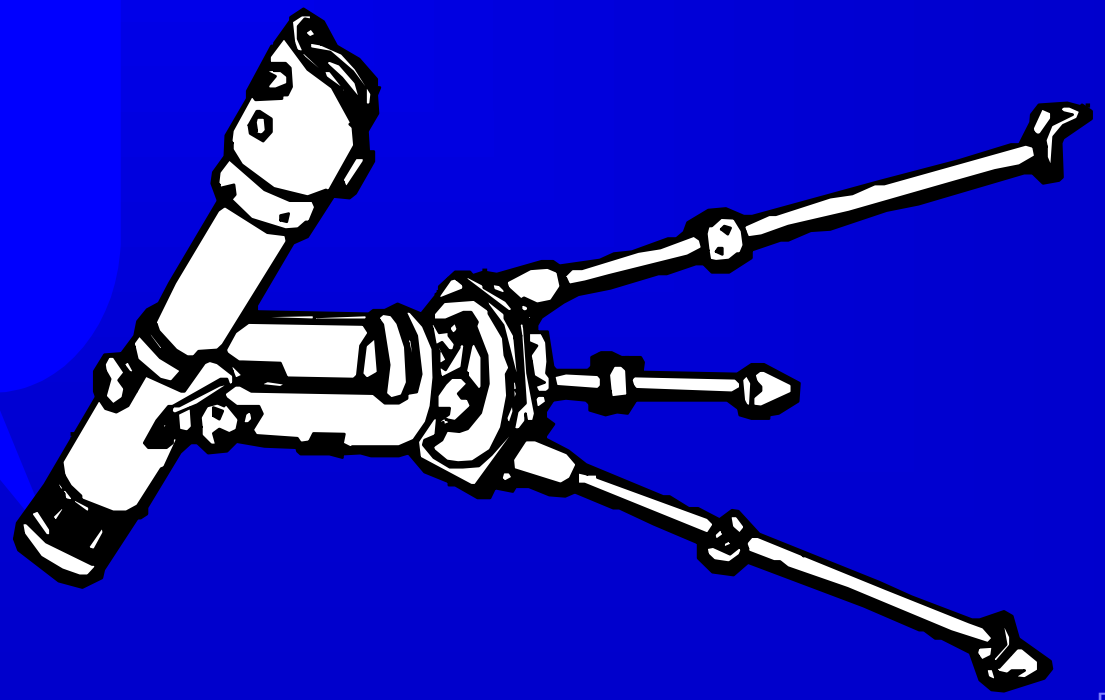
Tritium Hazards

- Tritium gas poses little hazard
  - Dissipates Quickly into the Atmosphere



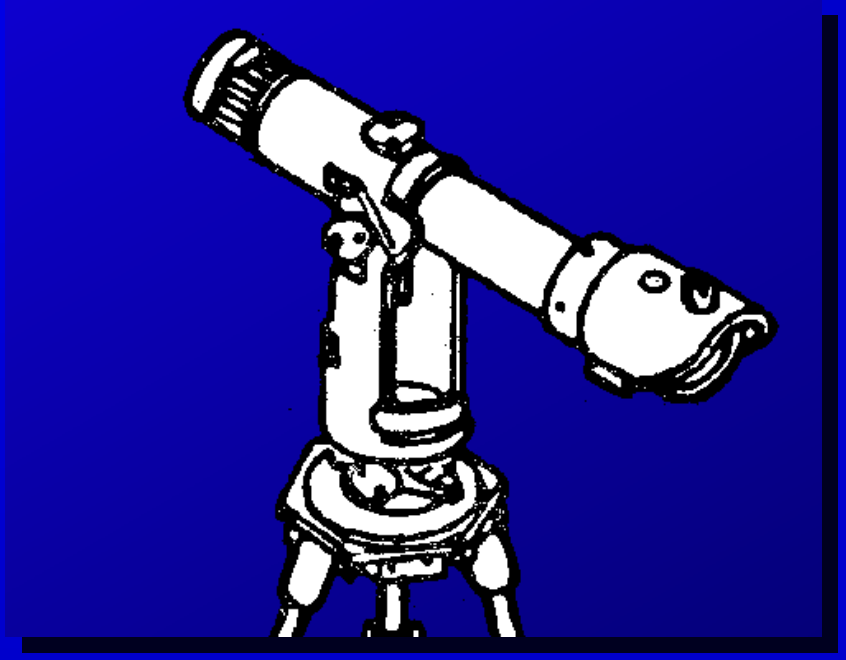
Tritium Hazards

- Tritium gas poses little hazard
  - Dissipates Quickly into the Atmosphere



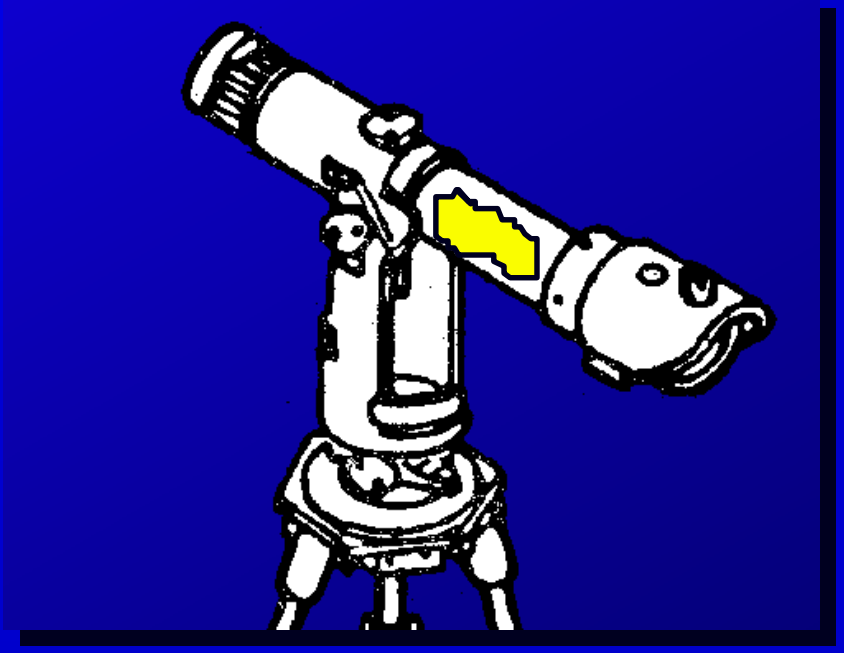
Tritium Hazards

- Tritium gas poses little hazard
  - Dissipates Quickly into the Atmosphere



Tritium Hazards

- Tritium gas poses little hazard
  - Dissipates Quickly into the Atmosphere
- Tritium Oxide
  - Readily absorbed by the body
  - Chemically Identical to water
  - Plates into other material



Illumination Test

1. Place the device in a dark place

   Ensures that phosphor agent is not activated by an outside light source.

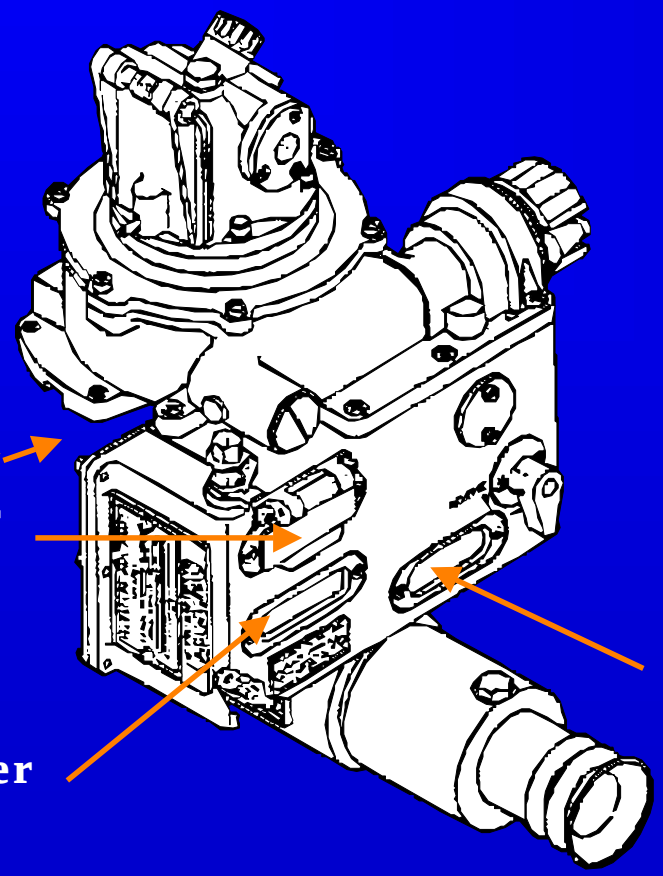
2. View to ensure proper illumination.

   Allow eyes to become accustomed to the dark.

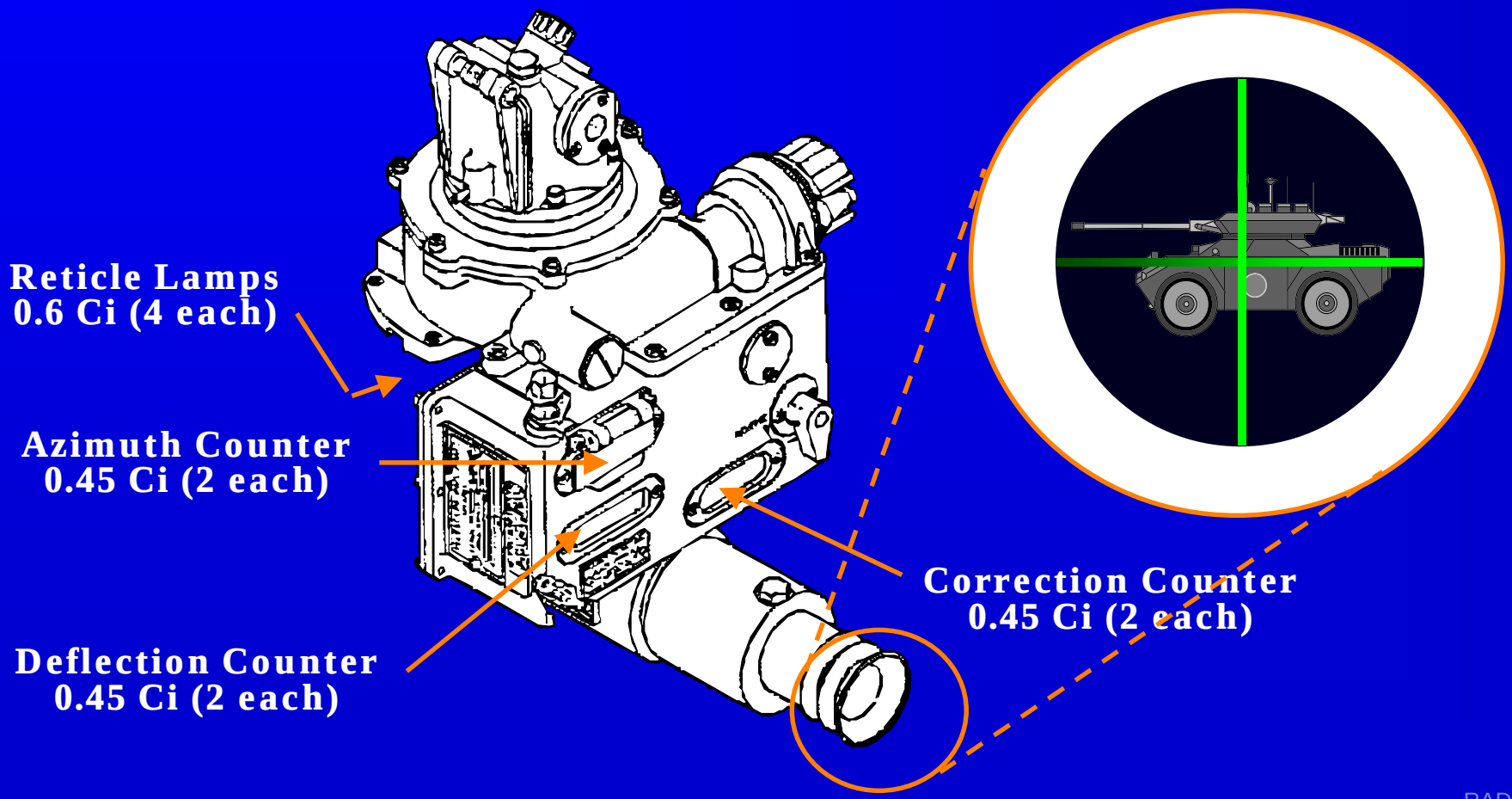
3. If no illumination:

   ASSUME THE SOURCE IS BROKEN!

Illumination Test



Illumination Test



Handling Damaged Devices

- Vacate the area
- Contact the local RPO or Safety Officer

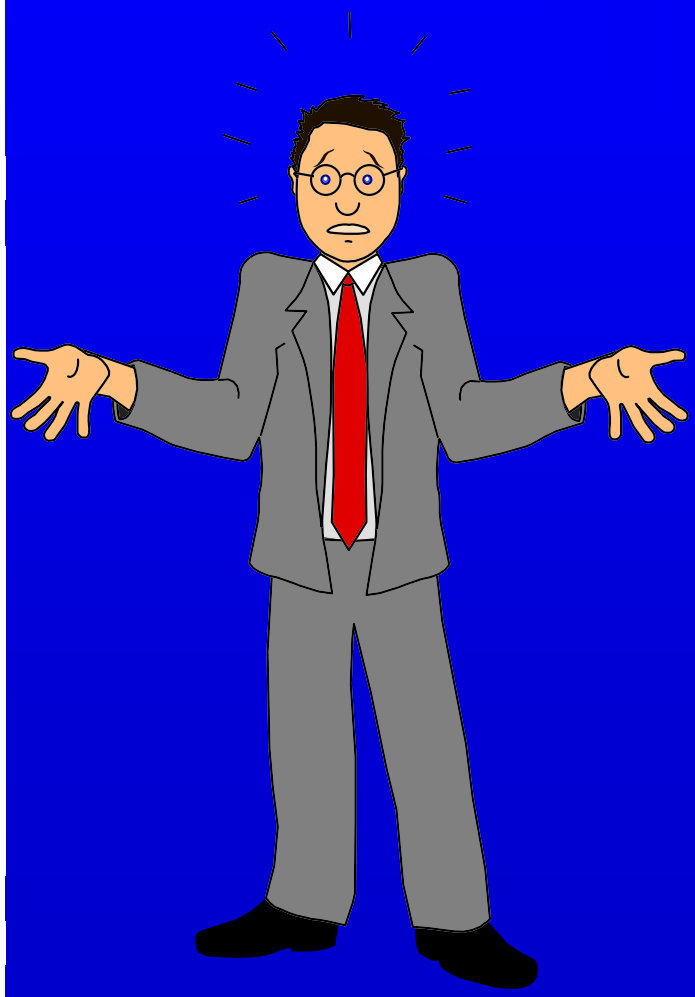
Handling Damaged Devices

Vacate the area

Contact the local RPO or Safety Officer

- Wash with non-abrasive soap and warm water
- Wear latex or rubber gloves
- Double bag the device
- Label container as "BROKEN TRITIUM DEVICE - DO NOT OPEN"
- Report for bioassay
- Wipe test the area
- Restrict access to area until results from wipe test are received

“Shade Tree Mechanic”



Personnel performing maintenance without proper tools or reference material in a hap-hazard manner with lax mental attitude while being shielded from solar radiation by large deciduous plant life.

Typical Warning Plates

CAUTION

RADIOACTIVE MATERIAL
CONTROLLED DISPOSAL REQUIRED
AEC LICENSE NO
RADIOISOTOPE H3
ACTIVITY
MILLICURIES CURIES
LOT NO DATE
IF FOUND,
RETURN TO NEAREST
MILITARY ACTIVITY

CAUTION

THIS CASE MAY CONTAIN
INSTRUMENT(S) USING
RADIOACTIVE MATERIAL
ISOTOPE H3 MAX CURIES

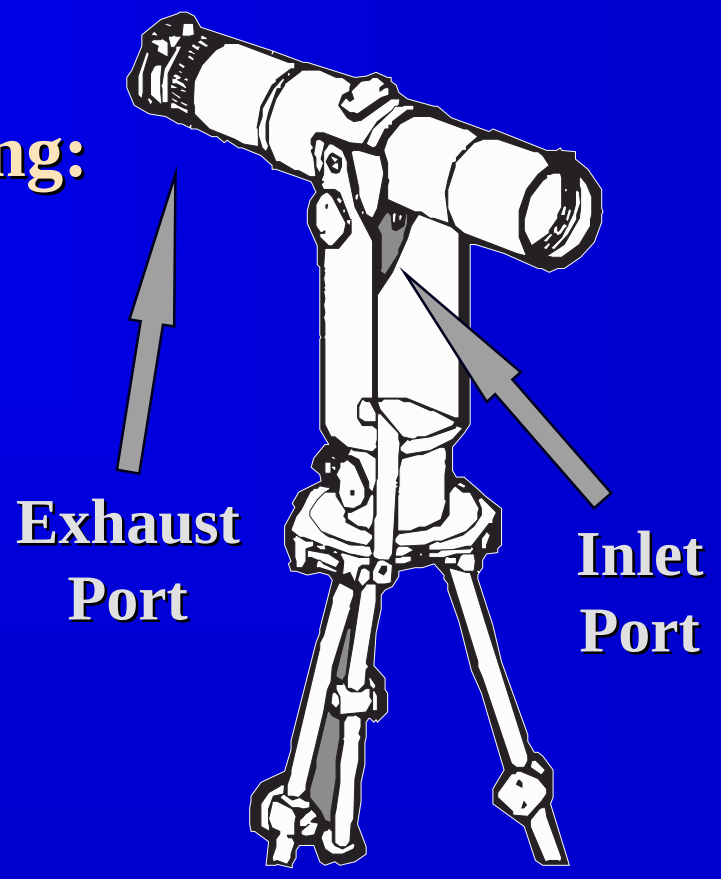
IF FOUND RETURN TO
A MILITARY BASE
DISPOSAL PER AR 385-11

RADIOACTIVE MATERIAL
CAUTION
COUNTERS
ISOTOPES H3
CURIES DATE

M1A1 Infinity Collimator

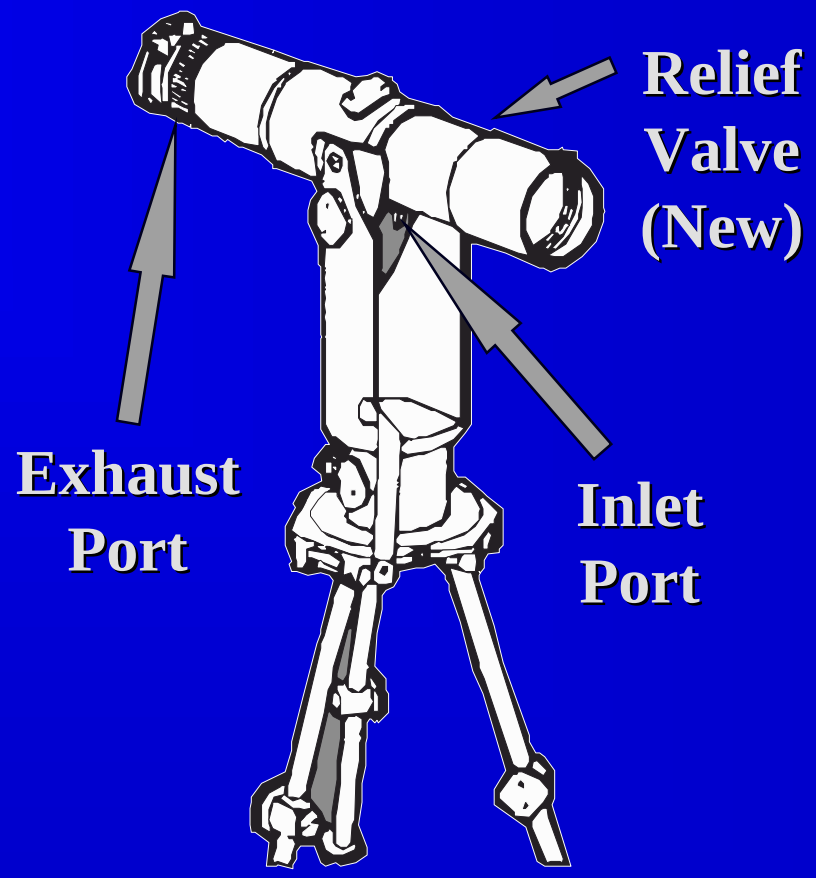
When Purging and Charging:

- Follow instructions in TM 750-116
- Use ONLY the approved Fire Control Instrument Purging Kit
  - SC 4931-95-CL-J54



M1A1 Infinity Collimator

- Pressure Relief Valve
  - PN 9356010
  - NSN 4820-01-343-0401
  - GS level modification



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US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-03

DATE: Oct 96

TITLE: Tritium

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 5.0 C (U)
0.0 PE

FACILITY REQ:
Classroom

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty

TRANSPORTATION: None

ISSUED TO STUDENTS: Student Reference Guide “Radioactive Material Handling Safety”

AIDS AND EQUIPMENT:

a. Overhead Projector
b. Computer Display Device
c. Computer
d. Display Screen
e. RAD_03.PPT File
f. Samples of devices which contain tritium light source (If available)
g. TV and VCR
h. Video: “Safety Requirements for Tritium Illuminated Instruments - - Part 1”
i. Video: “Safety Requirements for Tritium Illuminated Instruments - - Part 2”

REFERENCES:

TB 9-1300-278	"Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
McGraw-Hill Encyclopedia of Science and Technology	
Reference Guide	Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
NRC License BLM 12-00722-06	

COURSE TITLE: Radioactive Material Handling Safety.

LESSON TITLE: Tritium.

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

a. Introduction:

(1) Objective: Provide an overview of tritium and tritium devices used in the military.

(2) Reason and Tie-In:

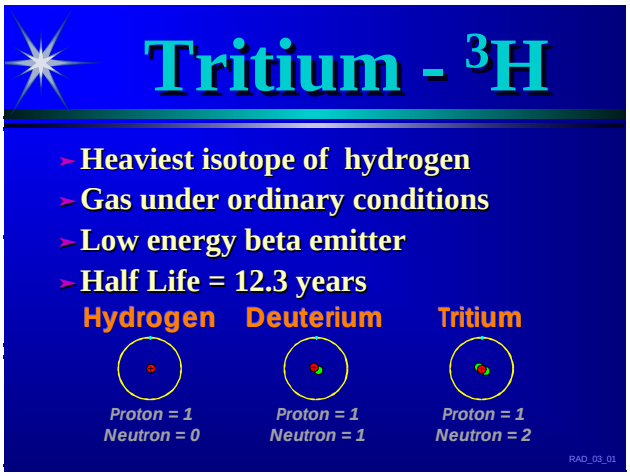
(a) Currently the Army's greatest problem with radioactive devices resulted from a series of accidents involving tritium ^{3}H devices.

(b) Many of these accidents involved the M1A1 Collimator. It is suspected that some of the tritium sources on these items were damaged by attempting to purge them using a *HIGH PRESSURE PURGING KIT*. Also some maintenance shops did not have SOPs informing personnel of how to handle tritium devices and what to do if one is broken. Some of the results from this have been personnel exposures in excess of 1500 mrem and very costly decontamination operations of entire shop areas and removal of very costly shop equipment for disposal as radioactive waste.

b. Explanation:

NOTE: *SHOW VIDEO:* "Safety Requirements for Tritium Illuminated Instruments - - Part 1"

NOTE: *SHOW SLIDE RAD_03_01*

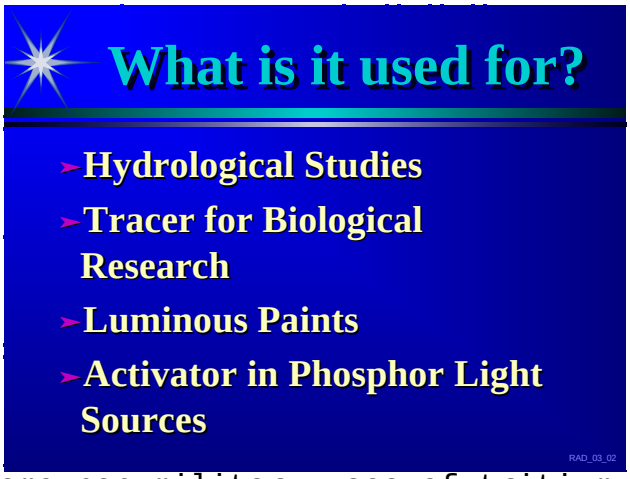


(1) Tritium is the heaviest isotope of the element hydrogen and is the only one which is radioactive. Both molecular tritium and hydrogen are gases under ordinary conditions. Because of the great difference in mass however, many of the properties of tritium differ substantially from those of ordinary hydrogen.

(a) The nucleus of the tritium atom consists of one proton and two neutrons. It undergoes radioactive decay by emission of a beta particle. No gamma rays are emitted in this process. The most energetic of the beta particle emitted by tritium have comparatively low energy and are completely stopped by 7 mm of air or 0.01 mm of paper. Tritium possesses a half-life of only 12.3 years

(b) Tritium was discovered in 1939. It has been allowed to release into the environment in fairly large quantities with no apparent adverse effect.

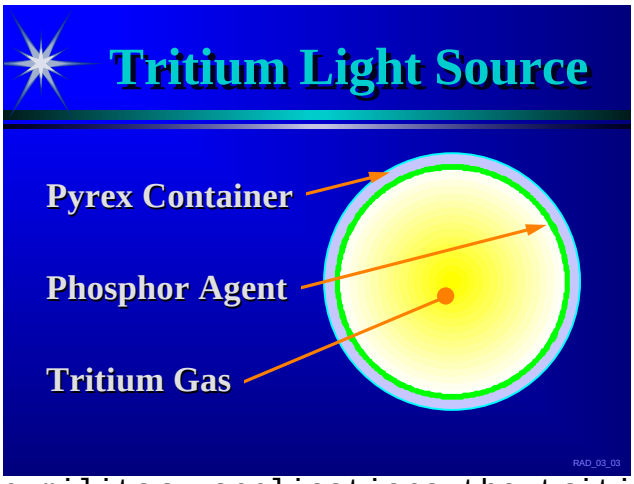
NOTE: *SHOW SLIDE RAD_03_02*



(2) Some non-military uses of tritium includes hydrological studies since it is an ideal tracer for water movement. In some cases, large amounts of tritium are deliberately added to track the distribution of ground water in oil fields, the tracing of springs, rivers and lakes, water loss and seepage from reservoirs, and the movement of glaciers. Tritium has also been used in an admixture with zinc-sulfide in the production of luminous paints, which have largely replaced radium.

(3) The most wide spread use of tritium has probably been in biological research. In particular, tritiated thymidine has been extensively used in studies of the formation of DNA and RNA.

NOTE: *SHOW SLIDE RAD_03_03*

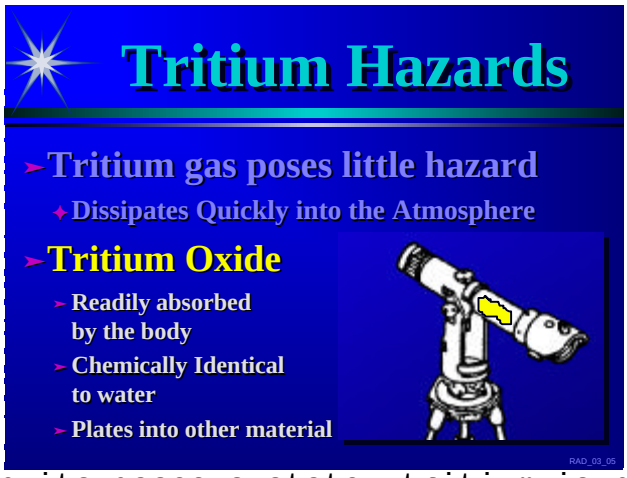


(4) In military applications the tritium is contained in a Pyrex glass tube that has been lined with phosphor. The interaction between the phosphor and the beta particles emitted by the tritium gas produces visible light. The amount of light and the size of the light source determines how much tritium activity the light will contain during manufacture.

(5) Watches, compasses and other small items viewed at only a few inches do not require significant amounts of tritium. The fire control devices used with mortars, howitzers, and tanks use tritium sources to illuminate them in low light conditions. A single howitzer can have 6 or more fire control devices, each of which can contain several tritium light sources. The fire control devices that contain the most tritium are collimators and aiming lights. These items must be visible from a distance of several meters. In all cases the equipment and its carrying case should have warning labels attached.

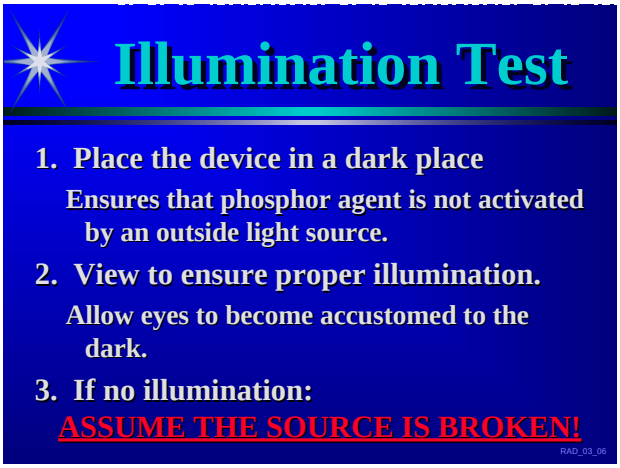
(6) Tritium is a low energy beta emitter that can not penetrate the intact Pyrex tube. However, if the tube is broken, the tritium gas will dissipate, and outer surfaces of the device and surfaces in the near vicinity of the break may become contaminated. Because of the weak beta radiation, tritium is NOT readily measured by the ordinary Geiger-Mueller counter and requires wipe testing to determine the level of contamination.

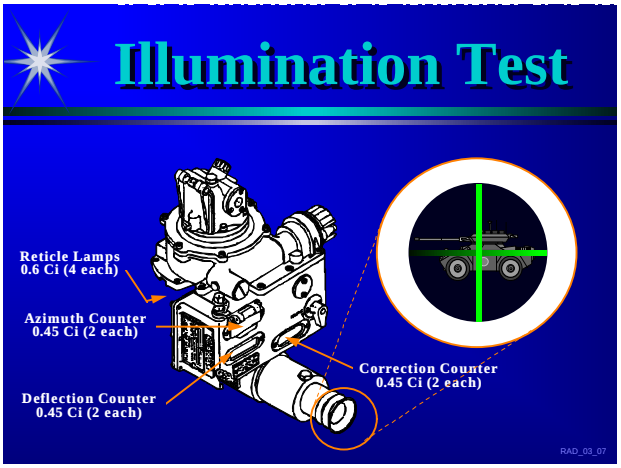
NOTE: *SHOW SLIDE RAD_03_04/5*



(7) In its gaseous state, tritium is not absorbed by the skin to any significant degree. The hazardous nature of tritium is due to its ability to combine with other materials. Tritium gas when combined with water forms a vapor that is readily absorbed by the body, both through inhalation and absorption through the skin. The radioactive water that enters the body is chemically identical to ordinary water and is distributed throughout the body tissue. In addition, tritium which has plated out on a surface or combined chemically with solid materials is a contact hazard.

NOTE: *SHOW SLIDE RAD_03_06/07*





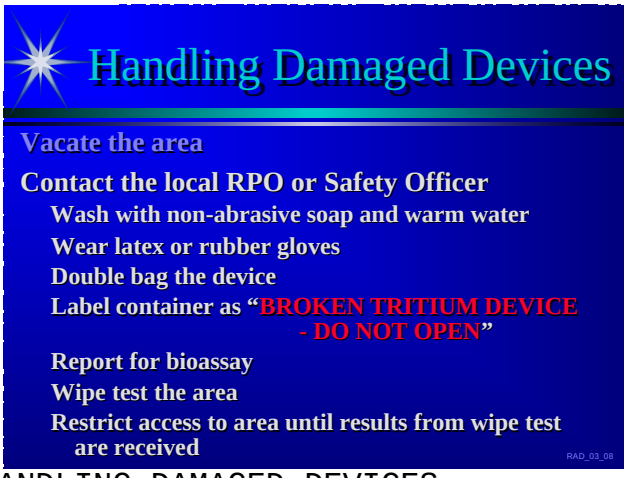
(8) <u>ILLUMINATION TEST FOR TRITIUM DEVICES</u>

(a) No maintenance action can be performed on devices that contain tritium if it is suspected that the Pyrex tube containing the tritium gas has been broken or is leaking.

Lack of illumination is an indication that the source may be damaged.

(b) To test for illumination of the light source, place the device in a dark place for a long enough time to ensure that the phosphor agent is not being activated by an outside light source. View the device in low light after your eyes have become accustomed to the dark. If there is no evidence of illumination, consider the light source to be broken.

NOTE: *SHOW SLIDE RAD_03_08*



(9) HANDLING DAMAGED DEVICES

(a) If a Tritium source is broken during handling, inform all personnel to vacate the area and move up wind from the device.

(b) When a tritium source breaks or is no longer illuminated, the local RPO must be notified, and the following actions must be taken under the direction of the RPO:

[1] Anyone who may have touched or handled the broken Pyrex tube should wash as soon as possible with non-abrasive soap and luke warm water.

[2] Personnel handling the device should wear rubber or latex gloves.

[3] The device must be immediately double wrapped in plastic. The outside container **must be labeled** "BROKEN TRITIUM DEVICE - DO NOT OPEN". Store the broken device outside in a secured container. Contact the supply item manager for disposition instructions. Dispose of used gloves as

radioactive waste per direction of the local RPO, and then wash hands well.

[4] Personnel who may have been exposed to contamination or who have handled the broken tritium device should report to the health clinic for a tritium bioassay. The optimum bioassay sample time is approximately four hours after the exposure. A minimum of four hours is necessary for tritium to reach an equilibrium in the human body. Only after this minimum time should a urine sample be taken.

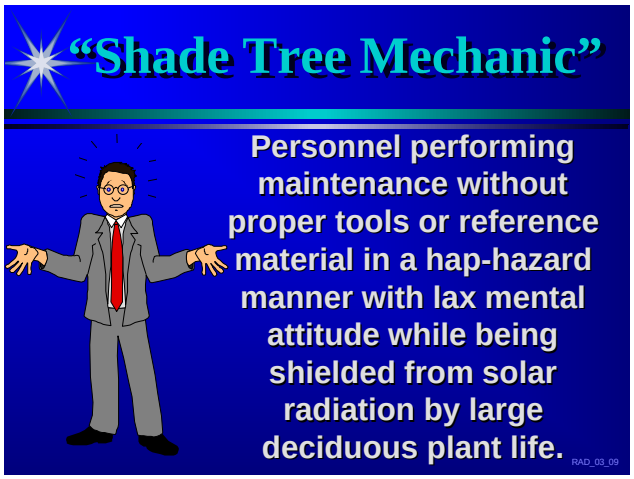
[5] Broken tritium devices indoors may result in tritium contamination of the work bench, table or the surrounding area. The area must be cordoned off and restricted until wipe test in the area indicates that no contamination remains on the surface.

[6] Due to tritium's low energy level, there is no portable detection equipment that will detect it's presence. The only method of detecting tritium is by performing wipe tests and evaluating the wipe test on a liquid scintillation counter.

[7] No maintenance will be performed on tritium devices that are not illuminated except by trained personnel at authorized depot facilities. Federal Law prohibits unauthorized tampering with any tritium light source.

[8] Dispose of used gloves as radioactive waste per instructions from the local RPO.

NOTE: *SHOW SLIDE RAD_03_09*



(10) **MAINTENANCE OF FIRE CONTROL DEVICES CONTAINING TRITIUM:**

(a) Maintenance on devices containing radioactive material can not be performed with a “shade tree mechanic” attitude. Maintenance personnel must be familiar with the TM for the equipment and must follow the instructions precisely.

(b) If a fire control device requires maintenance in the areas of the device that contain tritium check the TM to see if you are authorized to perform the maintenance. Opening the components that contain tritium sources that are broken or damaged will release tritium oxide and the work area will probably be contaminated.

(c) Over 99% of the tritium in light sources used by the Army is tritium gas. The rest is tritium oxide. Tritium oxide is formed when the hydrogen isotope ^{3}H, which is tritium in its natural gaseous state, interacts and combines chemically with oxygen. This 1% tritium oxide which is readily absorbed by the body poses no radiation threat as long as it is contained within the Pyrex tube.

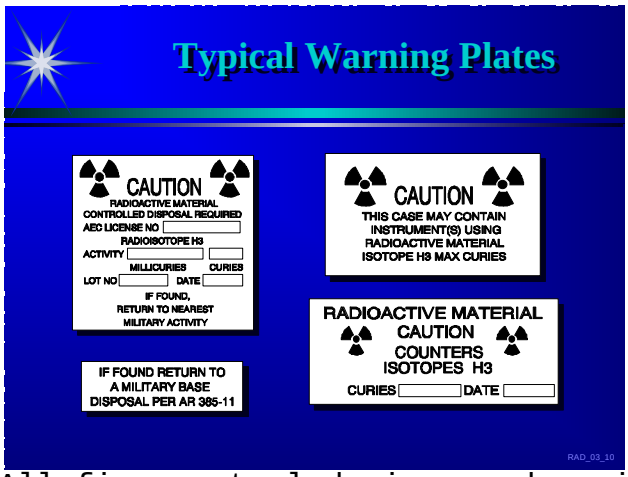
(d) If a tritium light source is broken or damaged while it is still contained in the fire control device the tritium gas is released into the interior of the device. In this confined space the gas does not dissipate into the atmosphere but has a tendency to combine with the available oxygen molecules to form significantly more tritium oxide. When contained like this, tritium, being a very small molecule, will leach into the metal and other materials it contacts in the interior of the device creating an additional contact hazard.

(e) Prior to performing ANY maintenance procedures on devices that contain tritium light sources, perform an illumination test to determine whether all tritium sources contained in the device are illuminated. If any light source is not illuminated, it must be considered broken and **NO FURTHER MAINTENANCE CAN BE PERFORMED BY FIELD LEVEL PERSONNEL**. Immediately double bag the device, contact your local RPO, and consult the appropriate TM for proper disposition instructions.

(f) Repair facilities which routinely perform maintenance on devices that contain tritium light sources must have quarterly wipe test of all work benches and tables used when working with these devices. All work benches and tables must be covered with Kraft paper during maintenance procedures. In addition, all personnel that work in these facilities will have baseline tritium bioassays.

NOTE: *SHOW VIDEO:* "Safety Requirements for Tritium Illuminated Instruments - - Part 2"

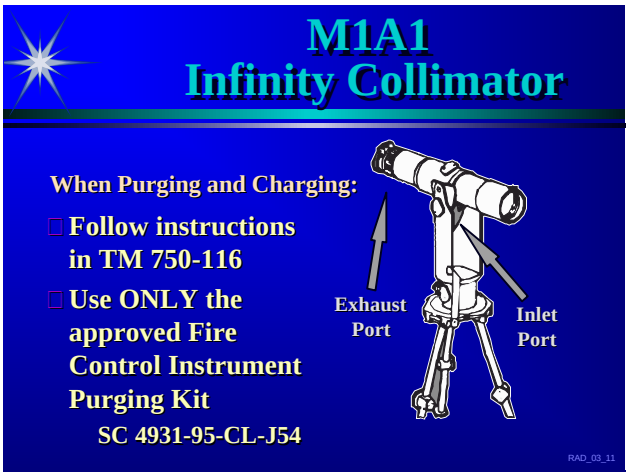
NOTE: *SHOW SLIDE RAD_03_10*

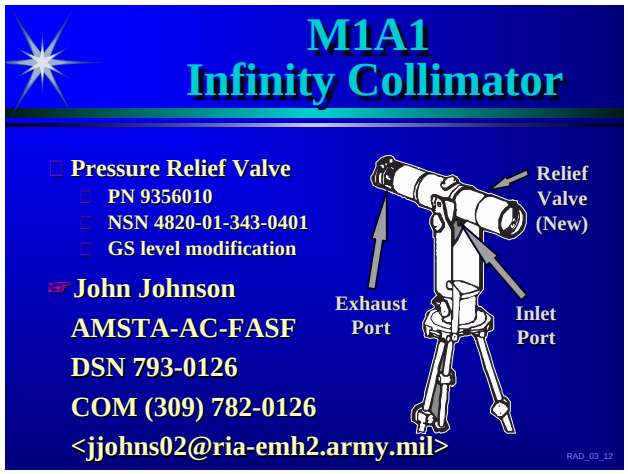


(11) All fire control devices and equipment that contain radioactive sources should be clearly label to indicate the type of radioactive material, the activity level, and date of manufacture. These labels should be replace immediately if they are missing or damaged.

(12) <u>Location of Tritium Devices</u>

NOTE: *SHOW SLIDE RAD_03_11/12*





(a) The **M1A1 Collimator** used with field artillery contains a 10 Curie Tritium Source, PN 10556135,. Prior to performing **any** maintenance actions on the M1A1 Collimator, check to see if the light source is illuminated. If the light source is not illuminated, immediately double bag the entire

collimator. This device has a field maintenance procedure that requires purging and charging with dry nitrogen. The procedure (TM 750-116) is performed using a nitrogen gas regulator set at 5 psi or less. **Do not** purge the collimator if you do not have the proper regulator. Failure of maintenance personnel to read and follow TM instructions has resulted in broken tritium sources on several occasions. **Do not** attempt to perform any maintenance if it is suspected that the Tritium light source is leaking (no illumination).

(b) The **Muzzle Reference Sensor (MRS)** located on the end of the main gun tube of all M1 Series tanks have a beamsplitter assembly which contains a 10 curie tritium light source. This light source is completely contain within the beamsplitter and poses no external radiation threat unless the Pyrex vial is broken. No apparent illumination when viewed in subdued light indicates that the source may be leaking. If the beamsplitter is still mounted in the MRS, the entire MRS should be double bagged. Do not remove the beamsplitter assembly from the MRS. If the MRS is still mounted to the main gun tube, put on rubber gloves and remove and double bag the MRS, then wipe test the end of the gun tube to check for possible contamination.

Muzzle Reference Sensor
NSN: 1240-01-324-2217

M1A1 Tank NSN: 2350-01-087-1095
Muzzle Reference Sensor
NSN: 1240-01-313-8932

M1A2 Tank NSN: 2350-01-328-5964
Muzzle Reference Sensor
NSN: 1240-01-356-5887

*	Beamsplitter	*	KFFFA
	B14 1		
*	Kit	1240-01-319-3983	PAFZA
	B14 1		

* The beamsplitter is part of kit NSN 1240-01-319-3983 and the kit is the same for all MRSs.

(c) **M58** and **M59 Aiming post lights** each contain a 9.0 curie tritium light source, PN 11739179-1 and PN 11739179-2.

(d) **M64** and **M64A1 Sight Units** have a total activity of 6.69 Ci:

Qty	Source Location	Part Number	Activity
	Reticle	11739555	0.8 Ci
	Scale	11733744-2	1.0 Ci
	Scale	11733744-1	0.7 Ci
	Scale	11733737	1.2 Ci
	Scale	11733736	1.0 Ci
	Scale Indices	11733738	0.03 Ci
	Level Vial	11729510-0	0.05 Ci

(e) The M67 Sight Unit has a total activity of 5.76 Ci.

Source Location	Activity
Reticle	0.4 Ci
Course Elevation Scale	1.1 Ci
Scale Indices (3)	0.3 Ci
Fine Elevation Scale	0.7 Ci
Fine Azimuth Scale (2)	1.0 Ci
Course Azimuth Scale	1.0 Ci
Level Vials (2)	0.05 Ci

(f) **M114A1 Elbow Telescope** contains a total of 5.6 Ci, one ballistic reticle light source, PN 11729519, containing 0.6 Ci and two light sources, PN 11729517, for the sliding reticle each of which contains 2.2 Ci.

(g) **M137** and **M137A1 Panoramic Telescope** - Total activity 5.1 Ci, six light sources, PN 11730922-2, with 0.45 Ci each for the azimuth, deflection, and correction counters, and four light sources, PN 11729514, with 0.6 Ci each to illuminate the reticle.

(h) **M138 Elbow Telescope** - Total activity 4.4 Ci, two light sources, PN 11748012, with 2.2 Ci each to illuminate the reticle.

(i) **M113A1 Panoramic Telescope** - Total activity 4.60 Ci, four light sources, PN 11730922-3, each with 0.5 Ci for the azimuth and reset dials, two sources, PN 10556228, with 0.6 Ci each, and two light sources, PN 11730273, with 0.4 Ci each for the correction counter dials.

(j) **M224 Mortar, 60mm, Range Indicator** - Total activity 3.2 Ci. Used to determine rough range estimates for the light weight mortar. This device contains four tritium lamps with 0.8 Ci each.

(k) **M139** and **M140 Alignment Device** each contain a light source, PN 10544163, which has 3.0 Ci tritium.

(l) **M187 Telescope Mount and Quadrant** - Total activity 2.65 Ci, two light sources, PN 11730922-2, with 0.45 Ci each, two light sources, PN 10556228, with 0.80 Ci each and two level vials, PN 11729510-2, with 0.075 Ci each.

(m) **M14A1 Fire Control Quadrant** has a total activity of 2.15 Ci, Two level vials, PN 11729510-2, with 0.075 Ci and four light sources, PN 11730922-3, with 0.5 Ci each for the elevation and correction counters.

(n) **M18 Fire Control Quadrant** has total activity of 1.95 Ci, two level vials, PN 11729510-2, with 0.075 Ci each and four light sources, PN 11730922-2, each with 0.45 Ci for the elevation and correction counters.

(o) **M17 Fire Control Quadrant** has total activity of 1.875 Ci, one level vial, PN 11729510-2, with 0.075 Ci and four light sources, PN 11730922-2, each with 0.45 Ci for the elevation and correction counters.

(p) **M90A2 Straight Telescope** - Total activity 1.60 Ci, two light sources, PN 10556228, with 0.80 Ci each.

(q) **M134A1 Telescope Mount** has a total activity level of 0.15 Ci contained in two level vials with 0.075 Ci each.

(r) **M171 Telescope Mount** - Total Activity 0.15 Ci, Two level vials, PN 11729510-2, with 0.075 Ci each.

(s) **M1A2 Gunners Quadrant** level vial, PN 11729510-2, contains 0.075 Ci tritium.

(t) **M16A1 Rifle Front Sight Post** - No longer in use.

(u) **M11 Pistol**. Pistol sights contain tritium gas sealed in a Pyrex tube.

c. Summary: The material presented in this lesson will help the student safely handle device containing tritium light sources. The lesson covered what tritium is, how it is used, what the hazards are, proper maintenance and handling procedures, and where it is used in Army equipment.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

Depleted Uranium

As a result of the Persian Gulf War, there are a number of concerns about destroyed or damaged US Army combat vehicles contaminated by *Depleted Uranium* (DU) munitions. The main concerns resulting from DU contamination are:

[1] Which soldiers were exposed?

[2] To What extent the Army has provided guidance and training in the proper handling and risks in order to minimize exposure.

[3] How effectively the Army has planned for and carried out decontamination and disposal of DU contaminated combat equipment.

[4] Medical evaluation of personnel exposed to DU.

Although the Army does not know the full extent to which personnel were exposed, a General Accounting Office (GAO) review showed that at least several dozen US soldiers, some unknowingly, were exposed to DU by inhalation, ingestion, or shrapnel during the Gulf War.

Army and the Nuclear Regulatory Commission (NRC) officials believe, however, that these personnel were not exposed to levels of DU that exceeded allowable limits established by the NRC. Because there may be **some** risk involved with **any** exposure to radiation, Army regulations require that personnel's exposure to radiation be minimized. During combat and life threatening situations these measures may not be appropriate.

Personnel in noncombat situations should take precautions to ensure that their exposure to DU is as low as reasonably achievable (ALARA).

Post Persian Gulf reviews have determined that although the Army's stated policy is to minimize personnel's exposure to radiation, it has not effectively educated its personnel in the hazards of DU contamination and in proper safety measures appropriate to the degree of hazard. Training on DU has been limited to tank crews, munitions handlers, and EOD personnel.

Its a matter of record that prior to the Gulf War, the Army did not have a formal plan or adequate facilities to decontaminate, dispose of, or quickly repair DU contaminated vehicles.

Risk Low, But Precautions Necessary. According to NRC and Army officials, troops externally exposed to DU radiation, during the Gulf War, were not exposed to external radiation or internal levels of DU that exceeded NRC limits for radiation exposure and toxicity which could cause toxic effects.

In establishing safety controls for DU operations it is important to place the potential hazard of DU in the proper perspective. Safety controls should be consistent with the manner in which the DU is to be used. Where DU and explosive ordnance are utilized**, the potential radiological hazard of DU becomes secondary** to that of the explosive.

Uranium is actually widely distributed around the world. The crust of the earth, for example, contains a concentration on the average of about four parts per million (PPM). In order to be considered usable, or economically viable as uranium ore, the concentration has to be in the vicinity of 30 PPM or higher. Common foods also contain uranium to a limited extent, about 0.1 - 1.0 PPM. Drinking water in the US contains on the average about 2 millionths of 1 microcurie (0.000000000002 Ci) for each liter.

Uranium has been mined from deposits in the Erz Mountains between Germany and Czechoslovakia since the 1500's. Uranium was originally used in pottery to produce a deep orange color in the glazing applied to the pottery before it was placed in the firing kiln. In fact, this process has remained in the pottery industry up until a few years ago. Bright orange dishes and pottery items made more than ten years ago will still show a reading when measured with a radiac meter.

In the chemically pure state, uranium appears as a shiny, silvery metal. Natural Uranium contains ^{234}U, ^{235}U, and ^{238}U. DU is a by-product of the uranium enrichment process which increases the percentage of the ^{235}U isotope. This enriched uranium is used in the nuclear industry as fuel for nuclear reactors. Uranium which has had a majority of the ^{235}U isotope removed is referred to as "Depleted Uranium" (DU). DU is the waste product left after natural uranium has gone through the enrichment process. The term "depleted" refers to the fact that **most** of the ^{235}U has been extracted, not that the radiation has been depleted. In other words, “depleted” uranium is the opposite of “enriched” uranium.

	Natural Uranium	Depleted Uranium
^{234}U	00.0057%	00.0005%
^{235}U	00.7204%	00.2500%
^{238}U	99.2739%	99.7495%
	100%	100%

Properties which make DU of interest to the military are its high density and strength, ease and relatively low cost of fabrication, and availability.

Student Notes

DU radiation results from spontaneous radioactive decay forming ***daughter atoms***. Uranium, along with a few other radioactive materials, is unusual in that it is a part of a radioactive decay chain. What this means is that when an atom of uranium 238 decays, it converts into a different element called a **daughter product**. The daughter product is also radioactive, and during its process of decay causes a third element to be formed. This process of successive decays from parent to daughter can go on for 17 steps - that is, for 17 generations of ^{238}U radioactive by-products.

Uranium decays by alpha particle emission. The daughter atoms formed during decay emit alpha, beta, and gamma radiation. Therefore the radiation emitted from DU contains alpha, beta and gamma radiation. Because of the long half life of ^{238}U (the major element of DU), the specific activity is unusually low. To help illustrate this, to obtain one curie of radioactivity from DU it would require a single piece weighing 6,615 pounds.

Uranium Decay Series

Nuclide	Half Life	Emissions
Uranium-238	4.5 billion yrs	alpha
Thorium-234	24.1 days	beta / gamma
Proactinium-234	6.7 hours	beta / gamma
Uranium-234	247,000 yrs	alpha / gamma
Thorium-230	80,000 yrs	alpha / gamma
Radium-226	1,600 yrs	alpha / gamma
Radon-222	91.752 hours	alpha / gamma
Polonium-218	3.05 min	alpha / beta
Lead-214	26.8 min	beta / gamma
Astatine-218	2 seconds	alpha
Bismuth-214	19.7 min	beta / gamma
Polonium-214	164 μsec	alpha / gamma
Thallium-210	1.3 min	beta / gamma
Lead-210	21 yrs	beta / gamma
Bismuth-210	5.0 days	beta
Polonium-210	138.4 days	alpha
Thallium-206	4.19 min	beta
Lead-206	STABLE	

DEPLETED URANIUM NON-NUCLEAR USES - Because of its high density and structural properties, DU is useful for non-nuclear applications. It can be applied defensively to protect against penetration by projectiles made of less

Student Notes

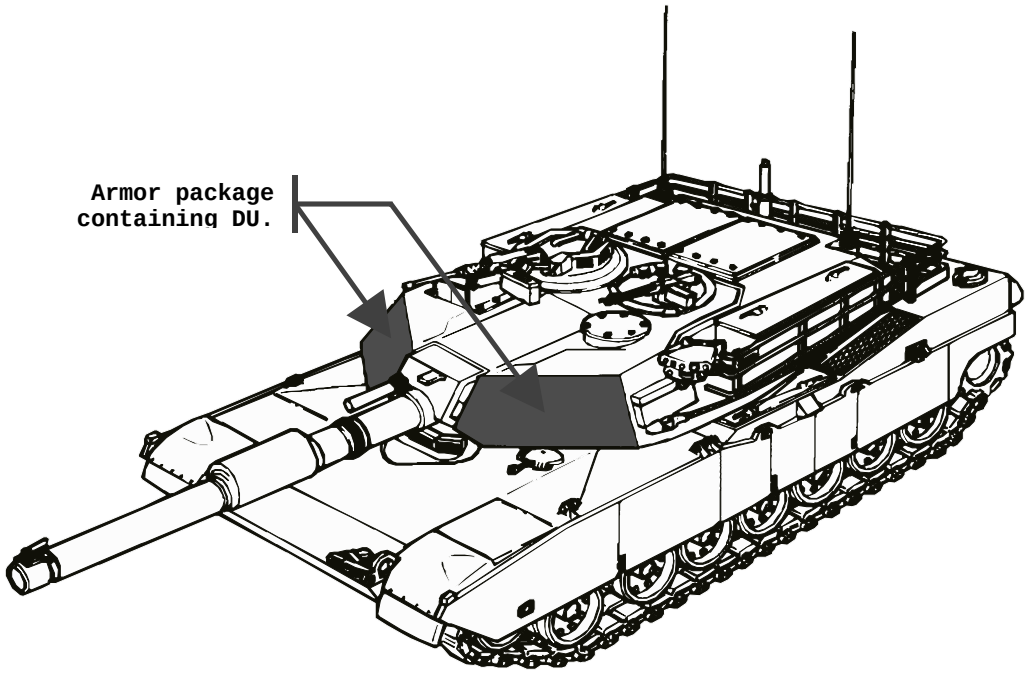
dense metals, such as tungstoncarbide subprojectiles, or offensively to defeat armored targets. US Abrams tanks, Bradley Fighting vehicles, and the Air Force's A-10 aircraft fire DU munitions. DU ammunition is NOT used for training.

DEFENSIVE USE OF DEPLETED URANIUM

RHA ARMOR: Prior to the introduction of the depleted uranium packets, the M1 series armor structure was comprised of *weld fabricated, rolled homogenous steel*. Meaning that it was manufactured and heat treated so that it possessed, as nearly as possible, the same chemical constituents and physical properties throughout.

