(cover)
EAI REPORT 69-4/95/002F

COMBINED ARMS IN A
NUCLEAR-CHEMICAL ENVIRONMENT

DEVELOPMENT OF DEPLETED URANIUM
TRAINING SUPPORT PACKAGES (TSPs):
TIER I - GENERAL AUDIENCE

INITIAL DRAFT LESSON PLANS:

TASK: [DU1] RECOGNIZE A DEPLETED URANIUM/LOW-LEVEL RADIOLOGICAL HAZARD

April 1995

U.S. Army Chemical School
Fort McClellan, Alabama 36205

SUPPORTED BY:

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This deliverable is the final phase in preparing Lesson Plans for Depleted Uranium and Other Low-Level Radioactive Materials Awareness Training (Tier I). Enclosed is the Final Lesson Plan for Task [DU 1] Recognize a DU/LLR Hazard.

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RECOGNIZE A DEPLETED URANIUM/LOW-LEVEL RADIOLOGICAL HAZARD

TABLE OF CONTENTS

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TSP XXXXXXXX

PREFACE

This training support package gives the instructor a standardized lesson plan for presenting information for:

TASK NUMBER: [DU1]

TASK TITLE: RECOGNIZE A DEPLETED URANIUM/LOW-LEVEL RADIOLOGICAL (DU/LLR) HAZARD

CONDITIONS: Given a suspected DU/LLR contaminated environment on a non-nuclear battlefield and any of the following situations:

1. You encounter a disabled U.S. or foreign armored vehicle or aircraft
2. You find a damaged U.S. or foreign chemical agent or radiation detection or monitoring set
3. You find expended or damaged DU penetrators or rounds
4. You find a night sight or night vision device, or a weapon mounting night sight components
5. You find a foreign vehicle with damaged dials or gauges

STANDARDS:

a) Without reference, define depleted uranium.
b) Without reference, describe the physical, chemical, and radiological characteristics of depleted uranium
c) Without reference, describe the Army's major weapon systems and ammunition types which contain depleted uranium.
d) Without reference, describe the visual characteristics of DU munitions strikes.
e) Identify from photographs or actual equipment other low-level radiological hazards
f) Describe equipment processing procedures
g) Identify applicable documents describing depleted uranium and other low-level radiological hazards

This TSP contains a lesson plan; paper masters for vugraphs and student handouts; and a test and test solution.

Instructors must thoroughly prepare by studying this lesson and identified reference material before presenting this lesson, to include reviewing the video, "Depleted Uranium Hazard Awareness."

The proponent of this publication is the U.S. Army Chemical School. Send comments and recommendations on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to:

Commandant
U.S. Army Chemical School
ATTN: ATZN-CM-CC
Fort McClellan, AL 36205-5020

TSP XXXXXXXX
October 1995
LESSON TITLE: [DU1] RECOGNIZE A DEPLETED URANIUM/LOW-LEVEL RADIOLOGICAL HAZARD
THIS LESSON IS USED IN THE FOLLOWING COURSES:
COURSE NUMBER(S) COURSE TITLE(S)
TBD TBD
SECTION I - ADMINISTRATIVE DATA
TASK(S) TAUGHT OR SUPPORTED:
TASK NUMBER TASK TITLE
TBD TBD
TASK(S) REINFORCED:
TASK NUMBER TASK TITLE
TBD TBD
ACADEMIC HOURS: PEACETIME MOBILIZATION
HOURS/TYPE HOURS/TYPE
LECTURE 2.2/ 2.2/
PRACTICAL EXERCISE 0/ 0/
TEST .2/ .2/
TEST REVIEW .2/ .2/___ __________
TOTAL HOURS 2.6 2.6
PREREQUISITE LESSON(S): NONE
CLEARANCE AND ACCESS: UNCLASSIFIED / UNRESTRICTED
REFERENCES:

NUMBER TITLE

AST-1500Z-100-93 Identification Guide for Radioactive Sources in Foreign Material

FM 3-3 Chemical and Biological Contamination Avoidance

FM 3-5 NBC Decontamination

FM 20-30 Battlefield Damage Assessment and Repair

STP 21-1-SMCT Soldier's Manual of Common Tasks - Skill Level 1

STP 3-54B34-SM-TG Soldier's Manual MOS 54B, Skill Levels 3 and 4, and Trainer's Guide

UNCLAS MSG, HQDA,
141130OCT93 SUBJECT Medical Management of Unusual Depleted Uranium Exposures

STUDENT STUDY ASSIGNMENTS: NONE

INSTRUCTOR REQUIREMENTS: One instructor

ADDITIONAL SUPPORT REQUIREMENTS: NONE

EQUIPMENT REQUIRED FOR THE INSTRUCTION:

One x overhead projector
One x video cassette player
One x video playback monitor

MATERIALS REQUIRED FOR THE INSTRUCTION:

INSTRUCTOR MATERIALS:

VIDEOTAPE "Depleted Uranium (DU) Hazard Awareness"

STUDENT MATERIALS: Pen, Pencil, Notebook

CLASSROOM, TRAINING AREA, AND RANGE REQUIREMENTS:
One standard classroom, or suitable training area.

AMMUNITION REQUIREMENTS: NONE
INSTRUCTIONAL GUIDANCE:

Instructors must thoroughly prepare by studying this lesson and identified reference materials before presenting this lesson to include reviewing the video, Depleted Uranium Hazard Awareness.

PROPONENT LESSON PLAN APPROVAL AUTHORITY:

NAME RANK POSITION DATE
(TBD)
SECTION II - INTRODUCTION

MOTIVATOR:

Operation Desert Storm saw the first widespread battlefield use of a metal called depleted uranium. The Army, Navy, and Air Force use depleted uranium, or DU, in a variety of weapon systems. We use DU for a simple reason: on today s battlefield, DU is the best metal or material for anti-armor penetrators. Conversely, it also provides the best armor protection to our crews. However, DU presents a possible health hazard because it is a toxic heavy metal which is radioactive. We fired thousands of DU rounds during Operation Desert Storm, and vehicles containing DU ammunition or armor were damaged. DU shrapnel injured several soldiers, and exposed others to DU contamination. The United States success with using DU in combat leads us to conclude that other nations, not all of them friendly, will be using DU in the future. As professional soldiers, we may all find ourselves in situations that contain DU hazards. DU hazards are almost entirely manageable if the proper knowledge exists. Although DU may expose unprotected personnel to a health hazard, DU contamination will not prevent mission completion unless the vehicle or equipment is destroyed or inoperable. We need to recognize DU on the battlefield, and how to take the simple steps necessary to avoid contamination. The purpose of this training is to teach you how to recognize depleted uranium and other low-level radiological hazards on the modern battlefield.

TERMINAL LEARNING OBJECTIVE:

ACTION:

At the completion of this lesson, you will understand the hazards of depleted uranium and other low-level radiological hazards. You will know the necessary protective measures if you must handle damaged equipment containing or contaminated with depleted uranium or low-level radiation.

CONDITIONS:

Given a suspected DU/LLR contaminated environment on a non-nuclear battlefield and any of the following situations:

1. You encounter a disabled U.S. or foreign armored vehicle or aircraft
2. You find a damaged US or foreign chemical agent or radiation detection or monitoring set
3. You find expended or damaged DU penetrators or rounds
4. You find a night sight or night vision device, or a weapon mounting night sight components
5. You find a foreign vehicle with damaged dials or gauges

STANDARDS:

a) Without reference, define depleted uranium.
b) Without reference, describe the physical, chemical, and radiological characteristics of depleted uranium
c) Without reference, describe the Army's major weapon systems and ammunition types which contain depleted uranium.
d) Without reference, describe the visual characteristics of DU munitions strikes.
e) Identify from photographs or actual equipment other low-level radiological hazards
f) Describe equipment processing procedures
g) Identify applicable documents describing depleted uranium and other low-level radiological hazards

SAFETY REQUIREMENTS: NONE

RISK ASSESSMENT LEVEL: LOW

ENVIRONMENTAL CONSIDERATIONS: NONE

EVALUATION: At the conclusion of this lesson you will take a written test to evaluate your understanding of the material presented during this instruction.

The test will comprise eleven multiple choice questions. You must answer eight correctly to pass the test.

INSTRUCTIONAL LEAD IN: Play video "Depleted Uranium (DU) Hazard Awareness" if available.

Playing Time: 15 minutes.
NOTE TO INSTRUCTOR

Do not play the video in place of the enclosed training. The video is intended to enhance, not replace, this training support package.

SECTION III - PRESENTATION

ENABLING LEARNING OBJECTIVE #1

ACTION:

Define Depleted Uranium

CONDITION:

Given a tactical or training environment.

STANDARD:

Without reference, define depleted uranium.

REFERENCES:

Depleted Uranium: Questions and Answers, Eric Kearsley and Eric Daxon, Radiation Biophysics Department, Armed Forces Radiobiology Research Institute, Bethesda, MD, page 2 (Daxon)

Health and Environmental Consequences of Depleted Uranium Use in the US Army, Army Environmental Policy Institute, Champaign, Illinois, February 1994, pages 2-16 (AEPI)

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is .1 hrs.

Media Vugraph
NOTE: Show OPT 1 (Uranium & enrichment)
a. Uranium is a natural, radioactive material. It contains three primary isotopes, U-234, U-235, and U-238. Uranium is used to develop nuclear fuels and nuclear weapons.

(1) U-235 is the isotope required for most types of nuclear power uses or for nuclear weapons. Nuclear fission, or the splitting of the uranium atom, produces this power. Natural uranium does not have enough U-235 to undergo fission.

(2) To create the percentage of U-235 needed, natural uranium is chemically treated. This creates "Enriched Uranium, and "Depleted Uranium."