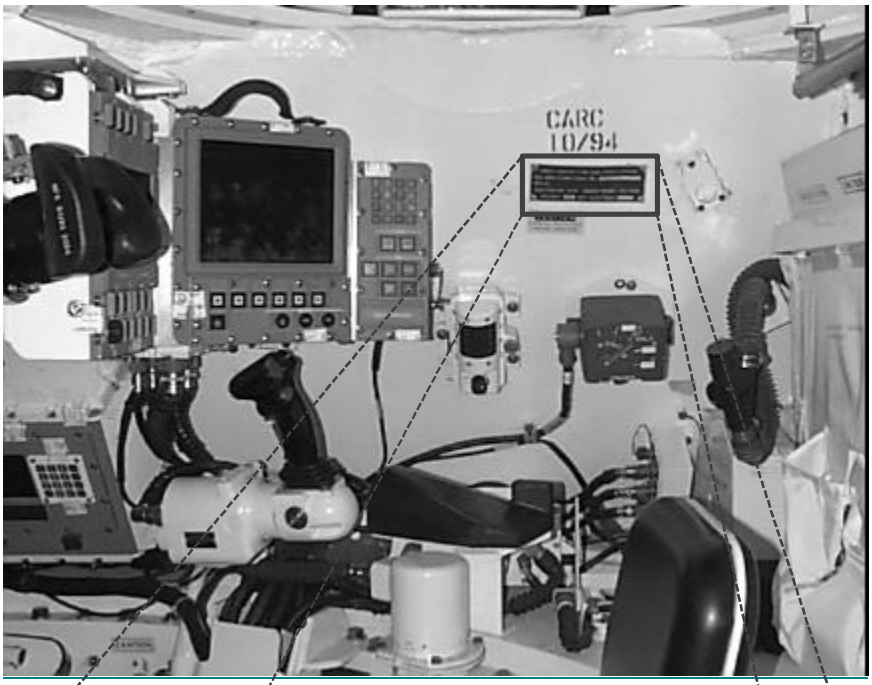
The Abrams family of tanks consists of four different models; M1, IPM1, M1A1, and M1A2. To ensure maximum crew survivability and provide increased protection against a broad spectrum of anti-tank weapons, the tank plants integrated armor improvements into the manufacturing process for these vehicles.

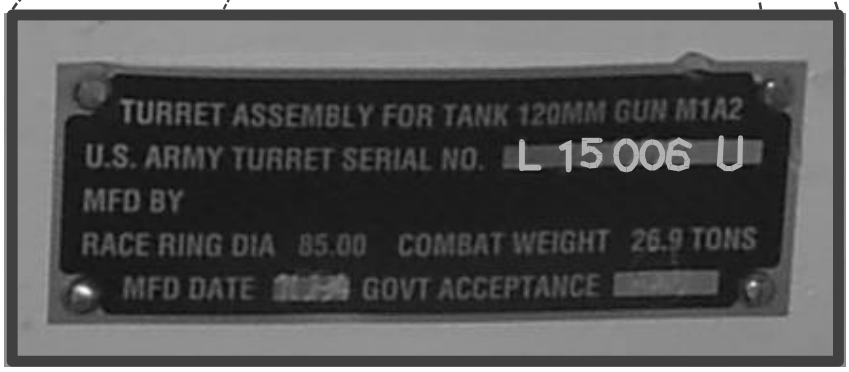
One such improvement to complete the hull armor envelope was the addition of *ballistic skirts*. This armor is considered "special armor" and is classified but contains no depleted uranium.



Student Notes

The newest M1A1 tanks, dubbed "Heavies", have depleted uranium packets "molded" into the left and right frontal turret armor. Tanks with this material are identified by a "**U**" at the end of the turret serial number. The M1A2 tanks also contain these DU packets in the turret armor package.





All armor on M1 Abrams series tanks is classified.

Student Notes

REQUIRED NOTIFICATION

Accidents and incidents involving DU armored tanks must be reported immediately (within 4 hours) through the Army accident reporting system to the local RPO or NBC NCO. This individual will in turn report the accident or incident to the TACOM RPO at:

Commander, TACOM
ATTN: AMSTA-CZ
Warren, MI 48397-5000

DSN: 786-7635/6121
Commercial: (810) 574-7635/6121

After duty hours:
DSN: 786-5935/5511
Commercial: (810) 574-5935/5511

These are NOT secure lines. If classified information must be discussed, a call-back from a secure line will be made after the initial notification. The TACOM RPO will then report the accident or incident to the NRC as required. Unless specifically directed otherwise, only unclassified information will be transmitted to the NRC.

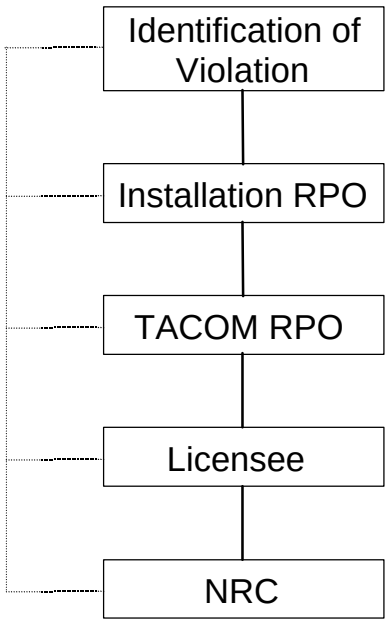


Figure 1~~1~~ Reporting Chain (DU Armor)

Accidents and incidents that must be reported as soon as possible are:

1. Theft or loss of control of DU armored tanks.
2. Fires, explosions or other types of accidents where DU armored tanks are or could be damaged.
3. Any accident or incident that damages or exposes the DU armor to the environment, or releases DU to the environment.
4. Accidents or incidents that result in an actual or potential radiation exposure from DU material covered under the applicable NRC license that are in excess to limits of exposure to ionizing radiation.

Student Notes

5. Accident/Incident reports will include:

- Name of the person submitting the report.
- The phone number of the person reporting.
- Name and title of the person in charge at the scene.
- Location of the accident/incident.
- Date and time of the occurrence.
- Organizations involved in the accident/incident.
- Equipment involved, to include radionuclide involved.
- List of the property damaged or contaminated.
- Extent of injuries or overexposure.
- Narrative description of the accident/incident.
- Cause of the accident if known.
- Type of accident and vehicle speed
- Was there fire involved
- Did weather conditions contribute to the accident.
- Did defective equipment contribute to the accident.
- List of the individuals and agencies known to have been notified and what actions are being taken.

REPAIR CRITERIA FOR NON SKIRT ARMOR

If the outer skin has been punctured, ripped, or cracked, a patch should be fabricated out of available materials and welded over the opening. The purpose of the patch is to secure the classified armor array and is not intended to improve the ballistic capabilities of the damaged armor. The damage should be evaluated at the appropriate maintenance level and repairs done as required.

NOTE

Personnel making the above type of repair to the armor where the exterior surface has been breached exposing the interior, should be cleared to the level of SECRET. If it is necessary to use uncleared personnel to expedite repairs, the damaged area should be concealed and then evacuated to an authorized repair facility.

Use caution when welding in the area of damaged DU turret armor. Depleted uranium is extremely pyrophoric (it will ignite spontaneously). Additionally DU will emit sparks when scratched or struck with steel. When welding, the patch size should exceed the size of the damaged area by 4 to 5 inches when possible. **DO NOT** weld directly to any exposed DU surface.

Student Notes

Any scrap materials associated with the classified armor shall be stored, safeguarded, and disposed of as ***Secret*** or ***Secret - Special Access Required*** in accordance with established procedures. All scrap will be placed in a metal container and shipped to:

COMMANDER, ABERDEEN PROVING GROUNDS
ATTN: STECS-LI-M
ABERDEEN PROVING GROUND, MD 21005

The shipment should be coordinated with the local Radiation Protection Officer (RPO) and the Live Fire Vulnerability Division, DSN 298-7301 or AC (410) 278-7301. The container will be shipped as classified to the above address under a continuous receipt system. The Special Program Chief:

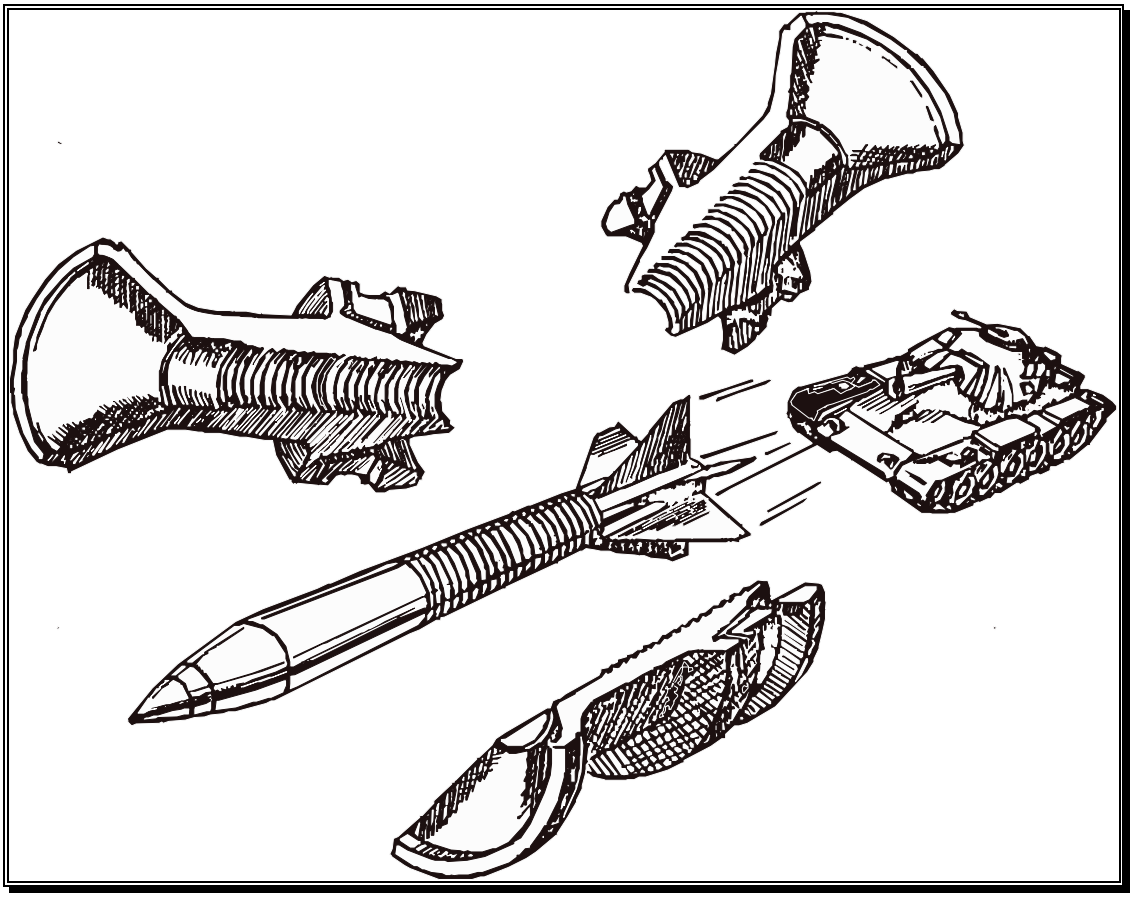
US ARMY TANK-AUTOMOTIVE COMMAND
ATTN: SFAE-ASM-S-S
WARREN, MI 48397-5000

DSN 786-5453
AC (810) 278-5453

will be notified that the shipment has been made. Armor scrap will NOT be disposed of outside of CONUS.

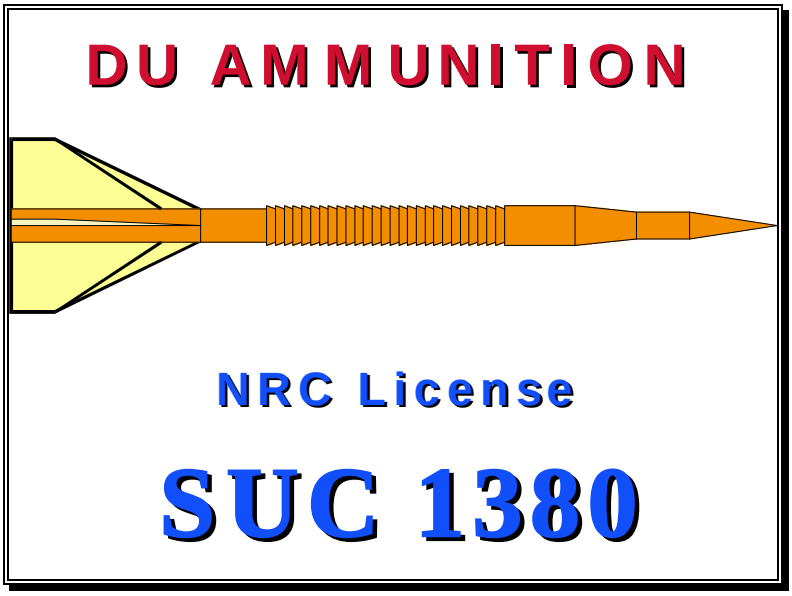
Student Notes

AUTHORIZED AMMUNITION CONTAINING DEPLETED URANIUM



Armor Piercing Projectiles: The combination of high hardness, strength, and density makes DU alloys well suited for armor piercing projectiles. DU costs are competitive with tungsten alloys and tungsten carbides.

Student Notes



The design and material composition of these cartridges represents a departure from previous generations of armor-piercing ammunitions. These rounds employ kinetic energy subprojectiles composed of monolithic (staballoy) depleted uranium cores. The design and material configurations warrant special emphasis during the life cycle of these cartridges. For general military applications, DU ammunition may only be fired during war emergency. All peacetime firings are prohibited except on ranges which are approved and licensed by the NRC and/or have host nation agreement.

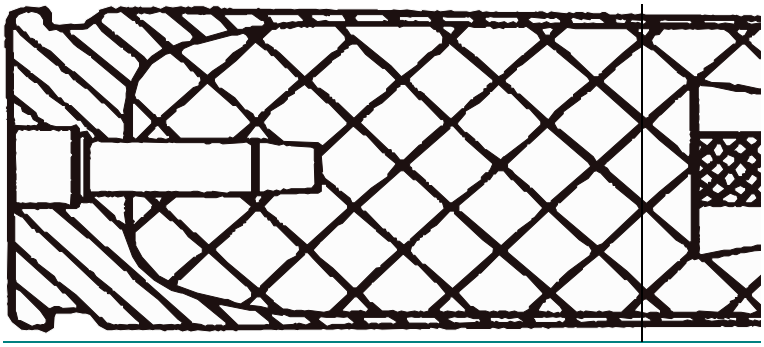
TANK AMMUNITION		BRADLEY	AIRCRAFT
105mm	120mm	25mm	30mm
M774	M827	M919	PGU-14/B
M833	M829		PGU-14A/B
M900	M829A1		PGU-14B/B
	M829A2		PGU-14A/A

Student Notes

25mm, M919, APFSDS-T

COLOR	MUZZLE VELOCITY
Black w/white obturator	4659 feet/second

The 25mm Armor-Piercing, Fin Stabilized Discarding Sabot with tracer (APFSDS-T) M919 has been designed and developed to replace the currently fielded M791 cartridge as the service armor piercing round for the Bradley. The M919 uses a high length/diameter ratio, depleted uranium penetrator and high energy propellant to achieve improved terminal ballistic characteristics.

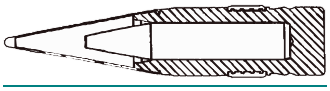


Hazard classification testing was conducted in 1988 at Nellis Air Force Base. Environmental sampling showed no indication that DU oxide had become airborne during the burn test (setting a pallet of ammo on fire). Essentially all of the oxide produced was insoluble when analyzed using a simulated lung fluid test. Only 0.1 to 0.2 percent of the oxide was small enough to be inhaled.

Radiological assessment of the M919 cartridge for external radiation levels was conducted in 1989. The components of the M919 effectively shielded out the predominant alpha and beta radiation. The gamma radiation penetrated the projectiles and the shipping containers. The highest radiation measurement was at the center of the shipping container. Radiation levels at the surface of a single shipping container, measured with field use exposure rate instruments, had a maximum reading of 0.6 mR/Hr. This exceeds the surface exposure rate criteria of 0.5 mR/Hr for excepted material. All other criteria are satisfied by the M919 shipping package.

30mm, API-T and API

The current production API has a boat tail and a shortened windscreen. The projectiles have an aluminum body which holds a depleted uranium penetrator and a hollow aluminum windscreen. Upon impact with the target, the windscreen and body are stripped away allowing the penetrator to continue through the target.

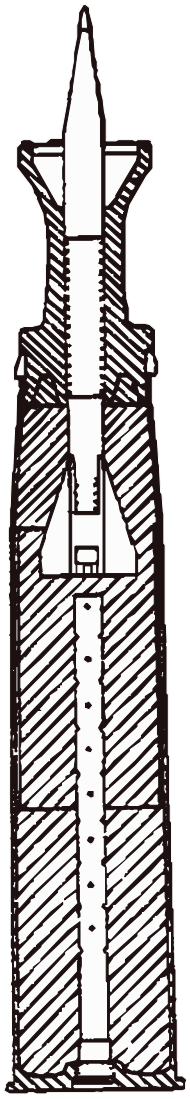


Student Notes

Target friction produces a large amount of heat providing incendiary effects.

Student Notes

105mm, APFSDS-T



The 105mm kinetic energy rounds consist of three models, M774, M833, and M900. These are armor-piercing antitank ammunition and are intended for use in the 105mm, M68 gun and are loaded and fired in the normal manner. The projectile is fin stabilized in flight. In order that only minimal spin is imparted to the projectile when the obturator engages the gun tube rifling, the plastic seal under the obturator produces approximately 80% slippage. Target penetration is effected strictly by the high kinetic energy of the subprojectile impacting the target.

The subprojectile consists of a monolithic staballoy (depleted uranium) core which is fitted with a steel tipped aluminum windscreen and an aluminum fin assembly.

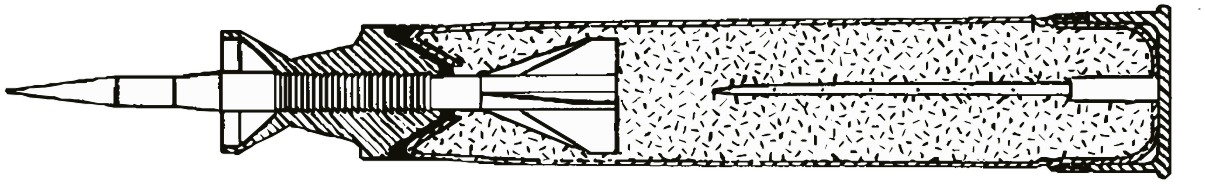
The basic material composition of the ammunition components are as follows:

COMPONENT	MATERIAL
Fin	Aluminum (anodized)
Windshield	Aluminum (anodized) w/ steel tip
Sobot	Aluminum (anodized)
Penetrator	Staballoy (depleted uranium)
Bourrelet	Steel
Sabot Seal	Rubber (Silicon)
Obturator	Nylon
Sealing Band	Polypropylene
Bourrelet Screws	Steel

Student Notes

120mm, APFSDS-T

The 120mm, M829 series, depleted uranium armor piercing fin stabilized discarding sabot-tracer (APFSDS-T) is the primary anti-armor 120mm smooth bore, M256 cannon, tank ammunition in service with the M1A1 and M1A2 Abrams tanks. This second generation kinetic energy projectile is capable of penetrating the frontal slope of all fielded armor systems and it's high technology penetrator and sabot design provides a munition which is accurate at all combat ranges. It's primary function is the destruction of threat tanks and armor fighting vehicles. Target penetration is affected strictly by the high kinetic energy of the DU core when it impacts. Like other DU munitions, these are identifiable by their black color with white markings on the projectile (pointed) end. M829 series ammunition is loaded and fired in the normal manner.



This ammunition will not be fired over the heads of friendly troops unless troops are protected by adequate cover as they may be struck by the discarded sabot.

155mm, Area Denial Artillery Munitions (ADAM)

The Area Denial Artillery Munitions (ADAM) is used for rapid, remote emplacement of point or tactical minefields used to restrict personnel movement. ADAM is a wedge shaped mine that fits efficiently into a 155mm projectile. When the projectile reaches the target area, 36 mines are expelled and shortly after impact with the ground they release trip lines and arm themselves. If not triggered by one of the trip lines, the mines will detonate at a predesignated self-destruct interval or if the battery reaches a level that impairs their proper functioning. When the mine detonates, a small charge propels the kill mechanism upward and then the kill mechanism detonates to optimize its effect against personnel. The ADAM and PDM are not of the kinetic energy "penetrator" type design. These munitions contain an extremely small amount of DU and not categorized as "DU ammunition".

Student Notes

The resin which forms the body of the ADAM mine wedge contains a small amount of DU in the "hardener" portion of the resin. The DU is less than 0.15% (0.024 oz) of the total resin and is present only as a chemical agent that allows the resin to cure at less then 160°F in less then 12 hours. These cure characteristics are required to efficiently produce the mine and to protect the electronic components during manufacture.

Mine, Antipersonnel, M86 Pursuit Deterrent Munitions (PDM)

The M86 PDM is a hand-emplaced anti-personnel mine used by ground forces to rapidly emplace short term minefields. It is activated like a hand grenade and is configured and functions similar to the ADAM mine.

DU Safety

TYPICAL CHARACTERISTICS FOR DU TANK AMMUNITION:

Color ----------Black w/white markings
Muzzle Velocity----------4925 + ft/sec
Round Weight----------37.8 - 40.8 lb.
Length----------35.75 - 39.5 in
Tracer----------M13

To help put the radiological hazards of these munitions in their proper prospective, here are some of the warning messages that are associated with various DU ammunition.

WARNING

Firing the M833 at ammunition temperatures above +125°F may result in excessive chamber pressures. Firing at ammunition temperatures below -35°F may result in weapon damage.

WARNING

The M900 is authorized for use in M1 tanks only. Firing the M900 from any other 105mm tank system

Student Notes

may result in failure of the gun mount. Firing in unauthorized gun mounts will result in failure of the recoil mechanism hydraulic seals.

WARNING

Do not fire the M900 from 105mm, M68 series cannon equipped with breeches having serial numbers lower than 4804. These breeches can fail catastrophically without warning. Initial quantities may be stenciled with a note indicating a cutoff point at serial number 6000. This number should no longer be considered valid.

WARNING

Do not fire the M900 cartridges where the projectile is loose within the case; i.e., rotating, wobbling, rattling, or any other unsecured manner. This condition may result in excessive pressure during firing resulting in catastrophic breech failure.

WARNING

Hatches must remain closed and the turret vent blower must remain on when firing to prevent buildup of toxic carbon monoxide gas.

Student Notes

All Army munitions containing DU penetrators are full service ammunition which may only be fired during war emergency. All peace time firings are prohibited except on ranges with special NRC license and/or with host nation agreement.

DU is frequently misunderstood which has resulted either in excessive or lack of safety controls. **Although potential users may believe that handling DU presents a complex safety problem, the fact remains that DU is the least hazardous when compared to the hazards presented by the propellant charge.** Sound industry hygiene practices afford adequate protection.

DU ammunition is not to be disposed of by burning, detonation, or buried nor will this ammunition be stored with pyrotechnics or incendiaries.

If cartridges containing DU projectiles are damaged to the point where the internal projectile components are visible, they shall be treated as confidential. The damaged cartridge shall be wrapped in plastic and placed in a container or otherwise covered to prevent exposure. The cartridge shall be returned in a sealed container (as classified material) to the appropriate ASP for disposition.

NOTE

Loss or unauthorized firing of depleted uranium rounds must be reported through the chain of command as soon as discovered (within 4 hours). All transmissions regarding incidents of this nature must be classified at least CONFIDENTIAL. HQ IOC must be notified within 24 hours of the discovery. Violations may result in a personal fine or imprisonment. Failure to report a noncompliance is punishable under federal law. Report to:

Student Notes

COMMANDER; HQ IOC
ATTN: AMSIO-DMW
ROCK ISLAND, IL 61299-6000

DSN 793-0338/2969/1766
AC (309) 782-0338/2969/1766

After duty hours:
DSN 793-1110
AC (309) 782-1110

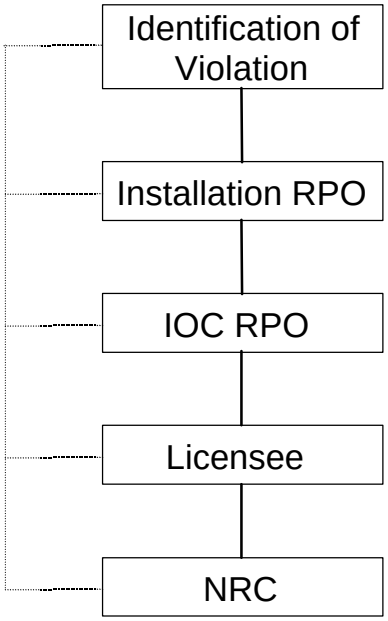


Figure 22 - Reporting Chain (DU Munitions)

Student Notes

DU Hazards

Radiation exposure from DU, in most situations, is of minor significance and is controllable. If in that rare event the dose limits have been exceeded due to exposure to DU, the actual over-exposure is less significant than the fact that safety controls have not functioned as required by law. Minor over-exposures make no significant changes to the individual's total risk situation, but the existence of the over-exposure usually indicates deficiencies or mismanagement which could eventually lead to a complete loss of controls.

DU presents a two fold hazard:

1. **CHEMICAL TOXICITY** The chemical hazard of DU is slightly greater than the radiological hazard. Chemical toxicity is only present after the victim has absorbed the contamination into the blood stream. Normally the body is capable of eliminating over 90% of the radioactive material through the bowels and urine.
2. **IONIZING RADIATION** DU presents an ionizing radiation hazard when:
    - Sufficient quantities are taken into the body.
    - When large amounts of DU with a large surface area are present in a very close proximity to the body for an extended period.

Fortunately, DU is absorbed to a very limited extent through unbroken skin or the gastrointestinal tract; and its specific activity is quite low in comparison with most other radioactive elements. Overexposure to either hazard is rare and easily prevented by maintaining adequate safety controls and training of personnel involved with DU.

EXTERNAL RADIATION

DU contains a series of radioactive elements (daughter products) that commonly emit either alpha or beta particles; this emission may also be accompanied by gamma ray activity. All of the alpha and most of the beta radiation emitted by the DU penetrator is effectively shielded by the shell casing, discarding sabot and aluminum wind screen while the ammunition is intact. Handling the

Student Notes

bare DU penetrator greatly increases the potential for external and internal radiation exposures.

ALPHA EMISSIONS do not present any ***external*** radiation hazard.

GAMMA RAY ENERGY is so low that for practical purposes it constitutes no hazard.

BETA RADIATION accounts for nearly all the penetrating radiation from DU. But, the beta intensity rapidly decrease with distance.

In keeping with NRC and US Army ALARA policies, any vehicle or object struck by DU munitions should be considered contaminated. Any M1A1 Abrams tank which has received combat damage resulting in ignition of stored DU munitions, onboard fires, or has been struck by missiles should be treated as contaminated until inspected by qualified personnel. Fortunately, DU armor and ammunition **does not** constitute a serious external radiation hazard. It is not necessary to use massive shielding or special manipulating devices to decrease exposure in working with DU. There is relatively little radiation exposure at a few feet from the material.

INTERNAL RADIATION

DU can gain access to the body by way of injection, ingestion, or inhalation. Inhalation is the principle safety hazard in dealing with DU compound.

ABSORPTION through unbroken skin is negligible. Absorption via injection is likely to occur in such cases as contamination of open wounds or penetration of the skin by pieces of DU shrapnel.

Absorption by INGESTION is approximately 1% of the intake.

INHALATION of DU is the most significant mode of entry. DU particles can be dispersed in the air from a fire involving DU or from DU ammunition impacting armored surfaces. Only very small particles can be inhaled. Of those inhaled particles, some will be soluble in lung fluid and others will not. Those particles that are *soluble* will be absorbed by the body to become a ***heavy metal*** poison (**chemically toxic**) primarily to the kidneys. The particles in the lungs that are *not soluble* will remain in the lungs and may be a radiation hazard. Insoluble particles that remain in the lungs are dispelled by the body very slowly.

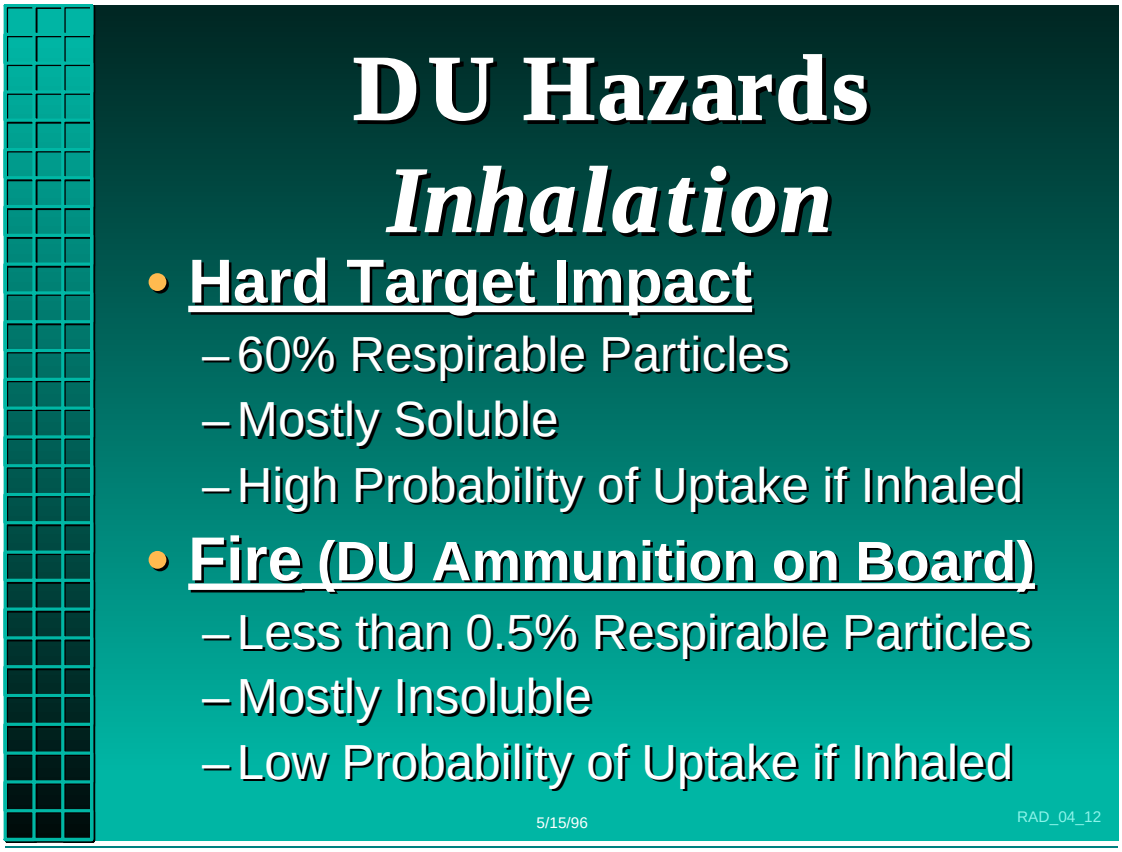
Once in the body, DU can cause damage by ionizing radiation. The principle radiation hazard from internal deposits of DU is the intense ionization in tissue

Student Notes

produced by alpha particles emitted during the radioactive decay process. The energy of the alpha particles is absorbed in the first 0.1mm of tissue, resulting in localized cellular damage while the beta and gamma radiation emissions dissipate their energies in relatively large volumes of tissue and produce comparatively little damage.

CHEMICAL TOXICITY

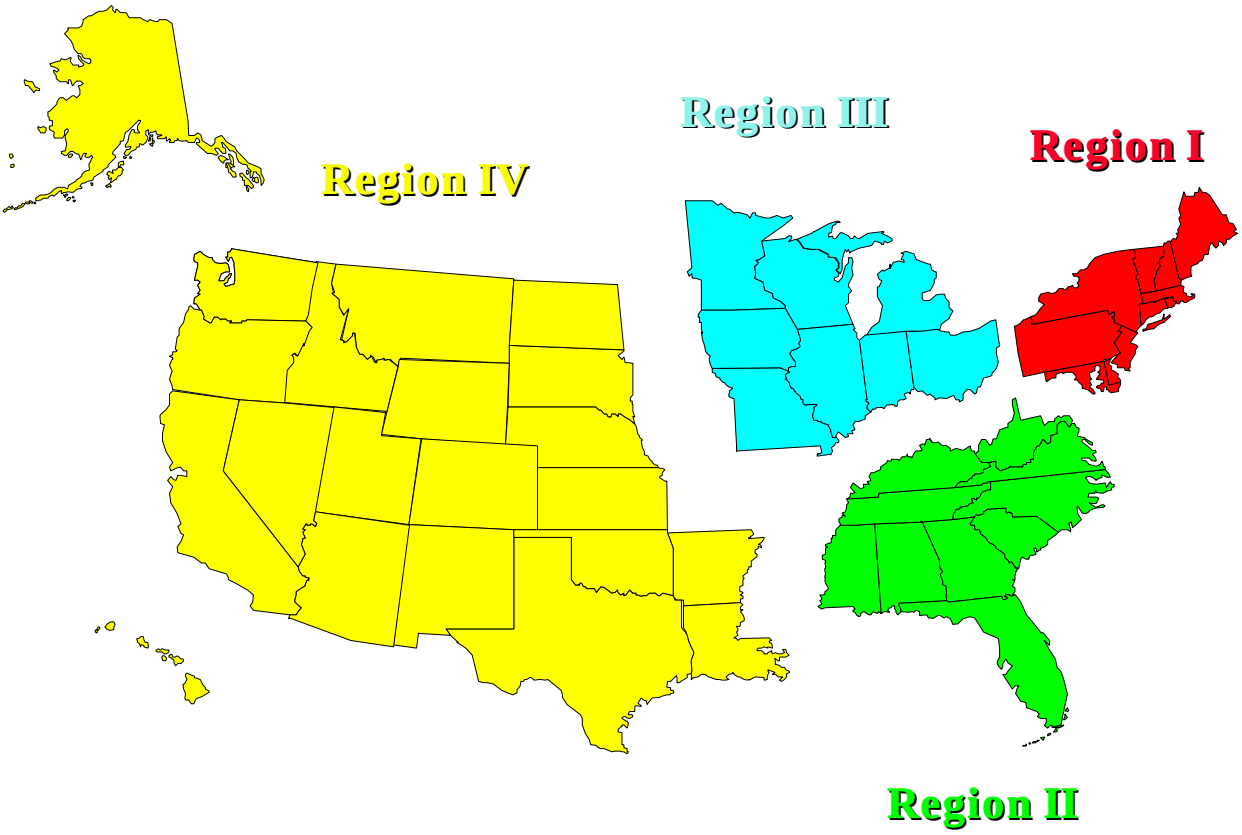
The more soluble components of DU are quickly taken into the blood stream via the lungs or contaminated wounds and may result in significant deposits in the kidney. Once there, some of the DU combines with the protein of cell walls, poisoning the cells and interfering with the vital functions of waste elimination and maintenance of electrolyte balance. The DU does not remain fixed in the kidney, but is eliminated at a rate of about half every two weeks. Moderately severe damage to the kidney as a result of acute exposure is repairable, and a return toward normal kidney function may occur even during continued exposure.



Student Notes

Nuclear Regulatory Commission

(NRC)



DEPLETED URANIUM

RAD_04_01

Depleted Uranium

	Natural Uranium	Depleted Uranium
^{234}U	00.0057 %	00.0005 %
^{235}U	00.7204 %	00.2500 %
^{238}U	99.2739 %	99.7495 %
Total	100.0000 %	100.0000 %

- By-product of uranium enrichment process
- 1.6 times denser than lead
- Slightly softer than steel
- Pyrophoricity
- Relatively low fabrication costs
- Readily available

Uranium Decay Chain

Nuclide	Half Life	Emissions
Uranium-238	4.5 billion yrs	alpha
Thorium-234	24.1 days	beta / gamma
Proactinium-234	6.7 hours	beta / gamma
Uranium-234	247,000 yrs	alpha / gamma
Thorium-230	80,000 yrs	alpha / gamma
Radium-226	1,600 yrs	alpha / gamma
Radon-222	91.752 hours	alpha / gamma
Polonium-218	3.05 min	alpha / beta
Lead-214	26.8 min	beta / gamma
Astatine-218	2 seconds	alpha
Bismuth-214	19.7 min	beta / gamma
Polonium-214	164 µsec	alpha / gamma
Thallium-210	1.3 min	beta / gamma
Lead-210	21 yrs	beta / gamma
Bismuth-210	5.0 days	beta
Polonium-210	138.4 days	alpha
Thallium-206	4.19 min	beta
Lead-206	STABLE	

Uranium Decay Chain

Nuclide	Half Life	Emissions
Uranium-238	4.5 billion yrs	alpha
Thorium-234	24.1 days	beta / gamma
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Lead-214	26.8 min	beta / gamma
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Bismuth-214	19.7 min	alpha/beta/gamma
Polonium-214	164 µsec	alpha / gamma
Thallium-210	1.3 min	beta / gamma
Lead-210	21 yrs	beta / gamma
Bismuth-210	5.0 days	beta
Polonium-210	138.4 days	alpha
Thallium-206	4.19 min	beta
Lead-206	STABLE	

High Probability

Low Probability

RAD_04_03

Depleted Uranium

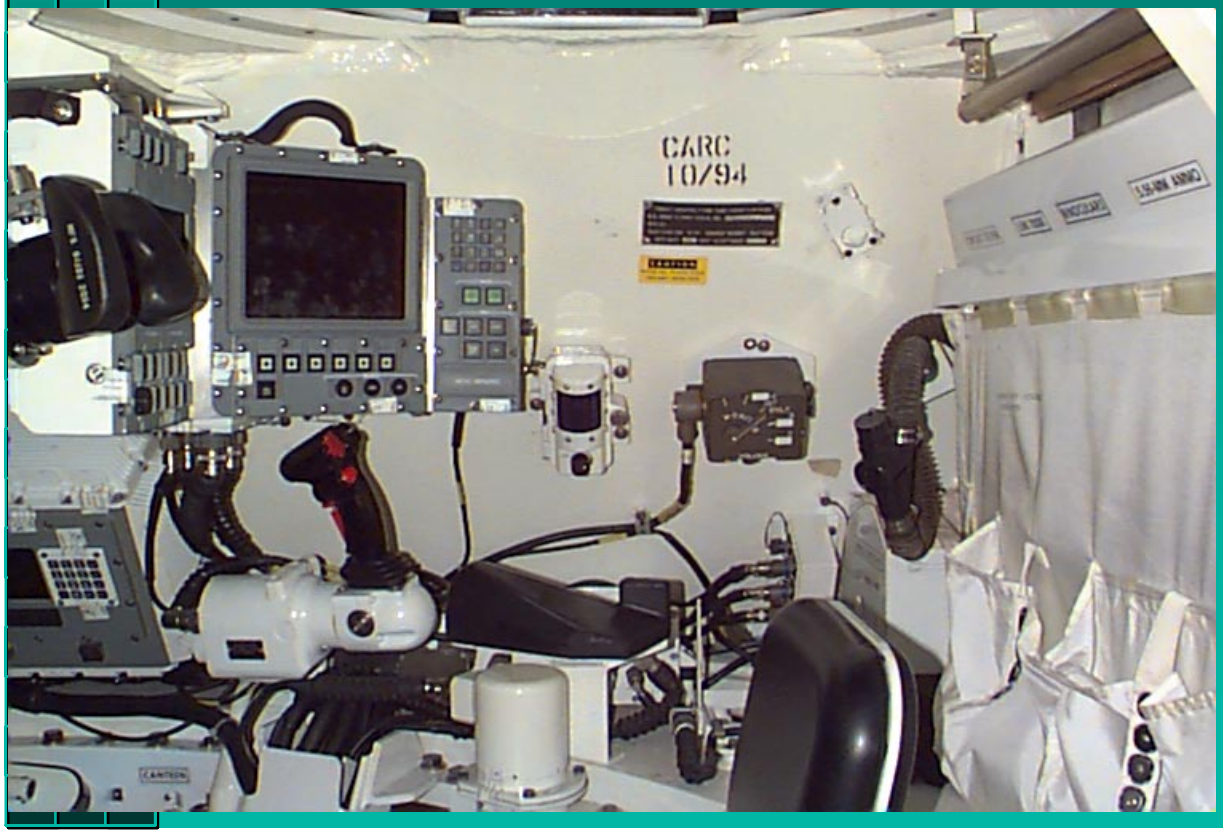
- Alpha, Beta, and Gamma Emission
- 4.5 Billion Year Half Life
- Specific Activity is Low
  - A 1 Ci source would weigh 6,615 lbs

DU ARMOR

- All M1A2 Tanks
- Some M1A1 Tanks
  - Commonly called "Heavy"
- Located only in the forward slope of the turret
- Detectable radiation on the outside of the turret

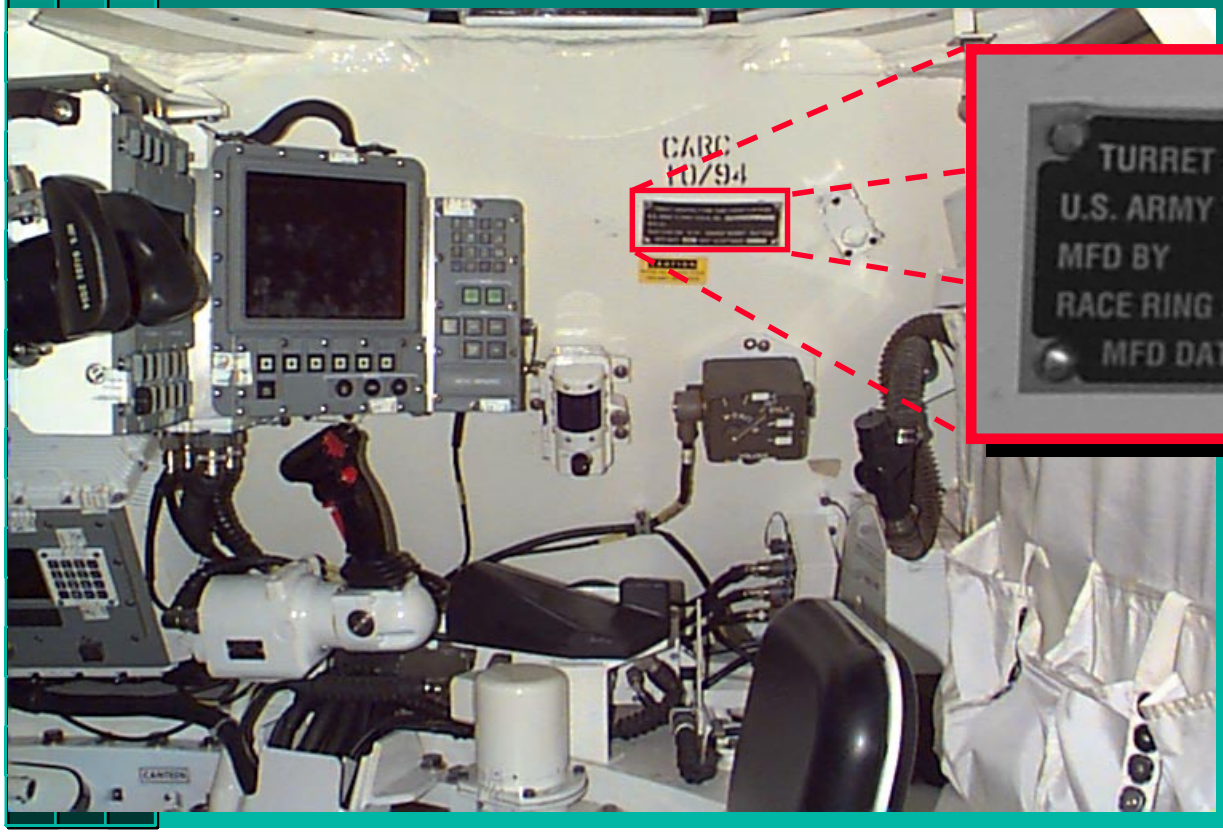
DU ARMOR

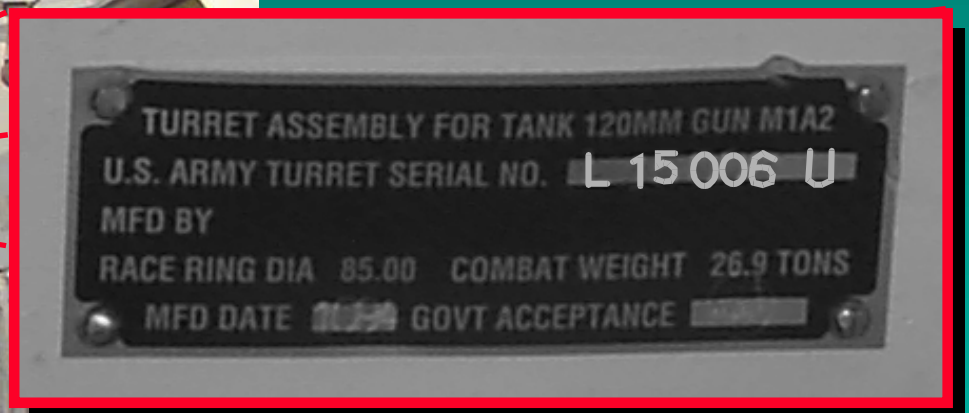
- Identified by the letter “U” in the turret serial number



DU ARMOR

- Identified by the letter “U” in the turret serial number





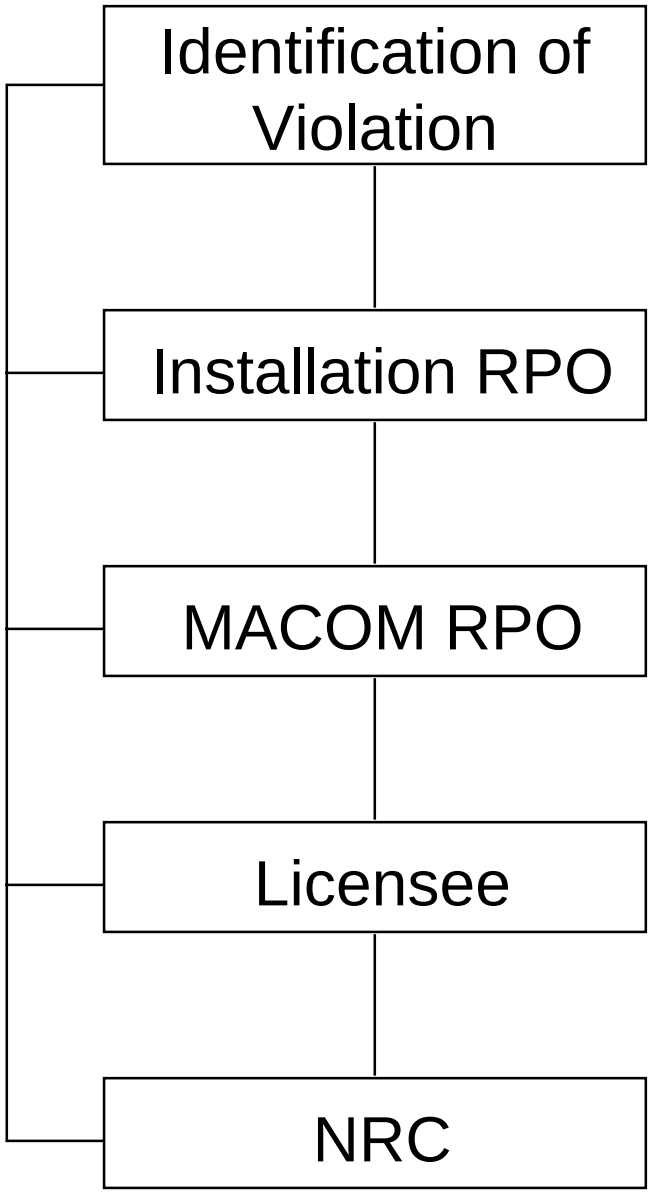
Required Notification

Commander, TACOM
ATTN: AMSTA-CS-CZ
Warren, MI 48397-5000

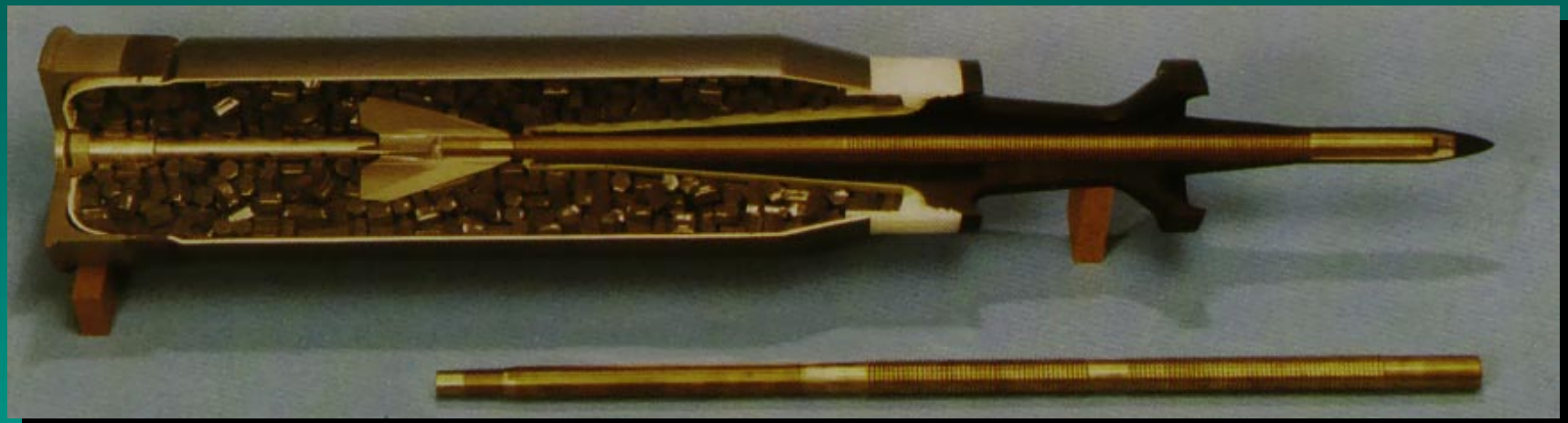
DSN: 786-7635/6121
Commercial: (810) 574-7635/6121

After duty hours:
DSN: 786-5935/5511
Commercial: (810) 574-5935/5511

Reporting Chain



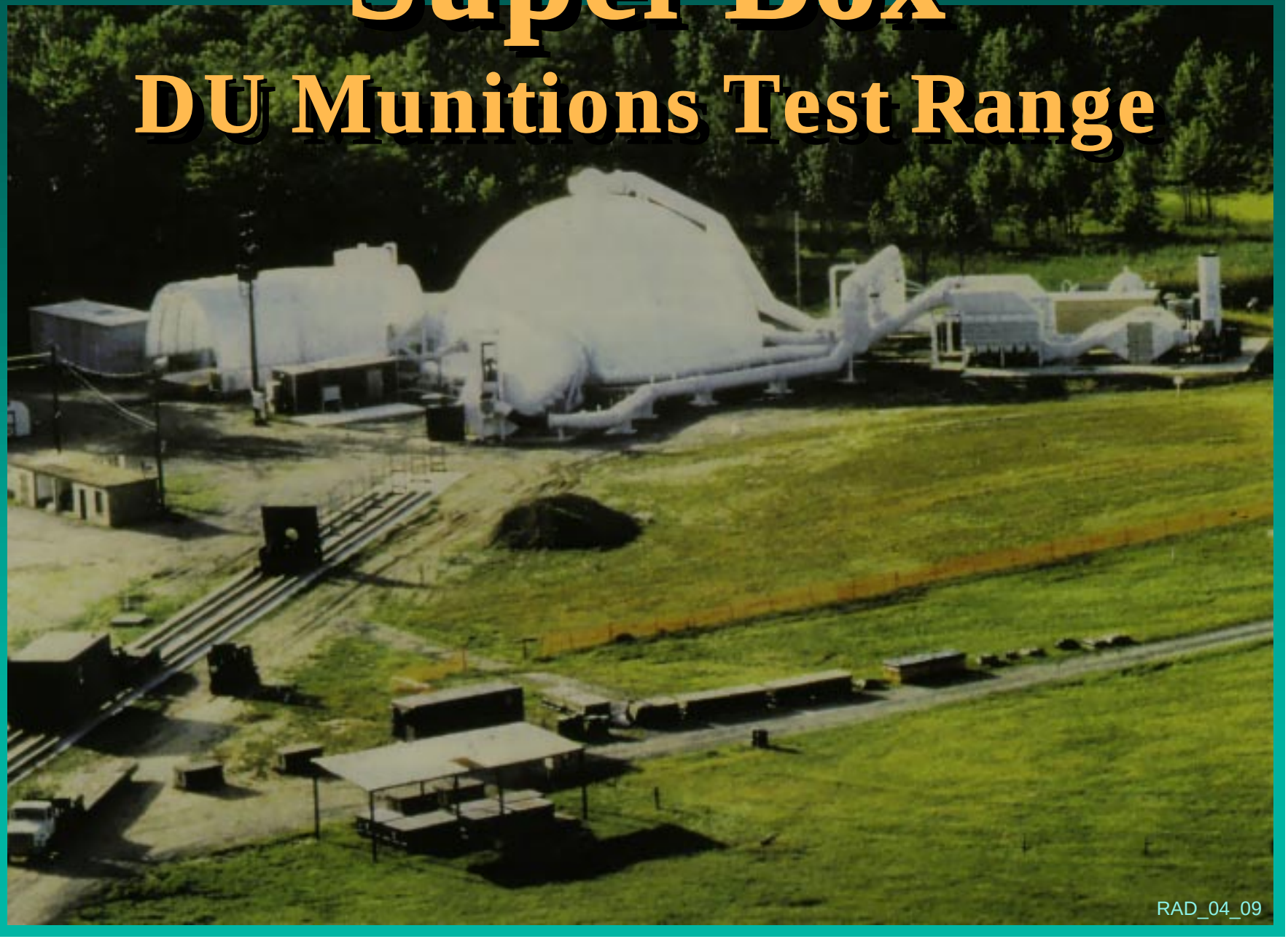
DU Munitions



105mm	120mm	25mm	30mm	155mm	Mine
M774	M827	M919	PGU-14/B	M692	M86
M833	M829		PGU-14A/B	M731	
M900	M829A1		PGU-14B/B		
	M829A2		PGU-14A/A		

Super Box

DU Munitions Test Range



RAD_04_09

Loss or Unauthorized Firing

COMMANDER; HQ IOC
ATTN: AMSIO-DMW
ROCK ISLAND, IL 61299-6000

DSN 793-0338/2969/1766
AC (309) 782- 0338/2969/1766

Non duty hour, call staff duty officer:

DSN 793-1110
AC (309) 782-1110

DU Hazards

DU Hazards

Tritium

DU Hazards

Tritium

DU Hazards

DU Hazards

DU Hazards

DU Hazards

DU Hazards

DU Hazards
Inhalation

- **Hard Target Impact**
  - 60% Respirable Particles
  - Mostly Soluble
  - High Probability of Uptake if Inhaled
- **Fire (DU Ammunition on Board)**
  - Less than 0.5% Respirable Particles
  - Mostly Insoluble
  - Low Probability of Uptake if Inhaled

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-04

DATE: Nov. 95

TITLE: Depleted Uranium

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 5.0 C (U)
0.0 PE

FACILITY REQ.: Classroom

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty

TRANSPORTATION: None

ISSUED TO STUDENTS: Student Reference Guide “Radioactive Material Handling Safety”

AIDS AND EQUIPMENT:

a. Overhead Projector
b. Computer Display Device
c. RAD_04.PPT (PowerPoint slide file)
d. Computer
e. Display Screen
f. VCR
g. Video tape of ABC Nightline, 8 June 93, “Depleted Uranium”
h. Video tape “Depleted Uranium Hazard Awareness” TVT 3-92
I. Video tape “DU Test firing”

REFERENCES:	TB 9-1300-278	"Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
	TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
	TM 9-2350-200-BD	"BATTLEFIELD DAMAGE ASSESSMENT AND REPAIR FOR M1, IPM1, AND M1A1 TANK, GENERAL ABRAMS
	Security Classification Guide for Abrams Tank System	
	10 CFR Part 40	
	Reference Guide	Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
	10 CFR 20	"Standards for Protection Against Radiation"

COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: Depleted Uranium

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

a. Introduction:

(1) Objective: Provide an overview of depleted uranium used in the US Army.