NOTE: Show OPT 2 (Depleted Uranium (DU))
b. Depleted Uranium (DU) is uranium metal that is the by-product of the uranium enrichment process. DU is almost entirely U-238, and is only 60% as radioactive as natural uranium.

(1) The percentages of uranium isotopes in natural and depleted uranium are:

URANIUM DEPLETED URANIUM

U-234 = 00.0057% U-234 = 00.001%
U-235 = 00.72% U-235 = 00.2%

U-238 = 99.28% U-238 = 99.8%

(2) Note the near-absence of U-234 and the very low level of U-235 in depleted uranium.

(3) We will discuss radioactivity in greater detail later in the lesson.

CONDUCT CHECK ON LEARNING

Ask your students to define depleted uranium.
A: See paragraph b.

Ask your students how much less radioactive DU is than natural uranium.
A: See paragraph b.

If your students are unable to answer these questions, review the material in this ELO.

ENABLING LEARNING OBJECTIVE #2

ACTION:

Identify Physical Properties of Depleted Uranium

CONDITION:

Given a training environment, either field or classroom.

STANDARDS:

Describe the color of DU metal
Compare the density of DU to lead
Define pyrophoric
Describe the appearance of DU oxide
Give an example of an oxide in another metal
List three types of radiation

REFERENCES:

AEPI, pages 2-1, 3-18
Daxon, page 2
Environmental Overview For Depleted Uranium (C. Reed Magness, Environmental Technology Directorate, USAAMCCOM, October, 1985.) pages 14, 15, 18 (Env Ov)
Fundamentals of Chemistry, Second Edition, James E. Brady and John R. Holum, John Wiley & Sons, New York, 1984, page 365 (Brady & Holum)
PNL Report 8890, Radiological Assessment of the 120-mm APFSDS-T, M829A2 Cartridge, October 1983 (PNL)

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is .2 hrs.

Media Vugraphs/slides

NOTE: Show OPT 3 (General properties of DU)
a. Depleted uranium metal contains unique physical, chemical, and radiological properties. It is extremely dense, it is toxic, and is radioactive. It is also pyrophoric, which means that very small particles may self-ignite. Understanding these characteristics will make it easier for you to recognize hazards on the battlefield.

NOTE: Show OPT 4 (Physical properties)
(1) Physical properties of DU. DU, like lead, is considered a heavy metal. Also like lead, it can be toxic, or poisonous, if swallowed or brought into the body another way.

(a) DU is a silver-white, very dense metal that is about 1.6 times as dense as lead. To give you an idea, a solid mass of DU about the size of a soda can weighs about fifteen pounds. A similar volume of lead weighs less than ten pounds. DU alloys are easily machinable.

(b) Very small particles of DU will self-ignite when exposed to air or to the friction from a munition strike. They catch fire and burn rapidly at very high temperatures. This adds to the destructive capability of DU munition strikes.

When a DU penetrator strikes a hard target, the core breaks and small particles of metal are scattered. In the presence of air, these small particles ignite and burn, causing a very bright greenish flash.

(c) In air, DU becomes coated with a layer of oxide that normally gives it a dull black color. Other colors, such as gold, yellow, or green may be present, but DU oxide is usually blackish.

NOTE: Show OPT 5 (Chemical properties)
(2) Chemical properties of DU

(a) Chemically, DU is identical to natural uranium. Uranium is a reactive element, which means that it forms compounds with other elements easily. It also oxidizes rapidly, especially in water. As an example, as iron oxidizes into iron oxide, or rust, DU oxidizes into uranium oxide.

(b) Oxidation occurs immediately with munition strikes and in fires because these events form very small particles that react easily with air. Oxidation may take several days for large pieces of DU.

(c) Uranium s ability to dissolve effects how well DU moves in the environment, or how readily the lungs absorb DU particles.

NOTE: Show OPT 6 (Radioactivity in general)
(3) Before we describe DU's radioactivity, let us describe radioactivity in general.

Early experiments with uranium crystals showed that they exposed photographic plates. Scientists believed that these crystals gave off some previously unknown kind of radiation which was capable of penetrating paper and exposing film. These crystals were called radioactive, or producing rays.

In the following years, many scientists worked to understand nuclear radiation. They thought radiation was of only one kind. Experiments which used electric plates proved that the scientists were wrong. Certain particles were attracted to certain electrical charges. They found three general types of nuclear radiation:

Alpha particles have a positive charge. Alpha particles are the same as the nucleus of the Helium atom. They contain no electrons. They lose their energy quickly in just a few centimeters of air.

Beta particles have a negative charge. Beta particles are the same as electrons. Beta particles move at very high speed. They have a much greater range in air than alpha particles.

Gamma rays have no charge. Gamma rays are not particles, but are energy. Gamma rays move at the speed of light. They may present a hazard at fairly large distances from the source.