(2) Reason and Tie-In:

NOTE: *SHOW SLIDE RAD_04_01*

NOTE: *SHOW VIDEO TAPE:* ABC Nightline, 8 June 93, "Depleted Uranium"

(a) Currently the Army does not know the full extent to which its personnel were exposed to DU contamination during the Gulf War.

(b) According to NRC and Army officials, troops externally exposed to DU radiation, during the Gulf War, were not exposed to external radiation or internal levels of DU that exceeded NRC limits for radiation exposure and toxicity which could cause toxic effects.

(c) One of the recommendations made by he GAO after the 1991 war with Iraq (Desert Storm) was that the Army must better educate its personnel on the hazards on DU. This block of instruction is just one part of an Army wide effort to better educate its personnel.

b. Explanation:

(1) In establishing safety controls for DU operations it is important to place the potential hazard of DU in the proper perspective. Safety controls should be consistent with the manner in which the DU is to be used. Where DU and explosive ordnance are utilized**, the potential radiological hazard of DU becomes secondary** to that of the explosive.

(2) BACKGROUND

(a) Uranium is actually widely distributed around the world. The crust of the earth, for example, contains a concentration on the average of about four parts per million (PPM). In order to be considered usable, or economically viable as uranium ore, the concentration has to be in the vicinity of 30 PPM or higher. Common foods also contain uranium to a limited extent, about 0.1 - 1.0 PPM. Drinking water in the US contains on the average about 2 millionths of 1 microcurie (0.000000000002 Ci) for each liter.

(b) Uranium has been mined from deposits in the Erz Mountains between Germany and Czechoslovakia since the 1500's. Uranium was originally used in pottery to produce a deep orange color in the glazing applied to the pottery before it was placed in the firing kiln. In fact, this process has remained in the pottery up to a few years ago. Bright orange dishes and pottery items made more than ten years ago will still show a reading when measured with a radiac meter.

NOTE: *SHOW SLIDE RAD_04_02*

(c) In the chemically pure state, uranium appears as a shiny, silvery metal. Natural Uranium contains ^{234}U, ^{235}U, and ^{238}U. DU is a by-product of the uranium enrichment process which increases the percentage of the ^{235}U isotope. This enriched uranium is used in the nuclear industry as fuel for nuclear reactors. Uranium which has had a majority of the ^{235}U isotope removed is referred to as "Depleted Uranium" (DU). DU, sometimes referred to as "Tuballoy", is the waste product left after natural uranium has gone through the enrichment process. The term "depleted" refers to the fact that **most** of the ^{235}U has been extracted, not that the radiation has been depleted.

	Natural Uranium	**Depleted Uranium**
^{234}U	00.0057	00.0005
^{235}U	00.7204	00.2500
^{238}U	99.2739	99.7495

(d) Properties which make DU of interest to the military are its high density and strength, ease and relatively low cost of fabrication, pyrophoricity, and availability.

NOTE: *SHOW SLIDE RAD_04_03*

(e) DU radiation results from spontaneous radioactive decay forming ***daughter atoms***. Uranium, along with a few other radioactive materials, is unusual in that it is a part of a radioactive decay chain. What this means is that when an atom of uranium 238 decays, it converts into a different element called a **daughter product**. The daughter product is also radioactive, and during its process of decay causes a third element to be formed. This process of successive decays from parent to daughter can go on for 17 steps - that is, for 17 generations of ^{238}U radioactive by-products.

Uranium Decay Series		
Nuclide	**Half Life**	**Emissions**
Uranium-238	4.5 billion yrs	alpha
Thorium-234	24.1 days	beta / gamma
Proactinium-234	6.7 hours	beta / gamma
Uranium-234	247,000 yrs	alpha / gamma
Thorium-230	80,000 yrs	alpha / gamma
Radium-226	1,600 yrs	alpha / gamma
Radon-222	91.752 hours	alpha / gamma
Polonium-218	3.05 min	alpha / beta
Lead-214	26.8 min	beta / gamma
Astatine-218	2 seconds	alpha
Bismuth-214	19.7 min	beta / gamma
Polonium-214	164 µsec	alpha / gamma
Thallium-210	1.3 min	beta / gamma
Lead-210	21 yrs	beta / gamma
Bismuth-210	5.0 days	beta
Polonium-210	138.4 days	alpha
Thallium-206	4.19 min	beta
Lead-206	**STABLE**	

NOTE: *SHOW SLIDE RAD_04_04*

(f) Uranium decays by alpha particle emission. The daughter atoms formed during decay emit alpha, beta, and gamma radiation. Therefore the radiation emitted from DU contains alpha, beta and gamma radiation. Because of the long half life of ^{238}U (the major element of DU), the specific activity is unusually low. To help illustrate this, to obtain one curie of radioactivity from DU it would require a single piece weighing 6,615 pounds.

(3) **DEPLETED URANIUM NON-NUCLEAR USES -** Because of its high density and structural properties, DU is useful for non-nuclear applications. It can be applied defensively to protect against penetration by projectiles made of less dense metals, such as tungstoncarbide subprojectiles, or offensively to defeat armored targets.

NOTE: *SHOW SLIDE RAD_04_05*

NOTE: *SHOW VIDEO TAPE:* "Depleted Uranium Hazard Awareness" TVT 3-92

(4) **DEFENSIVE USE OF DEPLETED URANIUM**

(a) RHA ARMOR: Prior to the introduction of the depleted uranium packets, the M1 series armor structure was comprised of *weld fabricated, rolled homogenous steel*. Meaning that it was manufactured and heat treated so that it possessed, as nearly as possible, the same chemical constituents and physical properties throughout.

(b) The Abrams family of tanks consists of four different models; M1, IPM1, M1A1, and M1A2. To ensure maximum crew survivability and provide increased protection against a broad spectrum of anti-tank weapons, the tank plants integrated armor improvements into the manufacturing process for these vehicles.

(c) One such improvement to complete the hull armor envelope was the addition of *ballistic skirts*. This armor is considered "special armor", contains no DU, and is classified.

(d) The newest M1A1 tanks, dubbed "Heavies", have depleted uranium packets "molded" into the turret armor. Tanks with this material are identified by a "**U**" at the end of the turret serial number. The M1A2 tanks also contain these DU packets in the turret armor package.

NOTE
There are 5 tanks at the Ft. Knox training school that have DU hulls and turrets.

(e) All armor on M1 Abrams series tanks is classified **secret**.

(f) M1A1 and M1A2 tanks with depleted uranium armor have a radiation signature on the surface of the turret.

(5) REQUIRED NOTIFICATION

NOTE: *SHOW SLIDE RAD_04_06/07*

(a) Accidents and incidents involving DU armored tanks must be reported immediately to the local RPO or NBC NCO who is then charged with reporting it further through the Army accident reporting system. This individual will in turn report the accident or incident to the TACOM RPO at:

Commander, TACOM
ATTN.: AMSTA-CZ
Warren, MI 48397-5000

DSN: 786-7635/6121
Commercial: (810) 574-7635/6121

After duty hours:
DSN: 786-5935/5511
Commercial: (810) 574-5935/5511

These are NOT secure lines. If classified information must be discussed, a call-back from a secure line will be made after the initial notification. The TACOM RPO will then report the accident or incident to the NRC as required. Unless specifically directed otherwise, only unclassified information will be transmitted to the NRC.

(b) Accidents and incidents which must be reported as expeditiously as possible are:

[1] Theft or loss of control of DU armored tanks.

[2] Fires, explosions or other types of accidents where DU armored tanks are or could be damaged.

[3] Any accident or incident that damages or exposes the DU armor to the environment, or releases DU to the environment.

[4] Accidents or incidents that result in an actual or potential radiation exposure from DU material covered under the applicable NRC license that are in excess of the limits of exposure to ionizing radiation.

(c) Accident/Incident reports will include:

- Name of the person submitting the report.
- The phone number of the person reporting.
- Name and title of the person in charge at the scene.
- Location of the accident/incident.
- Date and time of the occurrence.
- Organizations involved in the accident/incident.
- Equipment involved, to include radionuclide involved.
- List of the property damaged or contaminated.
- Extent of injuries or overexposure.
- Narrative description of the accident/incident.
- Cause of the accident if known.
- Type of accident and vehicle speed
- Was there fire involved
- Did weather conditions contribute to the accident.
- Did defective equipment contribute to the accident. What was the component and how is it defective.
- List of the individuals and agencies known to have been notified and what actions are being taken.

NOTE: *SHOW SLIDE RAD_04_08*

(7) **AMMUNITION CONTAINING DEPLETED URANIUM**

(a) Armor Piercing Projectiles: The combination of high hardness, strength, and density makes DU alloys well suited for armor piercing projectiles. DU costs are competitive with tungsten alloys and tungsten carbides.

(b) The design and material composition of these cartridges represents a departure from previous generations of armor-piercing ammunitions. These rounds employ kinetic energy subprojectiles composed of monolithic (staballoy) depleted uranium cores. The design and material configurations warrant special emphasis during the life cycle of these cartridges. For general military applications, DU ammunition may only be fired during war emergency. All peacetime firings are prohibited except on ranges which are approved and licensed by the NRC and/or have host nation agreement.

(c) Several different models of DU ammunition have been produced for various weapon systems used by the Department of Defense. Although, some of these models are owned by other services the Army does store them at Army depots and is involved in the shipping and handling of these munitions. The models listed below are categorized by weapon system type and are of the kinetic energy penetrator design.

TANK	**TANK**	**BRADLEY**	**A-10**	**PHALANX**	**HARRIER**
105mm	120mm	25mm	30mm	20MM	25MM
M774	M827	M919	PGU-14	MK-149	PGU-20
M833	M829		series	MK-149	
M900	M829A1			mod 1	
	M829A2				

(d) DU has also been used for its chemical properties to harden a type of plastic used in the body of a mine. Several of these mines are loaded into a 155mm artillery projectile called the Area Denial Artillery Munition (ADAM). Another version of this same mine is emplaced one-at-a-time, by hand, and is called the Pursuant Deterrent Munition (PDM). The ADAM and the PDM are not normally addressed in discussions on DU munitions because of the small amount of DU used in each mine and because they ate no of the kinetic energy penetrator design.

(e) Each family of DU munitions is discussed below.

[1] **25mm, M919, APFSDS-T**

COLOR	**MUZZLE VELOCITY**
Black w/white obturator	4659 feet/second

[a] The 25mm Armor-Piercing, Fin Stabilized Discarding Sabot with tracer (APFSDS-T) M919 has been designed and developed to replace the currently fielded M791 cartridge as the service armor piercing round for the Bradley. The M919 uses a high length/diameter ratio, depleted uranium penetrator and high energy propellant to achieve improved terminal ballistic characteristics.

[b] Hazard classification testing was conducted in 1988 at Nellis Air Force Base. Environmental sampling showed no indication that DU oxide had become airborne during the burn test (setting a pallet of ammo on fire). Essentially all of the oxide produced was insoluble when analyzed using a simulated lung

fluid test. Only 0.1 to 0.2 percent of the oxide was small enough to be inhaled.

[c] Radiological assessment of the M919 cartridge for external radiation levels was conducted in 1989. The components of the M919 effectively shielded out the predominant alpha and beta radiation. The gamma radiation penetrated the projectiles and the shipping containers. The highest radiation measurement was at the center of the shipping container. Radiation levels at the surface of a single shipping container, measured with field use exposure rate instruments, had a maximum reading of 0.6 mR/Hr.

[2] **30mm, API (Armor-Piercing, Incendiary) and API-T (Armor-Piercing, Incendiary, with Tracer) -** The current production API has a boat tail and a shortened windscreen. The projectiles have an aluminum body which holds a depleted uranium penetrator and a hollow aluminum windscreen. Upon impact with the target, the windscreen and body are stripped away allowing the penetrator to continue through the target. Target friction produces a large amount of heat providing incendiary effects.

[3] **105mm, APFSDS-T (Armor-Piercing, Fin Stabilized, Discarding Sabot, with Tracer)**

[a] The 105mm kinetic energy rounds consist of three models, M774, M833, and M900. These are armor-piercing antitank ammunition and are intended for use in the 105mm, M68 gun and are loaded and fired in the normal manner. The projectile is fin stabilized in flight. In order that only minimal spin is imparted to the projectile when the obturator engages the gun tube rifling, the plastic seal under the obturator produces approximately 80% slippage. Target penetration is effected strictly by the high kinetic energy of the subprojectile impacting the target.

[b] The subprojectile consists of a monolithic staballoy (depleted uranium) core which is fitted with a steel tipped aluminum windscreen and an aluminum fin assembly. The end item round of ammunition consists of two major components; the cartridge case, and the projectile assembly.

[c] The basic material composition of the ammunition components are as follows:

COMPONENT	MATERIAL
Fin	Aluminum (anodized)
Windshield	Aluminum (anodized) w/ steel tip
Sobot	Aluminum (anodized)
Penetrator	Staballoy (depleted uranium)
Bourrelet	Steel

Sabot Seal	Rubber (Silicon)
Obturator	Nylon
Sealing Band	Polypropylene
Bourrelet Screws	Steel

[4] **120mm, APFSDS-T**

[a] The 120mm, M829 series, depleted uranium armor piercing fin stabilized discarding sabot-tracer (APFSDS-T) is the primary anti-armor 120mm smooth bore, M256 cannon, tank ammunition in service with the M1A1 and M1A2 Abrams tanks. This second generation kinetic energy projectile is capable of penetrating the frontal slope of all fielded armor systems and it's high technology penetrator and sabot design provides a munitions which is accurate at all combat ranges. It's primary function is the destruction of threat tanks and armor fighting vehicles. Target penetration is affected strictly by the high kinetic energy of the DU core when it impacts. Like other DU munitions, these are identifiable by their black color with white markings. M829 series ammunition is loaded and fired in the normal manner. Similar to the 105mm rounds the two major components of the 120mm munitions are; the cartridge case, and the projectile assembly.

[b] This ammunition will not be fired over the heads of friendly troops unless troops are protected by adequate cover as they may be struck by the discarded sabot.

[5] **155mm, Area Denial Artillery Munitions (ADAM)**

[a] Of interest to this course are two 155mm projectiles, M692 and M731, which contain depleted uranium.

[b] The Area Denial Artillery Munitions (ADAM) is used for rapid, remote emplacement of point or tactical minefields used to restrict personnel movement. ADAM is a wedge shaped mine that fits efficiently into a 155mm projectile. When the projectile reaches the target area, 36 mines are expelled and shortly after impact with the ground they release trip lines and arm themselves. If not triggered by one of the trip lines, the mines will detonate at a pre-designated self-destruct interval or if the battery reaches a level that impairs their proper functioning. When the mine detonates, a small charge propels the kill mechanism upward and then the kill mechanism detonates to optimize its effect against personnel.

[c] The resin which forms the body of the ADAM mine wedge contains a small amount of DU in the "hardener" portion of the resin. The DU is less than 0.15% (0.024 oz) of the total resin and is present only as a chemical agent that allows the resin to cure at less then 160°F in less then 12 hours. These cure

characteristics are required to efficiently produce the mine and to protect the electronic components during manufacture.

[6] **Mine, Antipersonnel, M86 Pursuit Deterrent Munitions (PDM) -** The M86 PDM is a hand-emplaced anti-personnel mine used by ground forces to rapidly emplace short term minefields. It is activated like a hand grenade and is configured and functions similar to the ADAM mine.

NOTE: *SHOW VIDEO TAPE:* "DU Test Firing"

(7) **DU Safety**

(a) GENERAL INFORMATION CONCERNING DU MUNITIONS:

Color----------Black w/white markings
Muzzle Velocity------4925 + ft/sec

[1] The exterior surface of kinetic energy penetrating munitions are painted black with white lettering for easy identification. Although most kinetic energy munitions use DU for their penetrator, a limited number have been produced with tungsten.

[2] Here are some of the warning statements placed in technical manuals concerning DU munitions.

WARNING

Firing the M833 at ammunition temperatures above +125°F may result in excessive chamber pressures. Firing at ammunition temperatures below -35°F may result in weapon damage.

WARNING

The M900 is authorized for use in M1 tanks only. Firing the M900 from any other 105mm tank system may result in failure of the gun mount. Firing in unauthorized gun mounts will result in failure of the recoil mechanism hydraulic seals.

WARNING

Do not fire the M900 from 105mm, M68 series cannon equipped with breeches having serial numbers lower than 4804. These breeches can fail catastrophically without warning. Initial quantities may be stenciled with a note indicating

a cutoff point at serial number 6000. This number should no longer be considered valid.

WARNING

Do not fire the M900 cartridges where the projectile is loose within the case; i.e., rotating, wobbling, rattling, or any other unsecured manner. This condition may result in excessive pressure during firing resulting in catastrophic breech failure.

WARNING

Hatches must remain closed and the turret vent blower must remain on when firing to prevent buildup of toxic carbon monoxide gas.

WARNING

The cartridge, 25mm APFSDS-T M919 utilizes Depleted Uranium(DU) that emits very low level radiation. Care must be taken when handling this round to avoid direct contact with the DU penetrator.

WARNING

If the cartridge is exposed to adverse conditions, the probability of corrosion of the DU penetrator will increase. Evidence of DU corrosion is visible in the form of a yellowish or white powder or stain seen on the outer surface of the projectile, and can become a hazard to personnel.

NOTE: *SHOW SLIDE RAD_04_09*

[2] All Army munitions containing DU penetrators are full service ammunition which may only be fired during war emergency. All peace time firings are prohibited except on ranges with special NRC license and/or with host nation agreement.

(b) DU is frequently misunderstood which has resulted either in excessive or insufficient safety controls. **Although potential users may believe that handling DU presents a complex safety problem, the fact remains that DU is the least hazardous when compared to the hazards presented by the propellant charge.** Sound hygiene practices afford adequate protection.

(c) DU ammunition is not to be disposed of by burning, detonation or buried nor will this ammunition be stored with pyrotechnics or incendiaries.

(d) If cartridges containing DU projectiles are damaged to the point where the internal projectile components are visible, they shall be treated as confidential. The damaged cartridge shall be wrapped in plastic and placed in a container or otherwise covered to prevent exposure. The cartridge shall be returned in a sealed container (as classified material) to the appropriate ASP for disposition.

(e) The Army ships DU munitions under Department of Defense exemption 9649. Under this exemption DU munitions are shipped according to the primary hazard which is the explosives (propellant). As long as "DOT-E 9649" is stenciled on the outside, the package is not required to be labeled as containing radioactive material and allows a slightly higher surface dose rate (up to 2mR/hr) than what is used for exepted (unlabelled) radioactive material (up to 0.5mR/hr).

NOTE: *Show slide RAD_04_10*

NOTE

Loss or unauthorized firing of depleted uranium rounds must be reported through the chain of command as soon as discovered. All transmissions regarding incidents of this nature must be classified at least CONFIDENTIAL. HQ AMCCOM must be notified within 24 hours of the discovery. Violations may result in a personal fine or imprisonment. Failure to report a noncompliance is punishable under federal law. Report to:

COMMANDER; IOC
ATTN: AMSIO-DMW
ROCK ISLAND, IL 61299-6000

DSN 793-0338/2969/1766
AC (309) 782-0338/2969/1766

Non duty hour, call staff duty officer:

DSN 793-3510/4815
AC (309) 782-3510/4815

NOTE: *SHOW SLIDE RAD_04_11*

(8) Radiation exposure from DU, in most situations, is of minor significance and is controllable. If in that rare event the dose limits have been exceeded due to exposure to DU, the actual over-exposure is less significant than the fact that safety controls

have not functioned as required by law. Minor over-exposures make no significant changes to the individual's total risk situation, but the existence of the over-exposure usually indicates deficiencies or mismanagement which could eventually lead to a complete loss of controls.

(9) DU presents a two fold hazard:

(a) CHEMICAL TOXICITY The chemical hazard of DU is slightly greater than the radiological hazard. Chemical toxicity is only present after the victim has absorbed the contamination into the blood stream. Normally the body is capable of eliminating over 90% of the radioactive material through the bowels and urine.

(b) IONIZING RADIATION DU presents an ionizing radiation hazard when:

- Sufficient quantities are taken into the body.
- When large amounts of DU with a large surface area are present in a very close proximity to the body for an extended period.

(10) Fortunately, DU is absorbed to a very limited extent through unbroken skin or the gastrointestinal tract; and its specific activity is quite low in comparison with most other radioactive elements. Overexposure to either hazard is rare and easily prevented by maintaining adequate safety controls and training of personnel involved with DU.

(11) **EXTERNAL RADIATION**

(a) DU contains a series of radioactive elements (daughter products) that commonly emit either alpha or beta particles; this emission may also be accompanied by gamma ray activity. All of the alpha and most of the beta radiation emitted by the DU penetrator is effectively shielded by the shell casing, discarding sabot and aluminum wind screen while the ammunition is intact. Handling the bare DU penetrator greatly increases the potential for external and internal radiation exposures.

[1] ALPHA EMISSIONS do not present any external radiation hazard.

[2] GAMMA RAY ENERGY is so low that for practical purposes it constitutes no hazard.

[3] BETA RADIATION accounts for nearly all the penetrating radiation from DU. But, the beta intensity rapidly decrease with distance.

(b) In keeping with US Army ALARA policies, any vehicle or object struck by DU munitions should be considered contaminated. Any M1A1 Abrams tank which has received combat damage resulting in ignition of stored DU munitions, onboard fires, or has been struck by missiles should be treated as contaminated until inspected by qualified personnel. Fortunately, DU armor and ammunition **does not** constitute a serious external radiation hazard. It is not necessary to use massive shielding or special manipulating devices to decrease exposure in working with DU. There is relatively little radiation exposure at a few feet from the material.

(12) **INTERNAL RADIATION -** DU can gain access to the body by way of injection, ingestion, or inhalation. Inhalation is the principle safety hazard in dealing with DU compound.

(a) ABSORPTION through unbroken skin is negligible. Absorption via injection is likely to occur in such cases as contamination of open wounds.

(b) Absorption by INGESTION is approximately 1% of the intake.

(c) INHALATION of DU is the most significant mode of entry. Once in the body, DU can cause damage by ionizing radiation. The principle radiation hazard from internal deposits of DU is the intense ionization in tissue produced by alpha particles emitted during the radioactive decay process. The energy of the alpha particles is absorbed in the first 0.1mm of tissue, resulting in localized cellular damage while the beta and gamma radiation emissions dissipate their energies in relatively large volumes of tissue and produce comparatively little damage. The remaining *insoluble* DU particulate is deposited primarily in the respiratory system.

NOTE: *SHOW SLIDE RAD_04_12*

(13) **CHEMICAL TOXICITY** - Once DU enters the blood stream in a chemically active form, it may be toxic to the kidney and other internal organs. DU dust is relatively insoluble and so physiologically inert that they are considered as radiological rather than toxicological hazards. These are deposited primarily in the respiratory system from which they are mobilized slowly. The more soluble components of DU are quickly taken into the blood stream via the lungs or contaminated wounds and may result in significant deposits in the kidney. Once there, some of the DU combines with the protein of cell walls, poisoning the cells and interfering with the vital functions of waste elimination and maintenance of electrolyte

balance. The DU does not remain fixed in the kidney, but is eliminated at a rate of about half every two weeks. Moderately severe damage to the kidney as a result of acute exposure is repairable, and a return toward normal kidney function may occur even during continued exposure.

c. Summary: All students should now have sufficient knowledge to avoid any of the hazards of handling and maintaining items that contain depleted uranium to include what it is, where it is used, and specific handling procedures.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

Regulations & NRC Licenses

The development of the nuclear reactor and the production of large amounts of artificial radioactivity created the potential for injury on an unprecedented scale. Governments realized that extraordinary measures were necessary to protect radiation workers and the public from excessive exposure to radiation. The result, as every user of radionuclides knows, was the enactment of extensive legislation, the establishment of regulatory bodies and licensing mechanisms, the setting of standards for radiation exposure, and the requirements of training for radiation workers to conform with accepted practice in working with radionuclides.

Radiological operations should be carefully planned to minimize the risk to personnel and property.

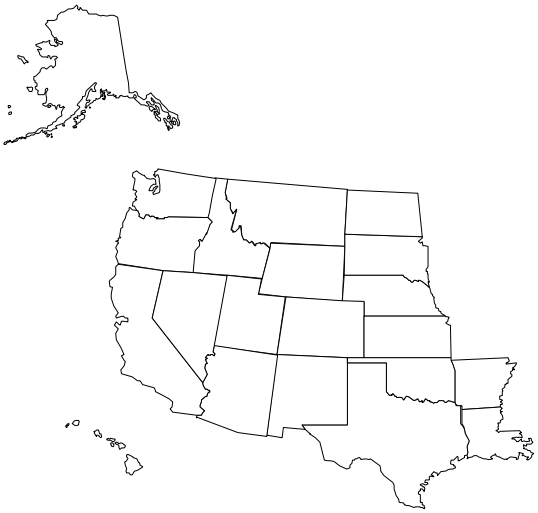
Prior to 1950 there were essentially no formal regulatory codes relating to radiation in the US. The Atomic Energy Commission (AEC) had been established in 1946, but the enabling Act was imprecise on the matter of establishing radiation protection standards, so the agency had no action. The atomic Energy Act of 1954 was more definitive, so the AEC was engaged in formulating some rules. Its area of influence was restricted to "by product material, source material and special nuclear material", that is, they had no jurisdiction over x-ray machines, accelerator produced isotopes, the accelerators themselves, naturally occurring radioisotopes, or the multitude of devices producing non-ionizing, but potentially hazardous, radiation.

The Nuclear Regulatory Commission (NRC) was established in 1974. General radiation responsibility remains with the NRC, although the Department of Energy (DOE) retains the authority in relation to nuclear energy research and development activities within its own organization and those conducted by its contractors.

REGION I
475 Allendale Road
King of Prussia, PA 19406-1415
(800) 432-1156

REGION II
101 Marietta St. NW, Suite 2900
Atlanta, GA 30323-0199
(800) 577-8510

REGION III
801 Warrenville Road
Lisle, IL 60532-4351
(800) 522-3025



REGION IV
611 Ryan Plaza Dr., Suite 400
Arlington, TX 76011-8064
(800) 952-9677

WALNUT CREEK FIELD OFFICE
1450 Maria Lane
Walnut Creek, CA 94596-5368
(800) 882-4672

To fully comprehend the many codes and regulations governing the use, transportation, and disposal of radioactive material it is important to understand the different types of standards.

A **STATUTORY REGULATION** is a legal statement actually written into a government code. It carries the force of law which means that penalties can and will be imposed for noncompliance. Regulations are generally written in the form of basic principles and philosophy to avoid complications if legislators attempt to write codes too specifically. By keeping the language general, future changes in practice and loopholes can be dealt with through interpretations by the regulatory agency. For example, the word "appropriate" might be used. At no place in the regulation is "appropriate" spelled out. As the state of the art changes, the interpretation by the NRC of "appropriateness" also changes.

A **DoD REGULATION** is the lead federal agency appointed to draw up detailed interpretations from statutory regulations for each branch of service. These regulations may be equally or more stringent than statutory requirements but will not be any less stringent.

ARMY REGULATIONS are derived from DoD requirements and are applicable to all Department of the Army personnel.

A **REGULATORY GUIDE** is published to describe and to make available to the public the methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations. Guides define techniques used in evaluating specific problems and postulated accidents, and to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, so compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license.

A **LICENSE** is another means of standardizing radiation protection. By its nature, a license condition carries the force of law relative to the license into which it is incorporated. Citations can and will be issued if the licensee does not live up to the specified conditions of the license.

NRC Regulatory Position. The Nuclear Regulatory Commission (NRC) requires licensees to minimize the radiation exposure to all workers. Much of the effort of the NRC is devoted to providing personnel protection against the radiation hazards present within a facility. However, radiation safety requires everyone's best effort and

Student Notes

attention. Title 10CFR20.1 states that licensees shall make every reasonable effort to maintain exposures to radiation as far below the limits specified in Title 10CFR20 as reasonably achievable.

Employer Responsibility

Any US Military facility or installation that conducts activities licensed by the NRC **must comply with NRC requirements.** The NRC is empowered to impose fines and revoke, suspend, or modify the installation's license.

Your supervisor is required to inform you of any NRC radiation requirement which applies to your duty or position and must post "NRC Notices of Violation" involving radiological working conditions.

In order to provide a conservative application of radiation protection exposure limits, it is recommended that each facility utilize what are called "Administrative Control Levels". These levels are more restrictive than the limits imposed by the NRC. If an installation exceeds NRC legal limits, without having applied for a waiver, the installation has in essence broken the law.

Your Responsibility

For your own protection and the protection of others, you should make an effort to learn what NRC requirements relate to your work and obey them. If you observe violations, you should report them.

You can request an NRC inspection. NRC inspectors are protected by Federal Law. Anyone who interferes with their inspections is subject to criminal prosecution.

If you believe that violations of NRC rules or of the terms of the installation license have occurred you should report them **immediately** through the chain of command or your immediate supervisor. If you believe that adequate corrective action is not being taken, you can report your finding to the nearest NRC inspector or the nearest NRC Regional office.

Your employer may not prevent you from contacting an NRC inspector. Additionally, you may talk privately with an inspector and request that the identity remain confidential.

Student Notes

To contact the NRC you call the nearest regional office **collect.**

You are protected by Federal Law against any adverse actions resulting from your contact with the NRC. No employer may fire you or discriminate against you with respect to pay, benefits, or working conditions because you helped the NRC. The penalties for employers who conduct adverse actions against employees are:

- Fines or suspension
- Revocation or suspension of Radiation License
- Compensation to employee

If you work with radioactive materials or in a radiation controlled area, the amount of radiation exposure that you may legally receive is limited by the NRC. The limits are specified in sections 20.101, 20.103, and 20.104 of Title 10 CFR 20. While those are the maximum allowable limits, your employer should also keep your radiation exposure as far below those limits as is reasonably achievable.

Your most important individual responsibility is to **keep your personal exposure to radiation AS LOW AS REASONABLY ACHIEVABLE (ALARA).**

Radiation Protection Officer (RPO)

The commander of an installation or activity where radioactive material is used or stored will appoint a Radiation Protection Officer (RPO), who will provide consultation on radiation hazards and control procedures.

The RPO must be **on orders** and technically qualified by virtue of education, training, and/or experience to assure a capability commensurate with the assignment. The term "RPO" is a functional title and is not intended as, and does not denote, a commissioned status or job classification with the Armed Forces (AR 40-14).

The RPO is the "resident technical expert" on radiation matters. You are doing a disservice to yourself and others by not consulting with the local RPO when you have a concern relating to radiation or radioactive materials or methods.

Student Notes

The duties of the local RPO include, but are not limited to:

All aspects of radiation protection in the sorting, handling, reporting, disposal, and shipping of radioactive material.

Inspection and survey monitoring as necessary to ensure that persons working with radioactive materials are complying with the designated safety measures and are not working under unsafe conditions.

Investigation of radiation incidents and submittal of reports on overexposure.

Providing guidance for protective clothing and equipment needed and when such equipment is warranted.

Instruct personnel working with radioactive materials. Personnel working in an area and/or handling radioactive material or waste will be informed of the following:

[a] The presence of radioactive materials in the workplace and the level of radiation emitted therefrom.

[b] The specific safety problems associated with radiation exposure.

[c] Proper precautions and procedures to minimize exposure.

[d] In the case of NRC controlled or licensed materials, personnel shall also be informed of the provisions of the applicable NRC regulations. i.e. The warning narrative inside technical manuals and the warning labels on equipment.

Must be familiar with applicable regulations.

The program's primary purpose is to provide management with a means to assure that exposure is kept to a minimum or as low as reasonably achievable IAW Title 10 CFR and AR 40-5.

Student Notes

NRC Licenses

12-00722-06

This license is for all **Tritium** illuminated Fire Control devices used by U.S. Army, U.S. Navy, and U.S. Marine Corps civilian and military personnel worldwide.

This licenses covers the **Tritium** illuminated devices used on fire control for howitzers, mortars, and the muzzle reference sensor used on M1 series tanks.

Sources range in size from 0.075 Ci - 10 Ci each. The license covers up to 950,000 Ci total.

Inventories must be kept at the user level by the hand receipt holder and annual physical inventories must be performed IAW AR 710-2 and AR 740-26.

The license covers the use of items by U.S. Army, Marine Corps, and Navy.

Training to the user consists of warning pages in the TMs. A new requirement adds a mandatory one hour radiation safety class on **Tritium**.

Maintenance is allowed below the depot level for the replacement of modules, level vials, and potted sources. Training consists of warnings and instructions in the TMs. A new requirement mandates four hours of radiation safety training and SOPs covering handling, annual audits by the installation RPO, quarterly monitoring of areas where devices are stored or used, and emergency procedures to include the availability of bioassay kits.

The license also covers depot level maintenance at Letterkenny, Anniston, Rock Island Arsenal, and Marine Corps Logistics Base - Albany and Barstow. At these installations the **Tritium** modules can be repaired and **Tritium** vials replaced. Depot level maintenance requires radiation safety trained personnel, monthly bioassays of maintenance personnel, fume hoods, surveys, and strict adherence to the depot SOPs.

Student Notes

12-00722-06 (cont.)

This license is for all **Tritium** illuminated Fire Control devices used by U.S. Army, U.S. Navy, and U.S. Marine Corps civilian and military personnel worldwide.

Bulk storage (more than 1,000 Ci) is allowed only at specific license-designated depots:

Letterkenny
Anniston
Red River
Sharpe
New Cumberland
Rock Island Arsenal
Marine Corps Logistics Base - Barstow
Marine Corps Logistics Base - Albany

Special requirements for depot storage areas are:

RPO and Alternate
Monthly surveys
Signs posted
Physical inventories
Liquid scintillation counter
Air monitors
Trained personnel

Depot storage is limited to 10,000 Ci per room or area delineated by a 10 ft. aisle and the area must have **Tritium** air monitors.

Field level storage of **Tritium** devices is limited to 200 Ci in one room.

Student Notes

12-00722-13

This license is for the **Americium241** in the M43A1 Chemical Agent Detector used by U.S. Army, U.S. Navy, and U.S. Marine Corps civilian and military personnel worldwide.

This license is for **Americium241** used in the M43A1 Chemical Agent Detector. No single cell can exceed 300 µCi and the total of all cells in the inventory can not exceed 25 Ci which is a maximum of 100,000 source components.

Sealed sources or detector cells containing **Americium241** shall not be opened or sources removed from the source holder.

The cell module can be replaced only at authorized depot locations or by properly trained intermediate direct support maintenance personnel.

User Requirements:

Technical Manuals apprise the user of the hazards associated with the devices and specify precautions that must be taken. This information is sufficiently broad in scope to cover the **use** of the device throughout its life cycle.

Removal of the cell module and pump module for any reason at the **user** level is prohibited. Installations authorized to possess and use the detectors will have either an appointed Chemical, Biological Radiological (CBR) officer, a Radiation Protection Officer (RPO) or an accountable individual designated to ensure local compliance with the requirements of this license.

User training must include a 2 hour portion addressing radiation safety, including hazards associated with **Americium241**, emergency procedures, maintenance restrictions, serial number tracking, and other radiation safety information associated with the equipment.

When used indoors a 0.2 micron exit port air filter must be used.

Student Notes

12-00722-13 (cont.)

This license is for the **Americium241** in the M43A1 Chemical Agent Detector used by U.S. Army, U.S. Navy, and U.S. Marine Corps civilian and military personnel worldwide.

User storage areas will be secured against unauthorized access and be located to be free from danger of flooding and be outside the danger radius of flammables and explosives.

Maintenance Requirements:

Technical Manuals apprise the user of the hazards associated with the devices and specify precautions that must be taken.

Personnel performing maintenance of the M43A1 involving removal of the pump or cell module and who perform the wipe testing must have at least 8 hours of radiation safety training which includes hazards of **Americium241**, radiation units of measure, biological effects of radiation, radiation detection instruments, wipe testing, serial number tracking, and emergency procedures.

Maintenance personnel must have an AN/PDR-56, AN/PDR-77, or equivalent alpha meter.

Maintenance areas must be surveyed at the end of each work day that maintenance is performed.

Survey equipment used to evaluate wipe tests will be calibrated by an alpha reference source traceable to the National Bureau of Standards at least every three months, and checked by an alpha source prior to each day's operation.

Depot Requirements:

Depot Maintenance Work Requirements (DMWR) apprise maintenance personnel of the hazards associated with the devices and specify precautions that must be taken.

Student Notes

12-00722-13 (cont.)

This license is for the **Americium**^{241} in the M43A1 Chemical Agent Detector used by U.S. Army, U.S. Navy, and U.S. Marine Corps civilian and military personnel worldwide.

Each depot should have a designated RPO and at least one alternate.

Depot storage areas will have all the requirements of user storage areas and will be posted with signs stating “Radioactive Material” and will be monitored monthly with portable radiac equipment. In addition, storage areas will be wipe tested quarterly.

The source must be tested for leakage and/or contamination at intervals not to exceed 3 years according to the license. There also was a Safety-Of-Use Message 95-04 , that change the wipe test from 3 years to 1 year.. Any source received which is not accompanied by a certificate indicating that a test was performed within 3 years before transfer must not be put into use until tested.

Any source in storage and not being used need not be tested. When the source is removed from storage for use or transfer it must be tested before use or transfer.

The cell module of the M43A1 is serialized and is tracked throughout its life cycle by the Radiation Testing and Tracking System (RATTS). Transactions are processed for every shipment, receipt, wipe test, cell removal and replacement action.

Licensed material may be stored at the Marine Corps Logistics Base - Albany, GA and may be used at U.S. Army, Marine Corps, or Navy installations throughout the United States.

The licensee must conduct a physical inventory annually to account for all **Americium241** cell modules received and possessed under the license. Inventory records must be maintained for inspection by the NRC.

Student Notes

12-00722-14

This license is for the **Nickel63** in the Chemical Agent Monitor used by U.S. Army, Defense Logistics Agency, and U.S. Marine Corps civilian and military personnel worldwide.

This license is for **Nickel63** used in the drift tube module of the Chemical Agent Monitor (CAM). The source is a cylindrical metallic foil containing 10 mCi of **Nickel63** plated on a brass cylinder. This cylinder is held in a Teflon housing which is installed in a larger aluminum alloy cylinder.

Each source can not exceed 12 mCi each and there can be no more than 1000 Ci total from all sources in the system.

The foil source will not be removed from the drift tube module.

The drift tube module can only be replaced by the contractor, designated depot facilities, or properly trained direct support personnel.

Maintenance operations on the CAM will not include or involve any repair or contact with the **Nickel63** plated source.

Direct support maintenance facilities will have an AN/PDR-77 or AN/VDR-2 Radiac Set (or equivalent) and the maintenance area will be surveyed at the end of each work day that maintenance is performed.

Depot maintenance facilities will have a liquid scintillation counting system.

Training Requirements:

User:

Technical Manuals apprise the user of the hazards associated with the devices and specify precautions that must be taken. This information is sufficiently broad in scope to cover the **use** of the device throughout its life cycle.

Student Notes

12-00722-14 (cont.)

This license is for the **Nickel**^{63} in the Chemical Agent Monitor used by U.S. Army, Defense Logistics Agency, and U.S. Marine Corps civilian and military personnel worldwide.

Installations within the U.S. Army and U.S. Marine Corps authorized to possess the CAM will have either an appointed Chemical Officer, an RPO, or an accountable individual designated to ensure local compliance with the requirements of the license.

Maintenance Personnel (DS):

Technical Manuals apprise the maintenance personnel of the hazards associated with the devices and specify precautions that must be taken.

Personnel performing the interior maintenance and annual wipe tests must have a minimum of 8 hours radiation training on:

1. Structure of matter, radiation units of measure, absorption of radiation and shielding.
2. Specific hazards of **Nickel63**.
3. Radiation detection instruments.
4. Emergencies and decontamination.
5. Army regulations governing use, storage, transfer, and disposal.
6. 10 CFR parts 19, 20, and 21.
7. Transactions required for serial number tracking.
8. Wipe testing.

Maintenance Personnel (Depot):

Depot Maintenance Work Requirements (DMWR) apprise maintenance personnel of the hazards associated with the devices and specify precautions that must be taken.

Each depot should have a designated RPO and at least one alternate.

Student Notes

12-00722-14 (cont.)

This license is for the **Nickel**^{63} in the Chemical Agent Monitor used by U.S. Army, Defense Logistics Agency, and U.S. Marine Corps civilian and military personnel worldwide.

The CAM must be wipe tested annually except while in depot storage. When transferred between accountable officers, the CAM will be wipe tested before use if the annual wipe test has not been performed with in the last 6 months. The owning installations are responsible for ensuring the wipe tests are performed annually whether they receive notification or not.

The user must turn the CAM in to direct Support for maintenance and wipe test.

Depot storage areas will have all the requirements of user storage areas and will be posted with signs stating "Radioactive Material" and will be monitored monthly with portable radiac equipment. In addition, storage areas will be wipe tested quarterly.

Any source in storage and not being used need not be tested. When the source is removed from storage for use or transfer to another person, it must be tested before use or transfer.

The drift tube module has a serial number and will be tracked throughout its life cycle using the Radiation Testing and Tracking System (RATTS).

The licensee must conduct a physical inventory every 12 months to account for all plated sources received and possessed under the license. Inventory records must be maintained for 2 years.

No manufacturing will be performed under this license. No maintenance under contract at the contractor's facility will be performed under this license. The contractor must obtain their own NRC license

Student Notes

21-01222-05

This license is for the **Cesium137** and **Americium241** in the MC-1 Density and Moisture Tester used by U.S. DoD activities worldwide.

This license is for **Cesium137** and **Americium241** used in the **Density and Moisture Tester, Campbell Pacific Model MC-1**.

Licensed material shall be used only at temporary job sites of the licensee anywhere in the United States where the U. S. NRC maintains jurisdiction for regulating the use of licensed material.

The MC-1 will be used by or under the direct supervision and in the physical presence of properly trained individuals.

The licensed sources shall be wipe tested at intervals not to exceed 6 months.

Any source received from another person which is not accompanied by a **certificate** indicating that a test was performed within 6 months before the transfer shall not be put into use until tested.

Any source in storage and not being used need not be tested. when the source is removed from storage for use or transfer to another person, it shall be tested before use or transfer.

If the test reveals contamination the source shall be removed from service and decontaminated, repaired, or disposed of IAW NRC regulations. A report shall be filed within 5 days of the date the leak test results are known with the NRC. The report shall specify the source involved, the test results, and corrective actions taken.

Records of leak test results shall be maintained for inspection by the NRC.

Tests for leakage and of contamination shall be performed by the licensee or by other persons specifically licensed the NRC.

Student Notes

21-01222-05 (cont.)

This license is for the **Cesium**^{137} and **Americium**^{241} in the MC-1 Density and Moisture Tester used by U.S. DoD activities worldwide.

Seal sources containing licensed material shall not be opened or removed from the MC-1 by the licensee.

When using the MC-1 at temporary job sights the authorized user shall not leave the device unattended. Upon completion of mission the device shall be locked in the licensee's vehicle or a secure building to prevent unauthorized use, loss, or theft.

The licensee shall conduct physical inventory every 6 months. Records of inventory shall be maintained for inspection by the NRC for a period of 2 years.

Except as specifically provided otherwise in the license, the licensee shall conduct it's radiation protection program IAW the statements, representations, and procedures contained in the documents including any enclosures, listed below:

- Complete POI and Lesson Outline for the Soil Analysis Course offered by the U.S. Army Engineer Center.
- **TM 5-6635-386-12&P** - UNIT MAINTENANCE MANUAL FOR TESTER, DENSITY AND MOISTURE (SOIL AND ASPHALT); NUCLEAR METHOD; CAMPBELL PACIFIC MODEL MC-1.

Student Notes

SUC-1380

This license is for Depleted Uranium used by Army fielding and storage

The Army's primary fielding and storage license for DU ammunition is, SUC-1380, is issued to the Industrial Operations Command (IOC), AMSIO-DMW.

A copy of SUC-1380 and TB 9-1300-278 must be maintained on-post.

Models of DU munitions range in weight (of DU) from a little less than 1 kilogram up to 4.8 kilograms, each.

Authorized activities include; storage, receipt, shipment, handling, inspection, minor maintenance, transportation, and render-safe.

Bulk storage (10 million kilograms) is authorized to the following Army installations; Anniston, Bluegrass, Crane, Hawthorn, Letterkenny, McAlester, Red River, Seneca, Sierra, and Tooele.

Non-bulk storage is authorized, for smaller quantities of DU, in any Army installation worldwide.

RPOs of bulk storage depots will have attended the Army's 3-week Rad Safety course at Ft. McClellan or have equivalent training and experience. Non bulk storage installations will have personnel trained in radiological matters commensurate with their responsibilities.

Workers or soldiers handling DU monition are not required to wear personnel dosimetry.

Installations storing DU munitions will perform annual inventories and maintain an inventory listing of DU munitions. Inventory listings will be provided to installation fire and security departments.

Student Notes

SUC-1380

This license is for Depleted Uranium used by Army fielding and storage

Structures used for the storage, shipping, or other handling of DU munitions will be included in the installation RPO's rad survey program.

Storage structures must be posted in accordance with 10 CFR.

Warning statements in TMs and annual on-post training provided by the installation RPO is considered adequate radiological instruction.

NASA are allowed to perform visual inspections of DU munitions. Inspection criteria directs when wipe tests are to be taken.

Installations are required to have written procedures (SOPs) in place for authorized activities involving Du munitions.

Installations must have written emergency and decontamination procedures.

Installations storing large quantities of DU munitions, or installations storing smaller quantities of DU munitions and other radioactive material are required to have Ionizing radiation control Committee meetings.

Student Notes

SUC-1380

This license is for Depleted Uranium used by Army fielding and storage

Theft, loss, damage, destruction, accident, disassembly, firing, burial, or unauthorized use must be reported to

DIRECTOR
HQ IOC
Att. AMSIO-DMW
ROCK ISLAND, IL
61299-7630

DSN 793-0338/2969/1766,
AC (309) 782, 0338/2969/1766

Student Notes

BML12-00722-07

This license is for Promethium-147 used on the LAW by Army

Storage is authorized at DOD installations worldwide

The LAW rocket is allowed to be fired under this license. After firing the front sight is removed and stored as radioactive waste. Disposal actions must be coordinated with

DIRECTOR
HQ IOC
Att. AMSIO-DMW
ROCK ISLAND, IL
61299-7630

DSN 793-0338/2969/1766,
AC (309) 782, 0338/2969/1766

Storage structures must be posted **IAW 10 CFR.**

Installation RPOs will have attended the Army's 3-week Rad Safety course at Ft McClellan or have equivalent training and experience.

Workers or soldiers handling LAW rockets are not required to wear personnel dosimetry.

Installations storing LAW rockets will perform annual inventories and maintain an inventory listing of LAW rockets. Inventory listings will be provided to installation fire and security departments.

Structures used for the storage, shipping, or other handling of LAW rockets will be included in the installation RPO's rad survey program.

Warning statements in TM's and annual on-post training provided by the installation RPO is considered adequate radiological instruction.

Student Notes

BML12-00722-07

This license is for Promethium-147 used on the LAW by Army

Structures used for the storage, shipping, or other handling of LAW rockets will be included in the installation RPO's rad survey program.

Installations are required to have written procedures (SOPs) in place for authorized activities involving LAW rockets.

Installations must have written emergency and decontamination procedures.

Installations storing LAW rockets and other radioactive material are required to have Ionizing Radiation Control Committee meetings.

Theft, loss, damage, destruction, accident, disassembly, firing, burial, or unauthorized use must be reported to

DIRECTOR
HQ IOC
Att. AMSIO-DMW
ROCK ISLAND, IL
61299-7630

DSN 793-0338/2969/1766,
AC (309) 782, 0338/2969/1766

Student Notes

SOPs

Radiation safety SOPs should be ***tailored*** to the specific operations being conducted. Documents that are referenced in your SOP become part of your SOP and must be readily available. The following outline information is not intended to be all inclusive; but is provided as a guideline to the minimum that should be included in a good SOP. Check all federal, Army, local, and commodity requirements to ensure that you have covered all essential information for your operations.

General Outline

A. General.

1. **Purpose and objective of the SOP.**
2. **Applicability.**
3. **Responsibilities.**

B. Control of radioactive material.

1. **Procurement.**
2. **Receipt.**
3. **Safety rules.**
4. **Storage.**
5. **Inventory.**
6. **Surveillance.**

<*> REMEMBER <*>
ANY REGULATION OR PUBLICATION YOU REFERENCE IN THE BODY OF YOUR SOP BECOMES PART OF THE SOP AND MUST BE AVAILABLE.

C. Safety procedures (to include specifics for use and handling).

1. **Purpose.**
2. **Philosophy.**
3. **Safety rules.**
4. **Instruction to personnel.**
5. **Radiation protection standards.**
6. **Surveys.**
7. **Caution signs, labels, and signals**
8. **Radiological emergencies**

D. References.

Student Notes

NRC Regions

Region IV

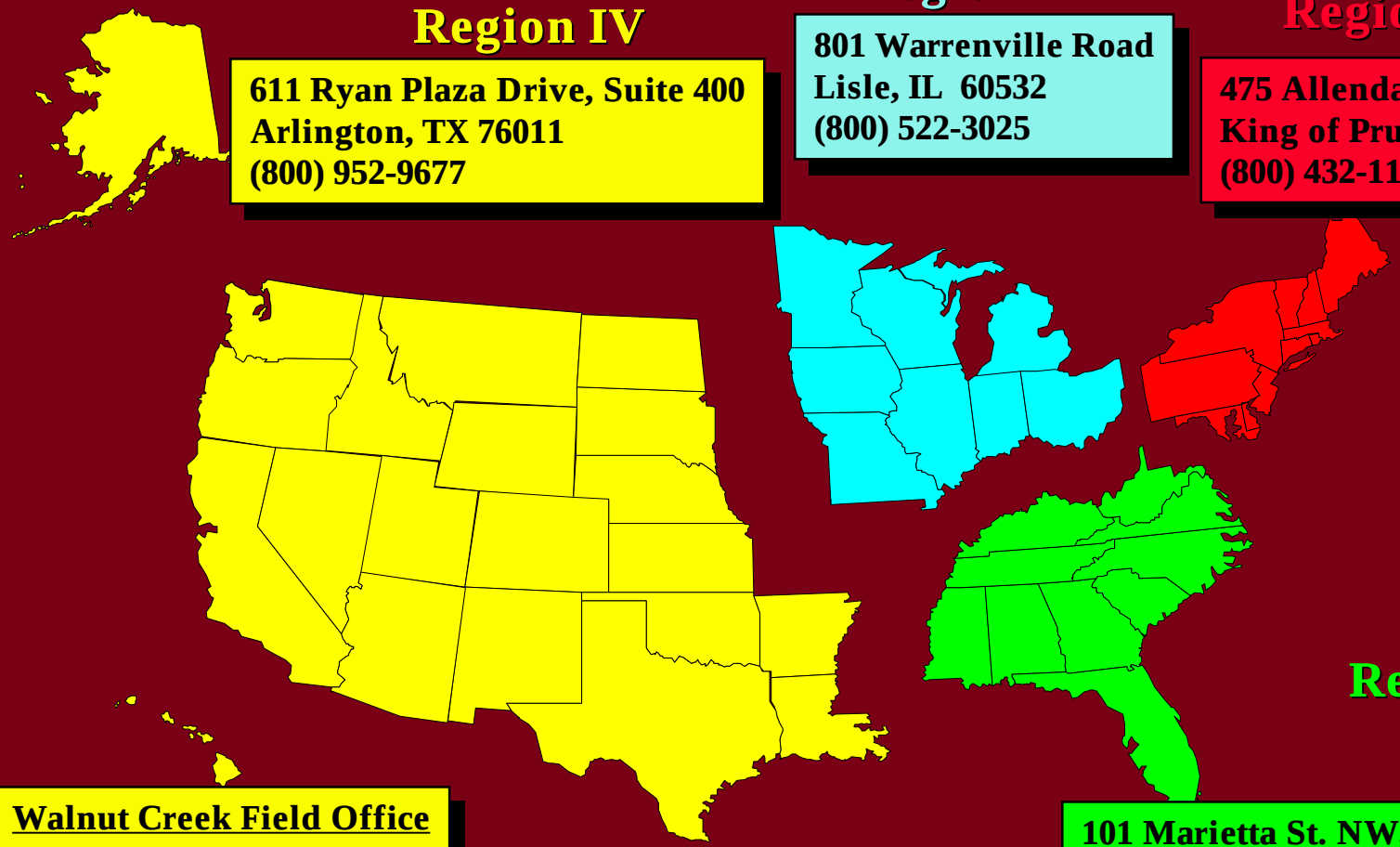
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011
(800) 952-9677

Region III

801 Warrenville Road
Lisle, IL 60532
(800) 522-3025

Region I

475 Allendale Road
King of Prussia, PA 19406
(800) 432-1156



Region II

101 Marietta St. NW, Suite 2900
Atlanta, GA 30323
(800) 577-8510

Walnut Creek Field Office
1450 Maria Lane
Walnut Creek, CA 94596
(800) 882-4672

Employer Responsibility

- Must comply with NRC requirements
  - NRC is empowered to:
    - Impose fines
    - Revoke or suspend the license
- Inform you of NRC requirements which apply to your job.
- Post "NRC Notices of Violation"
- Oversee local radiation protection program

Your Responsibility

- Know NRC Requirements for your job
- Report violations you observe
  - Report through your chain of command
  - You can request NRC inspection
    - Your employer can NOT prevent you from contacting the NRC directly
    - Identity can remain confidential
  - Protected by federal law from adverse actions
- Keep personal exposure ALARA

RPO Duties

- Must be on orders
- RPO duties take precedence over all other duties (AR 385-11)
- Must be technically qualified
- Duties include (but not limited to):
  - All aspects of the radiation protection program
  - Inspections and Surveys
  - Investigation of incidents
  - Provide guidance
  - Instruct personnel
  - Provide management with the means to keep exposures ALARA

NRC License 12-00722-06 (Tritium)

- *Covers fire control devices used by US Army, Navy, and Marine Corps civilian and military personnel worldwide*
- *Inventories must be kept at the user level*
- *1 hour training at the user level*
- *4 hours training to maintenance personnel*
- *SOPs must be posted*
- *Quarterly monitoring of storage areas*
- *Field storage limited to 200 Ci per room*
- *Baseline bioassays for maintenance personnel*

NRC License 12-00722-13 (Americium^{241})

- *Covers the M43A1 used by US Army, Navy, and Marine Corps civilian and military personnel worldwide*
- *Cell module replacement at depot level*

  or

  Properly trained DS level personnel
- *Removal of cell module NOT authorized at user level*
- *2 hours user training*
- *0.2 micron exit port filter for use indoors*
- *NOT to be stored with flammables or explosives*
- *Maintenance facilities must have actively calibrated alpha radiac meter*
- *Maintenance area surveyed daily*
- *Wipe testing required at least every 3 years*
- *Cell module must be tracked "Cradle to Grave"*

NRC License 12-00722-14 (Nickel^{63})

- *Cover CAMs used by US Army, Marine Corps, and DLA civilian and military personnel worldwide*
- *Drift tube module replaced by contractor, depot, or specially trained DS personnel*
- *Maintenance facility must have actively calibrated AN/PDR-27 (or equivalent)*
- *8 hours training for maintenance personnel*
- *Wipe tested at least annually*
- *Drift tube module tracked "Cradle to Grave"*

NRC License 21-01222-05 (MC-1)

- *Covers the MC-1 used by DoD activities worldwide*
- *Wipe test every 6 Months*
- *Wipe test shall be performed by the licensee or persons specifically licensed by the NRC*
- *The MC-1 must be secured or attended at all times*
- *The operators must be trained by the U.S. Army Engineer Center, Ft. Leonard Wood*
- *TLDs required for users/handlers*
- *Using Units must have an LRPO & an alternate*
- *TM is part of the license*

NRC License SUC-1380 (DU)

- Covers the fielding & storage for the Army
- A copy of license & TB 9-1300-278 must be maintained on-post.
- Bulk storage 10 million kilograms
- Non-bulk storage is authorized for small quantities
- RPOs of bulk storage at depots has to have attended Rad course at Ft. McCellan
- No personnel TLD is required
- Inventories will be performed annually
- Written SOPs
- Installations must have emergency and decontamination procedures

NRC LICENSE BML12-00722-07

- Storage is authorized at DOD installations world wide
- Is allowed to be fired
- Front sight has to be removed and stored as rad. waste
- Storage structures must be posted **IAW 10 CFR**
- **RPOs** attend Army's 3-week Rad Safety Course
- Annual inventory will be performed and a list be provided to the fire and security departments
- Annual training provided by **RPO**
- Written **SOPs** is required
- Installation have written emergency & decon. procedures
- Theft, loss, damage, accident, & Exc. **reported** to ***IOC***

SOPs

- Tailored to individual operations
- Documents referenced must be READILY available
- Must comply with ALL federal, Army, local, and commodity requirements

IRCC

Ionizing Radiation Control Committee

- Described in 10CFR35
- Recommended for all US Army Posts, Camps, and Stations
- Chaired by the Installation RPO
- Forum for coordinating the installation's Radiation Protection Program

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-05

DATE: Cot 96

TITLE: The Nuclear Regulatory Commission Licenses and Other Regulations

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 4.0 C (U)
0.0 PE

FACILITY RE: Classroom

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty

TRANSPORTATION: None

ISSUED TO STUDENTS: Student Handout

AIDS AND EQUIPMENT:
a. Overhead Projector
b. Computer Display Device
c. Computer
d. Display Screen
c. RAD_05.PPT file

REFERENCES:

TB 9-1300-278	"Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
Reference Guide	Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
10CFR20	“Standards for Protection Against Radiation”
NRC License 12-00722-06	
NRC License 12-00722-13	
NRC License 12-00722-14	
NRC License 21-01222-05	
AR 385-11	Ionizing Radiation Protection

COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: The Nuclear Regulatory Commission Licenses and other Regulations

1. Presentation: (This presentation is UNCLASSIFIED.)

a. Introduction:

(1) Objective: Provide information concerning the various licenses and regulations associated with radioactive materials.

(2) Reason and Tie-In:

(a) The development of the nuclear reactor and the production of large amounts of artificial radioactivity created the potential for injury on an unprecedented scale. Governments realized that extraordinary measures were necessary to protect radiation workers and the public from excessive exposure to radiation. The result, as every user of radionuclides knows, was the enactment of extensive legislation, the establishment of regulatory bodies and licensing mechanisms, the setting of standards for radiation exposure, and the requirements of training for radiation workers to conform with accepted practice in working with radionuclides.

(b) Radiological operations should be carefully planned to minimize the risk to personnel and property.

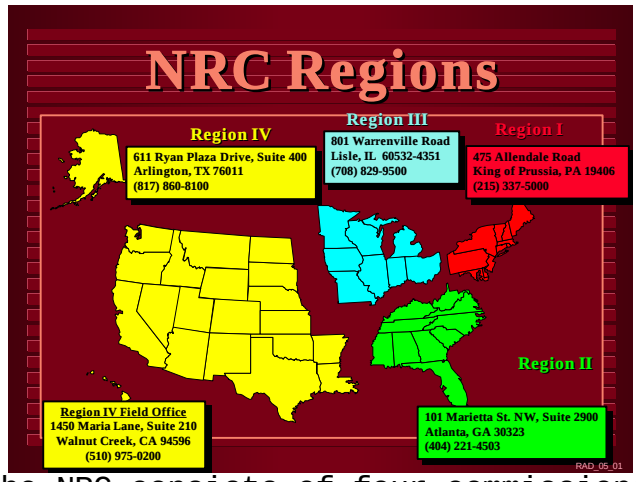
b. Explanation:

(1) Prior to 1950 there were essentially no formal regulatory codes relating to radiation in the US. The Atomic Energy Commission (AEC) had been established in 1946, but the enabling Act was imprecise on the matter of establishing radiation protection standards, so the agency had no action. The atomic Energy Act of 1954 was more definitive, so the AEC was engaged in formulating some rules. Its area of influence was restricted to “by product material, source material and special nuclear material”, that is, they had no jurisdiction over x-ray machines, accelerator produced isotopes, the accelerators themselves, naturally occurring radioisotopes, or the multitude of devices producing non-ionizing, but potentially hazardous, radiation.

(2) The Nuclear Regulatory Commission (NRC) was established in 1974. General radiation responsibility remains with the NRC, although the Department of Energy (DOE) retains the authority in relation to nuclear energy research and development

activities within its own organization and those conducted by its contractors.

NOTE: *SHOW SLIDE RAD_05_01*



(3) The NRC consists of four commissioners with supporting staff and four Regional Offices.

Region I
475 Allendale Road
King of Prussia, PA 19406-1415
(800) 432-1156

Region II
101 Marietta St. NW, Suite 2900
Atlanta, GA 30323-0199
(800) 577-8510

Region III
801 Warrenville Road
Lisle, IL 60532-4351
(800) 522-3025

Region IV
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064
(800) 952-9677

Walnut Creek Field Office
1450 Maria Lane, Suite 210
Walnut Creek, CA 94596-5368
(800) 882-4672

(4) Regulations established by the NRC are published in the Federal Register and become incorporated into the Code of Federal Regulations (CFR), Title 10, Chapter 1. The “Title” is divided into parts. References to the Code of Federal Regulations

are normally give in shorthand form, “10CFR20.1” for example, is Title 10, Part 20, Section 1. The CFR is an annually revised codification of the general and permanent rules published in the Federal Register. The revision date is printed on the cover of each volume. Each year’s cover is a different color for quick reference. Both the Federal Register and the CFR are issued by the US Government Printing Office and are available through the Superintendent of Documents, Washington, DC 20402.

(5) To fully comprehend the many codes and regulations governing the use, transportation, and disposal of radioactive material it is important to understand the different types of standards.

(a) A **STATUTORY REGULATION** is a legal statement actually written into a government code. It carries the force of law which means that penalties can and will be imposed for noncompliance. Regulations are generally written in the form of basic principles and philosophy to avoid complications if legislators attempt to write codes too specifically. By keeping the language general, future changes in practice and loopholes can be dealt with through interpretations by the regulatory agency. For example, the word “appropriate” might be used. At no place in the regulation is “appropriate” spelled out. As the state of the art changes, the interpretation by the NRC of “appropriateness” also changes.

(b) A **DoD REGULATION** is lead federal agency appointed to draw up detailed interpretations from statutory regulations for each branch of service. These regulations may be equally or more stringent than statutory requirements but will not be any less stringent.

(c) **ARMY REGULATIONS** are derived from DoD requirements and are applicable to all Department of the Army personnel.

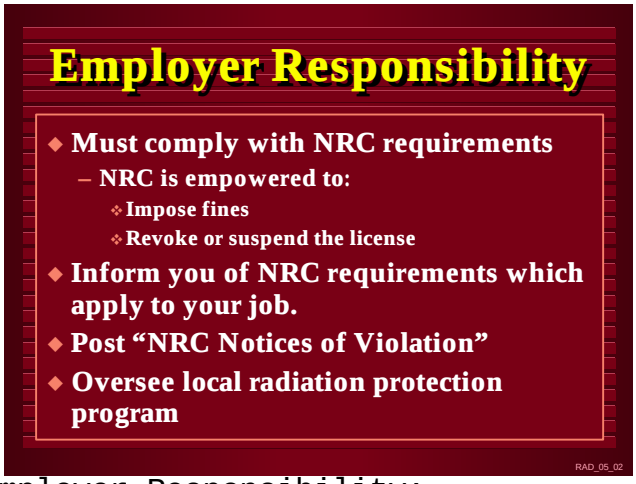
(d) A **REGULATORY GUIDE** is published to describe and to make available to the public the methods acceptable to the NRC staff for implementing specific parts of the Commission’s regulations. Guides define techniques used in evaluating specific problems and postulated accidents, and to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, so compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license.

(e) A **LICENSE** is another means of standardizing radiation protection. By its nature, a license condition carries

the force of law relative to the license into which it is incorporated. Citations can and will be issued if the licensee does not live up to the specified conditions of the license. The Army currently holds many NRC licenses which are maintained and managed by the individual MACOMs that are responsible for the devices and equipment that contain radioactive materials. Users of these devices and equipment are required to follow all requirements of the license held for that particular item. Any questions or concerns about licensed equipment should be directed through the appropriate RPO to the MACOM license holder.

(6) NRC Regulatory Position. The Nuclear Regulatory Commission (NRC) requires licensees to minimize the radiation exposure to all workers. Much of the effort of the NRC is devoted to providing personnel protection against the radiation hazards present within a facility. However, radiation safety requires everyone's best effort and attention. Title 10CFR20.1 states that licensees should make every reasonable effort to maintain exposures to radiation as far below the limits specified in Title 10CFR20 as reasonably achievable.

NOTE: *SHOW SLIDE RAD_05_02*



(7) Employer Responsibility:

(a) Any US Military facility or installation that conducts activities licensed by the NRC or using equipment that is controlled under a license held by any of the MACOMs must comply with all NRC requirements (to include all NRC License requirements) and all state and local requirements. The NRC is empowered to impose fines and revoke, suspend, or modify the license.

(b) Your supervisor is required to inform you of any federal, state, or local radiation requirement which applies to your duty or position and must post "NRC Notices of Violation" involving radiological working conditions.

(c) In order to provide a conservative application of radiation protection exposure limits, it is recommended that each facility utilize what are called "Administrative Control Levels". These levels are more restrictive than the limits imposed by the NRC. If an installation exceeds NRC legal limits, without having applied for a waiver, the installation has in essence broken the law.

NOTE: *SHOW SLIDE RAD_05_03*

(8) Your Responsibility:

(a) For your own protection and the protection of others, you should make an effort to learn what federal, state, and local requirements relate to your work and obey them. If you observe violations, you should report them. The recommended reporting chain is for you to first notify your RPO. It is the RPOs duty to then notify the MACOM license holder who will then notify the NRC if such reporting is required.

(b) **You can request an NRC inspection.** NRC inspectors are protected by Federal Law. Anyone who interferes with their inspections is subject to criminal prosecution.

(c) If you believe that violations of NRC rules or of the terms of the installation license have occurred you should report them **immediately** through the chain of command or your immediate supervisor. If you believe that adequate corrective action is not being taken, you can report your finding to the nearest NRC inspector or the nearest NRC Regional office.

(d) **Your employer may not prevent you from contacting an NRC inspector. Additionally, you may talk privately with an inspector and request that your identity remain confidential.**

(e) To contact the NRC you call the nearest regional office **collect.**

(f) You are protected by Federal Law against any adverse actions resulting from your contact with the NRC. No employer may fire you or discriminate against you with respect to pay, benefits, or working conditions because you helped the NRC. The penalties for employers who conduct adverse actions against employees are:

- Fines or suspension
- Revocation or suspension of Radiation License
- Compensation to employee

(g) If you work with radioactive materials or in a radiation controlled area, the amount of radiation exposure that you may legally receive is limited by the NRC. The limits are specified in sections 20.101, 20.103, and 20.104 of Title 10 CFR 20. While those are the maximum allowable limits, your employer should also keep your radiation exposure as far below those limits as is reasonably achievable.

(h) If there is a requirement to maintain exposure records (i.e. you are required to wear a personal dosimetry device) you can request a copy or your exposure records - DD Form 1141 "Record of Occupational Exposure to Ionizing Radiation" or computerized record. The criteria for maintaining a permanent radiation medical record is:

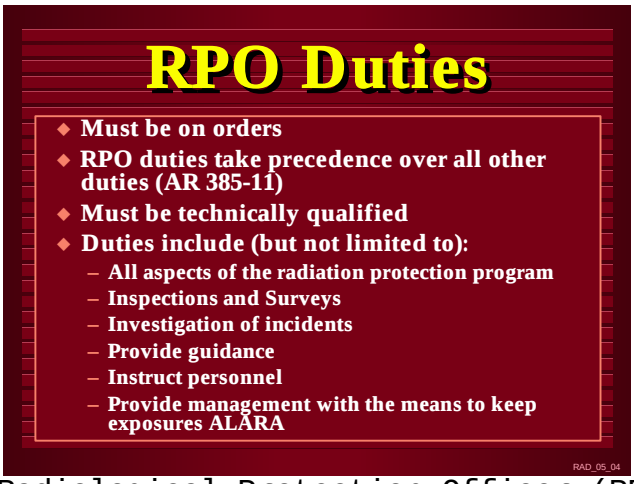
[1] Your job requirements indicate that you will receive radiation exposure above normal limits set by the NRC.

[2] You will exceed the exposure limits indicated in the installation's license.

(i) In either case if you are likely to receive a dose in excess of 25% of the legal limit, you must be supplied with personnel monitoring equipment such as a film badge or dosimeter.

(9) The NRC conducts regular inspections at installations to identify possible violations of requirements.

NOTE: *SHOW SLIDE RAD_05_04*



(10) Radiological Protection Officer (RPO)

(a) The commander of an installation or activity where radioactive material is used or stored will appoint a Radiological Protection Officer (RPO), who will provide consultation on radiation hazards and control procedures.

(b) The RPO must be technically qualified by virtue of education, training, and/or experience to assure a capability commensurate with the assignment. The term "RPO" is a functional title and is not intended as, and does not denote, a commissioned status or job classification with the Armed Forces (AR 40-14).

(c) The RPO is the "resident technical expert" on radiation matters. You are doing a disservice to yourself and others by not consulting with the local RPO when you have a concern relating to radiation or radioactive materials or methods.

(d) The duties of the local RPO include, but are not limited to:

[1] All aspects of radiation protection in the sorting, handling, reporting, disposal, and shipping of radioactive material.

[2] Inspection and survey monitoring as necessary to ensure that persons working with radioactive materials are complying with the designated safety measures and are not working under unsafe conditions.

[3] Investigation of radiation incidents and submittal of reports on overexposure.

[4] Providing guidance for protective clothing and equipment needed and when such equipment is warranted.

[5] Instruct personnel working with radioactive materials. Personnel working in an area and/or handling radioactive material or waste will be informed of the following:

[a] The presence of radioactive materials in the workplace and the level of radiation emitted therefrom.

[b] The specific safety problems associated with radiation exposure.

[c] Proper precautions and procedures to minimize exposure.

[d] In the case of NRC controlled or licensed materials, personnel shall also be informed of the provisions of the applicable NRC regulations. i.e. The warning narrative inside technical manuals and the warning labels on equipment.

[6] Must be familiar with applicable regulations.

(11) The program's primary purpose is to provide management with a means to assure that occupational exposure is kept to a minimum or as low as reasonably achievable IAW Title 10 CFR and AR 40-5.

(12) NRC Licenses

NOTE: *SHOW SLIDE RAD_05_05*

(a) **12-00722-06** This licenses covers the Tritium illuminated devices used on fire control for howitzers, mortars, and the muzzle reference sensor used on M1 series tanks.

[1] Sources range in size from 0.075 Ci - 10 Ci each. The license covers up to 950,000 Ci total.

[2] Inventories must be kept at the user level by the hand receipt holder and annual physical inventories must be performed IAW AR 710-2 and AR 740-26.

[3] The license covers the use of items by US Army, Marine Corps, and Navy.

[4] Training to the user consists of warning pages in the TMs. A new requirement adds a mandatory one hour radiation safety class on Tritium.

[5] Maintenance is allowed below the depot level for the replacement of modules, level vials, and potted sources. Training consists of warnings and instructions in the TMs. A new requirement mandates four hours of radiation safety training and SOPs covering handling, annual audits by the installation RPO, quarterly monitoring of areas where devices are stored or used, and emergency procedures to include the availability of bioassay kits.

[6] The license also covers depot level maintenance at Letterkenny, Anniston, Rock Island Arsenal, and Marine Corps Logistics Base - Albany and Barstow. At these installations the Tritium modules can be repaired and Tritium vials replaced. Depot level maintenance requires radiation safety trained personnel, monthly bioassays of maintenance personnel, fume hoods, surveys, and strict adherence to the depot SOPs.

[7] Bulk storage (more than 1,000 Ci) is allowed only at specific license-designated depots:

- Letterkenny
- Anniston
- Red River
- Sharpe
- New Cumberland
- Rock Island Arsenal
- Marine Corps Logistics Base - Barstow
- Marine Corps Logistics Base - Albany

Special requirements for depot storage areas are:

- RPO and Alternate
- Monthly surveys

- Signs posted
- Physical inventories
- Liquid scintillation counter
- Air monitors
- Trained personnel

[8] Depot storage is limited to 10,000 Ci per room or area delineated by a 10 ft. aisle and the area must have Tritium air monitors.

[9] Field level storage of Tritium devices is limited to 200 Ci in one room.

NOTE: *SHOW SLIDE RAD_05_06*

(b) **12-00722-13** This license is for americium-241 used in the M43A1 Chemical Agent Detector. No single cell can exceed 300 mCi and the total of all cells in the inventory can not exceed 25 Ci which is a maximum of 100,000 source components.

[1] Sealed sources or detector cells containing americium-241 shall not be opened or sources removed from the source holder.

[2] The cell module can be replaced only at authorized depot locations or by properly trained intermediate direct support maintenance personnel.

[3] User Requirements:

[a] Technical Manuals apprise the user of the hazards associated with the devices and specify precautions that must be taken. This information is sufficiently broad in scope to cover the use of the device throughout its life cycle.

[b] Removal of the cell module and pump module for any reason at the user level is prohibited. Installations authorized to possess and use the detectors will have either an appointed Chemical, Biological Radiological (CBR) officer, a Radiation Protection Officer (RPO) or an accountable individual designated to ensure local compliance with the requirements of this license.

[c] User training must include a 2 hour portion addressing radiation safety, including hazards associated with americium-241, emergency procedures, maintenance restrictions, serial number tracking, and other radiation safety information associated with the equipment.

[d] When used indoors a 0.2 micron exit port air filter must be used.

[e] User storage areas will be secured against unauthorized access and be located to be free from danger of flooding and be outside the danger radius of flammables and explosives.

[4] Maintenance Requirements:

[a] Technical Manuals apprise the user of the hazards associated with the devices and specify precautions that must be taken.

[b] Personnel performing maintenance of the M43A1 involving removal of the pump or cell module and who perform the wipe testing must have at least 8 hours of radiation safety training which includes hazards of americium-241, radiation units of measure, biological effects of radiation, radiation detection instruments, wipe testing, serial number tracking, and emergency procedures.

[c] Maintenance personnel must have an AN/PDR-56, AN/PDR-77, or equivalent alpha meter.

[d] Maintenance areas must be surveyed at the end of each work day that maintenance is performed.

[e] Survey equipment used to evaluate wipe tests will be calibrated by an alpha reference source traceable to the National Bureau of Standards at least every three months, and checked by an alpha source prior to each day’s operation.

[5] Depot Requirements:

[a] Depot Maintenance Work Requirements (DMWR) apprise maintenance personnel of the hazards associated with the devices and specify precautions that must be taken.

[b] Each depot should have a designated RPO and at least one alternate.

[c] Depot storage areas will have all the requirements of user storage areas and will be posted with signs stating “Radioactive Material” and will be monitored monthly with portable radiac equipment. In addition, storage areas will be wipe tested quarterly.

[6] The source must be tested for leakage and/or contamination at intervals not to exceed 3 years. Any source received which is not accompanied by a certificate indicating that a test was performed within 3 years before transfer must not be put into use until tested.

[7] Any source in storage and not being used need not be tested. When the source is removed from storage for use or transfer it must be tested before use or transfer.

[8] The cell module of the M43A1 is serialized and is tracked throughout its life cycle by the Radiation Testing and Tracking System (RATTS). Transactions are processed for every shipment, receipt, wipe test, cell removal and replacement action.

[9] Licensed material may be stored at the Marine Corps Logistics Base - Albany, GA and may be used at US Army, Marine Corps, or Navy installations throughout the United States.

[10] The licensee must conduct a physical inventory annually to account for all americium-241 cell modules received and possessed under the license. Inventory records must be maintained for inspection by the NRC.

NOTE: *SHOW SLIDE RAD_05_07*

(c) **12-00722-14** This license is for nickel-63 used in the drift tube module of the Chemical Agent Monitor (CAM). The source is a cylindrical metallic foil containing 10 mCi of nickel-63 plated on a brass cylinder. This cylinder is held in a Teflon housing which is installed in a larger aluminum alloy cylinder.

[1] Each source can not exceed 12 mCi each and there can be no more than 1000 Ci total from all sources in the system.

[2] The foil source will not be removed from the drift tube module.

[3] The drift tube module can only be replaced by the contractor, designated depot facilities, or properly trained direct support personnel.

[4] Maintenance operations on the CAM will not include or involve any repair or contact with the nickel-63 plated source.

[5] Direct support maintenance facilities will have an AN/PDR-27 or AN/VDR-2 Radiac Set (or equivalent) and the maintenance area will be surveyed at the end of each work day that maintenance is performed.

[6] Depot maintenance facilities will have a liquid scintillation counting system.

[7] Training Requirements, User:

[a] Technical Manuals apprise the user of the hazards associated with the devices and specify precautions that must be taken. This information is sufficiently

broad in scope to cover the use of the device throughout its life cycle.

[b] Installations within the US Army and US Marine Corps authorized to possess the CAM will have either an appointed Chemical Officer, an RPO, or an accountable individual designated to ensure local compliance with the requirements of the license.

[8] Training Requirements, Maintenance Personnel (DS):

[a] Technical Manuals apprise the maintenance personnel of the hazards associated with the devices and specify precautions that must be taken.

[b] Personnel performing the interior maintenance and annual wipe tests must have a minimum of 8 hours radiation training on:

- Structure of matter, radiation units of measure, absorption of radiation and shielding.
- Specific hazards of nickel-63.
- Radiation detection instruments.
- Emergencies and decontamination.
- Army regulations governing use, storage, transfer, and disposal.
- 10 CFR parts 19, 20, and 21.
- Transactions required for serial number tracking.
- Wipe testing.

[9] Training Requirements, Maintenance Personnel (Depot):

[a] Depot Maintenance Work Requirements (DMWR) apprise maintenance personnel of the hazards associated with the devices and specify precautions that must be taken.

[b] Each depot should have a designated RPO and at least one alternate.

[10] The CAM must be wipe tested annually except while in depot storage. When transferred between accountable officers, the CAM will be wipe tested before use if the annual wipe test has not been performed with in the last 6 months. The owning installations are responsible for ensuring

the wipe tests are performed annually whether they receive notification or not.

[11] The user must turn the CAM in to direct Support for maintenance and wipe test.

[12] Depot storage areas will have all the requirements of user storage areas and will be posted with signs stating “Radioactive Material” and will be monitored monthly with portable radiac equipment. In addition, storage areas will be wipe tested quarterly.

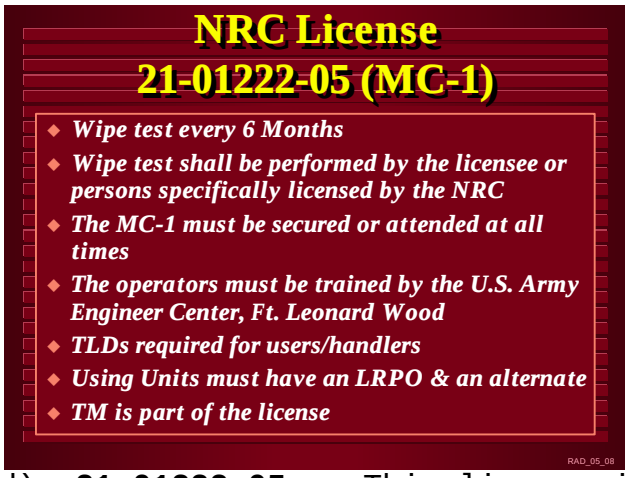
[13] Any source in storage and not being used need not be tested. When the source is removed from storage for use or transfer to another person, it must be tested before use or transfer.

[14] The drift tube module has a serial number and will be tracked throughout its life cycle using the Radiation Testing and Tracking System (RATTS).

[15] The licensee must conduct a physical inventory every 12 months to account for all plated sources received and possessed under the license. Inventory records must be maintained for 2 years.

[16] No manufacturing will be performed under this license. No maintenance under contract at the contractor’s facility will be performed under this license. The contractor must obtain their own NRC license

NOTE: *SHOW SLIDE RAD_05_08*



(d) **21-01222-05** This license is for cesium-137 and americium-241 used in the Density and Moisture Tester, Campbell Pacific Model MC-1.

[1] Licensed material shall be used only at temporary job sites of the licensee anywhere in the United States where the U. S. NRC maintains jurisdiction for regulating the use of licensed material.

[2] The MC-1 will be used by or under the direct supervision and in the physical presence of properly trained individuals.

[3] The licensed sources shall be wipe tested at intervals not to exceed 6 months.

[4] Any source received from another person which is not accompanied by a certificate indicating that a test was performed within 6 months before the transfer shall not be put into use until tested.

[5] Any source in storage and not being used need not be tested. when the source is removed from storage for use or transfer to another person, it shall be tested before use or transfer.

[6] If the test reveals contamination the source shall be removed from service and decontaminated, repaired, or disposed of IAW NRC regulations. A report shall be filed within 5 days of the date the leak test results are known with the NRC. The report shall specify the source involved, the test results, and corrective actions taken.

[7] Records of leak test results shall be maintained for inspection by the NRC.

[8] Tests for leakage and of contamination shall be performed by the licensee or by other persons specifically licensed the NRC.

[9] Sealed sources containing licensed material shall not be opened or removed from the MC-1 by the licensee.

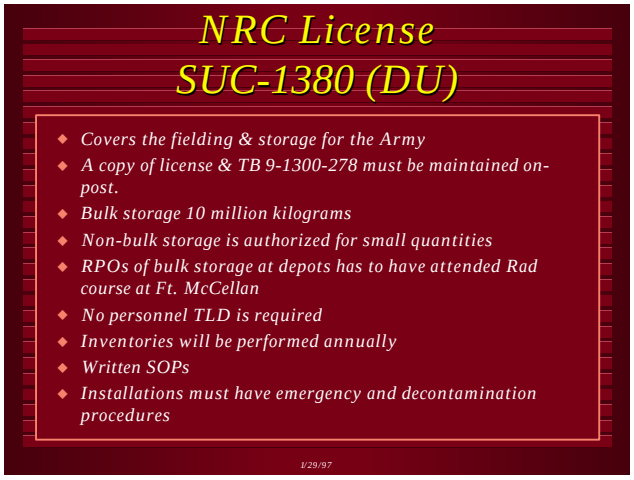
[10] When using the MC-1 at temporary job sights the authorized user shall not leave the device unattended. Upon completion of mission the device shall be locked in the licensee’s vehicle or a secure building to prevent unauthorized use, loss, or theft.

[11] The licensee shall conduct physical inventory every 6 months. Records of inventory shall be maintained for inspection by the NRC for a period of 2 years.

[12] Except as specifically provided otherwise in the license, the licensee shall conduct it's radiation protection program IAW the statements, representations, and procedures contained in the documents including any enclosures, listed below:

- · Complete POI and Lesson Outline for the Soil Analysis Course offered by the US Army Engineer Center.
- · TM 5-6635-386-12&P - UNIT MAINTENANCE MANUAL FOR TESTER, DENSITY AND MOISTURE (SOIL AND ASPHALT); NUCLEAR METHOD; CAMPBELL PACIFIC MODEL MC-1.
-

NOTE: *SHOW SLIDE RAD_05_09*



(e) **SUC - 1380** This license is for Depleted Uranium (DU) primary used by the Army's for fielding and storage license for.

[1] DU ammunition is, SUC-1380, is issued to the Industrial Operations Command (IOC), AMSIO-DMW.

[2] A copy of SUC-1380 and TB 9-1300-278 must be maintained on-post.

[3] Models of DU munitions range in weight (of DU) from a little less than 1 kilogram up to 4.8 kilograms, each.

[4] Authorized activities include; storage, receipt, shipment, handling, inspection, minor maintenance, transportation, and render-safe.

[5] Bulk storage (10 million kilograms) is authorized to the following Army installations; Anniston,

Bluegrass, Crane, Hawthorn, Letterkenny, McAlester, Red River, Seneca, Sierra, and Tooele.

[6] Non-bulk storage is authorized, for smaller quantities of DU, in any Army installation worldwide.

[7] RPOs of bulk storage depots will have attended the Army's 3-week Rad Safety course at Ft. McClellan or have equivalent training and experience. Non bulk storage installations will have personnel trained in radiological matters commensurate with their responsibilities.

[8] Workers or soldiers handling DU monition are not required to wear personnel dosimetry.

[9] Installations storing DU munitions will perform annual inventories and maintain an inventory listing of DU munitions. Inventory listings will be provided to installation fire and security departments.

[10] Structures used for the storage, shipping, or other handling of DU munitions will be included in the installation RPO's rad survey program.

[11] Storage structures must be posted in accordance with 10 CFR.

[12] Warning statements in TMs and annual on-post training provided by the installation RPO is considered adequate radiological instruction.

[13] NASA are allowed to perform visual inspections of DU munitions. Inspection criteria directs when wipe tests are to be taken.

[14] Installations are required to have written procedures (SOPs) in place for authorized activities involving Du munitions.

[15] Installations must have written emergency and decontamination procedures.

[16] Installations storing large quantities of DU munitions, or installations storing smaller quantities of DU munitions and other radioactive material are required to have Ionizing radiation control Committee meetings.

[17] Theft, loss, damage, destruction, accident, disassembly, firing, burial, or unauthorized use must be reported to

DIRECTOR
HQ IOC
Att. AMSIO-DMW
ROCK ISLAND, IL
61299-7630

DSN 793-0338/2969/1766,
AC (309) 782, 0338/2969/1766

NOTE: *SHOW SLIDE RAD_05_010*

(f) BML12-00722-07 This license is for the storage and firing of the LAW used by DOD installations used worldwide.

[1] The LAW rocket is allowed to be fired under this license. After firing the front sight is removed and stored as radioactive waste. Disposal actions must be coordinated with

DIRECTOR
HQ IOC
Att. AMSIO-DMW
ROCK ISLAND, IL
61299-7630

DSN 793-0338/2969/1766,
AC (309) 782, 0338/2969/1766

[2] Storage structures must be posted **IAW 10 CFR.**

[3] Installation RPOs will have attended the Army's 3-week Rad Safety course at Ft McClellan or have equivalent training and experience.

[4] Workers or soldiers handling LAW rockets are not required to wear personnel dosimetry.

[5] Installations storing LAW rockets will perform annual inventories and maintain an inventory listing of LAW rockets. Inventory listings will be provided to installation fire and security departments.

[6] Structures used for the storage, shipping, or other handling of LAW rockets will be included in the installation RPO's rad survey program.

[7] Warning statements in TM's and annual on-post training provided by the installation RPO is considered adequate radiological instruction.

[8] Structures used for the storage, shipping, or other handling of LAW rockets will be included in the installation RPO's rad survey program.

[9] Installations are required to have written procedures (SOPs) in place for authorized activities involving LAW rockets.

[`10] Installations must have written emergency and decontamination procedures.

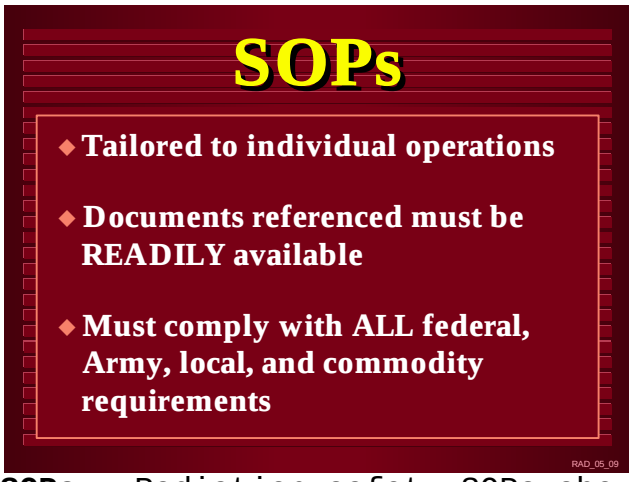
[11] Installations storing LAW rockets and other radioactive material are required to have Ionizing Radiation Control Committee meetings.

[12] Theft, loss, damage, destruction, accident, disassembly, firing, burial, or unauthorized use must be reported to

DIRECTOR
HQ IOC
Att. AMSIO-DMW
ROCK ISLAND, IL
61299-7630

DSN 793-0338/2969/1766,
AC (309) 782, 0338/2969/1766

NOTE: *SHOW SLIDE RAD_05_011*



(13) **SOPs**: Radiation safety SOPs should be tailored to the specific operations being conducted. Documents that are referenced in your SOP become part of your SOP and must be readily available. The following outline information is not intended to be all inclusive; but is provided as a guideline to the minimum that should be included in a good SOP. Check all federal, Army, local, and commodity requirements to ensure that you have covered all essential information for your operations.

(14) General Outline: The general outline for SOP format is show below:

- A. General.
  - 1. Purpose and objective of the SOP.
  - 2. Applicability.
  - 3. Responsibilities.
- B. Control of radioactive material.

<*> REMEMBER <*>
ANY REGULATION OR PUBLICATION YOU REFERENCE IN THE BODY OF YOUR SOP BECOMES PART OF THE SOP AND MUST BE AVAILABLE.

  - 1. Procurement.
  - 2. Receipt.
  - 3. Safety rules.
  - 4. Storage.
  - 5. Inventory.
  - 6. Surveillance.
- C. Safety procedures (to include specifics for use and handling).
  - 1. Purpose.

- 2. Philosophy.
- 3. Safety rules.
- 4. Instruction to personnel.
- 5. Radiation protection standards.
- 6. Surveys.
- 7. Caution signs, labels, and signals
- 8. Radiological emergencies

- D. References.

c. Summary: The NRC requires licensees to minimize the radiation exposure to all workers. Much of the effort of the RPO is devoted to providing personal protection against the radiation hazards present within a facility. However, radiation safety requires everyone's best effort and attention. A good radiation protection program depends on the philosophy and attitude of the management and workers.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

Wipe Testing & DoDRATTS

Requirements placed on the Army by NRC Licenses 12-00722-13 (Americium241) and 12-00722-14 (Nickel63) mandates periodic wipe testing of the Chemical Agent Monitor (CAM) and the M43A1 Chemical Agent Detector (CAD). Wipe testing is also performed to detect possible radiation contamination from defective source modules prior to performing any maintenance inside these devices.

These NRC licenses also require that the radioactive sources be tracked throughout their life cycle. To accomplish this and to record wipe test results the Department of Defense has developed a computerized system called the Radiation Testing and Tracking System known by the acronym DoDRATTS. This system was modeled after the system used to track small arms serial numbers.

Student Notes

Department of Defense Radiation Testing & Tracking System

In order to ensure compliance with NRC Licenses 12-00722-14, Nickel63 (CAM), and 12-00722-13, Americium241 (CAD), DoD has established a computerized tracking system called DoDRATTS. AR 710-3 section II governs the use of this tracking system. The system has been modeled after the Small Arms Serialization Program (SASP) and utilizes transaction reporting to track all significant actions to the device.

Reported transactions include:

- S - Shipment
- R - Receipt
- Q - Potential Loss
- L - Loss
- C/U - Found or Recovered
- X - Removal of Serial Numbered Source
- Y - Insertion of Serial Numbered Source
- W - Wipe Test
- V - Demil
- N - Shipment to Non-DoD
- F - FMS

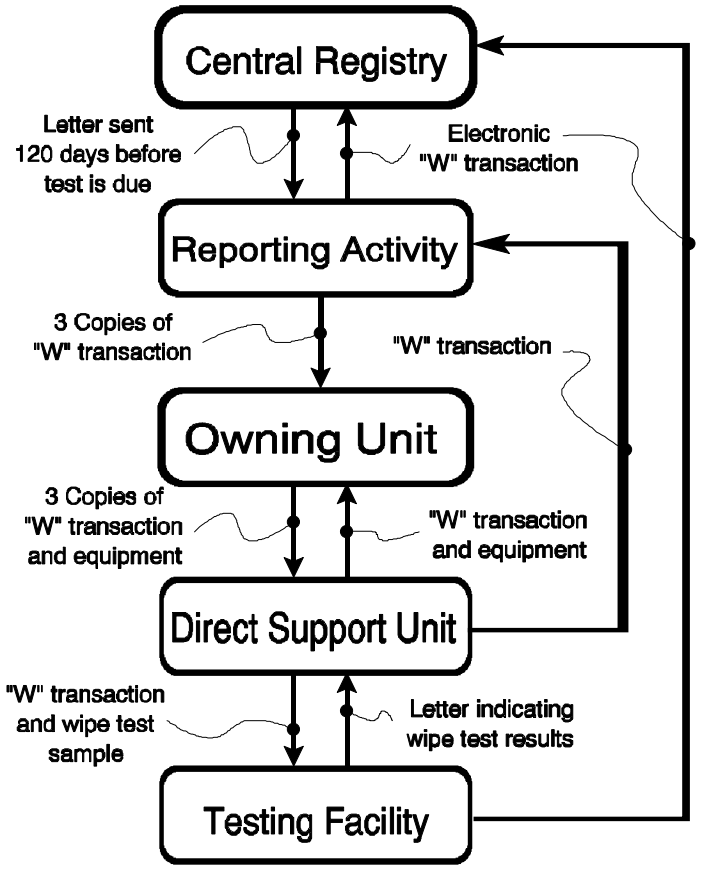
All actions taken on the source or device must be reported using one of the above transaction codes. This is so the radioactive source can be tracked throughout its life cycle.

The DoDRATTS Wipe Test Process:

Under normal circumstances, the wipe test cycle will start at Rock Island. The DoD Central Registry, located at Rock Island, AMSTA-AC-MMH-U, will send a letter to the installation POC indicating that a wipe test is due in 120 days. This letter goes to the “Reporting Activity” for the installation that owns the equipment that requires a scheduled wipe test. The reporting activity, normally a function of DOL supply, will generate 3 copies of a “W” transaction indicating the need for a wipe test and give these to the unit that owns the device.

Student Notes

If the owning unit knows that a required wipe test is due and they have not yet received notification from the reporting activity, it is their responsibility to generate the 3 copies of the “W” transaction and initiate the wipe test cycle. The owning unit then job orders the equipment to their supporting Direct Support unit requesting that a wipe test be performed. The owning unit will also provide the DS unit with all 3 copies of the “W” transaction.



The DS unit will perform the wipe test and initial screening. They send one copy of the “W” transaction and the wipe sample to the testing laboratory at Rock Island. They also fill out one copy of the “W” transaction annotating their initial screening result and send it back to the reporting activity where it will be transmitted electronically to the central registry at Rock Island.

The testing facility at Rock Island will analyze the wipe test sample and transmit the results electronically to the central registry and send a letter back to the DS unit telling them the results of the test.

The DS unit then fills out the remaining “W” transaction indicating the results of the test. If the radiation readings are within allowable limits the equipment and the final “W” transaction are sent back to the owning unit.

Student Notes

RADIOISOTOPE TRANSACTION WORKSHEET

for use of this worksheet, use AR 710-3

DOCUMENT IDENTIFIER CODE			DOCUMENT IDENTIFIER CODE			TRAN	CELL OR DRIFT TUBE SERIAL NUMBER IF M43A1, CIRCLE CELL; IF CAM, CIRCLE TUBE										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

DOCUMENT NUMBER (OPTIONAL)															WIPE TEST DATE (JULIAN DATE)				
20	21	22	23	24	45	26	27	28	29	30	31	32	33	34	35	36	37	38	39

REPORTING ACTIVITY (SSO DODAAC)							OWNING ACTIVITY (DODAAC)							TESTING ACTIVITY (ACTIVITY DOING TEST)					
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59

DETECTOR OR CAM SERIAL NUMBER IF M43A1, CIRCLE DETECTOR; IF CAM, CIRCLE CAM											WIPE TEST RESULT 555 - GO 999 - NO GO			LEAVE BLANK		TRANSACTION DATE (JULIAN DATE)				
60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

Testers Name, Address, and Telephone Number:

Student Notes

Wipe Test Procedures

Proper wipe test procedures are essential to ensure valid test results and to protect personnel from exposure to radiation.

Wipe test procedures for Tritium Contamination.

Tritium oxide contamination is difficult to detect. There are currently no portable radiac instruments in the Army that can detect the low energy beta emissions of tritium. A wipe test must be taken and the wipe sample analyzed using a *Liquid Scintillation Counter*.

Wipe tests must be taken anytime there is a reasonable possibility of tritium contamination from damage of a device containing tritium light sources. A routine wipe test is also required **quarterly** for maintenance and storage areas.

Wipe test materials consist of:

- Rubber gloves, NSN 8415-00-682-6786 (or equivalent)
- Scintillation Vials, NSN 6640-01-141-3871
- Metricel Filters, NSN 6640-01-142-8317
- Water (Taken from outside the area)

Procedures

1. Draw a map of the area to be tested. Information on the map must include:
   - Installation name
   - Building number
   - Name of person conducting wipe test
   - Phone number
   - Date
   - Identify on the map where each wipe is taken

   NOTE

   Be sure to leave enough room on the map to allow the laboratory technicians to annotate the result of each sample.

2. Put on rubber gloves

Student Notes

Wipe test procedures for Tritium Contamination (cont.).

3. Moisten the Metricel filter with water taken from outside the area.
4. Wipe an area approximately 4 inches square (100 sq cm)
5. Place the filter in the scintillation vial. Do not put the paper backing that comes with the filter in the vial.
6. Put 1 ml of water in the vial. This is about 20 drops of water. The added water is to keep the filter moist during shipping and must also be taken from outside the area.
7. Put the cap on the vial and shake it gently to thoroughly moisten the filter.
8. Mark the lid of the scintillation vial with a number to identify where on the map it was taken from. **MARK ONLY ON THE LID - DO NOT WRITE OR MARK THE SIDE OF THE VIAL.**
9. Once all samples have been taken, remove rubber gloves and wash hands thoroughly with non-abrasive soap and warm water.
10. Mail samples and a copy of the map to:

SIORI-SEM-L
RADIATION LEAK TEST SAMPLES
BLDG 210, 4TH FLOOR
ROCK ISLAND ARSENAL
ROCK ISLAND IL 61299-5000

Student Notes

Wipe test procedures for the CAM.

The CAM must be wipe tested once every year for potential contamination with Nickel63. There is no requirement to perform a wipe test while the CAM is in depot level storage however it must be wipe tested prior to transfer if the date of the last test was not within 6 months.

Wipe test materials consist of:

- Kraft Paper
- Rubber gloves, NSN 8415-00-682-6786 (or equivalent)
- Test swipes, NSN 6665-01-198-7573
- Large envelope
- Small envelope
- Radiac meter AN/PDR-27, AN/VDR-2, or equivalent

Procedures are as follows:

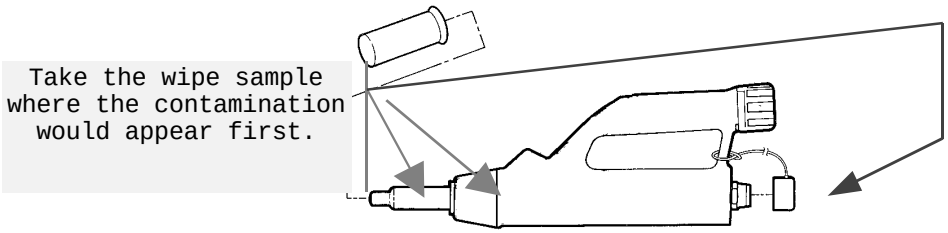
1. Cover the work area with Kraft paper.
2. Write the following information on the small envelope.
    - Name of the person performing the wipe test.
    - Installation name and location.
    - CAM serial number.
    - Drift tube module serial number

"MAIL ROOM - DO NOT OPEN"

Student Notes

Wipe test procedures for the CAM (cont.).

3. Wear rubber gloves.
4. Wipe the front part of the CAM and around the outside of the air intake nozzle



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5. Perform initial sample screening with the AN/VDR-2, or equivalent. Consider the CAM contaminated if a reading of twice background is detected.
6. Place the swipe into the smaller envelope. Use one envelope per swipe. Do not place more then one swipe in each envelope.
7. Seal the small envelope with tape. DO NOT lick the envelope to seal it.
8. Place all of the small envelopes into one large envelope.
9. Remove rubber gloves and store them in a sealed plastic bag until wipe test results are received to determine whether they can be disposed of as regular waste or if they must be handled as radioactive waste and disposed of IAW AR 385-11.
10. Seal the large envelope with tape. DO NOT lick the envelope to seal it.

Student Notes

Wipe test procedures for the CAM (cont.).

11. Mail samples to:

SIORI-SEM-L
RADIATION LEAK TEST SAMPLES
BLDG 210, 4TH FLOOR
ROCK ISLAND ARSENAL
ROCK ISLAND IL 61299-5000

Student Notes

Wipe testing the M43A1 CAD

Safety-of-Use-Message (SOUM) ACALA 95-01 changed the wipe test procedures and interval for the M43A1 Chemical Agent Detector. SOUM ACALA 95-04 rescinded 95-01 & 95-02 and basically clarified the entire procedure. Prior to this message the wipe test interval was once every three years and the procedures consisted of wiping the outer portion of the Detector cell module and the exit port. Now the wipe test is to be done annually and the wipe is taken from where the air leaves the detector cell module.

In order to understand why the wipe test interval and procedures changed it will be necessary to know how the M43A1 functions and how the Americium241 is configured inside the detector cell module.

The M43A1 functions by drawing outside air through the system with an internal air pump. The air enters the M43A1 through the air inlet port and passes through a user replaceable air filter designed to remove dust and other large air particles before the air enters the detector portion of the system. The air then enters the detector cell module were it passes through a chamber that contains the radioactive material. When exposed to radiation air molecules tend to cluster together. Impurities in the air, mainly nerve agent molecules, tend to form relatively large clusters. These air clusters then strike a detector that is sensitive to the size of clusters formed by known nerve agents. If nerve agent is present, a signal is processed through the electronics module and the alarm is activated. Home smoke detectors function in much the same way and also contain Americium241.

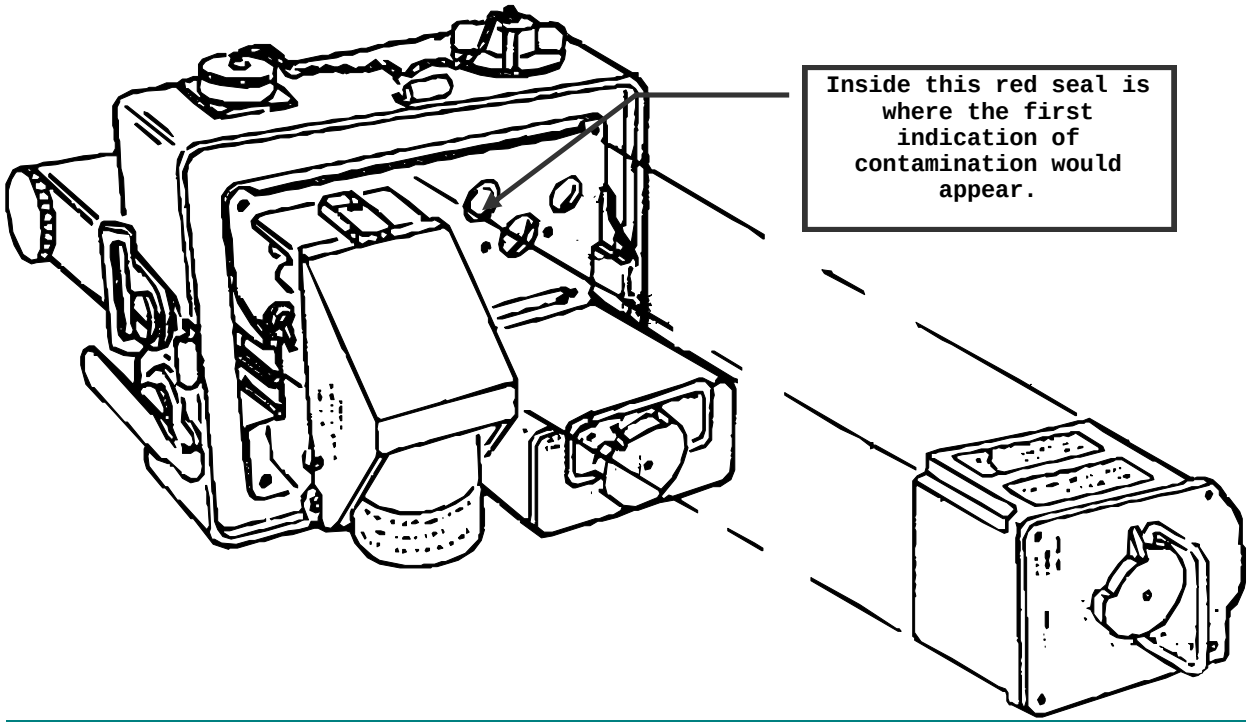
In the detector module the Am^{241} is encased in a gold-palladium alloy casing with a silver backing. The configuration and materials that were selected while designing the detector cell module were thought to be sufficient to insure that the Americium oxide would be contained during the life of the item. Recent testing and studies have revealed that this may not be the case. Natural oxidation and constant bombardment of radiation appears to be causing very fine, shallow cracks similar to heat checking in the gold-palladium alloy material. Further testing has shown that these surface defects do not penetrate all the way through the material. The possibility does exist that in some older detector modules these cracks may allow moisture to contact the Am^{241} causing it to oxidize and plate out onto the surface of the gold-palladium alloy cover in the form of a fine yellow or silver

Student Notes

colored dust. Further contact with moisture and the air passing over this surface can cause

Wipe testing the M43A1 CAD (cont.)

this radioactive material to migrate through the air passages of the M43A1 and eventually exit through the exit port causing contamination of the entire system.



It is the responsibility of the owning unit to ensure that the wipe test is performed annually. The wipe test can only be performed at depot level, T.M.D.E. or by properly trained direct support personnel. A minimum of 8 hours of training is required which must include the hazards associated with Americium241, safe handling of radioactive material, wipe test reporting procedures, radiac instrument operation, and the wipe test procedures.

There is no requirement to perform a wipe test while the CAD is in depot level storage however it must be wipe tested prior to transfer if the date of the last test was not within 6 months.

Student Notes

Wipe testing the M43A1 CAD (cont.)

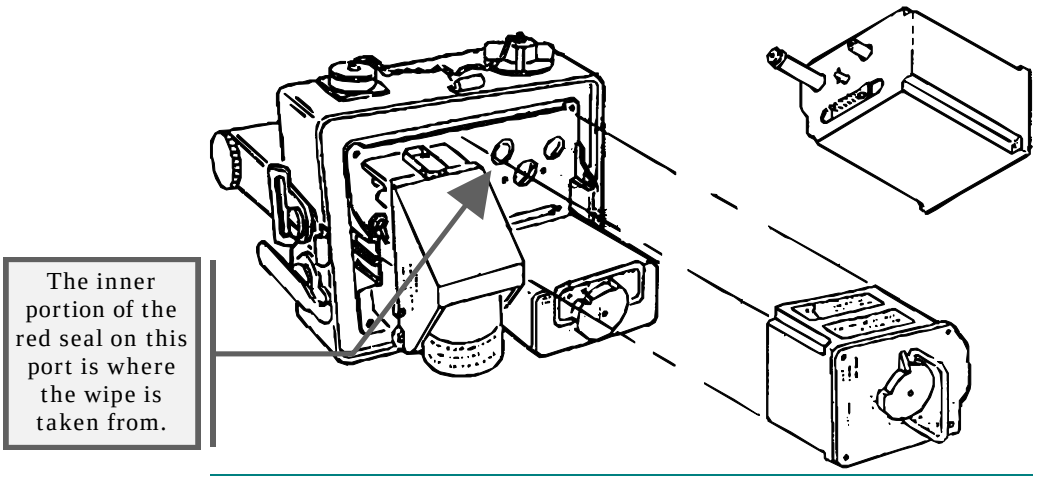
Prior to performing the wipe test it is important to have all of the materials and equipment readily available. You will need the following items to properly perform the wipe test:

- Kraft Paper
- Rubber Gloves, NSN 8415-00-682-6786 (or equivalent)
- Disposable Applicators, NSN 6515-01-234-6838
- Large Envelope
- Small Envelope (one for each wipe)
- Actively Calibrated Radiac Meter AN/PDR-56 or AN/PDR-77 (or equivalent)

Wipe Test Procedures

1. Cover the work area with Kraft paper.
2. Write the following information on the small envelope.
   - Name of the person performing the wipe test.
   - Installation name and location.
   - M43A1 serial number.
   - "MAIL ROOM - DO NOT OPEN"
3. Wear rubber gloves.
4. Unfasten the 4 catches and remove the bottom case.
5. Write the serial number of the detector cell module on the small envelope.
6. Rotate the lock handle on the detector cell module counter-clockwise 1/4 turn and pull the module from the chassis assembly.

Student Notes



Wipe testing the M43A1 CAD (cont.)

7. Insert a dry disposable applicator through the small hole with a red seal on the chassis assembly twisting the applicator as you pull it out.
8. Perform initial sample screening of the applicator with an alpha portable radiac meter, AN/PDR-56, AN/PDR-77, or equivalent.
9. Place the applicator into the smaller envelope. Use one envelope per swipe. Do not place more then one swipe in each envelope.
10. Seal the small envelope with tape. DO NOT lick the envelope to seal it.
11. Place all of the small envelopes and one copy of each of the "W" transaction work sheets into one large envelope.
12. Remove rubber gloves and store them in a sealed plastic bag until wipe test results are received to determine whether they can be disposed of as regular waste or if they must be handled as radioactive waste and disposed of IAW AR 385-11.
13. Seal the large envelope with tape. DO NOT lick the envelope to seal it.
14. Address the large envelope to:

SIORI-SEM-L
RADIATION LEAK TEST SAMPLES
BLDG 210, 4TH FLOOR
ROCK ISLAND ARSENAL
ROCK ISLAND IL 61299-5000

Student Notes

What is a WIPE TEST?