(4) We now know that radiation comes from the center, or nucleus, of the atom of radioactive elements. For this reason, it is called nuclear radiation. Nuclear radiation is produced because certain elements are unstable. These unstable elements release energy or particles in attempting to become stable. This process is known as radioactive decay.

(5) Let us discuss one more aspect of radioactivity. This is the concept of "half-life." Half-life is the time it takes for a given quantity to disintegrate so that only half of it remains. For example, radium has a half-life of 1,600 years. If we start with one gram of radium, in 1600 years only one-half gram of radium will remain. In 1600 more years, only one-quarter gram will remain. The other three-quarters will have been converted into other decay products, called "daughter products."

NOTE TO INSTRUCTOR

Your soldiers may ask you about the structure of an atom.

An atom is composed of protons, neutrons, and electrons. Protons and neutrons are found in the nucleus, or center, of the atom. Electrons are found in layers or shells around the nucleus. The structure of the atom has been compared loosely to the structure of our solar system, with the nucleus represented by the sun, and the electrons represented by the planets. The electrons have a negative charge, and the protons have a positive charge. Neutrons have no charge.

The Helium atom is composed of two protons, two neutrons, and two electrons. The nucleus is similar to an alpha particle.

Additional overhead projections are available for you: they are labeled EXTRA #s 1-4" and are at the end of Appendix A.

NOTE TO INSTRUCTOR (CONT D)

Your soldiers may ask you how alpha, beta, and gamma emissions affect other atoms.

The interaction of alpha, beta, and gamma with other matter is called ionizing radiation. An ion is a charged particle. When alpha and beta particles, and gamma rays ionize another atom, ion pairs are formed. An ion pair consists of the negative electron stripped from the atom, and the remainder of the atom which is now positively charged.

Alpha particles have a high ionizing capability. Alpha particles cause ionization by pulling or attracting electrons from their orbits. The ionizing potential for alpha is 300 times that of beta.

Beta particles have the next higher ionizing capability. The negatively-charged beta particle ionizes matter as it passes through it, thus losing speed and energy. Beta particles cause ionization by pushing/repelling electrons from orbit.

Gamma rays are pure energy. They have the lowest ionizing capability. They travel the furthest, so they present the greatest external hazard. Gamma radiation is similar to other forms of electromagnetic energy such as X-rays and radio waves. Gamma radiation is often discussed in terms of photons, in an identical manner that light is composed of photons. Photons have properties of both waves and particles.

For further information, consult the Operational Radiation Safety Course Student Handbook, October 94, chapter 2.

NOTE: Show OPT 7 (Radiological properties of DU)
(6) DU is only mildly radioactive. For example, it takes about 2.5 metric tons of DU to contain the same activity as one gram of radium. This does not mean that DU is not radioactive. Like natural uranium, DU is radioactive, but only 60% as natural uranium.

(a) DU emits alpha and beta particles, and gamma rays.

1. Alpha particles have a very limited range in air. Two inches of air or our outermost layer of skin blocks alpha particles.

2. Beta particles have a much greater range than alpha particles. However, plastic, leather, and aluminum easily block them.

3. Gamma rays are penetrating and only a heavy material such as lead blocks them.

4. The hazards from external exposure to DU are primarily radiological, because the body absorbs beta and gamma radiation.
NOTE: Show OPT 8 (Types of radiation)
(b) DU ammunition packaging effectively shields alpha and beta particles. It only slightly reduces gamma radiation. Gamma radiation from DU is very low. You could hold an unfired 120mm M829A2 cartridge for 940 hours (23.5 work weeks) and not exceed the occupational exposure limit.

Similarly, you could lean against a pallet of M829A2 cartridges for 4700 hours (117.5 work weeks) and not receive a radiation worker s yearly dose.

NOTE TO INSTRUCTOR

CONDUCT CHECK ON LEARNING

Ask your students the following questions. You may need to review some of the lecture material if they are unsure of the answer.

What color is DU metal?
A: See paragraph a(1)(a)

How much does DU weigh compared with lead?
A: See paragraph a(1)(a)

What does pyrophoric mean?
A: See paragraph a(1)(b)

What does DU oxide look like?
A: See paragraph a(1)(c)

What would be an example of an oxide in another metal?
A: See paragraph a(2)(a)

What are three types of radiation associated with DU?
A: See paragraph a(3)(a)1

What does radioactive mean?
A: See paragraph a(3)

What are the three types of nuclear radiation?
A: See paragraph a(3)

What is an alpha particle? What is its charge?
A: See paragraph a(3)

What is a beta particle? What is its charge?
A: See paragraph a(3)

What is a gamma ray? What is its charge?
A: See paragraph a(3)

What does half-life mean?
A: See paragraph a(5)

ENABLING LEARNING OBJECTIVE #3

ACTION:

Identify Military Uses of Depleted Uranium

CONDITION:

Given a training environment or given a suspected DU threat on a non-nuclear battlefield with any of the following situations:

1. You encounter a disabled U.S. or foreign armored vehicle or aircraft

2. You find expended or damaged DU penetrators or rounds.

STANDARDS:

Without reference, identify two tank munitions containing DU
Without reference, identify Bradley munitions containing DU
Without reference, identify vehicles containing DU armor
Identify three other military uses of DU

REFERENCES:

Brady & Holum, page 3-22

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is .2 hrs.

Media Vugraphs/slides/inert replicas of munitions

NOTE: Show OPT 9 (General military uses)
a. General military uses of depleted uranium.

Depleted uranium has a variety of military uses. Its density is its greatest asset. Because it is so dense, it can easily penetrate other metals. It is more difficult to be penetrated. The United States Military uses DU in armor penetrating munitions, and as armor "packages" in M1-Series tanks. Two scatterable mines in use by the United States use trace amounts of depleted uranium as a catalyst in making their bodies.

The primary focus on the battlefield is to find, fix, and destroy the enemy. On the modern battlefield, that has come to mean to defeat armored vehicles. DU munitions and armor packages allow us to increase our weapons' effective ranges, and to protect ourselves with very dense armor.

b. DU penetrators.

We use DU in Kinetic Energy (KE) ammunition. Kinetic energy is the energy generated by moving objects. The bullets fired by your M16 use kinetic energy to damage the target. DU KE ammunition has a DU core as the penetrator. DU penetrators are types of "bullets" containing several unique characteristics.

DU is used in munitions because of its high density and pyrophoric properties. We fire the round at high velocity. When it hits a target, it punches through the armor. DU penetrators have a so-called self-sharpening effect when they strike a hard target. I am sure we have all seen the mushrooming that occurs when regular bullets hit a target. When DU hits a target, the mushrooming fragments break off, leaving a narrower, sharper penetrator moving into the target. This also adds to spall and creates a gas-like mist of very small particles, or an aerosol. When these particles burn, they cause the DU s distinctive brilliant greenish flash. The DU round striking the target releases more energy than steel or tungsten rounds. This is a great edge in combat, as records from Operation Desert Storm show.

The Army issues DU munitions as combat ammunition only. It is never fired in training. The only U.S. forces that handle DU munitions are combat forces or forces that maintain high readiness levels as in South Korea. Air Force A-10s, Marine Corps M60A3 Tanks, and M1 Abrams Main Battle Tanks all fired DU penetrators during Operation Desert Storm.

c. In the Army, the ammunition that contains DU are:

25mm M919
105mm M833/M900-series
120mm M829/M829A1 & A2

1. In 20mm and 30mm munitions, depleted uranium is the core of a round jacketed with softer metal. The Navy Phalanx gun system fires the 20mm round, which the Navy is phasing out. The Air Force fires 30mm tank-killing rounds from the cannon in its A-10 aircraft.

2. The 25mm round M919 is essentially the same as tank ammunition. We will discuss that round in just a moment. The Bradley Fighting Vehicle M242 chain gun in both M2 and M3 configurations fires the M919 25mm round. The USMC s LAV with the M242 gun can fire the Army s munition.

The amount of DU in each of these rounds is small. The 25mm round, for example, contained only a little more than three ounces depleted uranium. The other smaller-caliber DU munitions are similar in composition.
NOTE: Show OPT 10 (Cut-away of 120mm round)
3. Tank Main Gun rounds.

U.S. Army armor-piercing KE penetrators are "discarding sabot" rounds. Discarding sabot munitions carry a dense penetrator in a full-caliber body. They discard the full-caliber support shortly after the projectile leaves the gun muzzle. It accelerates faster in the bore and exits with a very high velocity. The penetrator is a two-foot long, one-inch wide, "dart" weighing ten pounds or more. It goes on to the target. In Operation Desert Storm, tank commanders reported first round kills against Iraqi tanks at ranges greater than three thousand meters.

NOTE: Show OPT 11 (Picture of M1A1 Tank)
d. Depleted uranium is used to improve the armor of M1-Series tanks. The density that allows DU to penetrate other metals means that other metals cannot easily penetrate DU. When used as an armor package, DU is inserted into a "sleeve" in the regular steel armor of a tank, then welded shut. We call the DU armor package on M1-Series tanks "Abrams Heavy Armor, or AHA. We identify tank turrets containing AHA packages by a U stamped or welded near the right side grenade launcher as part of the turret serial number, and by having its serial number end with the letters DU when recorded in the vehicle log book.

The U.S. and other countries have been impressed by the effectiveness of DU armor. They are developing a number of combat vehicles which will have substantially more DU than the current generation of M1A1 tanks. These include developmental breacher vehicles and an Armored Gun System , or AGS.

CONDUCT CHECK ON LEARNING

Ask your students the following questions to make sure they understand your presentation. If they appear unsure or are unable to answer the questions, you should review the material.