- Collect contamination on the wipe material
- Samples are analyzed on laboratory equipment
- Always wear rubber gloves
- Use the proper wipe material and procedures
- Provide the proper paper work

Tritium Wipe Test

- Only way to detect tritium contamination
  - *Beta* energy is too weak to be detected with fielded radiac equipment
- Routine wipe tests are required quarterly
  - Maintenance and storage areas
- Anytime contamination is suspected
  - Indicated by any damage to devices containing tritium
  - Loss of illumination

Materials:

- **Rubber Gloves**
- **Scintillation Vials**
- **Metricel Filters**
- **Water**
  - –Distilled water

    or

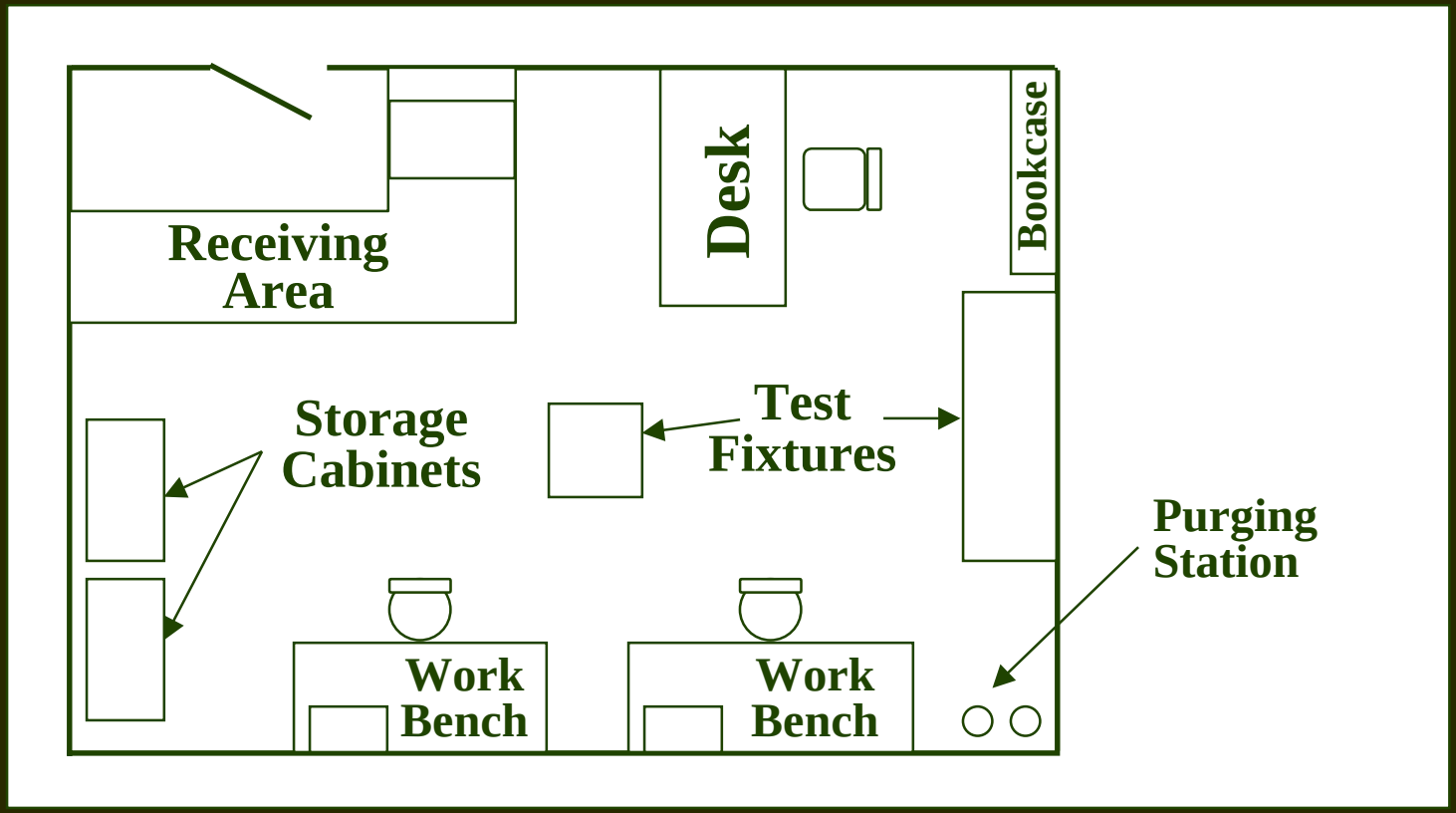
  - –Water taken from outside the area

Procedures:

1. Draw a map of the area to be tested

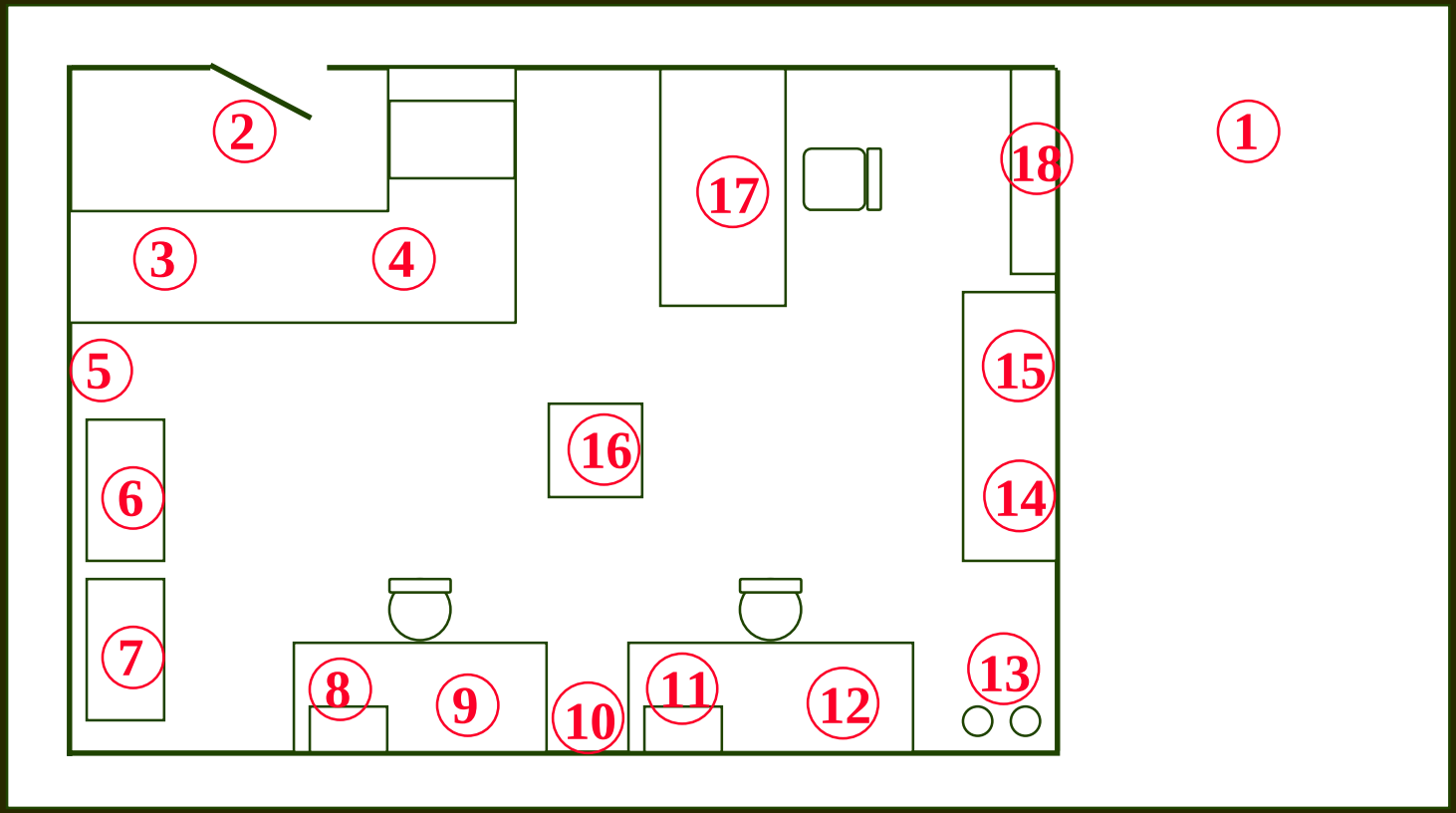
Procedures:

1. Draw a map of the area to be tested



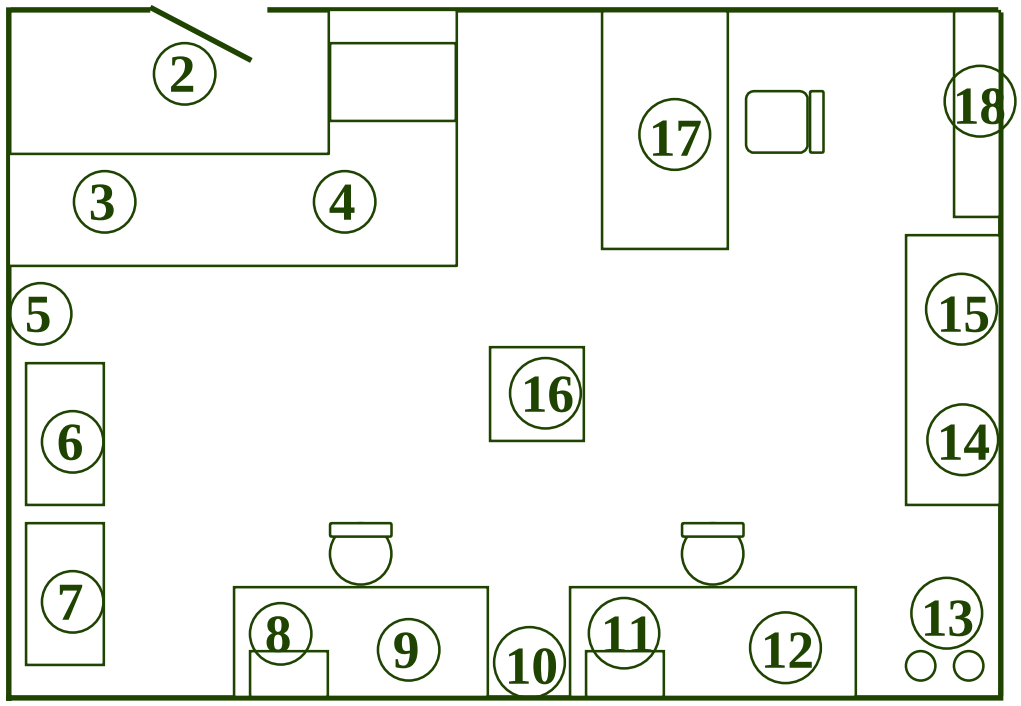
Procedures:

- Number the wipe sample locations



Procedures:

- Include:

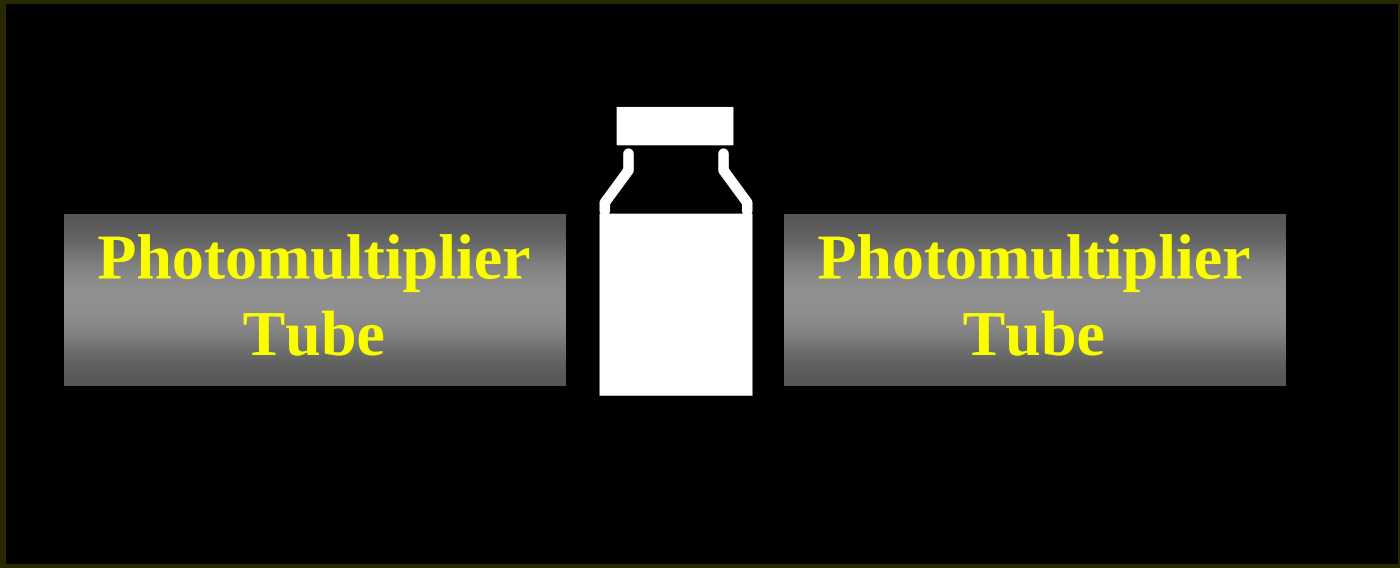


Installation
Bldg No.
Name
Phone
Date

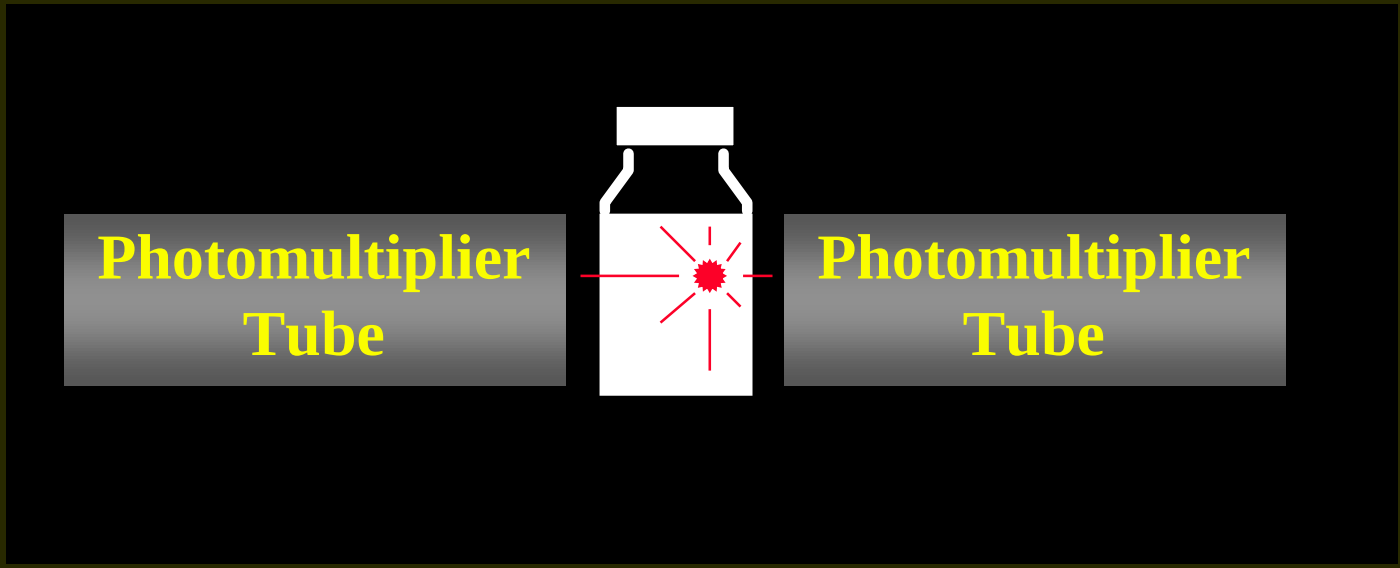
Procedures:

1. Make a map
2. Put on gloves
3. Moisten Metricel filter
4. Wipe a 16 Sq. In. area
5. Put filter in scintillation vial
6. Add water
7. Put the cap on the vial
8. Label the vial - **ON THE LID**

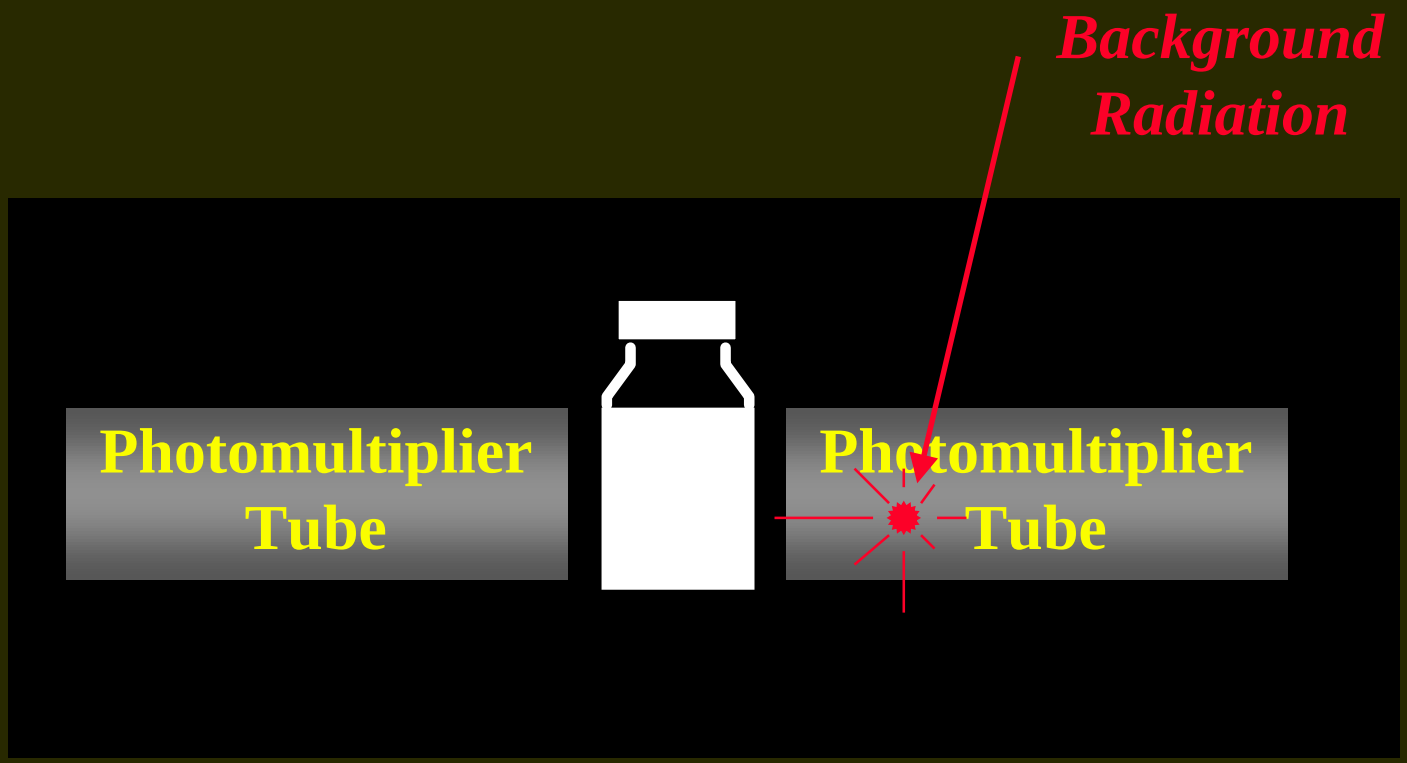
Why on the Lid???



Why on the Lid???



Why on the Lid???



CAM Wipe Test

- Looking for nickel-63 contamination caused by deterioration of drift tube module
  - Contamination will first appear where the air exits the CAM
- Annual testing required by NRC License
- Must be wipe tested prior to transfer if the date of the last wipe test was not within 6 months

Materials:

- Kraft paper
- Rubber gloves
- NuCon wipes
- Large envelope
- Small envelope
- Radiac meter
  - AN/PDR-27, AN/VDR-2, or equivalent

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope

Procedures:

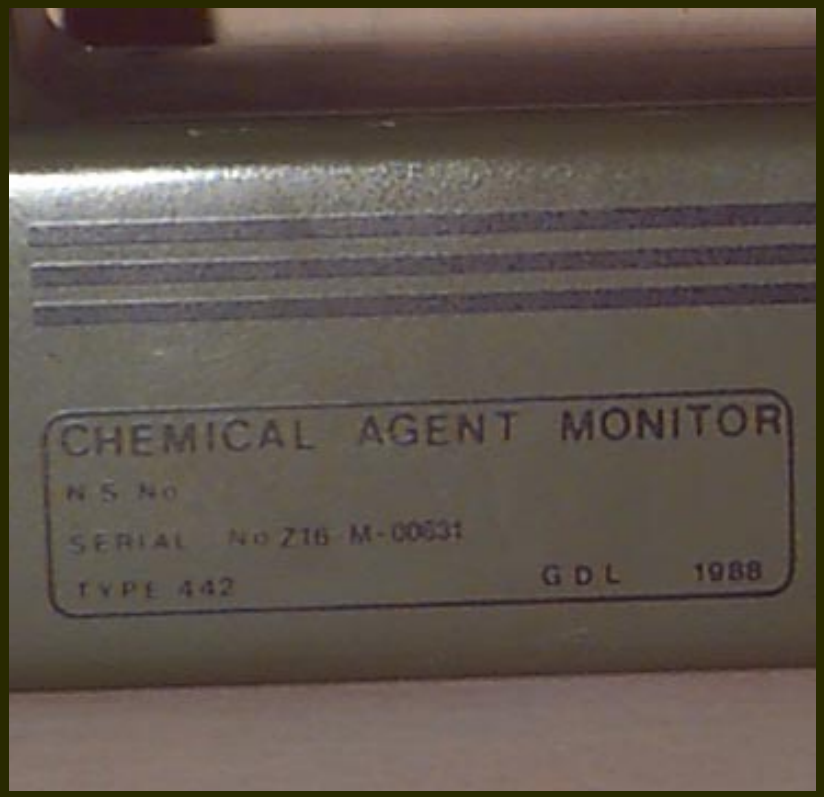
1. Cover the work area with Kraft paper
2. Write information on small envelope

Name: PVT Joe Snuffey
Installation: D Co. 777 Maint. Bn.
Ft. Run-A-Muck, IL
CAM Seriel #: Z-16-C-00000
Drift Tube Seriel #: Z-16-M-00000

MAIL ROOM - DO NOT OPEN

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope



Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves
4. Collect wipe sample

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves
4. Collect wipe sample
5. Monitor the sample

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves
4. Collect wipe sample
5. Monitor the sample
6. Place the swipe into small envelope
   One swipe per envelope
7. Seal the envelope with tape
   DO NOT LICK
8. Put all small envelopes into large one
9. Seal with tape - DO NOT LICK

At the end of each day

Monitor all work surfaces. Remember that nickel-63 is a low energy *beta* emitter and fielded radiac equipment will only detect gross contamination.

Place all suspected contaminated waste material into a properly marked container.

M43A1 Wipe Test

- Looking for americium-241 contamination caused by deterioration of the source in the detector module
  - Contamination will first appear where the air exits the detector module
- Annual testing required by ACALA SOUM 95-04
- Must be tested prior to transfer

Materials:

- Kraft paper
- Rubber gloves
- Cotton tipped applicator
- Large envelope
- Small envelope
- Radiac meter
  - AN/PDR-54, AN/PDR-56, or AN/PDR-77

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope

Procedures:

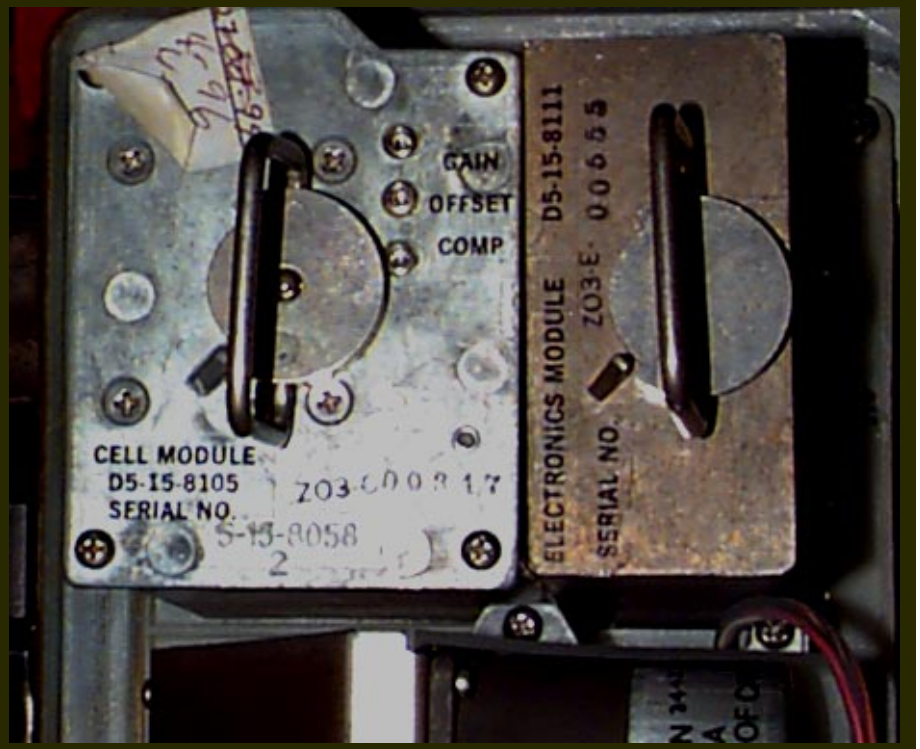
1. Cover the work area with Kraft paper
2. Write information on small envelope

Name: SGT Joe Schmoe
Installation: C Co 95 Chem
Camp Swampy, GA
Phone: (999) 555-0000
M43A1 Serial #: XXX-X-00000
Detector Module Seriel #: YYY-Y-00000

MAIL ROOM - DO NOT OPEN

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope

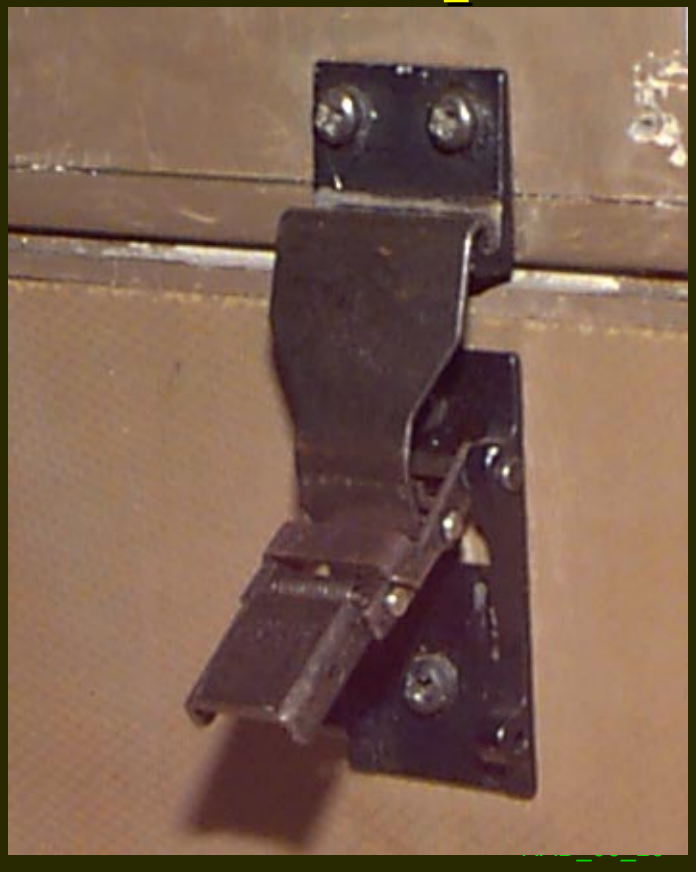


Procedures:

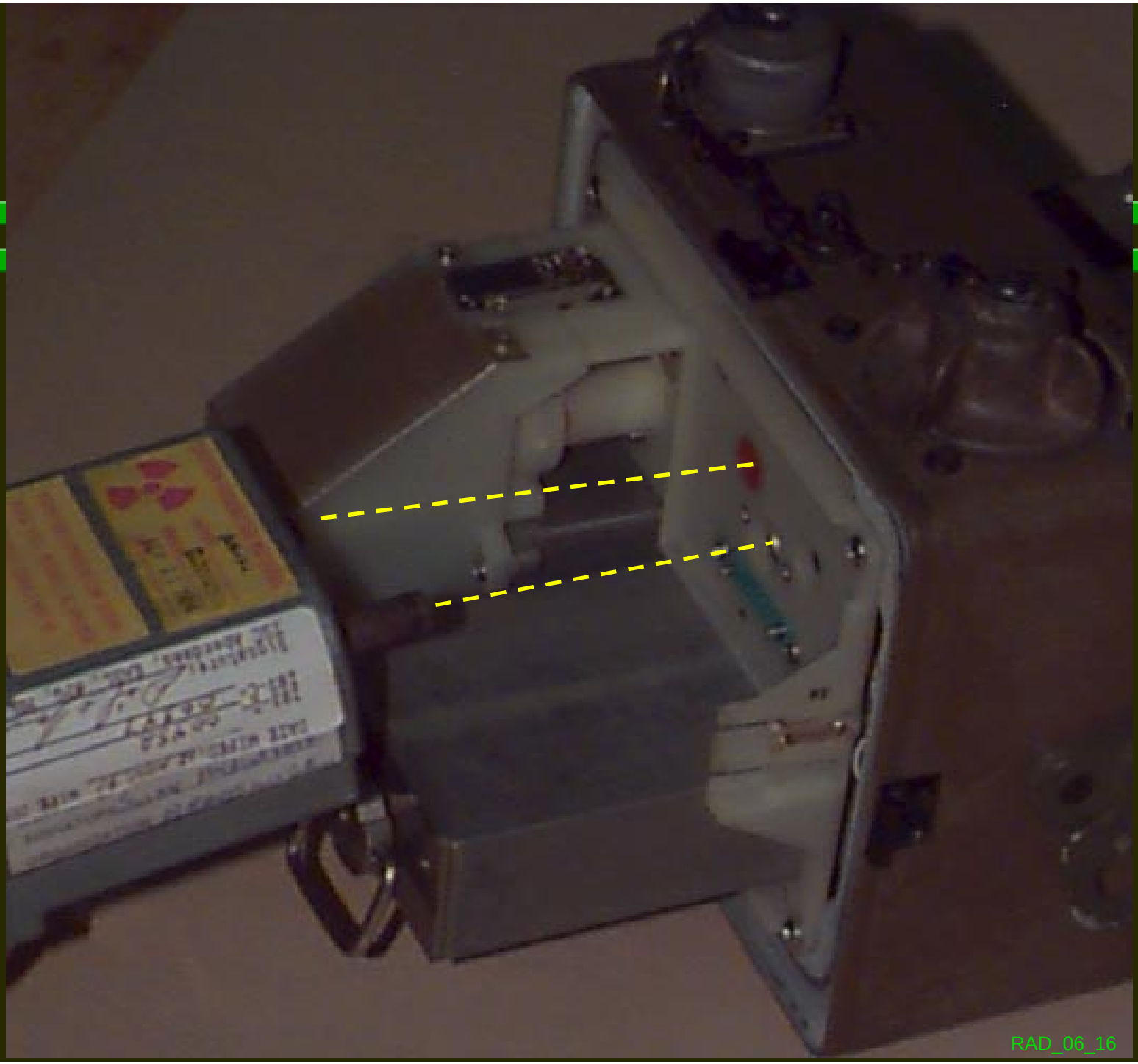
1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves



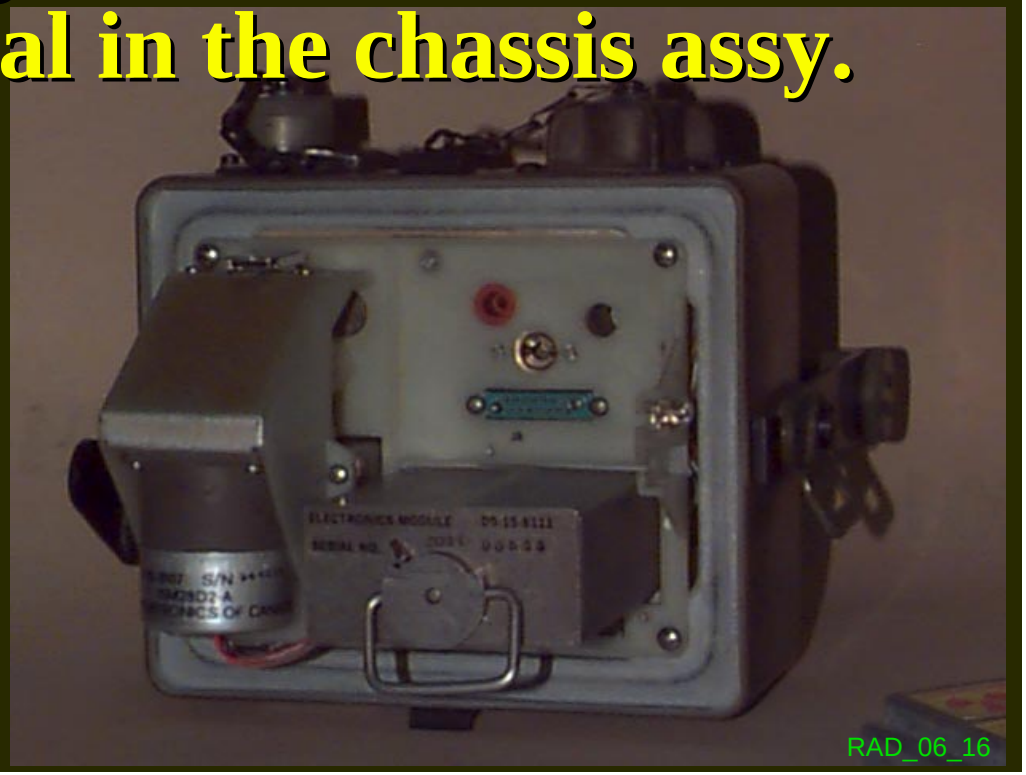
RAD_06_16



RAD_06_16

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves
4. Wipe the red seal in the chassis assy.



RAD_06_16

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves
4. Wipe the red seal in the chassis assy.

RAD_06_16

Procedures:

1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves
4. Wipe the red seal in the chassis assy.
5. Monitor the sample (optional)

Procedures:

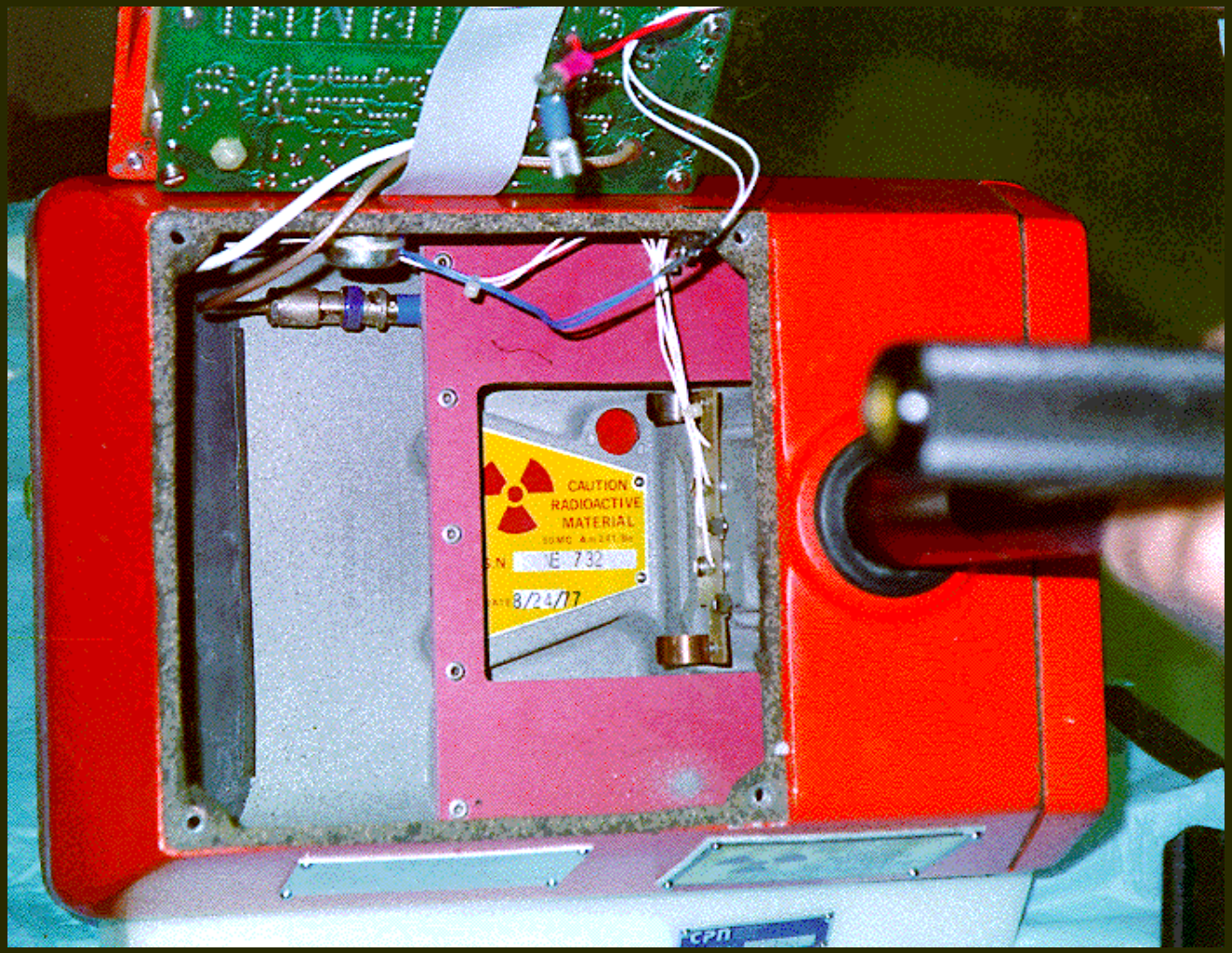
1. Cover the work area with Kraft paper
2. Write information on small envelope
3. Put on rubber gloves
4. Wipe the red seal in the chassis assy.
5. Monitor the sample (optional)
6. Place the swipe into small envelope
   One swipe per envelope
7. Seal the envelope with <u>tape</u>
   DO NOT LICK
8. Put all small envelopes into large one
9. Seal with tape - DO NOT LICK

At the end of each day

Monitor all work surfaces. Remember that americium-241 is an *alpha* emitter and can only be detected with the use of the proper *alpha* probe.

Place all suspected contaminated waste material into a properly marked container.

MC-1 Americium/Beryllium



MC-1 Cesium

DoDRATTS

- Department of Defense Radiation Testing & Tracking System
- Ensure NRC License Compliance
- AR 710-3, Section II

DoDRATTS Transactions

S - Shipment
R - Receipt
Q - Potential Loss
L - Loss
C/U - Found or Recovered
X - Removal of Source
Y - Installation of Source
W - Wipe Test

DoDRATTS Worksheet

RADIOISOTOPE TRANSACTION WORKSHEET

for use of this worksheet, use AR 710-3

DOCUMENT IDENTIFIER CODE			DOCUMENT IDENTIFIER CODE			TRAN	CELL OR DRIFT TUBE SERIAL NUMBER IF M43A1, CIRCLE CELL; IF CAM, CIRCLE TUBE											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

DOCUMENT NUMBER (OPTIONAL)															WIPE TEST DATE (JULIAN DATE)				
20	21	22	23	24	45	26	27	28	29	30	31	32	33	34	35	36	37	38	39

REPORTING ACTIVITY (SSO DODAAC)							OWNING ACTIVITY (DODAAC)							TESTING ACTIVITY (ACTIVITY DOING TEST)					
40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59

DETECTOR OR CAM SERIAL NUMBER IF M43A1, CIRCLE DETECTOR; IF CAM, CIRCLE CAM											WIPE TEST RESULT 555 - GO 999 - NO GO			LEAVE BLANK		TRANSACTION DATE (JULIAN DATE)				
60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

Tester's Name, Address, and Telephone:

Wipe Test Process

Central Registry

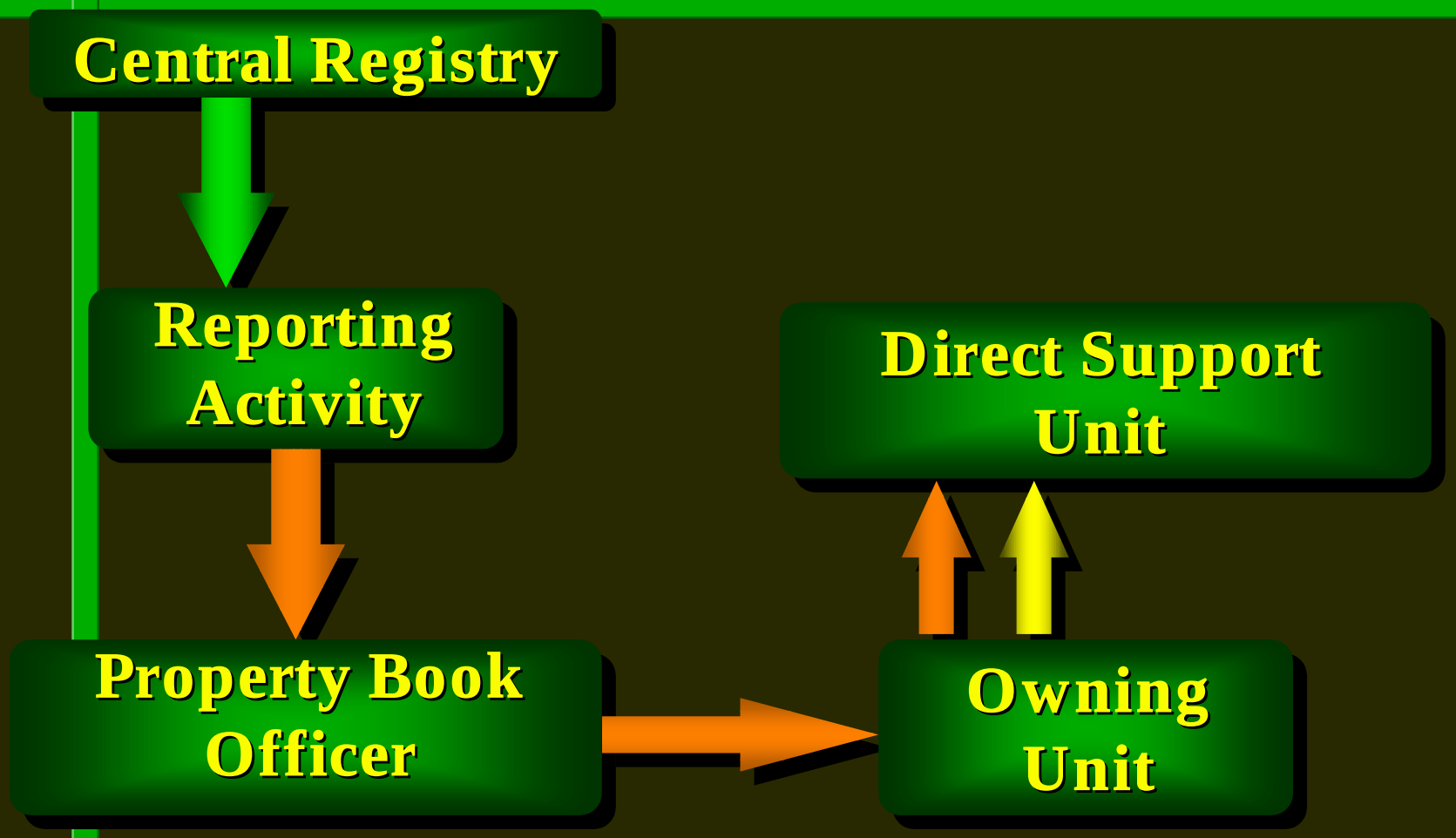
Wipe Test Process

Central Registry

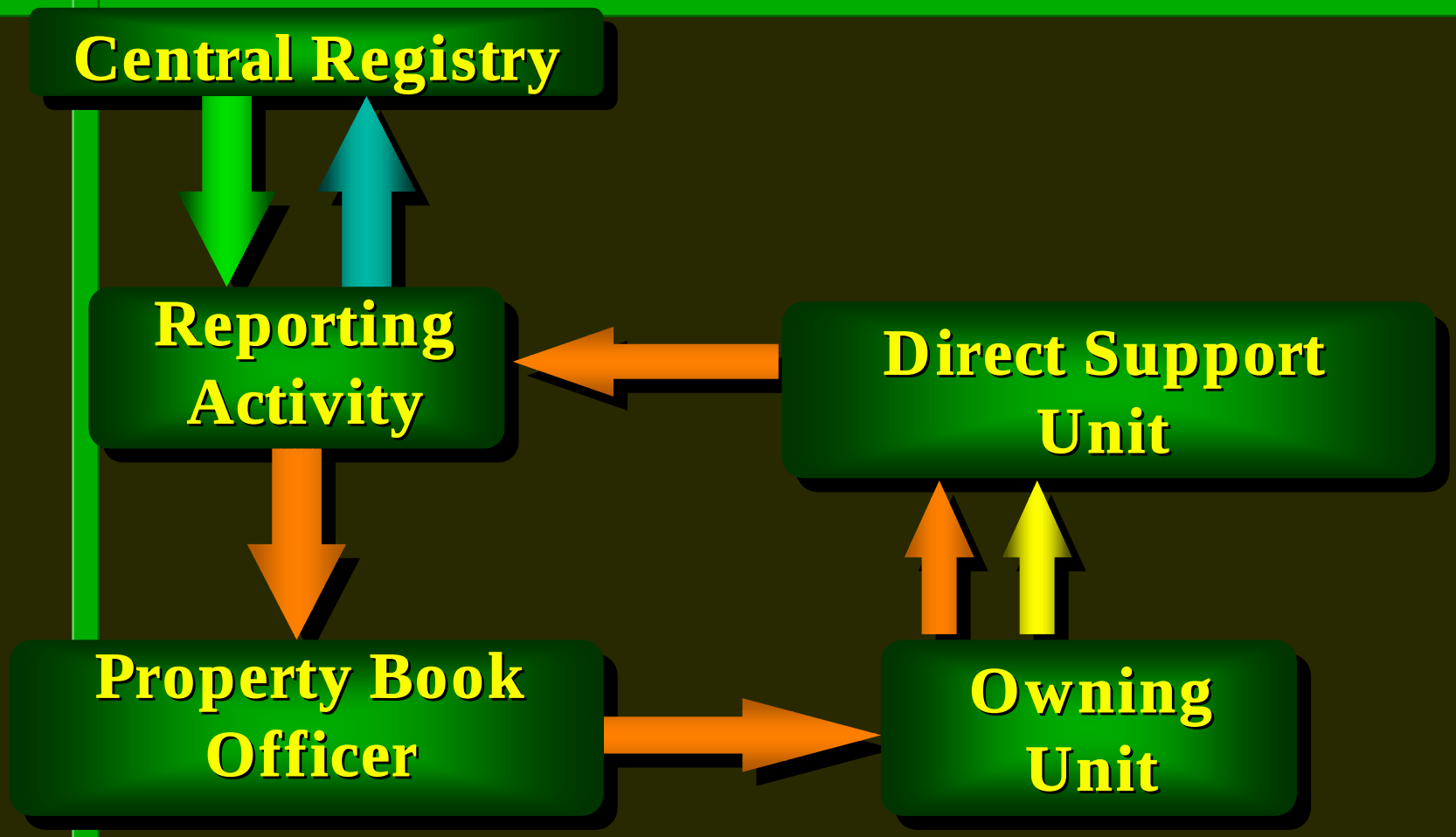
Reporting Activity

Wipe Test Process

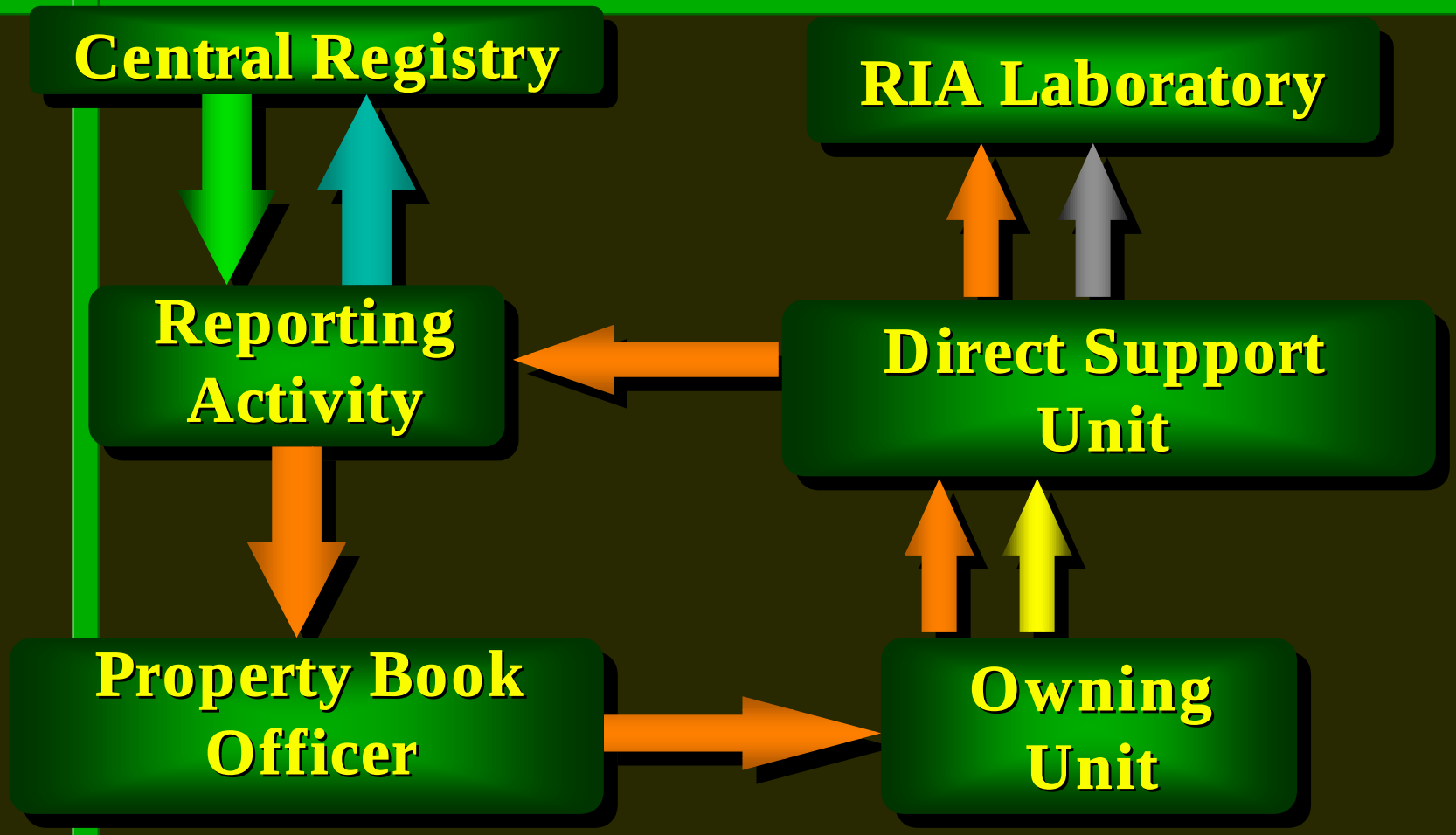
Wipe Test Process



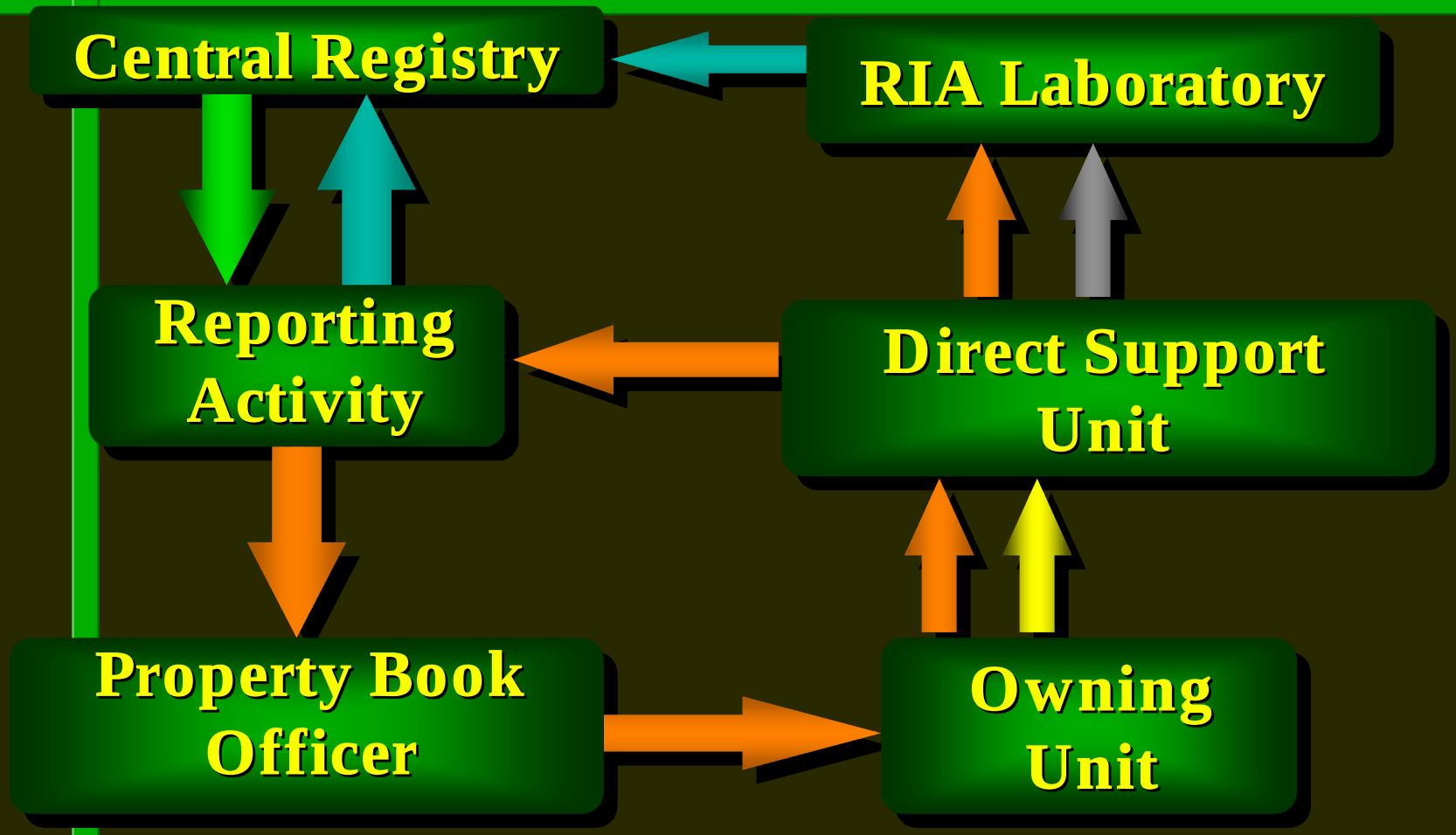
Wipe Test Process



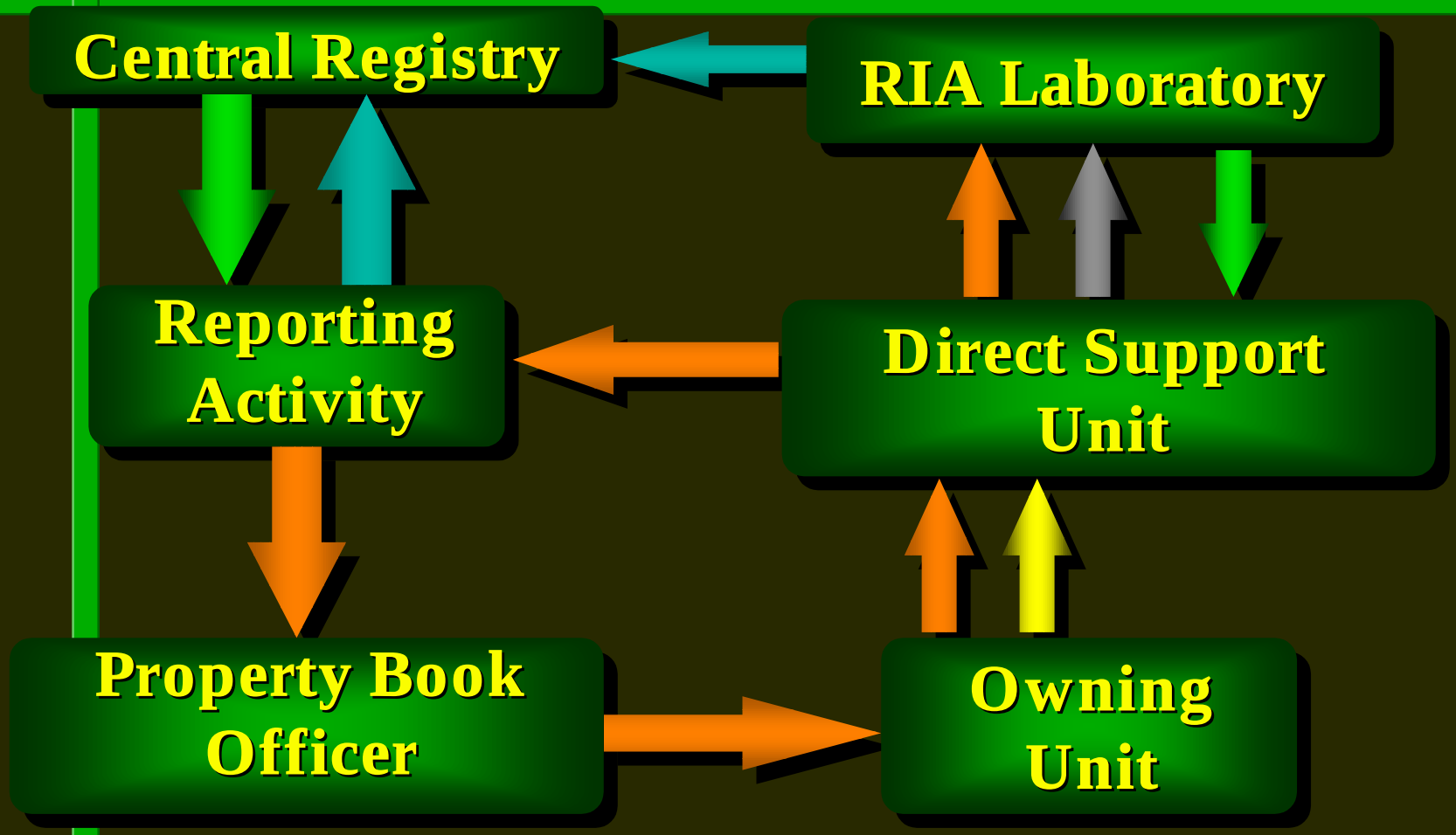
Wipe Test Process



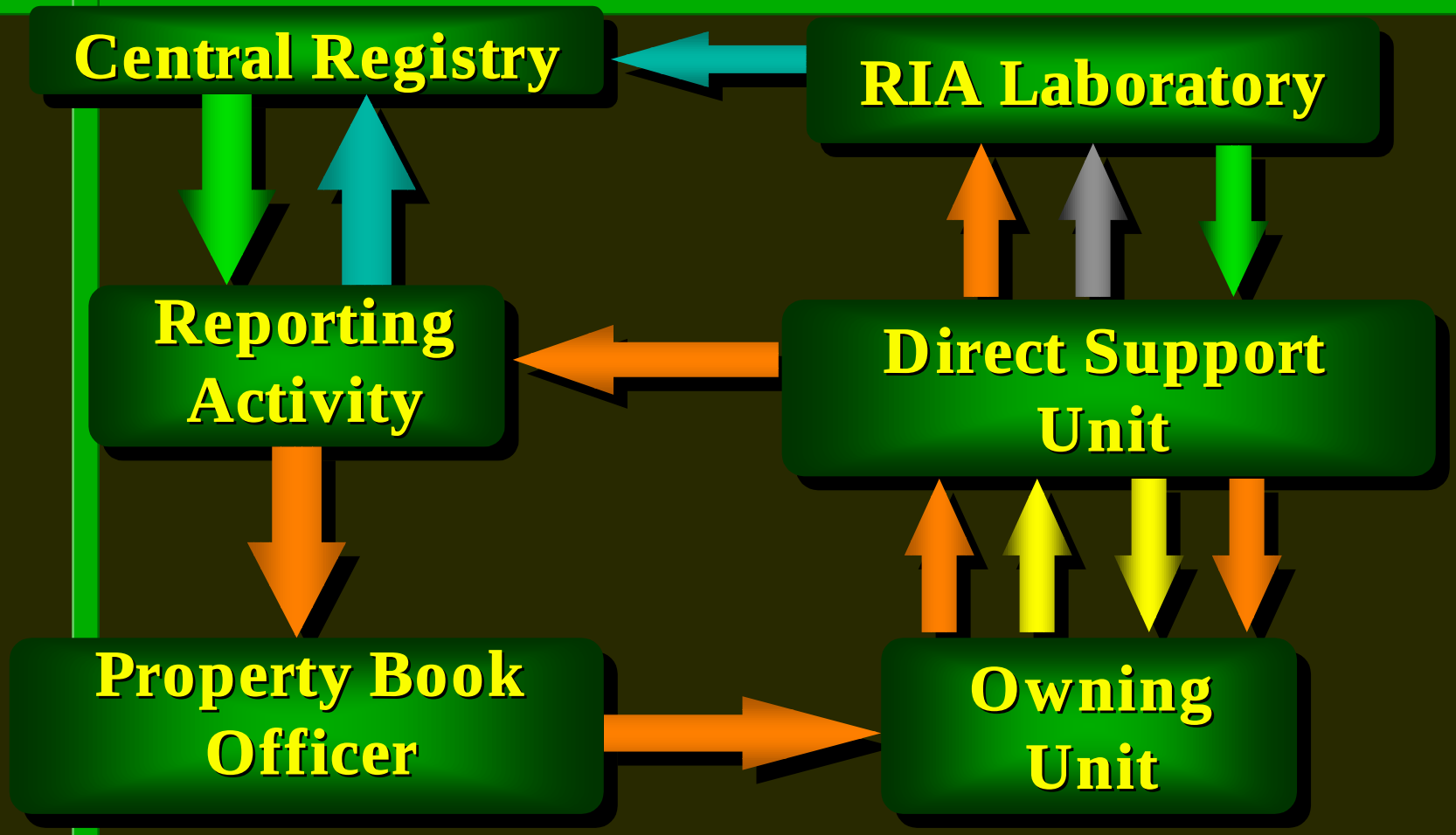
Wipe Test Process



Wipe Test Process



Wipe Test Process



US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-06

DATE: Oct 96

TITLE: Wipe Testing and DoDRATTS

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 2.0 C (U)
3.0 PE

FACILITY REQ: Classroom

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: Two

UNIFORM: Duty

TRANSPORTATION: None

ISSUED TO STUDENTS: Student Reference Guide "Radioactive Material Handling Safety"