What two types of tank munitions contain DU?
A: See paragraph 2

What type of DU ammunition does the Bradley fire?
A: See paragraph c(2)

What vehicles use DU armor? How can they be identified?
A: See paragraph d

ENABLING LEARNING OBJECTIVE #4

ACTION:

Identify Environmental Factors and Implications of DU

CONDITION:

Given a classroom or tactical environment

STANDARDS:

Identify three types of radiation sources
Identify two types of radiation hazards
Identify the three basic protective measures to avoid radiation
Identify the environmental effect of DU in the air
Identify the environmental effect of DU in the water
Identify the environmental effect of DU in the soil
Identify the environmental effect of DU in plants and animals

REFERENCES

Env Ov pages 20-22, 25-26
AEPI pages 5-24 - 26
AST-1500Z-100-93 Identification Guide for Radioactive Sources in Foreign Material, pages 1-3 (F-Mat Guide)

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is .4 hrs.

Media: Vugraph/slides

NOTE: Show OPT 12 (Environmental aspects of DU)
DU may have an impact on the environment. We take precautions in our programs to reduce potential health hazards or environmental pollution. Beyond the many federal regulations governing the use of DU, each Army installation has its own SOPs and programs designed to carry out DOD/DA policies and regulations. These ensure safe working conditions and prevent contamination of the environment. The

Army has conducted live-fire testing of both penetrators and armor packages for years, and has a large amount of data from analysis of the test ranges. This data helps us understand how DU acts. However, in recent years there has been no open air hard target testing. This testing is done inside large structures so the contamination is contained.

Combat in Desert Storm has shown us that all soldiers anytime during battle may come across depleted uranium and depleted uranium contamination. Approximately 40 tons of DU was scattered around Southwest Asian battlefields. It is unlikely that all of the DU rounds fired there will be found. Battlefield clean up or remediation has been conducted by the United States and other Coalition forces. The Kuwaiti Government is still cleaning up portions of Kuwait. Battlefield remediation is a host-nation responsibility.

Let us discuss possible environmental impacts of depleted uranium use and contamination as we act as environmental stewards.

DU's environmental effect is in its potential to move, or migrate, to living things. The radioactive elements of DU have "half-lives" of thousands of years. They will be around for the conceivable future. The heavy metal aspects of DU, like all metals, will also persist for generations.

Let us spend a few minutes talking about the hazards of radioactive materials. We will also discuss some of the basic protective actions we can take to reduce our exposure to them.

NOTE: Show OPT 13 (Hazards)
a. Hazards of Radioactive Materials

We broadly describe the hazards of radioactivity as external or internal. Let us briefly review these hazards.

(1) External radiation exposure. This is the radiation dose that a person receives from radioactive material that is outside the person's body. The dose that results from a radioactive source is dependent on the type, the strength, and the nearness of the source to the body.

Gamma sources are the primary contributors to external doses because they penetrate more than alpha and beta particles.

(2) Internal radiation exposure. An internal radiation exposure may occur from inhalation, ingestion, or absorption through the skin or an open wound. Factors that influence the internal doses a person receives include the form, the radioactive half-life, the type of radiation, and the source strength.

When inside the body, alpha radiation is more damaging than beta radiation, which in turn is more damaging than gamma radiation.

We generally seal almost all of the radioactive sources safely. However, we frequently find equipment in some damaged form due to combat actions. This is especially true of vehicle dials and switches.

NOTE: Show OPT 14 (Actions)
b. Protective actions

Three basic ideas are important in reducing or eliminating the exposure or dose you receive from radioactive materials: time, distance, and shielding.

(1) Time. Reduce the time you are exposed to the radioactive source. The shorter the time spent near the radioactive material, the smaller the radiation dose received.

(2) Distance. Maximize the distance between you and the source. The farther you are from a radioactive source, the smaller the radiation dose. In fact, for every doubling of the distance, a factor of four reduces the dose rate. Go near the source only when absolutely necessary, and prevent others from going near the source by posting warning signs.

(3) Shielding. Place shielding material between you and the source to absorb the radiation emitted by the source.

If you encounter an exposed or damaged radiation source, immediately inform your unit NBC officer or NCO, or your unit medical officer or NCO. Be prepared to provide as much information as you can about the nature of the equipment. Don t forget that equipment containing radioactive sources are safe if they remain in their intended configuration. Damaged or destroyed equipment may be a hazard.

NOTE: Show OPT 15 (Environmental Effects)
c. Environmental effects in the air

(1) DU s effect in the air is limited to the airborne transport of DU particles. The smaller the particle, the farther it will travel. It is important to consider wind speed and direction. You may breathe or otherwise ingest DU particles suspended in the air. They may come to rest on a surface and remain there. They may come to rest on a surface, like your hand, and you may ingest or inhale them. They may come to rest on an open wound.
(2) Due to the high density of DU particles, they settle rapidly and are not transported long distances. Test-firing and combat studies have shown that most particles of DU penetrators or armor packages come to rest within 50 meters of the target. Those that do not are large pieces and are easily found and avoided.