AIDS AND EQUIPMENT:

a. Overhead Projector
b. Computer Display Device
c. Computer
d. RAD_06.PPT file
e. RAD_05_2.PPT file
f. M43A1 Chemical Agent Detector
g. Chemical Agent Monitor
h. AN/PDR-77 (or equivalent)

REFERENCES:

TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
AR 710-3	
AR 385-11	Ionizing Radiation Protection
ACALA SOUM 95-04	
TM 3-6665-312-30&P	INTERMEDIATE DIRECT SUPPORT MAINTENANCE MANUAL FOR M8A1 AUTOMATIC CHEMICAL AGENT ALARM
TM 3-6665-331-23&P	UNIT AND DIRECT SUPPORT MAINTENANCE MANUAL FOR CHEMICAL AGENT MONITOR (CAM)

COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: Wipe Testing and DoDRATTS

1. Presentation: (This presentation is UNCLASSIFIED.)

a. Introduction:

(1) Objective: Train students on proper wipe test procedures. Provide information on how to properly report wipe tests and other transactions that are monitored through the Department of Defense Radiation Testing and Tracking System.

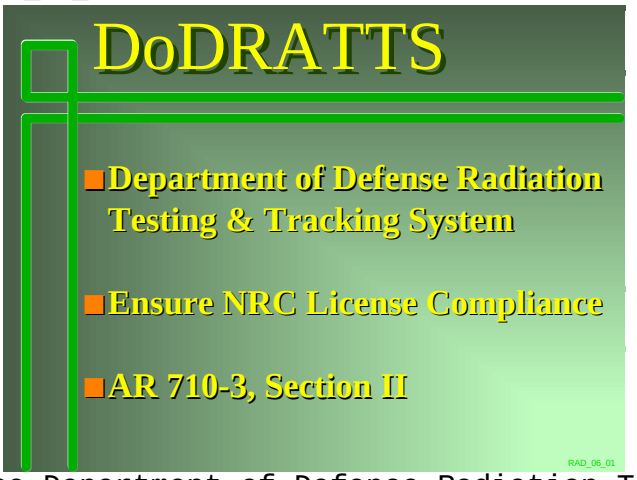
(2) Reason and Tie-In:

(a) The NRC Licenses which cover the radioactive materials used in the M43A1 Chemical Agent Detector (CAD) and the Chemical Agent Monitor (CAM) require scheduled wipe test and tracking of the radioactive components throughout their life cycle.

(b) Proper wipe test procedures are essential to ensure valid test results and to protect personnel from exposure to radiation.

b. Explanation:

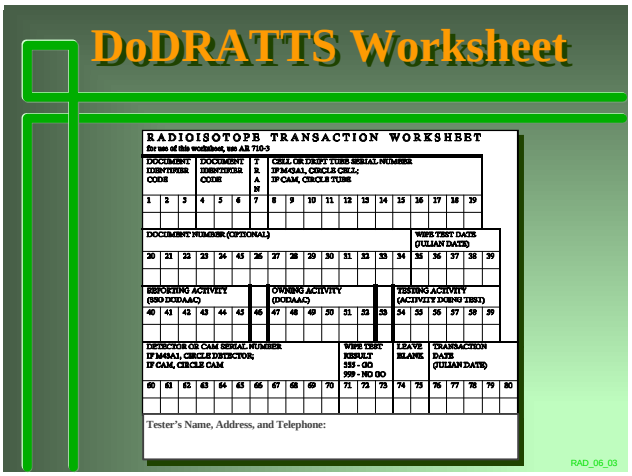
NOTE: *SHOW SLIDE RAD_06_01*



(1) The Department of Defense Radiation Testing and Tracking System (DoDRATTS).

(a) In order to ensure compliance with NRC Licenses 12-00722-14, nickel-63 (CAM), and 12-00722-13, americium-241 (CAD), DoD has established this computerized tracking system. The system has been modeled after the Small Arms Serialization Program (SASP) and utilizes transaction reporting to track all significant actions to the device.

NOTE: *SHOW SLIDE RAD_06_02/03*

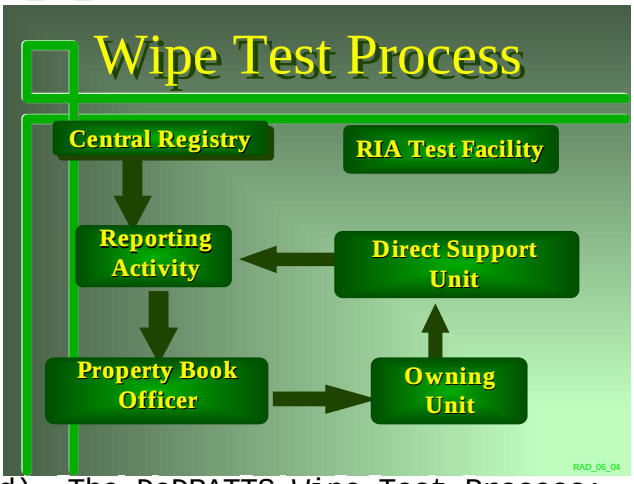


(b) Reported transactions include:

- S - Shipment
- R - Receipt
- Q - Potential Loss
- L - Loss
- C/U - Found or Recovered
- X - Removal of Serial Numbered Source
- Y - Insertion of Serial Numbered Source
- W - Wipe Test
- V - Demil
- N - Shipment to Non-DoD
- F - FMS

(c) All actions taken on the source or device must be reported using one of the above transaction codes. This is so the radioactive source can be tracked throughout its life cycle.

NOTE: *SHOW SLIDE RAD_06_04*



(d) The DoDRATTS Wipe Test Process:

[1] Under normal circumstances, the wipe test cycle will start at Rock Island. The DoD Central Registry, located at Rock Island, AMSTA-AC-MMH-U, will send a letter to the installation POC indicating that a wipe test is due in 120 days. This letter goes to the "Reporting Activity" for the installation that owns the equipment that requires a scheduled wipe test. The reporting activity, normally a function of DOL supply, will generate 3 copies of a "W" transaction indicating the need for a wipe test and give these to the unit that owns the device.

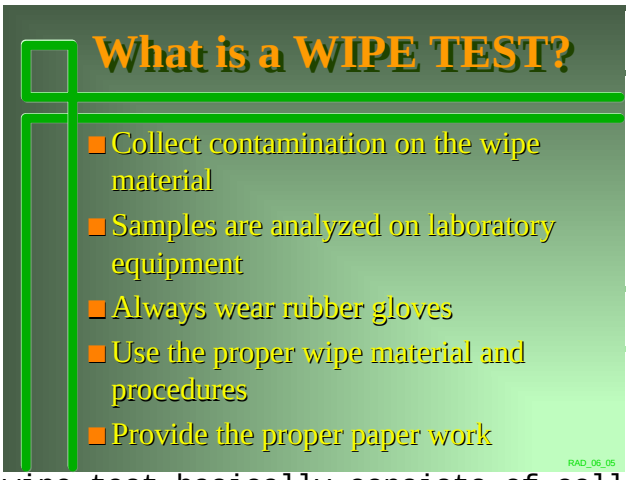
[2] If the owning unit knows that a required wipe test is due and they have not yet received notification from the reporting activity, it is their responsibility to generate the 3 copies of the "W" transaction and initiate the wipe test cycle. The owning unit then job orders the equipment to their supporting Direct Support unit requesting that a wipe test be performed. The owning unit will also provide the DS unit with all 3 copies of the "W" transaction.

[3] The DS unit will perform the wipe test and initial screening. They send one copy of the "W" transaction and the wipe sample to the testing laboratory at Rock Island. They also fill out one copy of the "W" transaction annotating their initial screening result and send it back to the reporting activity where it will be transmitted electronically to the central registry at Rock Island.

[4] The testing facility at Rock Island will analyze the wipe test sample and transmit the results electronically to the central registry and send a letter or FAX back to the DS unit telling them the results of the test.

[5] The DS unit then fills out the remaining "W" transaction indicating the results of the test. If the radiation readings are within allowable limits the equipment and the final "W" transaction are sent back to the owning unit.

NOTE: *SHOW SLIDE RAD_06_05*



(2) A wipe test basically consists of collecting potential contamination on a specific wipe material for analysis on laboratory test equipment. While taking wipe test samples it is important the individual taking the sample wear rubber gloves, use the proper wipe material, and provide the proper paper work.

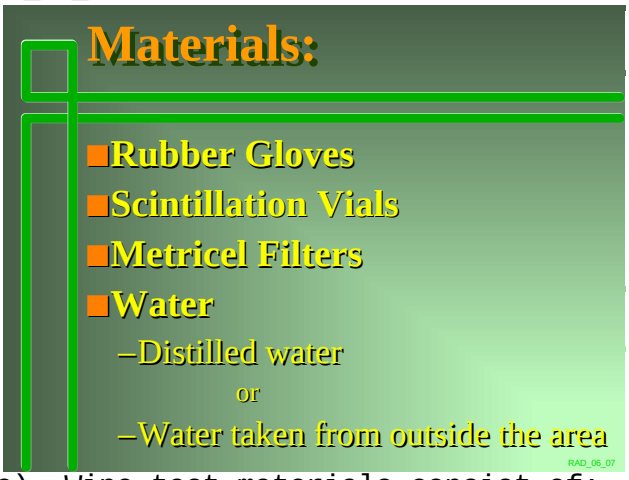
(3) Wipe test procedures for Tritium Contamination.

NOTE: *SHOW SLIDE RAD_06_06*

(a) Tritium oxide contamination is difficult to detect. There are currently no portable radiac instruments in the Army that can detect the low energy beta emissions of tritium. A wipe test must be taken and the wipe sample analyzed using a Liquid Scintillation Counter.

(b) Wipe tests must be taken anytime there is a reasonable possibility of tritium contamination from damage of a device containing tritium light sources. A routine wipe test is also required quarterly for maintenance and storage areas.

NOTE: *SHOW SLIDE RAD_06_07*



(c) Wipe test materials consist of:

[1] Rubber gloves, NSN 8415-00-682-6786 (or equivalent)

[2] Scintillation Vials, NSN 6640-01-141-3871
[3] Metricel Filters, NSN 6640-01-142-8317

[4] Water (Taken from outside the area)

NOTE: *SHOW SLIDE RAD_06_08*

(d) Procedures:

[1] Draw a map of the area to be tested. Information on the map must include:

[a]· Installation name

[b]· Building number

[c]· Name of person conducting wipe test

[d]· Phone number

[e]· Date

[2]· Identify on the map where each wipe is taken.

[3] Be sure to leave enough room on the map to allow the laboratory technicians to annotate the result of each sample.

[4] Put on rubber gloves

[5] Moisten the Metricel filter with water taken from outside the area.

[6] Wipe an area approximately 4 inches square (100 sq cm)

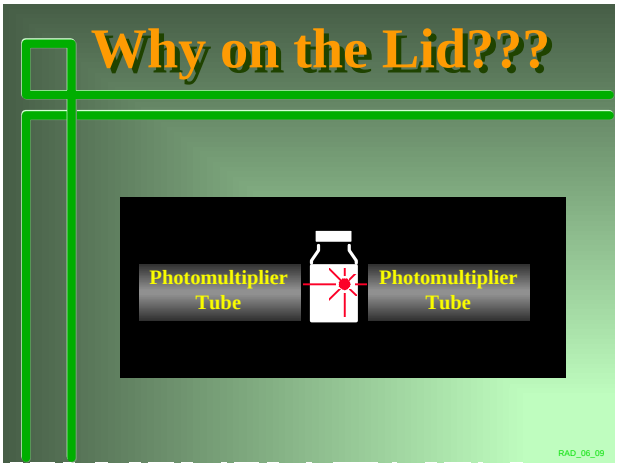
[7] Place the filter in the scintillation vial. Do not put the paper backing that comes with the filter in the vial.

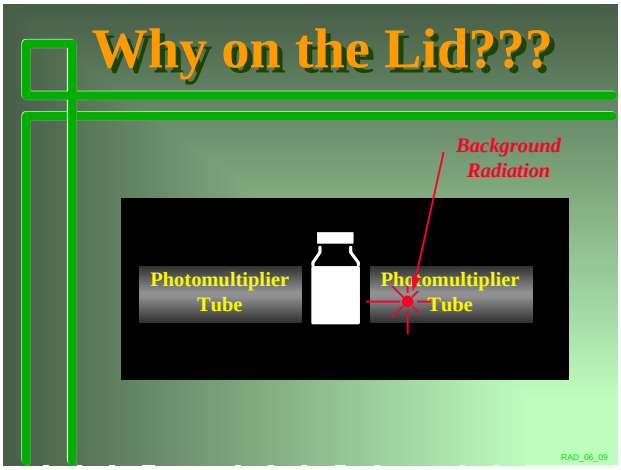
[8] Put 1 ml of water in the vial. This is about 20 drops of water. The added water is to keep the filter moist during shipping and must also be taken from outside the area.

[9] Put the cap on the vial and shake it gently to thoroughly moisten the filter.

[10] Mark the lid of the scintillation vial with a number to identify where on the map it was taken from. MARK ONLY ON THE LID - DO NOT WRITE OR MARK THE SIDE OF THE VIAL.

NOTE: *SHOW SLIDE RAD_06_09*





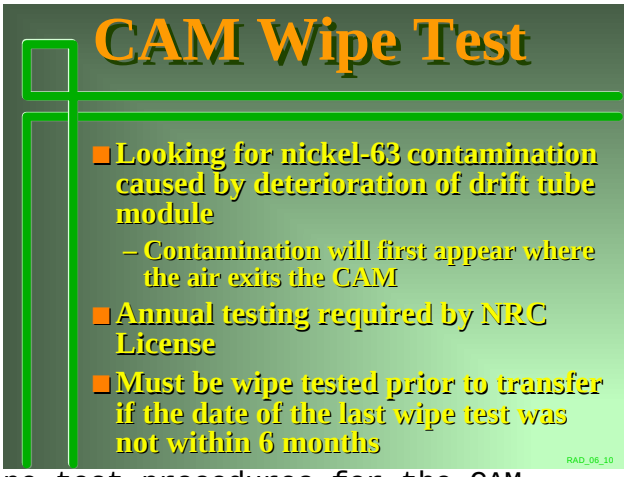
[11] Once all samples have been taken, remove rubber gloves and wash hands thoroughly with non-abrasive soap and warm water.

[12] Mail samples and a copy of the map to:

Commander

Rock Island Arsenal
ATTN: SMCRI-SEM-L (RPO)
Radiation Wipe Test Samples (H3)
Rock Island, IL 61299-5000

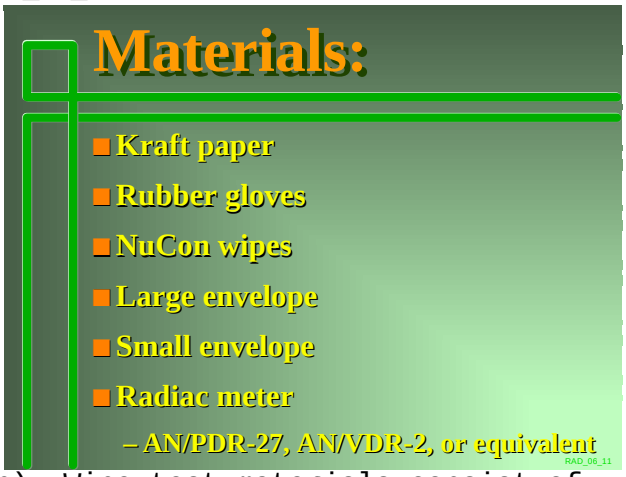
NOTE: *SHOW SLIDE RAD_06_10*



(4) Wipe test procedures for the CAM.

(a) The CAM must be wipe tested once every year for potential contamination with nickel-63. There is no requirement to perform a wipe test while the CAM is in depot level storage however it must be wipe tested prior to transfer if the date of the last test was not within 6 months.

NOTE: *SHOW SLIDE RAD_06_11*



(b) Wipe test materials consist of:

[1]· Kraft Paper

[2]· Rubber gloves, NSN 8415-00-682-6786 (or equivalent)

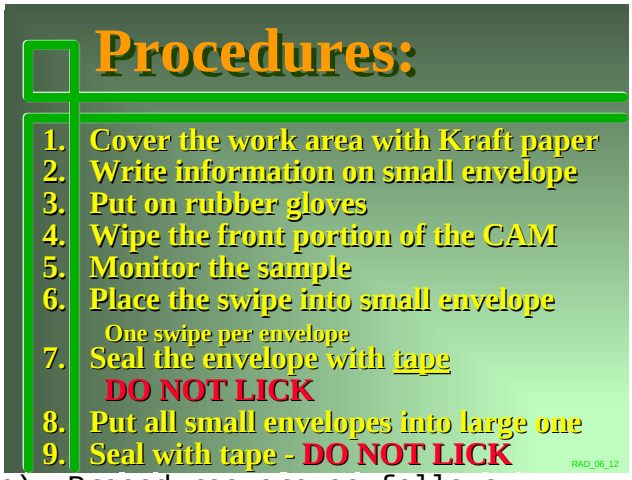
[3]· Test swipes, NSN 6665-01-198-7573

[4]· Large envelope

[5]· Small envelope

[6]· Radiac meter AN/PDR-27, AN/VDR-2, or equivalent

NOTE: *SHOW SLIDE RAD_06_12*



(c) Procedures are as follows:

[1] Cover the work area with Kraft paper.

[2] Write the following information on the small envelope.

[a]· Name of the person performing the wipe test.

[b]· Installation name and location.

[c]· CAM serial number.

[d]· Drift tube module serial number

[e]· “MAIL ROOM - DO NOT OPEN”

[3] Wear rubber gloves.

[4] Wipe the front part of the CAM and around the outside of the air intake nozzle.

[5] Perform initial sample screening with the AN/VDR-2, or equivalent. Consider the CAM contaminated if a reading of twice background is detected.

[6] Place the swipe into the smaller envelope. Use one envelope per swipe. Do not place more then one swipe in each envelope.

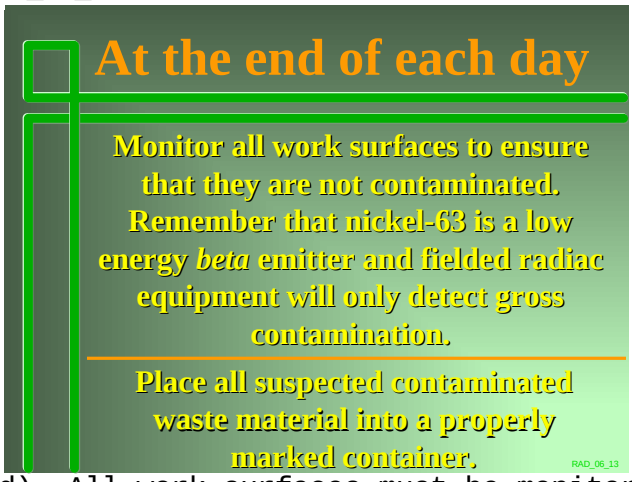
[7] Seal the small envelope with tape. DO NOT lick the envelope to seal it.

[8] Place all of the small envelopes into one large envelope.

[9] Remove rubber gloves and store them in a sealed plastic bag until wipe test results are received to determine whether they can be disposed of as regular waste or if they must be handled as radioactive waste and disposed of IAW AR 385-11.

[10] Seal the large envelope with tape. DO NOT lick the envelope to seal it.

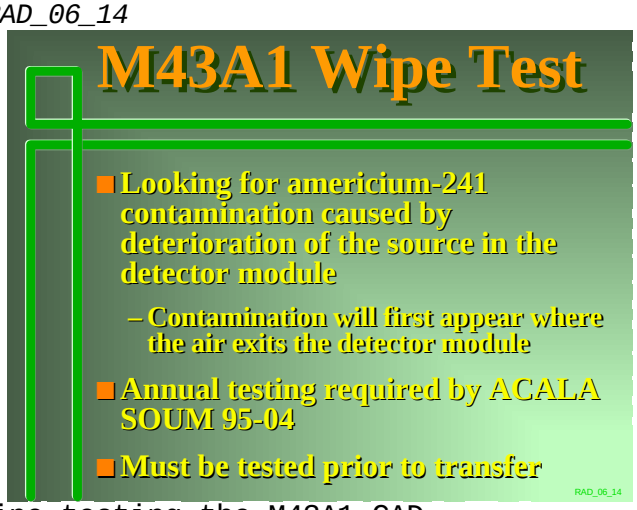
NOTE: *SHOW SLIDE RAD_06_13*



(d) All work surfaces must be monitored with an actively calibrated AN/PDR-27 (or equivalent) Radiac Meter at the end of each day that wipe test are taken or maintenance is performed

(e) Place all contaminated waste material into a properly marked radioactive material waste container.

NOTE: *SHOW SLIDE RAD_06_14*



(4) Wipe testing the M43A1 CAD

(a) Safety-of-Use-Message (SOUM) ACALA 95-01 changed the wipe test procedures and interval for the M43A1 Chemical Agent Detector. SOUM ACALA 95-04 rescinded 95-01 & 95-02 and basically clarified the entire procedure. Prior to this message the wipe test interval was once every three years and the procedures consisted of wiping the outer portion of the Detector cell module and the exit port. Now the wipe test is to be done annually and the wipe is taken from where the air leaves the detector cell module.

(b) In order to understand why the wipe test interval and procedures changed it will be necessary to know how the M43A1 functions and how the americium-241 is configured inside the detector cell module.

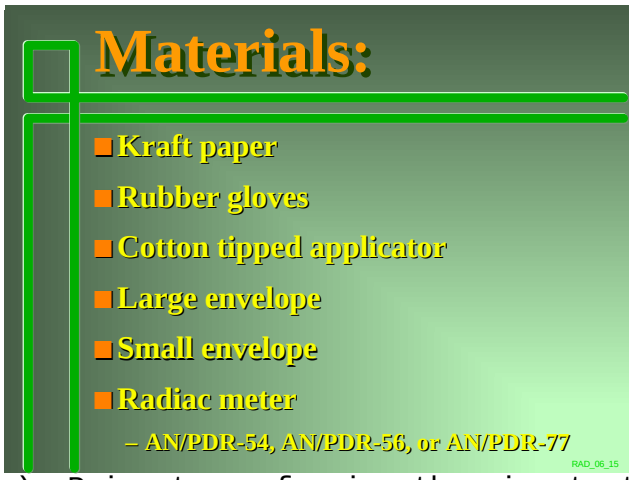
[1] The M43A1 functions by drawing outside air through the system with an internal air pump. The air enters the M43A1 through the air inlet port and passes through a user replaceable air filter designed to remove dust and other large air particles before the air enters the detector portion of the system. The air then enters the detector cell module were it passes through a chamber that contains the radioactive material. When exposed to radiation air molecules tend to cluster together. Impurities in the air, mainly nerve agent molecules, tend to form relatively large clusters. These air clusters then strike a detector that is sensitive to the size of clusters formed by known nerve agents. If nerve agent is present, a signal is processed through the electronics module and the alarm is activated. Home smoke detectors function in much the same way and also contain americium-241.

[2] In the detector module the ^{241}Am is encased in a gold-palladium alloy casing with a silver backing. The configuration and materials that were selected while designing the detector cell module were thought to be sufficient to insure that the Americium oxide would be contained during the life of the item. Recent testing and studies have revealed that this may not be the case. Natural oxidation and constant bombardment of radiation appears to be causing very fine, shallow cracks similar to heat checking in the gold-palladium alloy material. Further testing has shown that these surface defects do not penetrate all the way through the material. The possibility does exist that in some older detector modules these cracks may allow moisture to contact the ^{241}Am causing it to oxidize and plate out onto the surface of the gold-palladium alloy cover in the form of a fine yellow or silver colored dust. Further contact with moisture and the air passing over this surface can cause this radioactive material to migrate through the air passages of the M43A1 and eventually exit through the exit port causing contamination of the entire system.

[3] It is the responsibility of the owning unit to ensure that the wipe test is performed at least annually. The wipe test can only be performed at depot level or by properly trained direct support personnel. A minimum of 8 hours of training is required which must include the hazards associated with americium-241, safe handling of radioactive material, wipe test reporting procedures, radiac instrument operation, and the wipe test procedures.

[4] There is no requirement to perform a wipe test while the CAD is in depot level storage however it must be wipe tested prior to transfer if the date of the last test was not within 6 months.

NOTE: *SHOW SLIDE RAD_06_15*



(c) Prior to performing the wipe test it is important to have all of the materials and equipment readily available. You will need the following items to properly perform the wipe test:

[1]· Kraft Paper

[2]· Rubber Gloves, NSN 8415-00-682-6786 (or equivalent)

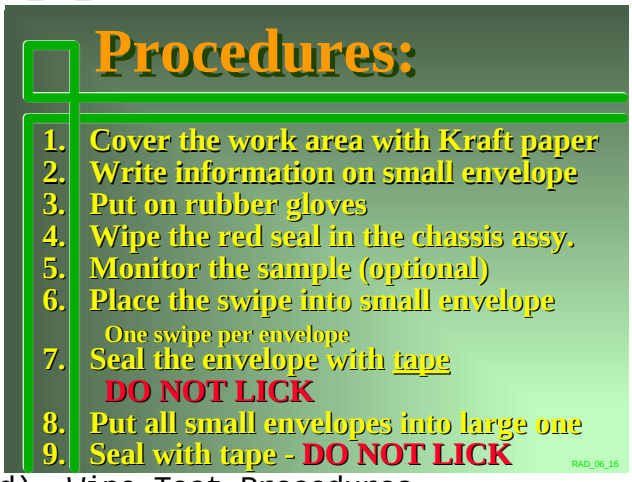
[3]· Disposable Applicators, NSN 6515-01-234-6838

[4]· Large Envelope

[5]· Small Envelope (one for each wipe)

[6]· Actively Calibrated Radiac Meter AN/PDR-56 or AN/PDR-77 (or equivalent)

NOTE: *SHOW SLIDE RAD_06_16*



(d) Wipe Test Procedures

[1] Cover the work area with Kraft paper.

[2] Write the following information on the small envelope.

[a]· Name of the person performing the wipe test.

[b]· Installation name and location.

[c]· M43A1 serial number.

[d] “MAIL ROOM - DO NOT OPEN”

[3] Wear rubber gloves.

[4] Unfasten the 4 catches and remove the bottom case.

[5] Write the serial number of the detector cell module on the small envelope.

[6] Rotate the lock handle on the detector cell module counter-clockwise 1/4 turn and pull the module from the chassis assembly.

[7] Insert a dry disposable applicator through the small hole with a red seal on the chassis assembly twisting the applicator as you pull it out.

[8] Perform initial sample screening of the applicator with an alpha portable radiac meter, AN/PDR-56, AN/PDR-77, or equivalent.

[9] Place the applicator into the smaller envelope. Use one envelope per swipe. Do not place more then one swipe in each envelope.

[10] Seal the small envelope with tape. DO NOT lick the envelope to seal it.

[11] Place all of the small envelopes and one copy of each of the "W" transaction work sheets into one large envelope.

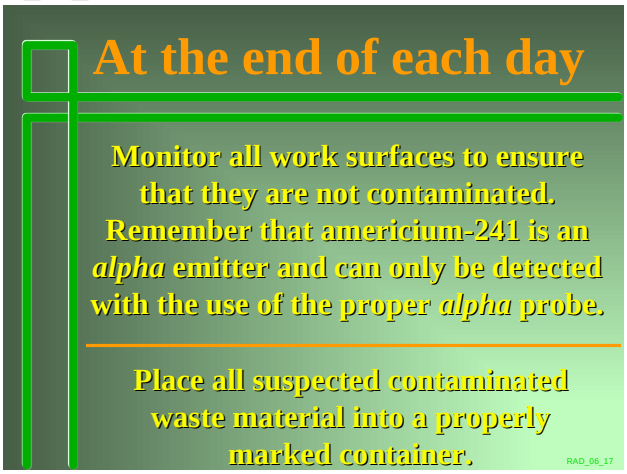
[12] Remove rubber gloves and store them in a sealed plastic bag until wipe test results are received to determine whether they can be disposed of as regular waste or if they must be handled as radioactive waste and disposed of IAW AR 385-11.

[13] Seal the large envelope with tape. DO NOT lick the envelope to seal it.

[14] Address the large envelope to:

Commander; Rock Island Arsenal
ATTN: SMCRI-SEM-L
RADIATION LEAK TEST SAMPLES
Bldg 210, 4th Floor
Rock Island, IL 61299-5000

NOTE: *SHOW SLIDE RAD_06_17*



(e) All work surfaces must be monitored with an actively calibrated AN/PDR-56 (or equivalent) Radiac Meter at the end of each day that wipe test are taken or maintenance is performed

(f) Place all contaminated waste material into a properly marked radioactive material waste container.

c. Summary:

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

Storage
and
Transportation

The Industrial Operations Command (IOC) has been designated by AR 385-11 as the responsible command for the safe disposal of all unwanted, low-level radioactive material in the US Army. Specifically, the IOC's Radioactive Waste Disposal office (AMSMC-RW), has been appointed the Program Manager. AMSMC-RW is accountable for providing information and guidance to all US Army "generators" of unwanted radioactive material to prevent violation of Federal and State regulations, thereby assuring safe and legal transport and burial of the material. A "radioactive waste generator" can be a DS maintenance shop, depot, etc. In all cases the post RPO or Safety Officer should be made aware that there is radioactive waste.

Student Notes

General Shipping Procedures

Once a determination has been made by the field that an item containing radioactive material is unserviceable the local RPO must be notified to help determine item disposition and proper shipping procedures.

If it is determined that the item must be shipped to a designated Depot Facility for further inspection and processing, the item would most likely be shipped as "Instruments and Articles" under 49CFR173.422 "**Exceptions for instruments and articles**".

The items should be double bagged in plastic and ***"...packaged in strong, tight packages that will not leak any of the radioactive materials during conditions normally incident to transportation."*** The outside of the container must have a label like the one shown that gives the name of the person or installation the item is being shipped from.

CONSIGNOR:_____
THIS PACKAGE CONFORMS TO THE CONDITIONS AND LIMITATIONS SPECIFIED IN 49 CFR 173.422 FOR EXCEPTED RADIOACTIVE MATERIAL, INSTRUMENTS AND ARTICLES, UN 2910.

All specific shipping instructions for these items to include destination, packaging, labeling and shipping papers will be provided by AMSMC-RW or the licensee of the radioactive material. All packages containing radioactive material must be wipe tested prior to shipment and upon receipt. On out going shipments this wipe test will ensure that the contents have been properly sealed and any contamination has not been spread to the outer package. For incoming shipments this wipe test will ensure that there has not been any damage to the contents of the container during shipment. Be especially careful if the shipping container shows any signs of damage that may have occurred during transportation.

If it is determined that the item requires no further disassembly and there are no recoverable parts on the item (in other words it is definitely waste material in its current condition), then a little bit different series of events will take place. The RPO or Safety Officer must take possession of the item, store it, and contact AMSMC-RW for disposition instructions.

Student Notes

Shipping Procedures for the MC-1

A letter of instruction must accompany the tester when it is moved from a government controlled facility, and from one job sight to another. A sample letter of instruction is located in Appendix G of TM 5-6635-386-12&P. The general requirements of AR 385-11 must be complied with as well as all state and local requirements. It is mandatory that the tester be packaged and locked in its approved carrying case during transport. The case must be properly secured to prevent damage to it and the tester during transportation.

MC-1 Moisture and Density Gauges that are to be shipped or moved around must meet all of the following requirements:

Consult with the unit Transportation Officer to insure that the tester is shipped IAW Department of Transportation requirements (49CFR170 thru 189), AR 385-11, TM 38-250, and the NRC Regulations (10CFR71).

The following information will assist in the preparation of shipping papers:

- **Proper shipping name:** Radioactive Material, Special Form, N.O.S.
- **Hazard class:** Radioactive Material
- **Identification number:** UN 2974
- **Total quantity:** 1 Box
- **Name of each radionuclide:** americium-241, cesium-137
- **Form:** Special Form
- **Activity:** 60 mCi total, 10 mCi ^{137}Cs and 50 mCi ^{241}Am
- **Label required:** Radioactive Yellow II

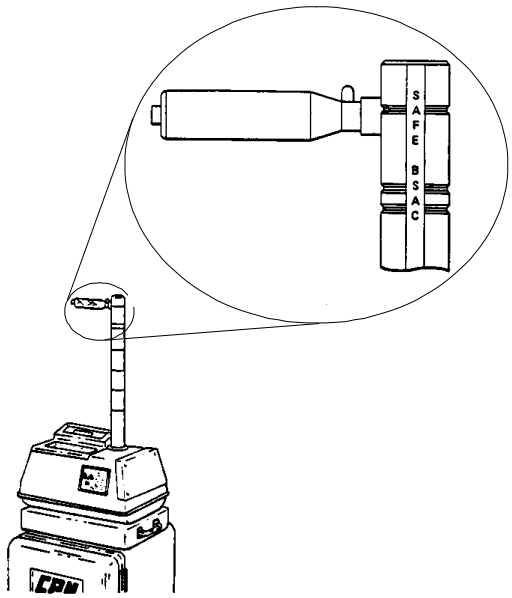
Check with TM 5-6635-386-12&P for a listing of the items that must accompany the MC-1 when it is being shipped for repair/overhaul and when transferring the tester to a new location.

Student Notes

The handle must be locked in the "**SAFE**" position and the batteries removed whenever the tester is moved.

The key for the padlock on the storage container for the MC-1 must be tagged with the tester serial number and sent by registered mail to the receiving or repair facility. The key to the probe handle must be stored inside the case.

Additional information may be required as appropriate depending on the mode of transportation.



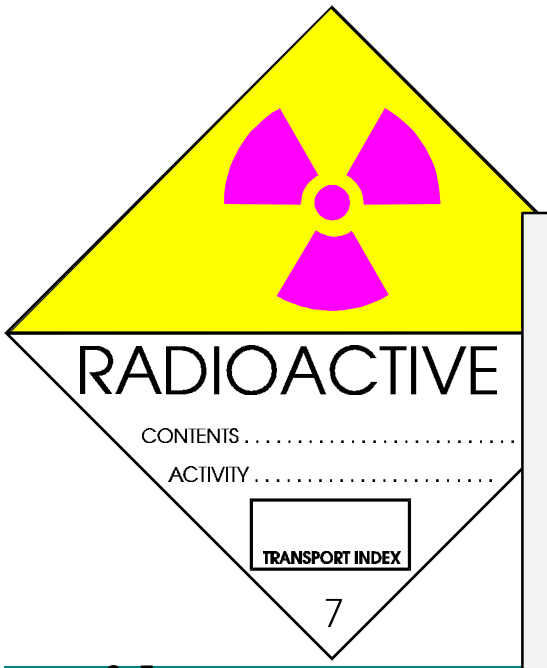
The following shipping certification must appear on the shipping papers:

> **This is to certify that the above named materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.**

The orange tester case meets the requirements of ***Type A*** packaging. ***Type A*** packaging is required for the tester since the radionuclides are in *Special Form* and the amount of activity of the two radioactive sources is below the maximum permitted for ***Type A*** packaging. However, to protect this case from damage during transportation, the tester and case should be placed in a wooden crate.

The outside of the crate must be labeled and marked IAW Title 10 Code of Federal Regulations (10CFR) Parts 172.310, 172.403 and 438.

Student Notes



The **TI** is a number expressing the maximum radiation level (in millirem/hr) at a distance of 1 meter from the outer surface of the container. This number must be rounded *up* to the nearest tenth of a millirem. For example, if the reading you get at 1 meter is 0.31 millirem/hr, the **TI** would be 0.4. The typical **TI** number for the MC-1 is 0.5. The **TI** is used to designate the degree of control required by the carrier during transportation.

0.5

label must appear on at least two opp
container (not top and bottom). The **Transport Index (TI)** must be marked on these labels.

When an MC-1 is received, immediately perform a wipe test to insure that the radioactive sources were not damaged during transportation.

The MC-1 Moisture and Density Gauge **IS NOT AUTHORIZED FOR AIR DROP**.

The MC-1 **IS NOT AUTHORIZED** for shipment on commercial passenger aircraft.

The MC-1 is approved for air transport by helicopter and fixed-wing Army, Air Force and commercial **NON-PASSENGER** aircraft when shipped IAW TM 38-250, AR 385-11, and all applicable NRC and DOT regulations.

Student Notes

ACCEPTABLE STORAGE AREAS FOR TRITIUM

Tritium devices and parts must be stored in ventilated areas. An outside, unoccupied, shed type area is recommended.

Do not store more than 200 curies of tritium in one field storage area.

The area must be posted with a "CAUTION - RADIOACTIVE MATERIAL" sign.

Annually perform a physical inventory of all radioactive devices.

Perform quarterly wipe tests of tritium storage areas.

STORAGE AREAS FOR CAM AND CAD

The Chemical Agent Monitor (CAM) and the Chemical Agent Detector (CAD) must be stored in a secured area (i.e. a lockable wall locker). The area must be posted with a "CAUTION - RADIOACTIVE MATERIAL" sign. There is currently no requirement to store the CAD and the CAM separately and no routine wipe tests are required.

STORAGE OF THE MC-1

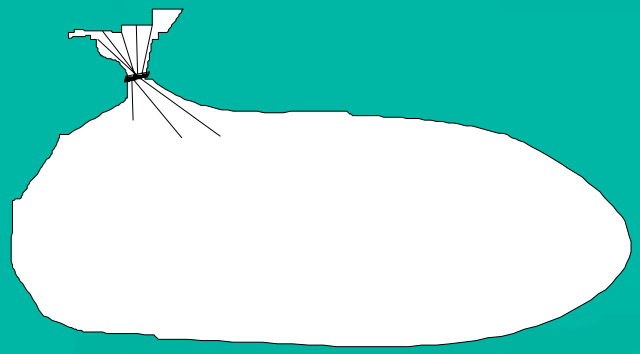
- Must be stored in a locked, unoccupied, and isolated area
- May be stored in a supply area or weapons storage area provided:
    - ◊ Stored in its approved container
    - ◊ Locked in a metal cabinet
    - ◊ As far as possible from personnel work areas
    - ◊ Floor markings to indicate a 2 meter radius to be entered only by the operator, LRPO with Thermal Luminescent Dosimeter (TLD)
- Must have an AN/PDR-27 or equivalent
- The area must be posted

Student Notes

Transportation Storage and Monitoring of Radioactive Materials

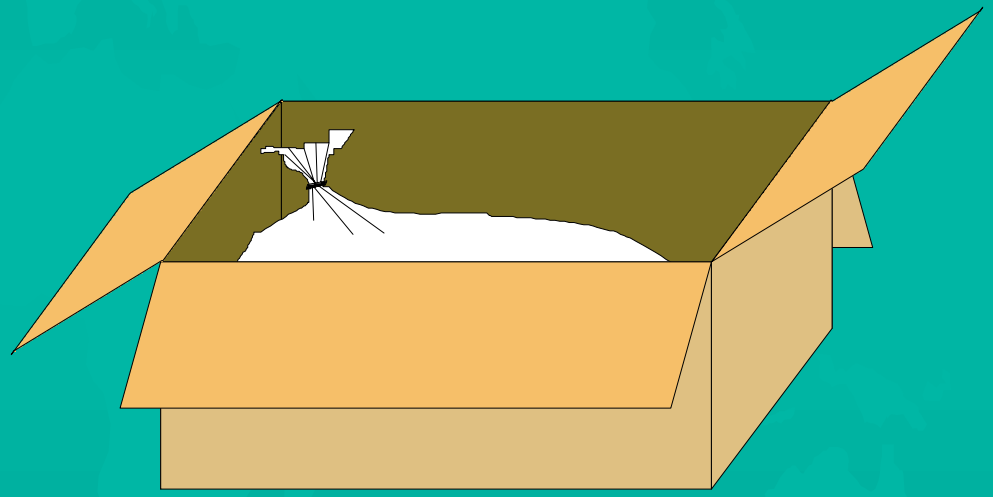
Packaging & Labeling

1. Double bagged in plastic



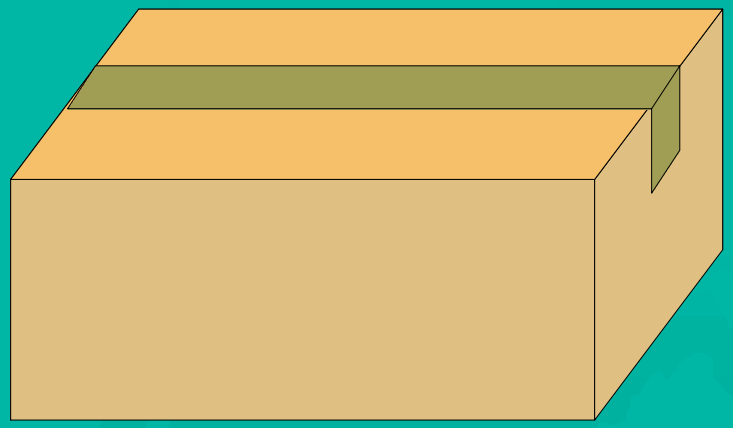
Packaging & Labeling

1. Double bagged in plastic
2. Placed in strong container



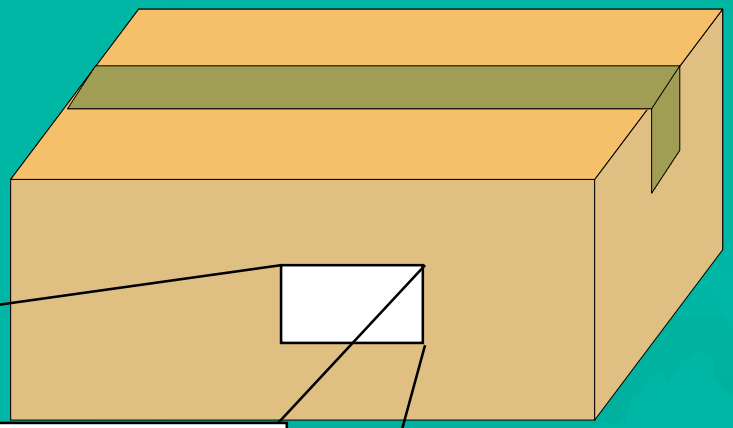
Packaging & Labeling

1. Double bagged in plastic
2. Placed in strong container
3. Tightly sealed



Packaging & Labeling

1. Double bagged in plastic
2. Placed in strong container
3. Tightly sealed
4. Apply the proper shipping label



CONSIGNOR: _____
THIS PACKAGE CONFORMS TO THE CON-
DITIONS AND LIMITATIONS SPECIFIED IN 49 CFR 173.422 FOR EXCEPTED RADIO-ACTIVE MATERIAL, INSTRUMENTS AND ARTICLES, UN 2910

Packaging & Labeling

Level II

0.5 - 50 mRem/hr @ Surface

and

Less than 1.0 mRem/hr @ 1 Meter

Shipping Labels

Level I

Less than 0.5 mRem/hr

Level II

0.5 - 50 mRem/hr @ Surface

and

Less than 1.0 mRem/hr @ 1 Meter

Level III

More than 50 mRem/hr @ Surface

or

More than 1.0 mRem/hr @ 1 Meter

Tritium Storage

- Store in well ventilated area
  - At least 12 air exchanges per day
- No more than 1000 Ci for supply type storage in the field
- No more than 200 Ci for maintenance and other storage areas in the field
- Annual inventories are required
- Quarterly Wipe Test is required

CAM and CAD Storage

- Store in a secured area
- Posted
- CAM & CAD may be stored together

Storage of MC-1

- Must be stored in a locked, unoccupied, and isolated area
- May be stored in a supply area or weapons storage area provided:
  - Stored in its approved container
  - Locked in a metal cabinet
  - As far as possible from personnel work areas
  - Floor markings to indicate 2 meter radius to be entered only by the RPO or operator with TLD
- Must have AN/PDR-27 or equivalent
- The area must be posted

Gas Ionization Detectors

- Gas filled ion chamber
- Metallic chamber walls
  - Penetrated by gamma and high energy beta
- May have a mylar window
  - Allows penetration by alpha and low energy beta
- Measures the ion pairs formed by external radiation ionization of the fill gas

Voltage vs Pulse Height

Simple Ionization **Gas Amplification**

Partial Recombination of Ion Pairs

Ionization Chamber Region

Proportional Region

Limited Proportional Region

Geiger Region

Region of Continuous Discharge

Selection Factors

- Purpose
  - Detection devices should not be used to measure dose rates
- Degree of accuracy required
- Type of radiation - *alpha*, *beta*, or *gamma*
- Energy of the radiation
- Source form - gas, liquid, solid, etc.
- Each facility should have a list of available radiac equipment

Radiac Meter Selection Chart

	Wipe Test	AN/PDR-56	AN/PDR-60	AN/PDR-77			AN/PDR-27	AN/VDR-2
		Alpha	Alpha	Alpha Probe	Beta/Gamma	X-Ray	Beta/Gamma	Beta/Gamma
M43A1 (Americium-241)								
Detect Contamination	XXX	XXX	XXX	XXX				
Measure Contamination Level	XXX							
Locate Missing Source					XXX	XXX	XXX	XXX
CAM (Nickel-63)								
Detect Contamination	XXX				XXX		XXX	XXX
Measure Contamination Level	XXX							
Locate Missing Source					XXX		XXX	XXX
MC-1								
Americium/Berillium								
Detect Contamination	XXX							
Measure Contamination Level	XXX							
Locate Missing Source								
Cesium								
Detect Contamination	XXX				XXX		XXX	XXX
Measure Contamination Level	XXX							
Locate Missing Source					XXX	XXX	XXX	XXX
Tritium								
Detect Contamination	XXX							
Measure Contamination Level	XXX							
Radium								
Detect					XXX		XXX	XXX
Thorium								
Detect Contamination	XXX	XXX	XXX	XXX	XXX		XXX	XXX
Measure Contamination Level	XXX							
Locate Missing Source					XXX	XXX	XXX	XXX
Depleted Uranium								
Detect Contamination	XXX	XXX	XXX	XXX	XXX		XXX	XXX
Measure Contamination Level	XXX							
Locate Missing Source					XXX	XXX	XXX	XXX
Cesium								
Detect Contamination	XXX				XXX		XXX	XXX
Measure Contamination Level	XXX							
Locate Missing Source					XXX	XXX	XXX	XXX

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-07

DATE: Oct 96

TITLE: Storage, Transportation, and Monitoring of Radioactive Materials

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 3.0 C (U) FACILITY REQ: Classroom
0.0 PE

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty TRANSPORTATION: None

ISSUED TO STUDENTS: Student Reference Guide “Radioactive Material Handling Safety”

AIDS AND EQUIPMENT:

a. Overhead Projector
b. Computer Display Device
c. Computer
d. Display Screen
e. RAD_07.PPT Power Point file
f. Ludlam Model 6 Geiger Counter (If available)
g. AN/PDR 27 (If available)
h. AN/PDR-77 (If available)
i. AN/PDR-56F Portable Alpha Counter (If available)
j. AN/VDR-2 Radiac Set (If available)

REFERENCES:	AMCCOM PAM 385-1	“Handbook for Disposal of Unwanted Radioactive Waste”
	TB 9-1300-278	“Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium”
	TM 3-261	“Handling and Disposal of Unwanted Radioactive Material”
	TM 11-6665-208-15	“Operator’s, Organizational, Direct Support, General Support, and Depot Maintenance Manual; RADIAC SET AN/PDR-54
	10 CFR 20	“Standards for Protection Against Radiation”
	49 CFR	Transportation
	49 CFR 73	“General Requirements for Shipment and Packaging”
	AR 385-11	Ionizing Radiation Protection
	AR 700-64	

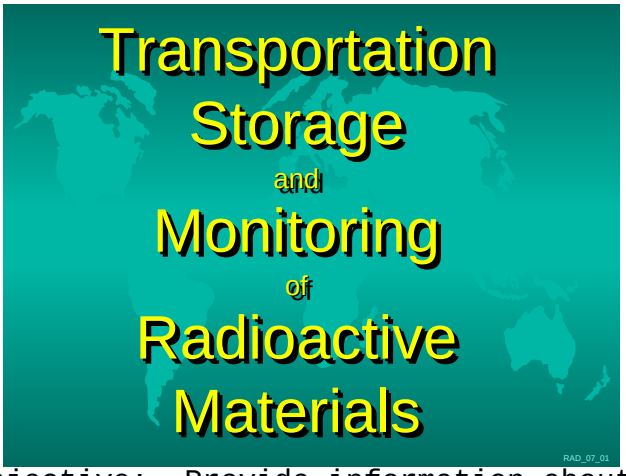
COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: Storage, Transportation, and Monitoring of Radioactive Material

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

a. Introduction:

NOTE: *SHOW SLIDE RAD_06_01*



(1) Objective: Provide information about storage, transportation, and monitoring requirements associated with radioactive material

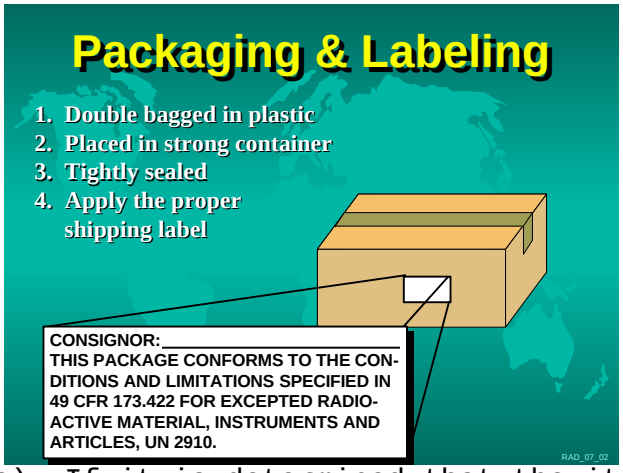
(2) Reason and Tie-In: Disposal and transportation of unwanted radioactive material is an extremely sensitive issue and must be conducted in the manner prescribed by relevant regulations. The purpose of this lesson is to acquaint the student with general radioactive labels, shipping containers, and radiac instruments.

b. Explanation:

(1) The Industrial Operations Command (IOC) has been designated by AR 385-11 as the responsible command for the safe disposal of all unwanted, low-level radioactive material in the US Army. Specifically, the IOC's Radioactive Waste Disposal Office (AMSIO-DMW), has been appointed the Program Manager. AMSMC-RW is accountable for providing information and guidance to all US Army "generators" of unwanted radioactive material to prevent violation of Federal and State regulations, thereby assuring safe and legal transport and disposition of the material. A "radioactive waste generator" can be a DS maintenance shop, depot, etc. In all cases the post RPO or Safety Officer should be made aware that there is radioactive waste.

(2) Once a determination has been made by the field that an item containing radioactive material is unserviceable, the local RPO must be notified to help determine item disposition and proper shipping procedures.

NOTE: *SHOW SLIDE RAD_06_02*

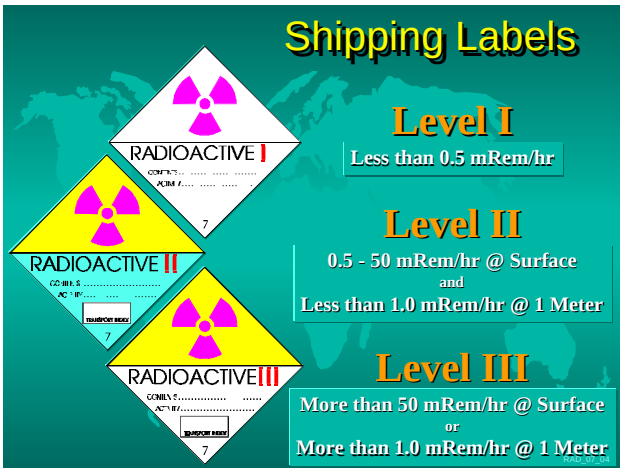


(a) If it is determined that the item must be shipped to a designated Depot Facility for further inspection and processing, the item would most likely be shipped as "Instruments and Articles" under 49CFR173.422 "**Exceptions for instruments and articles**". The items should be double bagged in plastic and "...*packaged in strong, tight packages that will not leak any of the radioactive materials during conditions normally incident to transportation*." The outside of the container should have a label that gives the name of the consignor (the person or installation the item is being shipped from) and the words "**THIS PACKAGE CONFORMS TO THE CONDITIONS AND LIMITATIONS SPECIFIED IN 49 CFR 173.422 FOR EXCEPTED RADIOACTIVE MATERIAL, INSTRUMENTS AND ARTICLES, UN 2910.**" All specific shipping instructions for these items to include destination, packaging, labeling and shipping papers will be provided by AMSIO-DMW or the licensee of the radioactive material.

(b) If it is determined that the item requires no further disassembly and there are no recoverable parts on the item (in other words it is definitely waste material in its current condition), then a little bit different series of events will take place. The local RPO or Safety Officer must take possession of the item, store it, and contact AMSIO-DMW for disposition instructions.

(3) To obtain assistance pertaining to specific questions on packaging, labeling, the NRC, the Department of Transportation, and Disposal Site criteria, call an IOC health physicist at DSN 793-0338/2966 or commercial (309) 782-0338/2966.

NOTE: *SHOW SLIDE RAD_06_03/04*



(4) Shipping Procedures for the MC-1

(a) A letter of instruction must accompany the tester when it is moved from a government controlled facility, and from one job sight to another. A sample letter of instruction is located in Appendix G of TM 5-6635-386-12&P. The general requirements of AR 385-11 must be complied with as well as all state and local requirements. It is mandatory that the tester be packaged and locked in its approved carrying case during transport. The case must be properly secured to prevent damage to it and the tester during transportation.

(b) MC-1 Moisture and Density Gauges that are to be shipped or moved around must meet all of the following requirements:

[1] Consult with the unit Transportation Officer to insure that the tester is shipped IAW Department of Transportation requirements (49CFR170 thru 189), AR 385-11, TM 38-250, and the NRC Regulations (10CFR71).

[2] The following information will assist in the preparation of shipping papers:

- Proper shipping name: Radioactive Material, Special Form, N.O.S.
- Hazard class: Radioactive Material
- Identification number: UN 2974
- Total quantity: 1 Box
- Name of each radionuclide: americium-241, cesium-137
- Form: Special Form
- Activity: 60 mCi total, 10 mCi ^{137}Cs and 50 mCi ^{241}Am
- Label required: Radioactive Yellow II

[3] Check with TM 5-6635-386-12&P for a listing of the items that must accompany the MC-1 when it is being shipped for repair/overhaul and when transferring the tester to a new location.

[4] The handle must be locked in the “SAFE” position and the batteries removed whenever the tester is moved.

[5] The key for the padlock on the storage container for the MC-1 must be tagged with the tester serial number and sent by registered mail to the receiving or repair facility. The key to the probe handle must be stored inside the case.

(c) Additional information may be required as appropriate depending on the mode of transportation.

(d) The following shipping certification must appear on the shipping papers:

> **This is to certify that the above named materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.**

(e) The orange tester case meets the requirements of Type A packaging. Type A packaging is required for the tester since the radionuclides are in Special Form and the amount of activity of the two radioactive sources is below the maximum permitted for Type A packaging. However, to protect this case from damage during transportation, the tester and case should be placed in a wooden crate.

(f) The outside of the crate must be labeled and marked IAW Title 10 Code of Federal Regulations (10CFR) Parts 172.310, 172.403 and 438.

(g) A Radioactive Yellow II label must appear on at least two opposing sides of the outer shipping container (not top and bottom). The Transport Index (TI) must be marked on these labels.

(h) The TI is a number expressing the maximum radiation level (in millirem/hr) at a distance of 1 meter from the outer surface of the container. This number must be rounded up to the nearest tenth of a millirem. For example, if the reading you get at 1 meter is 0.31 millirem/hr, the TI would be 0.4. The typical TI number for the MC-1 is 0.5. The TI is used to designate the degree of control required by the carrier during transportation.

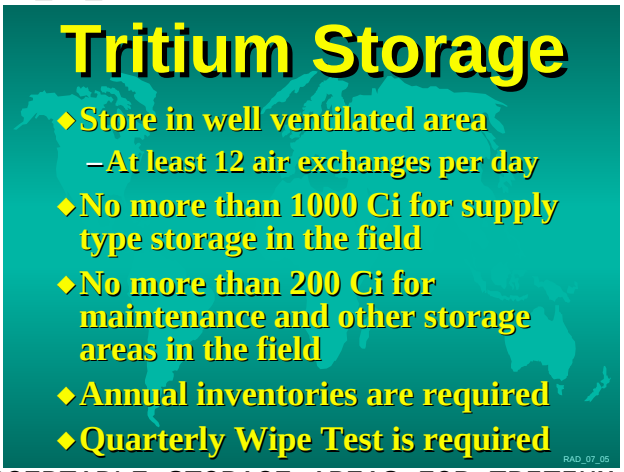
(i) When an MC-1 is received, immediately perform a wipe test to insure that the radioactive sources were not damaged during transportation.

(j) The MC-1 Moisture and Density Gauge IS NOT AUTHORIZED FOR AIR DROP.

(k) The MC-1 IS NOT AUTHORIZED for shipment on commercial passenger aircraft.

(l) The MC-1 is approved for air transport by helicopter and fixed-wing Army, Air Force and commercial NON-PASSENGER aircraft when shipped IAW TM 38-250, AR 385-11, and all applicable NRC and DOT regulations.

NOTE: *SHOW SLIDE RAD_06_05*



(5) ACCEPTABLE STORAGE AREAS FOR TRITIUM

(a) Tritium devices and parts must be stored in ventilated areas. An outside, unoccupied, shed type area is recommended.

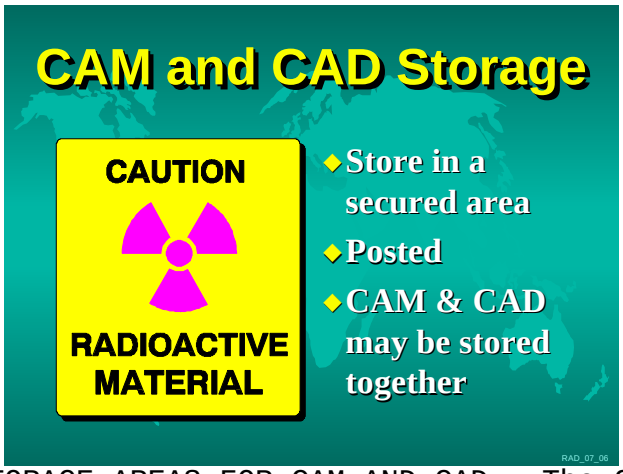
(b) Do not store more than 1,000 curies of tritium in one supply type field storage area.

(c) Do not store more than 200 curies of tritium in one maintenance or other type field storage area.

(d) Annually perform a physical inventory of all radioactive devices.

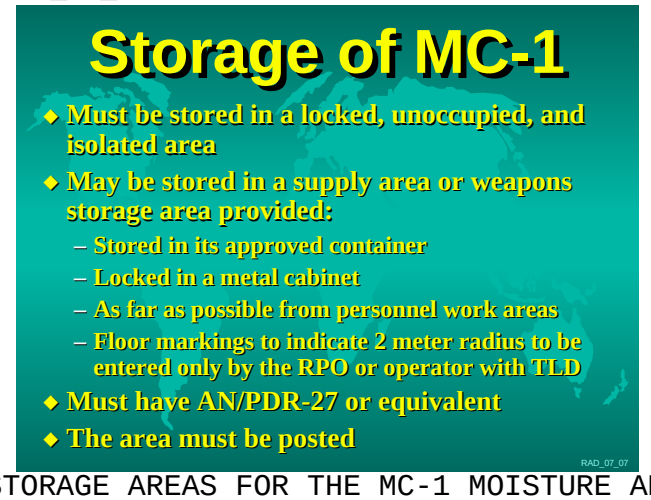
(e) Perform quarterly wipe tests of tritium storage areas.

NOTE: *SHOW SLIDE RAD_06_06*



(6) STORAGE AREAS FOR CAM AND CAD - The Chemical Agent Monitor (CAM) and the Chemical Agent Detector (CAD) must be stored in a secured area (i.e. a lockable wall locker). The area must be posted with a “CAUTION - RADIOACTIVE MATERIAL” sign. There is currently no requirement to store the CAD and the CAM separately.

NOTE: *SHOW SLIDE RAD_06_07*



(7) STORAGE AREAS FOR THE MC-1 MOISTURE AND DENSITY GAUGE

(a) This device must be stored in a locked, unoccupied, and isolated area.

(b) If this is not possible, the MC-1 may be stored in a supply area or weapons storage area if the following conditions are met:

[1] Must be stored in its approved container.

[2] Must be locked in a metal container.

[3] The storage area must be as far as possible from all personnel work areas.

[4] There must be markings on the floor to indicate a two meter radius from the outside of the container. This area can only be entered by the operator or LRPO and they must be wearing their TLDs.

(c) The unit must have an actively calibrated AN/PDR-27 or equivalent.

(d) The area must be posted.

(8) MEASURING INSTRUMENTS AND PORTABLE RADIAC METERS

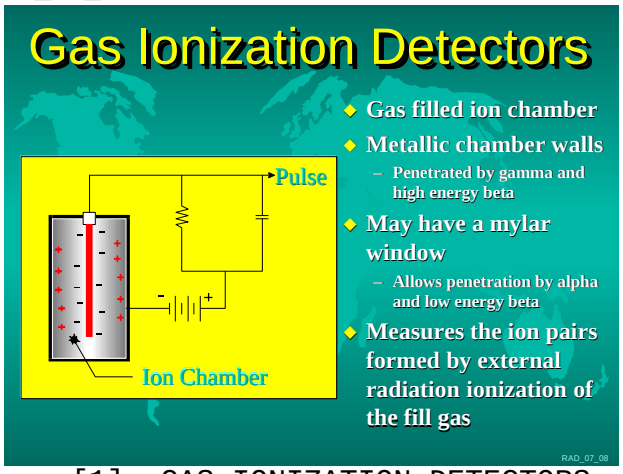
(a) Since none of the five senses can detect ionizing radiation, indirect methods must be used. Numerous types of instruments are used for a wide variety of purposes in the field of radiation protection. Some instruments simply detect the presence of radiation while others give a quantitative measurement of the dose rate.

NOTE

Instruments used for radiation protection **must** be calibrated at least every three months or IAW TB 43-180 and after every maintenance procedure to the device and after every battery change.

(b) Instruments used for radiation protection are of three general types: (1) Gas ionization detectors, (2) Scintillation detectors, and (3) Semiconductor detectors.

NOTE: *SHOW SLIDE RAD_06_08*



[1] GAS IONIZATION DETECTORS

[a] As radiation passes through a gas, it gives off energy to orbital electrons, causing ionization and excitation of the gas atoms.

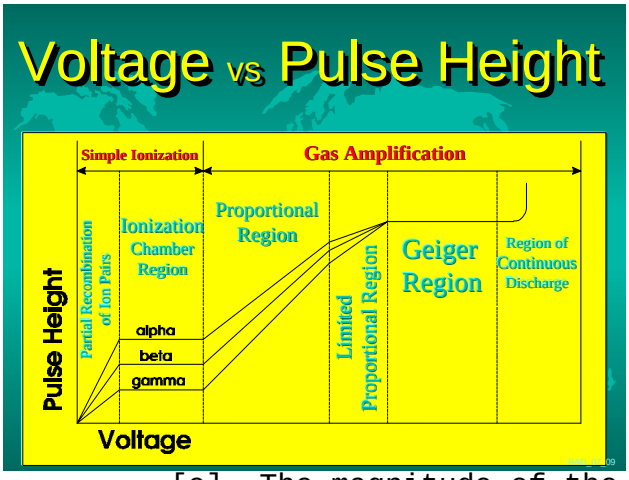
[b] The detector assembly consists of a power supply and a closed electrically conductive cylinder or chamber filled with gas. The chamber walls are usually made of metal which can be penetrated by photons (gamma) and high energy beta particles. The chamber may have a mylar window which can be easily penetrated by alpha particles and low energy beta. As radiation passes through the gas that fills the chamber, it causes ionization and the formation of ion pairs, one positively charged and one negatively charged.

[c] The number of ion pairs created in a given volume of gas depends on the type of gas and the type and energy of the radiation. A dense gas has more atoms available for ionization than does a less dense gas. Alpha particles create many ion pairs within a very short distance as they travel through the gas. Beta particles which are smaller and faster do not interact as readily as alpha particles and thus create fewer ion pairs. Gamma rays which are uncharged interact indirectly with the gas and produce even fewer ion pairs. If an alpha particle, a beta particle and a gamma ray with identical energies all passed through the same volume of fill gas, the alpha particle would create tens of thousands of ion pairs, the beta particle a few hundred, and the gamma ray just a few ion pairs. In addition the energy level of the radiation also effects how many ion pairs are created.

[d] When voltage is applied across the chamber, the negatively charged ions (electrons) move rapidly toward the positively charged anode while the Positively charged ions move very slowly toward the negatively charged cathode (outer wall). The electrons that collect on the anode produce a collected charge that

flows through the external circuits as a pulse or surge of current. Each pulse represents the interaction of one particle or photon with the fill gas.

NOTE: *SHOW SLIDE RAD_06_09*



[e] The magnitude of the voltage applied across the electrodes is another factor that affects the number of electrons collected on the anode. There are 6 distinct regions created depending on the amount of voltage applied.

1. **RECOMBINATION REGION** - With relatively low voltage applied across the electrodes the force of attraction between the ion pairs is greater than the attraction toward the electrodes. This allows most of the ion pairs to recombine. No radiation detectors operate in this region.

2. **IONIZATION CHAMBER REGION** - At a certain voltage, the force of attraction between the ions and the electrodes is sufficient to cause all of the electrons produced by incident radiation to collect on the anode. Subsequent moderate increases in the voltage does not cause further increases in the electron flow. The number of electrons collected at the anode is a function of the amount of ionization occurring in the chamber. In this region the different types of radiation can be distinguished from each other because of the different pulse heights produced in the external circuit.

3. **PROPORTIONAL REGION** - As the voltage continues to increase past the saturation level, the primary ions are accelerated toward the anode with enough force to cause additional ionization to occur. This multiplication or *avalanche* of electrons moving toward the anode is called **gas amplification**. Typical detectors operating in this region have multiplication factors of 100,000 though factors up to 10,000,000 are fairly common. These detectors, like those which operate in the ionization chamber region, can distinguish between alpha, beta, and gamma radiation.

4. **LIMITED PROPORTIONAL REGION** - At the upper range of the proportional region, the gas amplification factor is no longer constant. This region, in general, has no useful purpose for radiation measurement.

5. **GEIGER REGION** - At some point as the voltage increases, the gas amplification is so extensive that an avalanche of electrons spreads along the entire length of the instrument's anode and all pulses are the same size regardless of the type of radiation. A detector operated in the Geiger region can not distinguish between the different types of radiation. Pulses in this region are much larger than those in any of the previous regions and in fact, the production of only one primary ion pair results in an easily measurable pulse (about 1 volt).

6. **CONTINUOUS DISCHARGE REGION** - If the voltage is increased still further, arcing will occur across the electrodes and can cause the instrument to be permanently damaged in a very short period of time.

[f] The three types of ionization instruments commonly used are; **ionization chambers, proportional counters,** and **Geiger Mueller** counters.

1. The most popular use of active **ionization chambers** is as portable instruments to survey for beta and gamma radiation. These instruments come in various forms, shapes, and sizes. Most of these survey instruments are thin-window ionization chambers that have a removable shield over the window end of a cylindrical chamber. When the shield is removed, the instrument responds to both beta and gamma radiation, but with the shield in place, only the gamma rays can penetrate to enter the chamber.

2. A **proportional counter**, first introduced in the 1940's is a gas ionization detector that is operated in the proportional region of the pulse height voltage curve.

2.1 The proportional counters used today are either gas flow or sealed. Repeated or prolonged interaction between radiation and the fill gas in a closed chamber gradually causes the degradation of the gas until eventually the detector loses its effectiveness. At this point, either the gas is replaced by new gas or the entire chamber is replaced. In gas flow proportional counters, gas flows through the counting chamber at a very low rate, removing the degraded gas and any residual contaminants. Before a gas flow proportional counter is operated, it must be *purged* with a brief, large flow of the counting gas.

2.2 Windowless gas flow counters are used to count alpha and beta particles.

3. **Geiger-Mueller (GM)** counters are gas ionization detectors designed to operate in the Geiger region of the pulse height voltage curve. They can be used as pulse counters in the laboratory or as portable survey instruments to detect alpha, beta, and gamma radiation. However, they cannot be used to distinguish between the different types of radiation so should not be used as dose rate or exposure rate meters.

4. Portable GM survey meters can be equipped with either a head set or external speaker. These are extremely useful in surveying for radiation because their response is much faster than the meter indication and the audible circuit is separate from the meter circuit and does not fail even if the device saturates and the meter indicates zero.

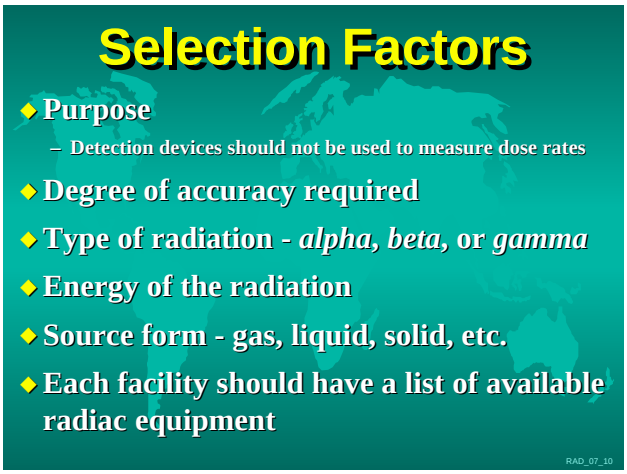
[2] Shortly after x rays were discovered, researchers found certain materials emit light (fluoresce) when struck by radiation. These materials are referred to as phosphors, or *scintillators*. **Scintillation Detectors** were among the earliest instruments for detecting and measuring ionizing radiation and are still widely used today.

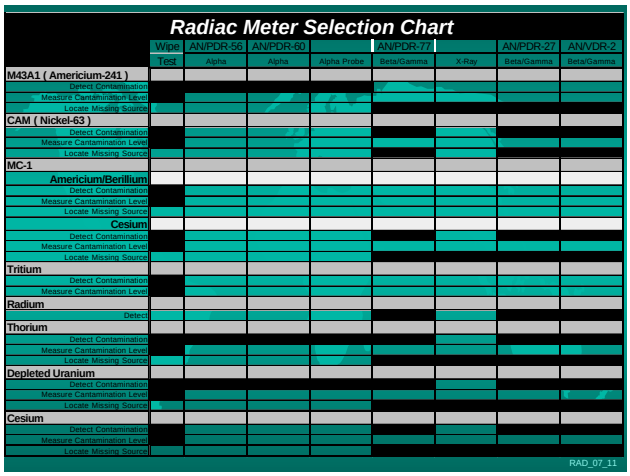
[a] As radiation enters and passes through a phosphor, it gives up its energy by both ionization and excitation to electrons in the phosphor. This energy is released in the form of visible light in a process called *scintillation*. The light flashes can be detected by means of a photomultiplier tube and output as electrical pulses.

[b] <u>Liquid scintillators</u> are made by dissolving an organic scintillator material in an organic solvent. The radioactive sample is then dissolved in the solution to create a *scintillator solution* (often referred to as a cocktail). After the cocktail is prepared it is enclosed in a plastic vial. Plastic vials are popular because plastic contains no potassium and therefore have lower radioactive background than glass vials and have slightly higher efficiency for counting tritium.

[3] **SEMICONDUCTOR**, or solid-state detectors operate on the same principle as gas ionization detectors. Semiconductor detectors are relatively expensive, and because of their fragile nature and design, they cannot be decontaminated.

NOTE: *SHOW SLIDE RAD_06_10/11*





(c) FACTORS THAT AFFECT THE SELECTION AND USE OF RADIATION MONITORING INSTRUMENTS

[1] Individuals who are selecting instruments for radiation monitoring should know:

[a] The **purpose** for which the instrument will be used. An instrument designed for detection should not be used to measure radiation dose rate or exposure rate.

[b] The degree of **accuracy** needed.

[c] The **type of radiation** to be detected or measured. A specially designed GM counter can detect alpha, beta, and gamma radiation, but a portable alpha counter that is properly calibrated should **not** measure gamma radiation.

[d] The **energy** of the radiation. The instrument selected must be capable of measuring or detecting the radiation in question. Most instruments are designed to respond to a wide energy spectrum. However, a GM counter or an ionization chamber cannot monitor tritium; the weak beta radiation emitted by tritium requires measurement by liquid scintillation or special windowless counters.

[e] The source **form** - gas, liquid, or solid - organic or inorganic.

[f] The **intensity and uniformity** of the field to be measured.

[g] The **environment** the instrument is to be used in. Some instruments may respond to heat, light, radio frequency radiation, and shock. When used near operating equipment,

particularly vehicles with generators or alternators, survey instruments may respond to induced electrical fields.

[2] Each facility should have on hand a list of available radiation survey instruments, including the types of instruments available and, for each type, the number available, the radiation it detects, its sensitivity and range, the thickness of any windows, the general use it was designed for, and the calibration date for each instrument.

(d) **TYPES OF RADIATION MONITORING INSTRUMENTS** - Radiation monitoring instruments are generally classed in one of four areas: 1) portable survey meters, 2) laboratory counting instruments, 3) air monitoring equipment, and 4) other fixed instruments.

[1] **PORTABLE SURVEY METERS** are small and light enough to be carried from place to place. Some are used for detecting radiation while others are for taking quantitative measurements of radiation levels. Some degree of accuracy must be sacrificed to provide the light weight, small size, and ruggedness required for portable instruments.

[a] Portable survey instruments for *DETECTING* radiation and radioactive materials should be selected based upon the type, energy, and intensity of the radiation to be encountered. For surveys of areas, equipment, or personnel, the audio output should be used if available. The audio circuitry responds more rapidly than the meter. Small radioactive spots or beams can be more readily detected by sound and the audio circuitry does not fail if the device saturates and the meter reads zero.

[b] Portable survey instruments for *MEASURING* exposure and exposure rate are generally small, portable ionization chambers. Like detection instruments, these should be selected based on the type, energy, and intensity of the radiation to be measured plus the methods and radioisotope used to calibrate the instrument, the calibration curves, and the necessary correction factors all affect the suitability of an instrument.

[2] Field assessments of radioactive contamination are generally qualitative rather than quantitative and they cannot measure levels of radioactivity as low as the levels that **laboratory counters** can. Laboratory counters may include GM tube detectors in heavily shielded chambers (to minimize the background radiation) with scalar readouts, scintillation counters, proportional counters, semiconductor detectors, and multi-channel spectrometers with computer analysis capabilities.

[3] Instruments used to monitor gaseous or particulate radioactivity in the air should be highly sensitive since the amount of radioactivity to be measured or detected is usually

small. Air sampling equipment takes a sample of the air or draws air through a filter to trap particles for analysis at some other time. No immediate response is given. Air monitoring is performed when the results are needed immediately.

[a] Most air monitors cannot detect low levels of radioactivity. For example, an alpha air monitor is relatively ineffective for measuring airborne depleted uranium. By the time an alpha monitor detected DU and sounded an alarm, the airborne activity would be several times above acceptable limits.

[b] Some airborne activity, such as low-energy beta particles from tritium, can be monitored using a *Kanne chamber*, an ionization chamber through which the air flows. These chambers, however, are also sensitive to high-energy background radiation and some compensation is normally required.

[4] Other radiation monitoring devices include **personnel dosimeters**. These devices come in various forms including pocket ionization chambers or pencil dosimeters, photographic film, nuclear track emulsions, and thermoluminescence dosimeters (TLD).

(e) **Alpha Portable Survey Instruments.**

[1] Detection of alpha radiation is difficult due to the short range of the alpha particle in the air. Test data shows that the detector should be placed within one-quarter inch from the source, preferably at 1/8 inch standoff for accuracy. The detector must also be constructed of a material which is thin enough to allow passage of the alpha particle, since a sheet of tissue paper will completely absorb an alpha particle.

[2] Alpha particle monitoring of surfaces is not definitive data of the radiation hazard. Fixed alpha contamination is not a problem while loose alpha contamination cannot be determined in the presence of fixed alpha particle contamination. In addition, alpha contamination cannot be accurately monitored off of wet surfaces.

[3] The recommended type of instruments for monitoring or counting alpha particles is either *gas proportional* (which uses propane as the counting gas) or *scintillation* (which uses ambient air as the counting gas). Both types can discriminate between alpha and beta particles which is required for alpha determination.

[4] **AN/PDR-60 Portable Alpha Counter.**

[a] A portable alpha-survey counter operating on the scintillation principle. It also incorporates a GM detector for measurement of gamma radiation.

[b] There are several models of this instrument available depending on the date of manufacture. Originally this was a commercial radiacmeter, and the first models were known as the PAC-1S. A later model, the PAC-1SA, employed a modified chassis in which ordinary flashlight batteries could be used. The present AN/PDR-60 is similar to this model, except that a Geiger-Mueller tube has been added to allow gamma monitoring up to 2 r/hr.

[c] Accessories include:

1. A **PG-1** probe used to detect the presence, not to measure the quantity, of plutonium under adverse conditions such as rain, snow, or after fire fighting operations.

2. A **RASP-1** (Ruggedized Alpha Scintillation Probe) which is similar to the standard alpha probe except that it has a smaller sensitive area that is well protected by a screen.

[d] The AN/PDR-60 is the standard alpha-survey instrument for the Army and Air Force. It is a good, high-range alpha-survey instrument with excellent operational flexibility. It is extremely sensitive to light leaks. Even minor probe damage will cause malfunction.

[e] One caution to observe with this meter is it's check source. The AN/UDM-6 Radiac Calibrator check source contains Plutonium-239. ^{239}Pu is extremely dangerous to living tissue. When very small amounts of ^{239}Pu are inhaled, ingested, or absorbed in open cuts or wounds, they can cause serious injury or death. **HANDLE THIS SOURCE CAREFULLY.**

[5] **AN/PDR-56F Portable Alpha Counter.**

[a] A portable survey counter operating on the scintillation principle and is quite similar to the AN/PDR-60. The main probe may be attached to the case or used separately. There is also an auxiliary probe which is useful for monitoring small areas.

[b] The AN/PDR-56 is the standard alpha Radiacmeter for the Navy. It is a rugged, waterproof instrument with an integral battery check feature. A check source is attached to the base of the main case so that instrument operation may be check at any time.

[6] **AN/PDR-54 Portable Alpha Counter.**

[a] A gas-ionization, portable, alpha-survey counter operating in the proportional region using propane as the detector gas.

[b] The single-probe construction is an advantage since probes may be interchanged if damaged. Minor damage to the probe (1/8-inch holes or less) is not serious and operation may continue until repairs can be made.

[c] A problem with any alpha detector using gas-ionization is that the detector must be open to the atmosphere which causes variations in the probe pressure due to barometric or altitude changes. These changes will cause the gas-amplification factor to vary, affecting instrument accuracy. The probe voltage must be adjusted to compensate for fluctuations in gas pressure.

[d] Propane is used as the counting gas because:

- It provides a controlled atmosphere.
- It is easily liquefied for storage.
- It is inexpensive and widely available.
- It has good radiation counting properties.
- Allows low probe voltages.

[e] Propane is a polyatomic gas and will not recombine once used. Therefore a continuous gas flow is necessary, exhausting the spent gas into the atmosphere. The propane supply will last 24 hours with the control valve in the OPERATE position. Replacement of the gas cylinder is a simple screw on operation.

[f] When the instrument is properly adjusted, beta pulses will fail to cause the trigger circuit to function but all alpha pulses will.

[g] The AN/PDR-54 is an excellent low- and medium-range alpha survey instrument, is well suited for personnel monitoring and is used by the Army, Navy, and Air Force. Although it’s altitude sensitivity and propane gas usage present serious problems for certain applications, overall it is well suited for field monitoring.

[h] The AN/PDR-54 set contains a Radioactive Test Sample CS-12. The radioactive area of the check source is a 3/4 inch diameter metal disc which has thorium-230 electroplated to it. The active area contains 0.1 microcuries and has an emission rate of 14,000 counts per minute (cpm). Do not allow the active surface of the check source to contact your skin.

[7] AN/PDR-77

[a] The AN/PDR-77 is the latest fielded radiac instrument used by the Army. When used in conjunction with it's alpha probe it will detect and measure alpha radiation and provide the user with a digital readout in Counts Per Minute (CPM). The alpha probe for this instrument uses a 100 sq cm Mylar surface to convert the alpha energy into light flashes that are detected internally by a photomultiplier tube.

[b] As with most alpha portable radiac instruments, the AN/PDR-77 Radiac Set also contains a radioactive check source to ensure that the alpha probe is functioning properly. This particular check source is NOT labeled as radioactive though it contains thorium-232 and should be handled carefully. Since alpha particles are very easily shielded the thorium in the check source is exposed on the "ALPHA SIDE". Handle the check source by the edges only and wash your hands afterwards.

(f) **Beta/Gamma Portable Survey Instruments.**

[1] Geiger-Mueller Detectors (GM devices) are generally used for low level Beta/Gamma detection. They are rugged, provide a rapid response, are sensitive to beta/gamma emissions, and are ideal for scanning for depleted uranium contamination.

[2] Types of beta/gamma instruments are:

[a] **Ludlum Model 6 Geiger Counter.**

[b] **AN/PDR-60 with a PG-1 Detector Probe.**

[c] **AN/PDR-56F with x-ray Probe.**

[d] **AN/PDR-27.**

[e] **AN/VDR-2 Radiac Set** - contains thorium-232, 1 nanocurie. Used to locate and measure radioactivity in the form of gamma rays and beta particles. Displays dose rates and total accumulated dose resulting from a fallout field. Operating ranges:

- Gamma 0.01 µGy/hr. to 100 Gy/hr.

- Beta 0.01 µGy/hr. to 5 cGy/hr.
- Dose 0.01 µGy to 9.99 Gy

[f] **AN/PDR-77 with beta/gamma Probe** - The AN/PDR-77 Radiac Set also contains a beta/gamma probe (AN/VDR-2) that can detect beta and measure gamma. When this probe is attached the meter will provide the user with a digital display in mrem/hr.

c. Summary: During this lesson the student learned some of the restrictions for storage areas, shipping requirements, and the types of instruments used to detect and measure radioactive materials.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

MEASURING INSTRUMENTS AND PORTABLE RADIAC METERS

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Student Notes

NOTE

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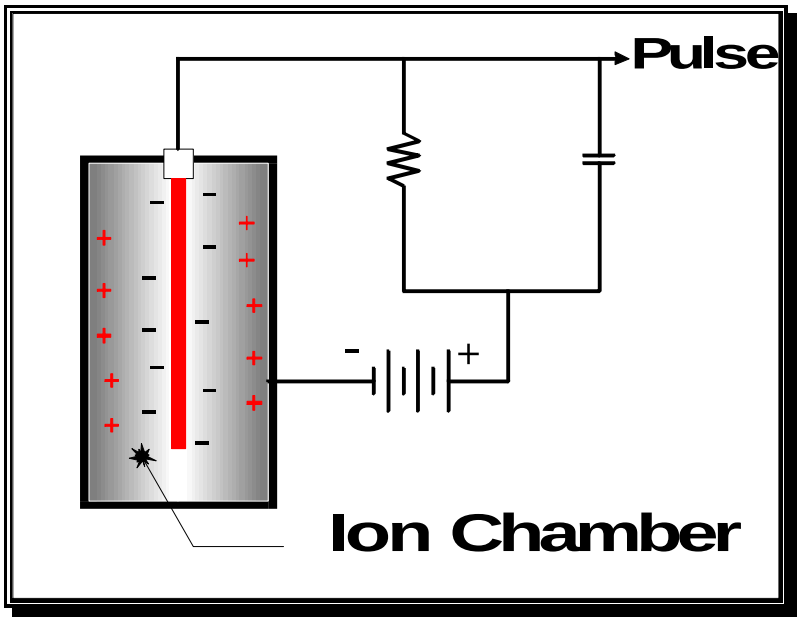
Instruments used for radiation protection are of three general types: (1) Gas ionization detectors, (2) Scintillation detectors, and (3) Semiconductor detectors.

GAS IONIZATION DETECTORS

As radiation passes through a gas, it gives off energy to orbital electrons, causing ionization and excitation of the gas atoms.

The detector assembly consists of a power supply and a closed electrically conductive cylinder or chamber filled with gas. The chamber walls are usually made of metal which can be penetrated by photons (gamma) and high energy beta particles. The chamber may have a mylar window which can be easily penetrated by alpha particles and low energy beta. As radiation passes through the gas that fills the chamber, it causes ionization and the formation of ion pairs, one positively charged and one negatively charged.



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Student Notes

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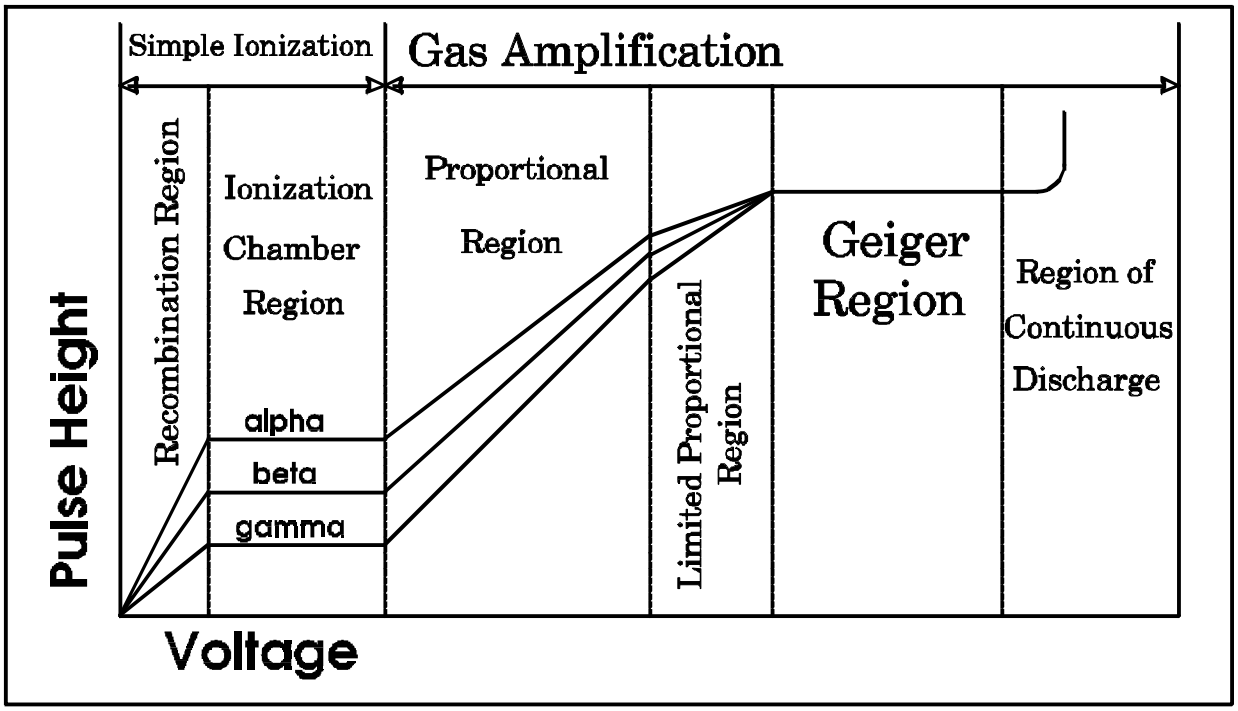
When voltage is applied across the chamber, the negatively charged ions (electrons) move rapidly toward the positively charged anode while the Positively charged ions move very slowly toward the negatively charged cathode (outer wall). The electrons that collect on the anode produce a collected charge that flows through the external circuits as a pulse or surge of current. Each pulse represents the interaction of one particle or photon with the fill gas.

The magnitude of the voltage applied across the electrodes is another factor that affects the number of electrons collected on the anode. There are 6 distinct regions created depending on the amount of voltage applied.

RECOMBINATION REGION - With relatively low voltage applied across the electrodes the force of attraction between the ion pairs is greater than the attraction toward the electrodes. This allows most of the ion pairs to recombine. No radiation detectors operate in this region.

Student Notes

IONIZATION CHAMBER REGION - At a certain voltage, the force of attraction between the ions and the electrodes is sufficient to cause all of the electrons produced by incident radiation to collect on the anode. Subsequent moderate increases in the voltage does not cause further increases in the electron flow. The number of electrons collected at the anode is a function of the amount of ionization occurring in the chamber. In this region the different types of radiation can be distinguished from each other because of the different pulse heights produced in the external circuit.



PROPORTIONAL REGION - As the voltage continues to increase past the saturation level, the primary ions are accelerated toward the anode with enough force to cause additional ionization to occur. This multiplication or *avalanche* of electrons moving toward the anode is called **gas amplification**. Typical detectors operating in this region have multiplication factors of 100,000 though factors up to 10,000,000 are fairly common. These detectors, like those which operate in the ionization chamber region, can distinguish between alpha, beta, and gamma radiation.

Student Notes

LIMITED PROPORTIONAL REGION - At the upper range of the proportional region, the gas amplification factor is no longer constant. This region, in general, has no useful purpose for radiation measurement.

GEIGER REGION - At some point as the voltage increases, the gas amplification is so extensive that an avalanche of electrons spreads along the entire length of the instrument's anode and all pulses are the same size regardless of the type of radiation. A detector operated in the Geiger region can not distinguish between the different types of radiation. Pulses in this region are much larger than those in any of the previous regions and in fact, the production of only one primary ion pair results in an easily measurable pulse (about 1 volt).

CONTINUOUS DISCHARGE REGION - If the voltage is increased still further, arcing will occur across the electrodes and can cause the instrument to be permanently damaged in a very short period of time.

Instruments

The three types of ionization instruments commonly used are; **ionization chambers, proportional counters,** and **Geiger Mueller** counters.

The most popular use of active **ionization chambers** is as portable instruments to survey for beta and gamma radiation. These instruments come in various forms, shapes, and sizes. Most of these survey instruments are thin-window ionization chambers that have a removable shield over the window end of a cylindrical chamber. When the shield is removed, the instrument responds to both beta and gamma radiation, but with the shield in place, only the gamma rays can penetrate to enter the chamber.

A **proportional counter**, first introduced in the 1940's is a gas ionization detector that is operated in the proportional region of the pulse height voltage curve.

The proportional counters used today are either gas flow or sealed. Repeated or prolonged interaction between radiation and the fill gas in a closed chamber gradually causes the degradation of the gas until eventually the detector loses its effectiveness. At this point, either the gas is replaced by new gas or the entire chamber is replaced. In gas flow proportional counters, gas flows through the counting chamber at a very low rate, removing the degraded gas and any residual contaminants. Before a gas flow proportional counter is operated, it must be *purged* with a brief, large flow of the counting gas.

Student Notes

Windowless gas flow counters are used to count alpha and beta particles.

Geiger-Mueller (GM) counters are gas ionization detectors designed to operate in the Geiger region of the pulse height voltage curve. They can be used as pulse counters in the laboratory or as portable survey instruments to detect alpha, beta, and gamma radiation. However, they cannot be used to distinguish between the different types of radiation so should not be used as dose rate or exposure rate meters.

Portable GM survey meters can be equipped with either a head set or external speaker. These are extremely useful in surveying for radiation because their response is much faster than the meter indication and the audible circuit is separate from the meter circuit and does not fail even if the device saturates and the meter indicates zero.

Shortly after x rays were discovered, researchers found certain materials emit light (fluoresce) when struck by radiation. These materials are referred to as phosphors, or *scintillators*. **Scintillation Detectors** were among the earliest instruments for detecting and measuring ionizing radiation and are still widely used today.

As radiation enters and passes through a phosphor, it gives up its energy by both ionization and excitation to electrons in the phosphor. This energy is released in the form of visible light in a process called *scintillation*. The light flashes can be detected by means of a photomultiplier tube and output as electrical pulses.

Liquid scintillators are made by dissolving an organic scintillator material in an organic solvent. The radioactive sample is then dissolved in the solution to create a *scintillator solution* (often referred to as a cocktail). After the cocktail is prepared it is enclosed in a plastic vial. Plastic vials are popular because plastic contains no potassium and therefore have lower radioactive background than glass vials and have slightly higher efficiency for counting tritium.

SEMICONDUCTOR, or solid-state detectors operate on the same principle as gas ionization detectors.

Student Notes

FACTORS THAT AFFECT THE SELECTION AND USE OF RADIATION MONITORING INSTRUMENTS

Individuals who are selecting instruments for radiation monitoring should know:

The **purpose** for which the instrument will be used. An instrument designed for detection should not be used to measure radiation dose rate or exposure rate.

The degree of **accuracy** needed.

The **type of radiation** to be detected or measured. A specially designed GM counter can detect alpha, beta, and gamma radiation, but a portable alpha counter that is properly calibrated should **not** measure gamma radiation.

The **energy** of the radiation. The instrument selected must be capable of measuring or detecting the radiation in question. Most instruments are designed to respond to a wide energy spectrum. However, a GM counter or an ionization chamber cannot monitor tritium; the weak beta radiation emitted by tritium requires measurement by liquid scintillation or special windowless counters.

The source **form** - gas, liquid, or solid - organic or inorganic.

The **intensity and uniformity** of the field to be measured.

The **environment** the instrument is to be used in. Some instruments may respond to heat, light, radio frequency radiation, and shock. When used near operating equipment, particularly vehicles with generators or alternators, survey instruments may respond to induced electrical fields.

Each facility should have on hand a list of available radiation survey instruments, including the types of instruments available and, for each type, the number available, the radiation it detects, its sensitivity and range, the general use it was designed for, and the calibration date for each instrument.

TYPES OF RADIATION MONITORING INSTRUMENTS

Radiation monitoring instruments are generally classed in one of four areas: 1) portable survey meters, 2) laboratory counting instruments, 3) air monitoring equipment, and 4) other fixed instruments.

PORTABLE SURVEY METERS are small and light enough to be carried from place to place. Some are used for detecting radiation while others are for

Student Notes

taking quantitative measurements of radiation levels. Some degree of accuracy must be sacrificed to provide the light weight, small size, and ruggedness required for portable instruments.

Portable survey instruments for *DETECTING* radiation and radioactive materials should be selected based upon the type, energy, and intensity of the radiation to be encountered. For surveys of areas, equipment, or personnel, the audio output should be used if available. The audio circuitry responds more rapidly than the meter. Small radioactive spots or beams can be more readily detected by sound and the audio circuitry does not fail if the device saturates and the meter reads zero.

Portable survey instruments for *MEASURING* exposure and exposure rate are generally small, portable ionization chambers. Like detection instruments, these should be selected based on the type, energy, and intensity of the radiation to be measured plus the methods and radioisotope used to calibrate the instrument, the calibration curves, and the necessary correction factors all affect the suitability of an instrument.

Field assessments of radioactive contamination are generally qualitative rather than quantitative and they cannot measure levels of radioactivity as low as the levels that **laboratory counters** can. Laboratory counters may include GM tube detectors in heavily shielded chambers (to minimize the background radiation) with scalar readouts, scintillation counters, proportional counters, semiconductor detectors, and multi-channel spectrometers with computer analysis capabilities.

Instruments used to monitor gaseous or particulate radioactivity in the air should be highly sensitive since the amount of radioactivity to be measured or detected is usually small. Air sampling equipment takes a sample of the air or draws air through a filter to trap particles for analysis at some other time. No immediate response is given. Air monitoring is performed when the results are needed immediately.

Most air monitors cannot detect low levels of radioactivity. For example, an alpha air monitor is relatively ineffective for measuring airborne depleted uranium. By the time an alpha monitor detected DU and sounded an alarm, the airborne activity would be several times above acceptable limits.

Some airborne activity, such as low-energy beta particles from tritium, can be monitored using a *Kanne chamber*, an ionization chamber through which the air

Student Notes

flows. These chambers, however, are also sensitive to high-energy background radiation and some compensation is normally required.

Other radiation monitoring devices include **personnel dosimeters**. These devices come in various forms including pocket ionization chambers or pencil dosimeters, photographic film, nuclear track emulsions, and thermoluminescence dosimeters.

Alpha Portable Survey Instruments.

Detection of alpha radiation is difficult due to the short range of the alpha particle in the air. Test data shows that the detector should be placed within one-quarter inch from the source, preferably at 1/8 inch standoff for accuracy. The detector must also be constructed of a material which is thin enough to allow passage of the alpha particle, since a sheet of tissue paper will completely absorb an alpha particle.

Alpha particle monitoring of surfaces is not definitive data of the radiation hazard. Fixed alpha contamination is not a problem while loose alpha contamination cannot be determined in the presence of fixed alpha particle contamination. In addition, alpha contamination cannot be accurately monitored off of wet surfaces.

The recommended type of instruments for monitoring or counting alpha particles is either *gas proportional* (which uses propane as the counting gas) or *scintillation* (which uses ambient air as the counting gas). Both types can discriminate between alpha and beta particles which is required for alpha determination.

AN/PDR-60 Portable Alpha Counter.

A portable alpha-survey counter operating on the scintillation principle. It also incorporates a GM detector for measurement of gamma radiation.

There are several models of this instrument available depending on the date of manufacture. Originally this was a commercial radiacmeter, and the first models were known as the PAC-1S. A later model, the PAC-1SA, employed a modified chassis in which ordinary flashlight batteries could be used. The present AN/PDR-60 is similar to this model, except that a Geiger-Mueller tube has been added to allow gamma monitoring up to 2 r/hr.

Accessories include:

Student Notes

A **PG-1** probe used to detect the presence, not to measure the quantity, of plutonium under adverse conditions such as rain, snow, or after fire fighting operations.

A **RASP-1** (Ruggedized Alpha Scintillation Probe) which is similar to the standard alpha probe except that it has a smaller sensitive area that is well protected by a screen.

The AN/PDR-60 is the standard alpha-survey instrument for the Army and Air Force. It is a good, high-range alpha-survey instrument with excellent operational flexibility. It is extremely sensitive to light leaks. Even minor probe damage will cause malfunction.

One caution to observe with this meter is it's check source. The AN/UDM-6 Radiac Calibrator check source contains plutonium-239. ^{239}Pu is extremely dangerous to living tissue. When very small amounts of ^{239}Pu are inhaled, ingested, or absorbed in open cuts or wounds, they can cause serious injury or death. **HANDLE THIS SOURCE CAREFULLY.**

AN/PDR-56F Portable Alpha Counter.

A portable survey counter operating on the scintillation principle and is quite similar to the AN/PDR-60. The main probe may be attached to the case or used separately. There is also an auxiliary probe which is useful for monitoring small areas.

The AN/PDR-56 is the standard alpha Radiacmeter for the Navy. It is a rugged, waterproof instrument with an integral battery check feature. A check source is attached to the base of the main case so that instrument operation may be check at any time.

AN/PDR-54 Portable Alpha Counter. (*No longer in active inventory*)

A gas-ionization, portable, alpha-survey counter operating in the proportional region using propane as the detector gas.

Student Notes

The single-probe construction is an advantage since probes may be interchanged if damaged. Minor damage to the probe (1/8-inch holes or less) is not serious and operation may continue until repairs can be made.

A problem with any alpha detector using gas-ionization is that the detector must be open to the atmosphere which causes variations in the probe pressure due to barometric or altitude changes. These changes will cause the gas-amplification factor to vary, affecting instrument accuracy. The probe voltage must be adjusted to compensate for fluctuations in gas pressure.

Propane is used as the counting gas because:

- It provides a controlled atmosphere.
- It is easily liquefied for storage.
- It is inexpensive and widely available.
- It has good radiation counting properties.
- Allows low probe voltages.

Propane is a polyatomic gas and will not recombine once used. Therefore a continuous gas flow is necessary, exhausting the spent gas into the atmosphere. The propane supply will last 24 hours with the control valve in the OPERATE position. Replacement of the gas cylinder is a simple screw on operation.

When the instrument is properly adjusted, beta pulses will fail to cause the trigger circuit to function but all alpha pulses will.

The AN/PDR-54 is an excellent low- and medium-range alpha survey instrument, is well suited for personnel monitoring and is used by the Army, Navy, and Air Force. Although it's altitude sensitivity and propane gas usage present serious problems for certain applications, overall it is well suited for field monitoring.

The AN/PDR-54 set contains a Radioactive Test Sample CS-12. The radioactive area of the check source is a 3/4 inch diameter metal disc which has Thorium-232 electroplated to it. The active area contains 0.1 microcuries and has an emission rate of 14,000 counts per minute (cpm). **Do not allow the active surface of the check source to contact your skin.**

Student Notes

AN/PDR-77

The AN/PDR-77 is the latest fielded radiac instrument used by the Army. When used in conjunction with its alpha probe it will detect and measure alpha radiation and provide the user with a digital readout in Counts Per Minute (CPM). The alpha probe for this instrument uses a 100 sq cm Mylar surface to convert the alpha energy into light flashes that are detected internally by a photomultiplier tube.

As with most alpha portable radiac instruments, the AN/PDR-77 Radiac Set also contains a radioactive check source to ensure that the alpha probe is functioning properly. This particular check source is NOT labeled as radioactive though it contains thorium-232 and should be handled carefully. Since alpha particles are very easily shielded the thorium in the check source is exposed on the "ALPHA SIDE". Handle the check source by the edges only and wash your hands afterwards.

Student Notes

Beta/Gamma Portable Survey Instruments.

Geiger-Mueller Detectors (GM devices) are generally used for low level Beta/Gamma measurements. They are rugged, provide a rapid response, are sensitive to beta/gamma emissions, and are ideal for fast scanning for depleted uranium contamination.

Types of beta/gamma instruments are:

Ludlum Model 6 Geiger Counter.

AN/PDR-60 with a PG-1 Detector Probe.

AN/PDR-56F with x-ray Probe.

AN/PDR-27.

AN/VDR-2 Radiac Set - contains thorium-232, 1 nanocurie. Used to locate and measure radioactivity in the form of gamma rays and beta particles. Displays dose rates and total accumulated dose resulting from a fallout field.

Operating ranges:

- Gamma 0.01 µGy/hr. to 100 Gy/hr.
- Beta 0.01 µGy/hr. to 5 cGy/hr.
- Dose 0.01 µGy to 9.99 Gy

AN/PDR-77 with beta/gamma Probe - The AN/PDR-77 Radiac Set also contains a beta/gamma probe (AN/VDR-2) that can *detect* beta and *measure* gamma. When this probe is attached the meter will provide the user with a digital display in mrem/hr.

Student Notes

EMERGENCY PROCEDURES

It is important to understand what the appropriate actions are in the event of an emergency situation involving radioactive material to help minimize the spread of radioactive contaminants.
In view of the complicating factors that may arise in an emergency, it is impossible to establish simple rules or procedures to cover all situations. However, in any emergency the primary concern must always be the protection of personnel from radiation hazards. Second should be the confinement of the contamination to the local area of the accident, if that is possible.