Vehicles or personnel may stir up the particles that settle by moving through the contaminated area. The particles may move a short distance. They may be inhaled or ingested.

d. Environmental effects in the water

DU s mobility in water is due to how easily it dissolves. Soluble compounds of DU will readily dissolve and migrate with surface or ground water. Drinking or washing or other contact with contaminated water will spread the contamination.

Within inches of the point of contamination, uranium concentrations decrease greatly. This suggests limited movement downstream from the target areas. The particles come to rest in the soil.

e. Environmental effects in the soil

The end result of air and water contamination is that DU is deposited in the soil. Once in the soil, it stays there unless moved. This means that the area remains contaminated, and will not decontaminate itself.

In combat, large chunks of shattered penetrators or very small vapor-like particles may fall to the ground. Except individual spots containing large concentrations of DU, radiation is the same as natural, or background, levels. The heavy metal threat persists.

f. Environmental effects on plants and animals

Most of our data comes from the Army s continuous testing of DU over the years. These tests show that the greatest threat is during open-air live-fire testing. We anticipate no other effects on living creatures during their lives. We can call combat a great big open-air live-fire test. Understanding the effects of DU to the creatures living on depleted uranium battlefields is important because we as humans routinely eat plants and animals.

Let s take a brief moment to introduce the concept of biological half-life. Biological half-life refers to the amount of time it takes the body to rid itself of half of the radiation from the radioactive material. In terms of DU contamination, the biological half-life means how long the body will metabolize an internal radiological material, such as ingested or inhaled DU dust.

(1) Effects on plants

The most likely place for injury to plants is in the root system. Some plants may be more tolerant to high concentrations of uranium than others. However, one study has shown that the uranium concentration in plant tissue is less than that in the surrounding soil. Most samples had undetectable concentrations after vigorous surface washing to remove uranium dust. This shows almost no effect on plants.

If we ingest surface dust on a plant, we will contaminate our digestive and respiratory tracts.

(2) Effects on animals

The greatest DU hazard is its toxicity due to ingestion, rather than radiation poisoning. Soluble uranium compounds are kidney poisons. However, because of the short life span of animals, the damage to the kidneys is negligible.
NOTE: Show OPT 16 (Summary: DU s effects in the environment)

(3) Conclusion for environmental effects

Studies have shown that the food chain does not effectively transport DU. The most common uptake of uranium is from particles suspended in the air. They are usually only present in significant quantities immediately following a munition strike. Uptake of uranium by animals may occur through consumption of vegetation, or incidental ingestion from preening. The conclusion is that DU does not seriously affect wildlife.

NOTE: Show OPT 17 (Impact on the battlefield)
(4) Implications for operations.

DU's largest effect is on humans. We must remember the hazards and do our best to avoid them. The application of these environmental effects to operations are minor if the proper precautions are followed.

First, DU or LLR contamination does not prevent you from continuing your mission. Take personal safety measures, and continue your mission. Seek the guidance of your unit NBC personnel or chain of command as soon as the mission allows.
Second, don't place contaminated equipment or personnel near water sources or near roads or trails. Even though DU is not very mobile in the environment, it is better to avoid chances of spreading contamination.

Third, remember that the only way to positively identify DU contamination is with a radiacmeter. If you suspect there is a threat, use a radiation detector to check out the equipment or area.

Fourth, avoid entering a contaminated or possibly-contaminated area unless you are wearing a mask and gloves.

Fifth, any support sites, such as bivouac, feeding, sleeping, maintenance, or medical areas should be located upwind from the contaminated area. Place these sites outside of any surface danger area for UXOs, which could be as far as 400 meters or more.

Lastly, if you will conduct decon operations, don't locate the decon station near any of the above-mentioned areas. If you must, put it downwind from them.

CONDUCT CHECK ON LEARNING

Ask your students the following questions to determine their understanding of this ELO.

What are the two general types of radiation hazards?
A: See paragraph a(1) and a(2)

What are the three basic guidelines for protecting yourself from radiation?
A: See paragraph b

What is the primary environmental concern for DU in the air?
A: See paragraph c(1)

In the water?
A: See paragraph d

In plants and animals?
A: See paragraph f and f(3)

What are some guidelines for conducting your operations near potential DU contamination?
A: See paragraph f(4)

ENABLING LEARNING OBJECTIVE #5

ACTION:

Identify Potential Depleted Uranium Contamination

CONDITION:

Given a training environment or given a suspected DU threat on a non-nuclear battlefield with any of the following situations:

1. You encounter a disabled U.S. or foreign armored vehicle or aircraft
2. You find expended or damaged DU penetrators or rounds.

STANDARD:

Describe the three possible hazards associated with DU strikes on vehicles
Identify the three locations where expended DU ammunition will be found on the battlefield.
Describe the appearance of DU oxides.
Identify how far (in meters) DU oxides will normally be found from a destroyed vehicle.
Identify three situations in which a person is most likely to be contaminated by DU oxides.