MEDICAL ASSISTANCE: Effectiveness of eliminating radioactive materials from the body depends on promptness of medical treatment. **Immediate** medical treatment is required for persons:

- Who have eaten or inhaled radioactive contamination
- With wounds which may have been contaminated.
- Whose face or extensive areas of their body has been contaminated.

Some examples of emergencies which may be encountered are:

- Explosion - combat related
- Fires
- Overexposure
- Injury to personnel in a contaminated area

Student Notes

ACCIDENTS INVOLVING RADIOACTIVE DUSTS, MISTS, FUMES, ORGANIC VAPORS, AND GASSES:

[1] Notify all personnel not directly involved to vacate the area. If at all possible, personnel should vacate to an area that is up wind of the accident.

[2] Hold your breath, switch off all fans and central air circulation equipment.

[3] Vacate the area

[4] Close all entrances to the accident area and post guards to prevent unauthorized access.

[5] Notify the local RPO.

[6] Identify to the local RPO any personnel who may have exposed to radioactive contamination.

[7] In coordination with the RPO:

[a] Decontaminate non-essential personnel.

[b] Remove the hazardous material.

[c] Decontaminate the area

[d] Perform an area survey to determine effectiveness of decontamination procedures.

[e] Monitor all personnel suspected of being contaminated.

[f] Make sure that proper reporting procedures are implemented. Reporting requirements depend on the severity of the accident and the degree of contamination. See 10 CFR 20.2202 and 20.2203 and 29 CFR 1910.96 for specific requirements. For items that are managed by ACALA, see Appendix D. For additional guidance, contact:

	COM 309-782-2962/2965
Director, ACALA	DSN 793-2962/2965
ATTN: AMSTA-AC-SF	FAX COM 309-783-6758
Rock Island, IL 61299-7630	FAX DSN 793-6758

or

Student Notes

Commander, TACOM
ATTN: AMSTA-CZ
Warren, MI 48397-5000

COM 810-574-7635/6121
DSN 786-7635/6121
FAX COM 810-574-5277
FAX DSN 786-5277

INJURIES TO PERSONNEL INVOLVING RADIATION HAZARDS:

[1] Immediately flush minor wounds thoroughly with running water.

[2] Regardless of how minor the wound, the individual MUST be examined by medical personnel.

[3] Personnel with minor wounds should be monitored, and decontaminated if necessary before leaving the area.

[4] If the wounds are serious, the injured individual must be immediately moved to a medical facility. Those persons accompanying that person will warn medical personnel that the injured person might be contaminated.

[5] Notify the local RPO.

[6] No person involved in a radiation injury will return to work without the approval of the attending physician and the local RPO.

[7] Make sure that a report is submitted within 10 working days to:

or

Director, ACALA
ATTN: AMSTA-AC-SF
Rock Island, IL 61299-7630

COM 309-782-2962/2965
DSN 793-2962/2965
FAX COM 309-782-6758
FAX DSN 793-6758

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ATTN: AMSTA-CZ
Warren, MI 48397-5000

COM 810-574-7635/6121
DSN 786-7635/6121
FAX COM 810-574-5277
FAX DSN 786-5277

Student Notes

FIRES AND MAJOR EMERGENCIES:

[1] Notify **all** personnel to leave the area at once.

[2] Attempt to put out the fire if it can be accomplished safely.

[3] Notify the fire department and any other emergency personnel that may be required.

[4] Notify the local RPO. In coordination with the RPO:

[a] Monitor the area and determine the protective devices necessary for safe decontamination.

[b] Decontaminate the area when necessary.

[c] Monitor all persons who were in the emergency area and those who were involved in combating the emergency.

[5] No one is to be permitted to resume work without the approval of the RPO.

[6] Make sure that a report is submitted within 10 working days to:

Director, ACALA
ATTN: AMSTA-AC-SF
Rock Island, IL 61299-7630

COM 309-782-2962/2965
DSN 793-2962/2965
FAX COM 309-782-6758
FAX DSN 793-6758

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Commander, TACOM
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Warren, MI 48397-5000

COM 810-574-7635/6121
DSN 786-7635/6121
FAX COM 810-574-5277
FAX DSN 786-5277

Student Notes

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-08

DATE: Oct 96

TITLE: Emergency Procedures

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 2.0 C (U)
0.0 PE

FACILITY REQ: Classroom

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty

TRANSPORTATION: None

ISSUED TO STUDENTS: Student Reference Guide “Radioactive Material Handling Safety”

AIDS AND EQUIPMENT:

a. Overhead Projector
b. Computer Display Device
c. Computer
d. Display Screen
c. RAD_08.PPT File

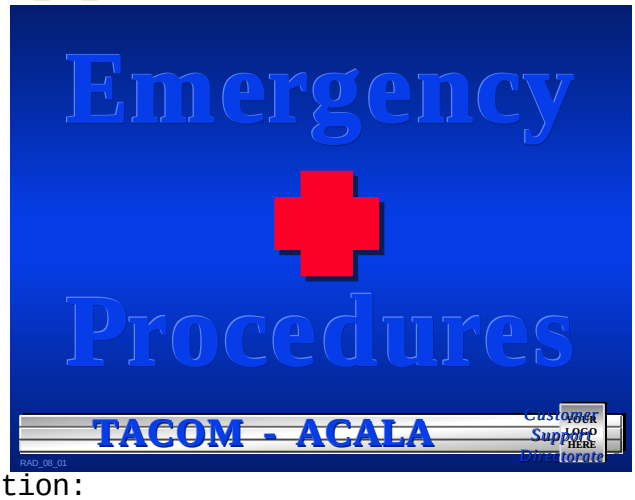
REFERENCES:	TB 9-1300-278	"Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
	TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
	10CFR20	“Standards for Protection Against Radiation”
	10CFR40	
	AR 385-11	Ionizing Radiation Protection
	AR 385-40	

COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: Emergency Procedures

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

NOTE: *Show Slide RAD_08_01*



a. Introduction:

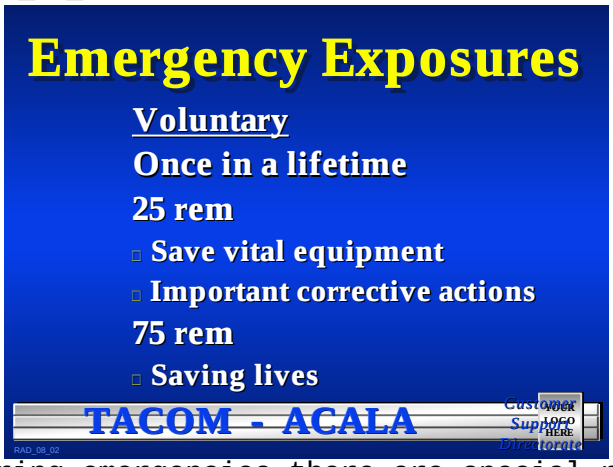
(1) Objective: Provide an overview of radioactive material emergency procedures.

(2) Reason and Tie-In: It is important for the student to understand what the appropriate actions are in the event of an emergency situation involving radioactive material to help minimize the spread of radioactive contaminants.

b. Explanation:

(1) In view of the complicating factors that may arise in an emergency, it is impossible to establish simple rules or procedures to cover all situations. However, in any emergency the primary concern must always be the protection of personnel from radiation hazards. Second should be the confinement of the contamination to the local area of the accident, if that is possible.

NOTE: *Show Slide RAD_08_02*



(2) During emergencies there are special radiation exposure guidelines. In an emergency there may be a need for certain actions to save a life, prevent extreme damage to an area or facility, or to save many lives. Exposure guidelines are strictly for use during an emergency, and are **voluntary.** Emergency exposures can only be received once in a lifetime:

(a) 25 rem for saving vital equipment or providing very important corrective actions.

(b) 75 rem for saving a life or many lives.

(3) Emergency procedures should be rehearsed and pre-planned.

(4) MEDICAL ASSISTANCE: Effectiveness of eliminating radioactive materials from the body depends on promptness of medical treatment. **Immediate** medical treatment is required for persons:

- Who have eaten or inhaled radioactive contamination
- With wounds which may have been contaminated.
- Whose face or extensive areas of their body has been contaminated.

(5) Some examples of emergencies which may be encountered are:

- Spills of radioactive material
- Explosion - combat related
- Fires
- Overexposure
- Injury to personnel in a contaminated area

(a) **SPILLS:**

[1] **Notify all personnel not involved to vacate the** areas. Personnel believed to be contaminated should be segregated and instructed not to mingle with clean persons.

[2] If the spill is liquid and the hands of emergency personnel are protected, attempt to right the container and take steps to contain the spill.

[3] Wash skin thoroughly

[4] Notify the local RPO. In coordination with the RPO:

[a] Decontaminate personnel

[b] Decontaminate area

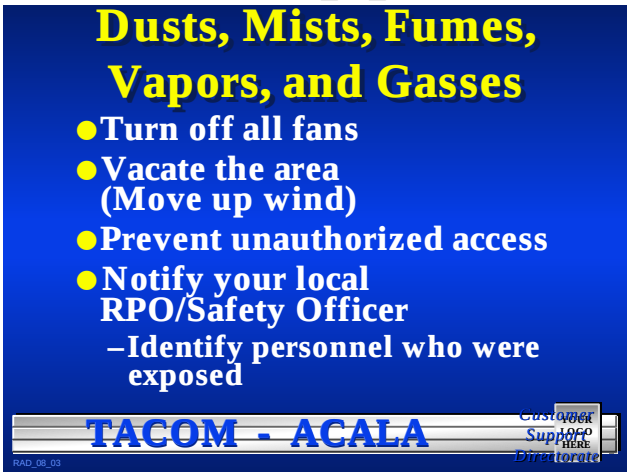
[c] Monitor all people involved in the spill and cleaning operation to determine the adequacy of emergency procedures used.

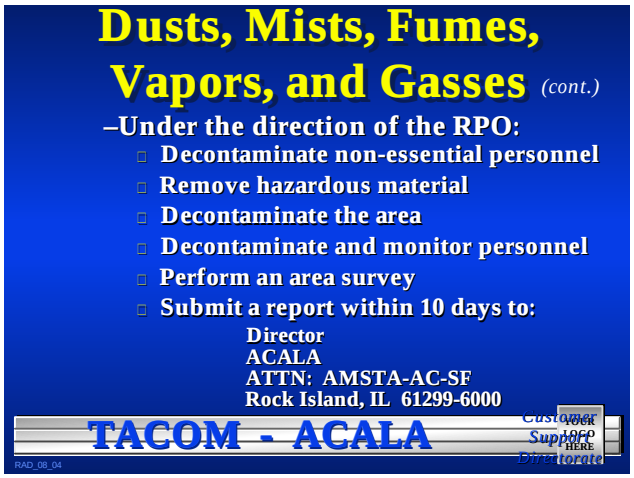
[5] Do not permit personnel back into the area until it has been cleared by the RPO.

[6] Make sure that a report is submitted within 10 working days to:

Director
ACALA
ATTN: AMSTA-AC-SF
Rock Island, IL 61299-6000

NOTE: *Show Slide RAD_08_03/04*





(b) **ACCIDENTS INVOLVING RADIOACTIVE DUSTS, MISTS, FUMES, ORGANIC VAPORS, AND GASSES:**

[1] Notify all personnel not directly involved to vacate the area. If at all possible, personnel should vacate to an area that is up wind of the accident.

[2] Hold your breath, switch off all fans and central air circulation equipment.

[3] Vacate the area

[4] Close all entrances to the accident area and post guards to prevent unauthorized access.

[5] Notify the local RPO.

[6] Identify to the local RPO any personnel who may have exposed to radioactive contamination.

[7] In coordination with the RPO:

[a] Decontaminate non-essential personnel.

[b] Remove the hazardous material.

[c] Decontaminate the area

[d] Perform an area survey to determine effectiveness of decontamination procedures.

[e] Monitor and decontaminate all personnel suspected of being contaminated.

[f] Make sure that proper reporting procedures are implemented. Reporting requirements depend on the severity of the accident and the degree of contamination. See 10 CFR 20.2202 and 20.2203 and 29 CFR 1910.96 for specific requirements. For items that are managed by ACALA, see Appendix D. For additional guidance, contact:

Director; ACALA
ATTN: AMSTA-AC-SF
Rock Island, IL 61299-6000

or

Commander, TACOM
ATTN: AMSTA-CZ
Warren, MI 48397-5000

(c) **INJURIES TO PERSONNEL INVOLVING RADIATION HAZARDS:**

[1] Immediately flush minor wounds thoroughly with running water.

[2] Regardless of how minor the wound, the individual MUST be examined by medical personnel.

[3] Notify the local RPO.

[4] Under the direction of the RPO:

[a] Personnel with minor wounds should be monitored, and decontaminated if necessary before leaving the area.

[b] If the wounds are serious, the injured individual must be immediately moved to a medical facility. Those persons accompanying that person will warn medical personnel that the injured person might be contaminated.

[5] No person involved in a radiation injury will return to work without the approval of the attending physician and the local RPO.

[6] Make sure that a report is submitted within 10 working days to:

Director
ACALA
ATTN: AMSTA-AC-SF
Rock Island, IL 61299-6000

(d) **FIRES AND MAJOR EMERGENCIES:**

[1] Notify **all** personnel to leave the area at once.

[2] Attempt to put out the fire if it can be accomplished safely.

[3] Notify the fire department and any other emergency personnel that may be required.

[4] Notify the local RPO. In coordination with the RPO:

[a] Monitor the area and determine the protective devices necessary for safe decontamination.

[b] Decontaminate the area when necessary.

[c] Monitor all persons who were in the emergency area and those who were involved in combating the emergency.

[8] No one is to be permitted to resume work without the approval of the RPO.

[9] Make sure that a report is submitted within 10 working days to:

Director
ACALA
ATTN: AMSTA-AC-SF
Rock Island, IL 61299-6000

EXE COM 309-793-2962/2965
DSN 782-2962/2965

FAX COM 309-793-6758
DSN 782-6758

c. Summary: Procedures for emergency operations were covered in this lesson.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

Emergency

Procedures

TACOM - ACALA

Training Team

General Conciderations

It is impossible to establish simple rules or procedures to cover all situations.

1.

Protect personnel from radiation hazards

2.

Confine the contamination

Emergency Exposures

- <u>Voluntary</u>
- Once in a lifetime
- 25 rem
  - Save vital equipment
  - Important corrective actions
- 75 rem
  - Saving lives

Injuries to Personnel

- Flush wounds with water
- Wounds MUST be examined by medical personnel
- Wounds should be monitored and decontaminated
- Warn medical personnel that the individual may be contaminated
- Notify the RPO
- Injured personnel cannot return to work until released by physician and RPO
- File a report within 10 working days

Fires and Major Emergencies

- Evacuate the area immediately
- Attempt to put out any fires
- Notify required emergency personnel
- Notify the RPO
  - Monitor the area
    - » Determine required protective devices
  - Decontaminate the area
  - Monitor all personnel leaving the emergency area
- Normal operations cannot resume without approval of the RPO
- Submit report within 10 working days

DECONTAMINATION PROCEDURES

GENERAL

Thorough washing with non-abrasive soap and luke warm water is the best general method of decontamination of the hands and other parts of the body. Further, it should be noted that alpha particle radiation cannot be detected from moist or wet surfaces.

If the contamination is localized, it is often more practical to cleanse with swabs rather then to risk the danger of spreading the contamination. Special attention must be given to the area between the fingers and around the nails.

Organic solvents must be avoided as a decontamination agent because they may increase the probability of the radioactive material penetrating through the pores of the skin.

After repeated washings, the skin may tend to chap. To avoid this, apply lanolin or hand cream and then continue to wash. If repeated washing with soap and water is unsuccessful, the individual should be referred to the local medical officer for application of more drastic chemical decontamination.

NOTE

Radiac equipment can't measure alpha contamination on wet surfaces.

If residual contamination is localized, repeat procedures should be limited to those areas still showing contamination.

In all cases of contamination the RPO must be consulted. In most situations the RPO is the only qualified person who can accurately read radiac equipment measurements.

Student Notes

In the event the contamination on an individual is not localized to a small portion of the body, the following procedure is recommended:

1. Place the individual in a luke warm shower.

2. Lather the entire body with a mild soap.

3. While still covered with a thick lather of mild soap, have the individual step out of the shower.

4 Sprinkle a heavy coat of mild soap flakes all over the individuals body. The purpose of the lather is to make the soap flakes stick to the body.

5. Rub the soap flakes on the body to produce a thick paste.

6. Have the individual return to the shower and rinse off all of the soap paste starting at the head (top) and working down. Pay particular attention to hairy portions of the body.

NOTE

It will be necessary to rub the body surface with your hands while rinsing in order to remove all of the soap paste. Soap paste will stick to those areas which have not been thoroughly washed and rinsed. It is permissible to use a soft cloth but avoid any type of brush.

7. After rinsing to the point that the body no longer feels slimy, and while still under the shower, examine the body for any trace of soap paste.

8. When assured that all trace of soap paste is removed, leave the shower and dry off.

9. After drying off, check for any presence of contamination. If still contaminated, repeat the above procedures.

Student Notes

EQUIPMENT AND AREA CONTAMINATION

GENERAL PRACTICES:

Care must be taken during the decontamination process to avoid further spread of the contamination. This can be accomplished by:

Always working from the least contaminated area towards the area of heaviest contamination.

Take precautions not to track contamination. Use protective clothing and shoe covers. Periodically re-monitor the area.

Using a minimum amount of decontamination liquids and being aware that the runoff solutions, mops, rags, and brushes may also be contaminated.

The following decontamination methods should be tried in the sequence that they are listed:

[1] **Damp mopping**: The area is wetted with a damp rag. The wiping surface of the rag is changed repeatedly to minimize spreading of the contaminant.

[2] **Water and detergent**: The area is wetted with a minimum amount of detergent solution. The area is then wiped dry with absorbent gauze or cloth.

[3] **Steam Cleaning**.

[4] **Cleaning with solvents other than water.**

[5] **Surface removal** by controlled use of chemicals, abrasives, sand blasting, and grinding.

NOTE

Use of a vacuum cleaner is not recommended. If used, vacuum system must have a HEPA filter and be dedicated to radiation decontamination.

Student Notes

SPECIFIC METHODS: If the above decontamination methods do not work, the following specific methods may be tried:

Metals

Clean oily surfaces with organic solvents.

Soak in a solution of citric acid prepared by adding one pint citric acid to one gallon of water.

Soak in a solution of diluted hydrochloric acid prepared by carefully adding one part of commercial grade concentrated hydrochloric acid to four parts of water. Hydrochloric acid should not be used on stainless steel because the etching will destroy the smooth surface.

Coat with nail polish.

Plastics

Clean with ammonium citrate, dilute acids, or organic solvents.

Glass or porcelain

Clean with detergent solution. If this does not work, soak in concentrated nitric acid or chromic acid cleaning solution.

Painted surfaces

Use liquid scrape-off paint remover, brush, and scraper or putty knife. Discard the brush with the paint scrapings, decontaminate the scraper with rags. In cases where surfaces were covered with strippable paint, peel the paint from the surface.

Student Notes

Rubber, including respirators and gas masks

Wash with detergent and water, or with a hot water and sodium citrate solution prepared by mixing one part sodium citrate with four parts hot water.

Clothing

Determine the extent of contamination using an AN/PDR-27 with the beta shield removed and with an AN/PDR-54, AN/PDR-60, or an AN/PDR-56F.

Segregate the clothing into two classes.

Class 1 used for low activity, i.e. less than 0.1 millirads/hr above background on AN/PDR-27 and 50 cpm on AN/PDR-54, AN/PDR-60, or AN/PDR-56F. Release for ordinary laundering.

Class 2 is for activity of 0.1 to 10 millirads/hr. Wash in a special laundry facility washer or washer-dryer kept in the facility for washing "hot" clothing only. Use the following steps:

1. Soak overnight in a solution of water and laundry detergent.
2. Drain.
3. Wash for 15 minutes with hot water and powdered soap or laundry detergent.
4. Rinse.
5. Dry and re-monitor.

Student Notes

DECONTAMINATION

Key Considerations

- Radioactive material CANNOT be made non-radioactive
- Remove the contamination
  - DON'T spread it around
  - Contain the contamination
- Start with the least intrusive method
  - Mild detergent and water works well in most cases
  - Last resort is surface removal
- Monitor the surface as you go

General Practices

- Avoid spread of contamination
  - Work from least contaminated area toward most contaminated area
  - Take care not to track the contamination around
- Use minimum amount of liquid
- Periodically re-monitor the area

General Methods

1. Damp Mopping
2. Water and Detergent
3. Steam Cleaning
4. Solvents other than water

General Methods

1. Damp Mopping
2. Water and Detergent
3. Steam Cleaning
4. Solvents other than water
5. Surface Removal

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-09

DATE: Oct 96

TITLE: Decontamination Procedures

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 1.0 C (U) FACILITY REQ: Classroom
0.0 PE

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Duty TRANSPORTATION: None

ISSUED TO STUDENTS: Student Handout

AIDS AND EQUIPMENT:
a. Overhead Projector
b. Computer Display Device
c. Computer
d. Display Screen
e. RAD_09.PPT PowerPoint File

REFERENCES: TB 9-1300-278 "Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
TM 3-261 "Handling and Disposal of Unwanted Radioactive Material"

COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: Decontamination Procedures

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

a. Introduction:

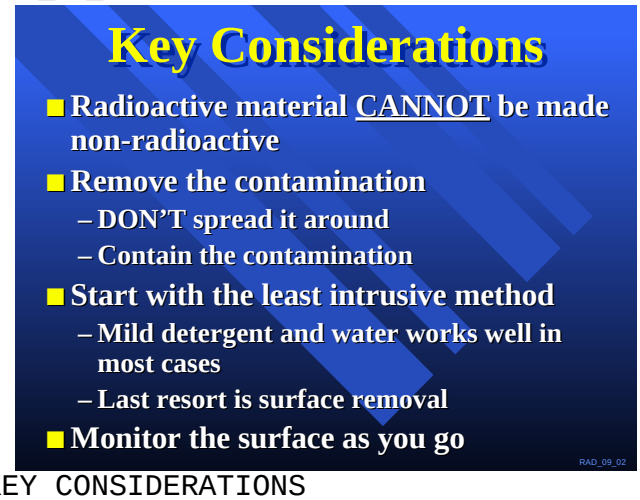
NOTE: *Show Slide RAD_09_01*

(1) Objective: Provide an overview of decontamination procedures that are most effective with the various types of radioactive material covered in this course.

(2) Reason and Tie-In: In the event of an incident involving radioactive material it is important for the student to have a basic working knowledge of the proper procedures to decontaminate a piece of equipment and/or personnel.

b. Explanation:

NOTE: *Show Slide RAD_09_02*



(1) KEY CONSIDERATIONS

(a) Radioactive material cannot be made non-radioactive. Man has not yet found any process or procedure to counter act radiation. We cannot speed it up or slow it down.

(b) Radioactive contamination must be removed. Contamination, by definition, is some material in a location that it does not belong. When removing the contamination, be careful not to just spread it around. Remember, you are trying to remove the material causing the contamination; not dilute it.

(c) Always start with the least intrusive method of decontamination. This is usually the easiest and least expensive procedure.

(d) Monitor the surface as you go to determine if your methods are effective.

(2) GENERAL PERSONNEL DECONTAMINATION PROCEDURES

(a) Thorough washing with non-abrasive soap and luke warm water is the best general method of decontamination of the hands and other parts of the body. Whenever possible, all water used during decontamination should be collected. Further, it should be noted that alpha particle radiation cannot be detected from moist or wet surfaces.

(b) If the contamination is localized, it is often more practical to cleanse with swabs rather then to risk the danger of spreading the contamination. Special attention must be given to the area between the fingers and around the nails.

(c) Organic solvents must be avoided as a decontamination agent because they may increase the probability of the radioactive material penetrating through the pores of the skin.

(d) After repeated washings, the skin may tend to chap. To avoid this, apply lanolin or hand cream and then continue to wash. If repeated washing with soap and water is unsuccessful, the individual should be referred to the local medical officer for application of more drastic chemical decontamination.

NOTE

Radiac equipment can't measure alpha contamination on wet surfaces.

(e) If residual contamination is localized, repeat procedures should be limited to those areas still showing contamination.

(f) **In all cases of contamination the RPO must be consulted.** In most situations the RPO is the only qualified person who can accurately read radiac equipment measurements.

(3) In the event the contamination on an individual is not localized to a small portion of the body, the following procedure is recommended:

(a) Place the individual in a luke warm shower.

(b) Lather the entire body with a mild soap.

(c) While still covered with a thick lather of mild soap, have the individual step out of the shower.

(d) Sprinkle a heavy coat of mild soap flakes all over the individuals body. The purpose of the lather is to make the soap flakes stick to the body.

(e) Rub the soap flakes on the body to produce a thick paste.

(f) Have the individual return to the shower and rinse off all of the soap paste starting at the head (top) and working down. Pay particular attention to hairy portions of the body.

NOTE

It will be necessary to rub the body surface with your hands while rinsing in order to remove all of the soap paste. Soap paste will stick to those areas which have not been thoroughly washed and

rinsed. It is permissible to use a soft cloth but avoid <u>any</u> type of brush.

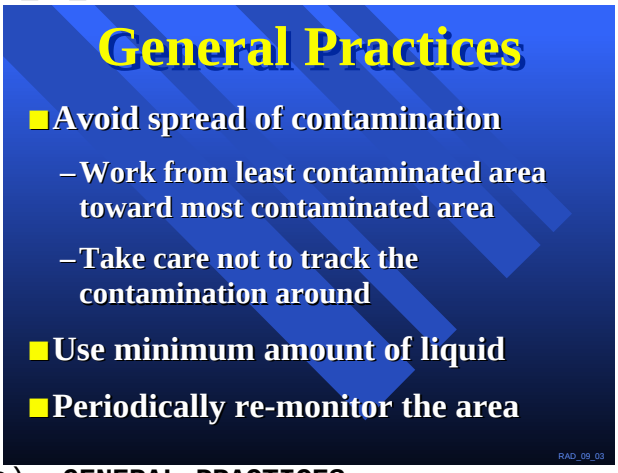
(g) After rinsing to the point that the body no longer feels slimy, and while still under the shower, examine the body for any trace of soap paste.

(h) When assured that all trace of soap paste is removed, leave the shower and dry off.

(i) After drying off, check for any presence of contamination. If still contaminated, repeat the above procedures.

(4) <u>EQUIPMENT AND AREA DECONTAMINATION</u>

NOTE: *Show Slide RAD_09_03*



(a) **GENERAL PRACTICES:**

[1] Care must be taken during the decontamination process to avoid further spread of the contamination. This can be accomplished by:

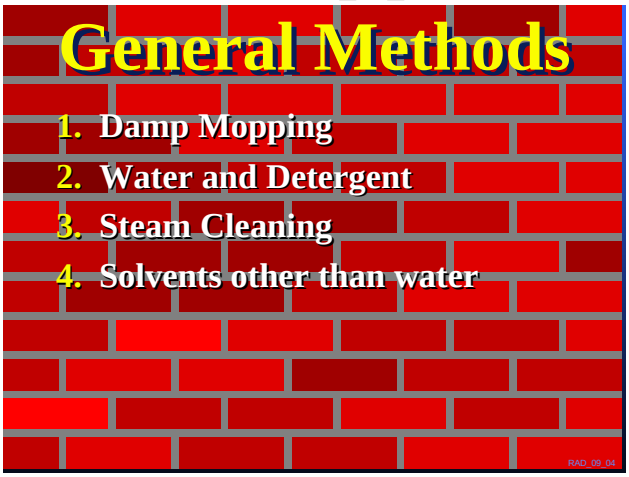
[2] Always working from the least contaminated area towards the area of heaviest contamination.

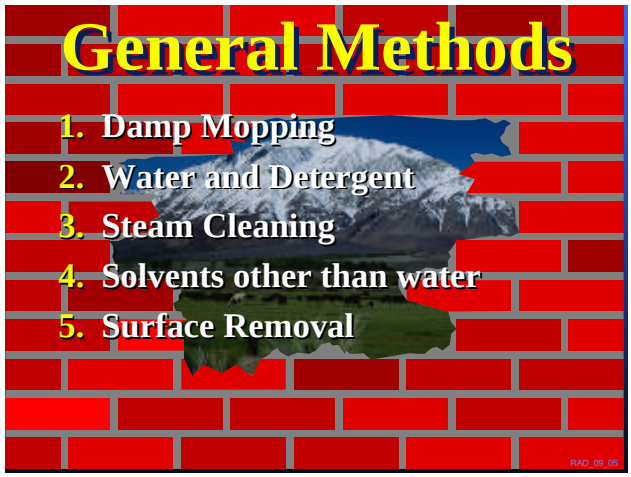
[3] Take precautions not to track contamination. Use protective clothing and shoe covers. Periodically re-monitor the area.

[4] Using a minimum amount of decontamination liquids and being aware that the runoff solutions, mops, rags, and brushes may also be contaminated.

(b) The following decontamination methods should be tried in the sequence that they are listed:

NOTE: *Show Slide RAD_09_04/05*





[1] **Damp mopping**: The area is wetted with a damp rag. The wiping surface of the rag is changed repeatedly to minimize spreading of the contaminant.

[2] **Water and detergent**: The area is wetted with a minimum amount of detergent solution. The area is then wiped dry with absorbent gauze or cloth.

[3] **Steam Cleaning**.

[4] **Cleaning with solvents other than water.**

[5] **Surface removal** by controlled use of chemicals, abrasives, sand blasting, and grinding.

NOTE

Use of a vacuum cleaner is not recommended. If used, the vacuum system must be equipped with a HEPA filter and be dedicated to radiation decontamination only.

(c) SPECIFIC METHODS: If the above decontamination methods do not work, the following specific methods may be tried:

[1] **Metals**

[a] Clean oily surfaces with organic solvents.

[b] Soak in a solution of citric acid prepared by adding one pint citric acid to one gallon of water.

[c] Soak in a solution of diluted hydrochloric acid prepared by carefully adding one part of commercial grade concentrated hydrochloric acid to four parts of water. Hydrochloric acid should not be used on stainless steel because the etching will destroy the smooth surface.

[d] Coat with nail polish.

[2] **Plastics**: Clean with ammonium citrate, dilute acids, or organic solvents.

[3] **Glass or porcelain**: Clean with detergent solution. If this does not work, soak in concentrated nitric acid or chromic acid cleaning solution.

[4] **Painted surfaces**: Use liquid scrape-off paint remover, brush, and scraper or putty knife. Discard the brush with the paint scrapings, decontaminate the scraper with rags. In cases where surfaces were covered with strippable paint, peel the paint from the surface.

[5] **Rubber, including respirators and gas masks**: Wash with detergent and water, or with a hot water and sodium citrate solution prepared by mixing one part sodium citrate with four parts hot water.

[6] **Clothing:**

[a] Determine the extent of contamination using an AN/PDR-27 with the beta shield removed and with an AN/PDR-54, AN/PDR-60, or an AN/PDR-56F.

[b] Segregate the clothing into two classes.

1. **Class 1** used for low activity, i.e. less than 0.1 millirads/hr above background on AN/PDR-27 and 50 cpm on AN/PDR-54, AN/PDR-60, or AN/PDR-56F. Release for ordinary laundering.

2. **Class 2** is for activity of 0.1 to 10 millirads/hr. Wash in a special laundry facility washer or washer-dryer kept in the facility for washing “hot” clothing only. Use the following steps:

2.1 Soak overnight in a solution of water and laundry detergent.

2.2 Drain.

2.3 Wash for 15 minutes with hot water and powdered soap or laundry detergent.

2.4 Rinse.

2.5 Dry and re-monitor.

c. Summary: This lesson covered general decontamination procedures and some of the more common procedures to use with specific items to include personnel decontamination.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

MEDICAL EVALUATION & MONITORING

There are four (4) primary reasons for performing a medical examination for exposure to radiation:

1. To determine whether or not an individual is physically and mentally able to perform their job without undue risk of harm to themselves or others.
2. To monitor the effects of the individual's exposure.
3. To detect early or sub-clinical effects resulting from accidental or inadvertent exposure.
4. To perform baseline bioassays for personnel that perform maintenance on devices that contain tritium.

Student Notes

Radioactive contaminants that enter the body are often classified into the somewhat loosely defined categories of "**Soluble**" and "**Insoluble**" where solubility is with respect to body fluids.

Insoluble contaminants are usually the more difficult problem in measuring body burdens. When an ingested radioactive material is insoluble, it passes relatively unscathed directly through the gastrointestinal tract.

With **solubility** the route of intake to the body is specified as:

Inhalation - Through the nose. Most common route along with ingestion. Potential inhalation of alpha emitting radionuclides is the most serious problem. Any person exposed to higher than 200 disintegrations per minute (as determined by nasal swipe) has very likely had a serious inhalation exposure. These personnel should immediately be referred to a physician for further analysis and should be put in a urine sampling program.

Ingestion - Through the mouth.

Percutaneous - Absorption of radionuclides directly through the skin. This is a common route for Tritium (H3) exposures since the tritium molecule is so small.

Wounds - Injection through the skin.

The category of contaminants which are **soluble** in the body fluids are usually subdivided into the following categories:

- Body water
- Specific organ
- Bone seekers

PERIODIC MEDICAL EXAMINATIONS

Annual or periodic physical examinations are usually not warranted solely because of potential exposure to DU. Personnel monitoring is far more effective in determining the amount of exposure. Personnel monitoring may include any of the following:

Student Notes

[1] **Self Reading Dosimetry Devices (SRD)** - Is a cylindrical metal barrel filled with air and an electrometer detects and provides an estimate of gamma radiation.

[2] **Thermoluminescent Dosimeters (TLD)** - A type of radiation film badge and is very effective for monitoring exposure to the head, lens of the eyes, hands, trunk, gonads, arms above the elbows, legs above the knees, and fingers where DU may pose a potential external exposure hazard.

[3] **Nasal Swabs** - Nasal swabs (moistened with alcohol) are only useful in quickly determining that personnel have definitely inhaled DU particulate matter. Nasal swabs can give negative results for personnel exposed to DU fumes or sub-micron size particles. There are three important rules of nasal swab monitoring:

1. Always collect the nasal sample after the individual has taken a decontamination shower.
2. Double bag the swabs.
3. Take random samples from non-victims. This provides a comparison set of samples for analysis and points out problems in counting equipment and/or collection procedures.

Bioassays

The analysis procedure for determining the nature and activity of the internal contamination present in a person by making measurements on a body product. It is assumed that the concentration of radioactivity in the body elimination product (e.g. urine) is proportional to the activity deposited in the body. Routine bioassay programs almost exclusively use urine as the sampler.

The actual calculated contamination level is called the "*body burden*". If the specific distribution is known, the "*organ burden*" might be specified.

Bioassay procedures should be undertaken only at the direction of qualified health physics or medical personnel.

Some other body products useful for bioassay are:

- Exhaled air
- Nail clippings
- Nasal mucous
- Feces
- Sweat
- Saliva
- Hair

Student Notes

Under a minimum program, bioassays are performed semi-annually or annually for all personnel in order to measure the accumulation of DU in the lungs and bones. Preparatory base line data should be performed on personnel prior to an assignment involving potential exposure.

Urinary Excretion - Used under accident conditions and routine monitoring. Very effective in determining internal exposure to DU particulate. **Any internally deposited contaminant which is even slightly soluble in body fluids will eventually show up in a persons urine.** Bioassay should be given semi-annually to personnel exposed to airborne concentrations of DU. For internal exposure, DU can be measured in the urine of the exposed individual and can be valuable in deciding whether or not the individual was overexposed. A short fall to the urinary technique is that it does not provide acceptable data to estimate DU contamination in the lungs. Under accident conditions several rules apply:

1. If less than one hour from the accident to the time of sample collection, the victim should be instructed to void the bladder of urine and then capture the next sample.. Physiologically, it takes about four hours for the contaminates to dissolve, be absorbed in the blood stream, be filtered out into the kidneys and appear in the bladder. The four hour period is necessary before the maximum urine concentration is reached following an acute intake.. Failure to wait and not drain the bladder will result in a diluted concentration and show a deceptively low test result. If treatment is determined based on this inaccurate reading, the victim could be dismissed without proper treatment.

2. Urine samples are normally collected in waxed or polyethylene bottles. If tritium is the possible contaminant, glass bottles should be used to store the specimens. Tritium has the potential to diffuse when stored in plastic and could effect other samples.

3. Take random urine samples from non-victims in order to checkout equipment and collection procedures.

Student Notes

In-vivo Spectrometry (whole body count) - Used to count a representative sample of internal exposure from gamma or x-ray radiation effecting all personnel at a given accident or location. In general In-vivo spectrometry is performed with specialized equipment such as a large scintillation counter or a semiconductor counter in conjunction with a massive shield (used to reduce background interference). Radium dial painters were the first occupation to use the In-vivo test. When In-vivo spectrometry is supplemented with urinary data a more accurate evaluation is achievable. Keep in mind that urinary data is usually not suitable by itself to measure for gamma or x-ray exposure due to the low level of radiation which would collect in the excretes.

In the event of chronic exposure a prompt evaluation is warranted with one or more follow-up evaluations. Acute exposure is usually needed within a couple of days.

A well managed Bioassay Program will include a combination of urinary and In-vivo spectrometry techniques. More frequent bioassays are performed for a sample of the most highly exposed personnel. The necessity for bioassay measurements will arise following an accident such as fire, spill, equipment malfunction, combat, or other departures from normal operations which could have caused abnormally high concentrations of radioactive contaminants in the air.

The ideal basis for radiation dose measurement would be the number of ion pairs (or ionizations) taking place within the medium of interest. However, for certain practical reasons, the medium used in establishing a unit of measurement was air.

Every effort must be made to maintain the radiation dose equivalent and the dose commitment to individuals as far below established radiation protection standards (10CFR20, AR 40-14, AFR 161-8, NAVMED P-5055) as reasonably achievable. The standards to be discussed here are all expressed in concrete numbers limiting dose per year, limiting concentrations in air and water and so on. Through constant usage, numbers of this type can be taken for granted. It is then easy to assume that there will be no problems or injuries if the limits are not exceeded. This may be true, but, no one can be absolutely sure of this in light of *present knowledge*. Since the relationship between low level radiation exposure and biological damage is still uncertain and hotly debated, standards have been established on a very conservative basis. The International Commission on Radiological Protection (ICRP) has never the less taken the reasonable stand that all unnecessary exposure should be avoided, even if it is within established limits.

Student Notes

FINAL NOTE

Numerical limits, in addition to producing a false sense of security, can also generate problems in the other direction if practitioners apply them too rigidly in all situations. The ICRP addresses this real life contingency, and ALARA has as one of its aims the provision of more latitude to the professional in the field for making reasonable decisions in particular situations, in effect saying that ***common sense*** is still a very valuable commodity when it comes to applying any set of rules.

Student Notes

US ARMY ARMAMENT AND CHEMICAL ACQUISITION AND LOGISTICS ACTIVITY
Integrated Materiel Management Center
Weapons and Logistics Integration Division
Training and Fielding Group
Training Team
Rock Island, IL 61299-7630

LESSON OUTLINE/TITLE PAGE

FILE NO: LP-RAD-10

DATE: Oct 96

TITLE: Medical Evaluation and Monitoring

APPROVED:

COURSE: Radioactive Material Handling Safety

HOURS AND TYPE: 1.0 C (U)
0.0 PE

FACILITY REQ: Classroom

CLASSIFICATION: DOCUMENTS - (U)
PRESENTATION - (U)

INSTRUCTORS: One

UNIFORM: Work

TRANSPORTATION: None

ISSUED TO STUDENTS: Student Handout

AIDS AND EQUIPMENT:

a. Overhead Projector
b. Computer Display Device
c. Computer
d. Display Screen

REFERENCES:	TB 9-1300-278	"Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium"
	TM 3-261	"Handling and Disposal of Unwanted Radioactive Material"
	DARCOM HDBK 385-1.1-78	"Safety Procedures for Processing Depleted Uranium"
	"BASIC RADIATION PROTECTION TECHNOLOGY"	by D.A. Gollnick
	10CFR20	"Standards for Protection Against Radiation"
	Reference Guide	Conventional Ammunition - Radiation Training Course; US Army Defense Ammunition Center and School
	AR 40-5	Preventive Medicine

COURSE TITLE: Radioactive Material Handling Safety

LESSON TITLE: Medical Evaluation and Monitoring

1. PRESENTATION: (This presentation is UNCLASSIFIED.)

a. Introduction:

(1) OBJECTIVE: Provide a basic understanding of the methods used to evaluate and monitor personnel for exposure to radioactive contaminants.

(2) REASON AND TIE-IN: The recommendations presented contain guidelines for performing medical examination of personnel. These guidelines are intended primarily to provide DoD civilians and military personnel with pertinent information concerning an effective medical surveillance program.

b. Explanation:

(1) There are four (4) primary reasons for performing a medical examination for exposure to radiation:

(a) To determine whether or not an individual is physically and mentally able to perform their job without undue risk of harm to themselves or others.

(b) To monitor the effects of the individual's exposure.

(c) To detect early or sub-clinical effects resulting from accidental or inadvertent exposure.

(d) To perform baseline bioassays for personnel that perform maintenance on devices that contain tritium.

(2) RADIOACTIVE CONTAMINANTS that enter the body are often classified into the somewhat loosely defined categories of **"Soluble"** and **"Insoluble"** where solubility is with respect to body fluids.

(a) **Insoluble** contaminants are usually the more difficult problem in measuring body burdens. When an ingested radioactive material is insoluble, it passes relatively unscathed directly through the gastrointestinal tract.

(b) With **solubility** the route of intake to the body is specified as:

[1] Inhalation - Through the nose. Most common route along with ingestion. Potential inhalation of alpha emitting radionuclides is the most serious problem. Any person exposed to higher than 200 disintegrations per minute (as determined by nasal swipe) has very likely had a serious inhalation exposure. These personnel should

immediately be referred to a physician for further analysis and should be put in a urine sampling program.

[2] Ingestion - Through the mouth.

[3] Percutaneous - Absorption of radionuclides directly through the skin. This is a common route for Tritium (H3) exposures since the tritium molecule is so small.

[4] Wounds - Injection through the skin.

(c) The category of contaminants which are **soluble** in the body fluids are usually subdivided into the following categories:

- Body water
- Specific organ
- Bone seekers

(3) **PERIODIC MEDICAL EXAMINATIONS:** Annual or periodic physical examinations are usually not warranted solely because of potential exposure to DU. Personnel monitoring is far more effective in determining the amount of exposure. Personnel monitoring may include any of the following:

(a) **Self Reading Dosimetry Devices (SRD)** - Is a cylindrical metal barrel filled with air and an electrometer detects and provides an estimate of gamma radiation.

(b) **Thermoluminescent Dosimeters (TLD)** - A type of radiation film badge and is very effective for monitoring exposure to the head, lens of the eyes, hands, trunk, gonads, arms above the elbows, legs above the knees, and fingers where DU may pose a potential external exposure hazard.

(c) **Nasal Swabs** - Nasal swabs (moistened with alcohol) are only useful in quickly determining that personnel have definitely inhaled DU particulate matter. Nasal swabs can give negative results for personnel exposed to DU fumes or sub-micron size particles. There are three important rules of nasal swab monitoring:

[1] Always collect the nasal sample after the individual has taken a decontamination shower.

[2] Double bag the swabs.

[3] Take random samples from non-victims. This provides a comparison set of samples for analysis and points out problems in counting equipment and/or collection procedures.

(d) **Bioassays** - The analysis procedure for determining the nature and activity of the internal contamination present in a person by making measurements on a body product. It is assumed that the concentration of radioactivity in the body elimination product (e.g.

urine) is proportional to the activity deposited in the body. Routine bioassay programs almost exclusively use urine as the sampler.

[1] The actual calculated contamination level is called the "*body burden*". If the specific distribution is known, the "*organ burden*" might be specified.

[2] Bioassay procedures should be undertaken only at the direction of qualified health physics or medical personnel.

[3] Some other body products useful for bioassay are:

- Exhaled air
- Nail clippings
- Nasal mucous
- Feces
- Sweat
- Saliva
- Hair

[4] Under a minimum program, bioassays are performed semi-annually or annually for all personnel in order to measure the accumulation of DU in the lungs and bones. Preparatory base line data should be performed on personnel prior to an assignment involving potential exposure.

[5] **Urinary Excretion** - Used under accident conditions and routine monitoring. Very effective in determining internal exposure to DU particulate and exposure to tritium. **Any internally deposited contaminant which is even slightly soluble in body fluids will eventually show up in a persons urine.** Bioassay should be given semi-annually to personnel exposed to airborne concentrations of DU. For internal exposure, DU can be measured in the urine of the exposed individual and can be valuable in deciding whether or not the individual was overexposed. A short fall to the urinary technique is that it does not provide acceptable data to estimate DU contamination in the lungs. Under accident conditions several rules apply:

[a] If less than one hour from the accident to the time of sample collection, the victim should be instructed to void the bladder of urine and then capture the next sample.. Physiologically, it takes about four hours for the contaminates to dissolve, be absorbed in the blood stream, be filtered out into the kidneys and appear in the bladder. The four hour period is necessary before the maximum urine concentration is reached following an acute intake.. Failure to wait and not drain the bladder will result in a diluted concentration and show a deceptively low test result. If treatment is determined based on this inaccurate reading, the victim could be dismissed without proper treatment.

[b] Urine samples are normally collected in waxed or polyethylene bottles. If tritium is the possible contaminant,

glass bottles should be used to store the specimens. Tritium has the potential to diffuse when stored in plastic and could effect other samples.

[c] Take random urine samples from non-victims in order to checkout equipment and collection procedures.

(e) **In-vivo Spectrometry (whole body count)** - Used to count a representative sample of internal exposure from gamma or x-ray radiation effecting all personnel at a given accident or location. In general In-vivo spectrometry is performed with specialized equipment such as a large scintillation counter or a semiconductor counter in conjunction with a massive shield (used to reduce background interference). Radium dial painters were the first occupation to use the In-vivo test. When In-vivo spectrometry is supplemented with urinary data a more accurate evaluation is achievable. Keep in mind that urinary data is usually not suitable by itself to measure for gamma or x-ray exposure due to the low level of radiation which would collect in the excretes.

(4) In the event of chronic exposure a prompt evaluation is warranted with one or more follow-up evaluations. Acute exposure is usually needed within a couple of days.

(5) A well managed Bioassay Program will include a combination of urinary and In-vivo spectrometry techniques. More frequent bioassays are performed for a sample of the most highly exposed personnel. The necessity for bioassay measurements will arise following an accident such as fire, spill, equipment malfunction, combat, or other departures from normal operations which could have caused abnormally high concentrations of radioactive contaminants in the air.

(6) The ideal basis for radiation dose measurement would be the number of ion pairs (or ionizations) taking place within the medium of interest. However, for certain practical reasons, the medium used in establishing a unit of measurement was air.

(7) Every effort must be made to maintain the radiation dose equivalent and the dose commitment to individuals as far below established radiation protection standards (10CFR20, AR 40-5, AR 40-14, AFR 161-8, NAVMED P-5055) as reasonably achievable. The standards to be discussed here are all expressed in concrete numbers limiting dose per year, limiting concentrations in air and water and so on. Through constant usage, numbers of this type can be taken for granted. It is then easy to assume that there will be no problems or injuries if the limits are not exceeded. This may be true, but no one can be absolutely sure of this in light of *present knowledge*. Since the relationship between low level radiation exposure and biological damage is still uncertain and hotly debated, standards have been established on a very conservative basis. The International Commission on Radiological Protection (ICRP) has never the less taken the reasonable stand that all unnecessary exposure should be avoided, even if it is within established limits.

(8) Numerical limits, in addition to producing a false sense of security, can also generate problems in the other direction if practitioners apply them too rigidly in all situations. The ICRP addresses this real life contingency, and ALARA has as one of its aims the provision of more latitude to the professional in the field for making reasonable decisions in particular situations, in effect saying that common sense is still a very valuable commodity when it comes to applying any set of rules.

c. Summary: During this lesson we covered some of the basics of medical evaluation and monitoring. Every installation should establish an effective monitoring program to help protect their personnel from the hazards of working with radioactive materials.

2. APPLICATION: None.

3. EVALUATION: None.

4. REVIEW AND CRITIQUE:

a. Are there any questions.

b. Clarify any misunderstood material.

References

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Last Word`

Numerical limits, in addition to producing a false sense of security, can also generate problems in the other direction if practitioners apply them too rigidly in all situations. The International Commission on Radiological Protection addresses this real life contingency, and ALARA has as one of its aims the provision of more latitude to the professional in the field for making reasonable decisions in particular situations, in effect saying that common sense is still a very valuable commodity when it comes to applying any set of rules.

Test Time

Test Review

1. Which of the following radioactive materials would you expect to find on M1 series tanks?
(Indicate all that apply)

A. Thorium
B. Nickel 63
C. Americium
D. Cesium
E. Radium
F. Promethium
G. Depleted Uranium
H. Tritium
I. Strontium

Test Review

1. Which of the following radioactive materials would you expect to find on M1 series tanks?
(Indicate all that apply)

A. **Thorium - Combustor Liner / Thermal Optics**
B. Nickel 63
C. Americium
D. Cesium
E. Radium
F. Promethium
G. Depleted Uranium
H. Tritium
I. Strontium

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G. **Depleted Uranium - M1A1 Heavy / M1A2**
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(Indicate all that apply)

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B. Nickel 63
C. Americium
D. Cesium
E. Radium
F. Promethium
G. Depleted Uranium - M1A1 Heavy / M1A2
H. Tritium - All MRSs
I. Strontium

Test Review

2. By NRC regulations, the radiation dose to members of the general public must be kept below:
(Indicate all that apply)

A. 0.1 RAD per year
B. 10 Curies per exposure
C. 2 millirem per hour
D. 100 millirem per year

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C. 2 millirem per hour
D. 100 millirem per year

Test Review

3. Indicate which of the following items are needed to perform a scheduled wipe test on an M43A1 Chemical Agent Detector.

A. Rubber Gloves
B. AN/PDR-27 Radiac Meter
C. NuCon Filters
D. Kraft Paper
E. Scintillation Vials
F. Large Envelope
G. Grease Pencil
H. AN/PDR-56 Radiac Meter
I. Metricel Filters
J. Distilled Water
K. Q-Tips
L. Small Envelopes
M. Plastic Bags
N. Cotton Tipped Applicators
O. Tape
P. Map
Q. Rad Waste Container
R. AN/PDR-77 Radiac Set
S. Type A Cardboard Container
T. Tweezers
U. 14 Inch Pipe Wrench
V. Mirror
W. Scintillation Vial Labels
X. ACALA SOUM 95-04
Y. Snickers Candy Bar
Z. Abrasive Soap

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W. Scintillation Vial Labels
X. ACALA SOUM 95-04
Y. Snickers Candy Bar
Z. Abrasive Soap

Test Review

4. The M1A1 Collimator contains a 10 Curie Thorium source that is easily damaged by over pressure purging and charging.

   A. True

   B. False

Test Review

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A. True

B. False

Test Review

Tritium

4. The M1A1 Collimator contains a 10 Curie ~~Thorium~~ source that is easily damaged by over pressure purging and charging.

   A. True

   B. False

Test Review

5. How can a M1A1 tank with Depleted Uranium (DU) armor be identified?

A. Trifoil stamped near the location of the DU.
B. Warning label located in the engine compartment.
C. Only with the use of proper radiac instruments.
D. The letter “U” in the turret serial number.
E. All of the above.

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B. Warning label located in the engine compartment.
C. Only with the use of proper radiac instruments.
D. The letter "U" in the turret serial number.
E. All of the above.

Test Review

6. Although potential users may believe that handling DU ammunition presents a complex safety problem, the fact remains that DU is the lesser hazard when compared to the hazards presented by the propellant charge.

A. True

B. False

Test Review

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A. True

B. False

Test Review

7. Indicate which of the following items are needed to perform a scheduled wipe test on the Chemical Agent Monitor.

A. Rubber Gloves
B. AN/PDR-27 Radiac Meter
C. NuCon Filters
D. Kraft Paper
E. Scintillation Vials
F. Large Envelope
G. Grease Pencil
H. AN/PDR-56 Radiac Meter
I. Metricel Filters
J. Distilled Water
K. Q-Tips
L. Small Envelopes
M. Plastic Bags
N. Cotton Tipped Applicators
O. Tape
P. Map
Q. Rad Waste Container
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S. Type A Cardboard Container
T. Tweezers
U. 14 Inch Pipe Wrench
V. Mirror
W. Scintillation Vial Labels
X. ACALA SOUM 95-04
Y. Snickers Candy Bar
Z. Abrasive Soap

Test Review

8. Field level storage of Tritium devices which can be stored in one room is limited to _____ .

A. 10,000 Ci
B. 1000 RAD
C. 200 Ci
D. No limit

Test Review

8. Field level storage of Tritium devices which can be stored in one room is limited to _____ .

A. 10,000 Ci **(Depot level storage limit)**
B. 1000 **RAD**
C. 200 Ci
D. No limit

Test Review

9. When used indoors the M43A1 must have a 0.2 micron exit port air filter. This is a requirement of NRC License 12-00722-13

A. True

B. False

Test Review

9. When used indoors the M43A1 must have a 0.2 micron exit port air filter. This is a requirement of NRC License 12-00722-13

A. True

B. False

Test Review

10. Who has the responsibility to keep an individual's exposures to radiation as low as reasonably achievable (ALARA)?
(Indicate the single best answer)

A. The NRC
B. The employer
C. The RPO
D. The individual

Test Review

10. Who has the responsibility to keep an individual's exposures to radiation as low as reasonably achievable (ALARA)?
(Indicate the single best answer)

A. The NRC
B. The employer
C. The RPO
D. The individual

Test Review

11. A bioassay must be performed immediately after potential exposure to Tritium.

A. True

B. False

Test Review

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A. True

B. False

Test Review

11. A bioassay must be performed immediately after potential exposure to Tritium.

A. True

B. False

Test Review

12. Who has the ultimate responsibility to ensure that the M43A1 Chemical Agent Detector and the Chemical Agent Monitor (CAM) receives their periodic wipe test?

A. The installation RPO
B. The owning unit
C. TMDE
D. The installation DoDRATTS POC
E. All of the above

Test Review

12. Who has the ultimate responsibility to ensure that the M43A1 Chemical Agent Detector and the Chemical Agent Monitor (CAM) receives their periodic wipe test?

A. The installation RPO
B. The owning unit
C. TMDE
D. The installation DoDRATTS POC
E. All of the above

Test Review

12. Who has the **ultimate** responsibility to ensure that the M43A1 Chemical Agent Detector and the Chemical Agent Monitor (CAM) receives their periodic wipe test?

A. The installation RPO
B. The owning unit
C. TMDE
D. The installation DoDRATTS POC
E. All of the above

Test Review

13. An illumination test must be performed on the M1A1 Infinity Collimator prior to purging and charging operations.

    A. True
    B. False
    C. Who cares!

Test Review

13. An illumination test must be performed on the M1A1 Infinity Collimator prior to purging and charging operations.

A. True

B. False

C. Who cares!

Test Review

14. Indicate which of the following items are needed to perform a routine tritium survey.

A. Rubber Gloves
B. AN/PDR-27 Radiac Meter
C. NuCon Filters
D. Kraft Paper
E. Scintillation Vials
F. Large Envelope
G. Grease Pencil
H. AN/PDR-56 Radiac Meter
I. Metricel Filters
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Y. Snickers Candy Bar
Z. Abrasive Soap

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Graduation