REFERENCES:

Memorandum Report BRL-MR-3760: M774 Cartridges Impacting Armor-Bustle Targets: Depleted Uranium Airborne and Fallout Material, Edward F. Wilsey and Ernest W. Bloore, Ballistic Research Laboratory, Aberdeen Proving Ground, MD, May 1989. (BRL)

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__
Time of instruction is .2 hrs.

Media: Vugraphs/slides
NOTE: Show OPT 18 (DU vs combat hazards)

Depleted uranium is toxic and radioactive. DU poses a health threat. This threat is not imaginary. However, there are greater dangers on the battlefield than DU contamination. People are shooting at you! Artillery is falling and exploding! You are shooting back, and moving about the battlefield in your tanks and Bradleys! The explosive propellant in DU ammunition is a great hazard if not handled correctly. Obviously, a round that accidentally explodes is not just a health threat, but may kill you. DU contamination by comparison is a minor health hazard against the very real dangers of combat.

Now that things are a bit more in perspective, let us spend some time describing just how you might become contaminated with DU during wartime.

NOTE: Show OPT 19 (DU contamination sources: vehicles)
a. Sources of DU contamination on the battlefield

(1) Destroyed or damaged vehicles

(a) When a DU round penetrates an armored vehicle, it may pass through the vehicle, ricochet around, or break into fragments inside the vehicle. Broken metal fragments from the penetrator can scatter through the vehicle interior, killing and injuring personnel, destroying equipment, and causing secondary explosions and fires.

(b) Combat exposes crews to smoke, flames, and flying shrapnel. Don't forget that DU often burns when striking a target. Up to seventy (70) percent of a DU penetrator can aerosolize (turn into gas-like airborne particles), immediately exposing the crew to respirable particles. The vehicle becomes contaminated with dust and fragments from the DU penetrator.

(c) When DU armor is pierced, the DU armor shrapnel and spall adds to the munition's effect. For tank crews, the DU in the armor makes the fires and shrapnel effects worse, and adds more particles to the air. This increases the contamination level.

Also, the DU in armor that is exposed by the munition strike is a source of contamination, both particle and radiation. The more time spent near this contamination, the greater the health risk.

(d) Most of the contamination from these vehicles will remain within fifty meters of the vehicle.

DU is the primary armor-killing projectile for the U.S., and will most likely be for other nations. Many destroyed vehicles found on the battlefield will be potentially DU-contaminated. Unless your mission requires you to inspect or repair destroyed or disabled vehicles, avoid them and report them to your unit NBC officer or NCO, or your chain of command. If you must inspect or evacuate them, take appropriate protective measures, and carry on. We will describe the protective measures later.
NOTE: Show OPT 20 (DU contamination sources CONT D: Munitions)
(2) DU munitions

(a) Ammunition in storage poses very little threat if it remains in its intended form. This means that the ammunition is either in shipping containers, in ready racks, or in the chamber of the designed weapon. Unfired rounds are safe, but handle as live.

(b) DU projectiles fired in combat will be found in three places:

1. In or near the target vehicles: Most tank rounds will hit the target and remain within or near it.

2. On the soil surface: Projectiles that miss the target will often ricochet off the ground like a stone skipping across water. They will usually come to rest within a mile or two of the intended target.

3. Buried under the soil surface: Some projectiles will strike the ground at an angle and bury themselves. The percentage of buried rounds depends on engagement angles and ranges, soil types, and terrain.

Fragments of penetrators should be considered hazardous, and treated accordingly. Take personal protective measures when handling them. Always wear gloves. Use a shovel or something similar to scoop up penetrators or fragments. Handle them only if essential to accomplish or continue your mission. Notify your NBC Officer or NCO, or your chain of command. We will discuss the specific health hazards later.

(c) DU munitions may themselves catch fire because of combat actions or accidents. The greater dangers in these cases are the propellants. Still, there will be a lingering DU contamination when rounds burn or are destroyed. Treat these sites as you would a destroyed vehicle.
NOTE: Show OPT 21 (DU contamination sources CONT D: Particles)
(3) DU particles and oxides

After DU fragments and burns, what remains are small black piles of uranium oxide. These piles may look like piles of black charcoal dust or chunks of charcoal, and if kicked or stepped on immediately after impact may pop. They are contaminants. Avoid handling them. Avoid breathing without a mask near them.

NOTE: Show OPT 22 (DU contamination sources CONT D: Personnel)
b. Personnel

The person most likely to be contaminated is breathing without protection when DU munitions hit and penetrate his AHA M1 tank and the DU aerosolizes into the tank turret. He will inhale large amounts of DU dust. Next is the person in an AHA M1 hit and penetrated by non-DU munitions. The DU in the armor would aerosolize into the turret. Other persons include crew members in Bradleys struck by DU ammunition. Last are individuals moving in, on, or near such vehicles after such an incident.

Soldiers involved in these incidents should be considered contaminated. If they are wounded, annotate their field medical card. You should inform the medics of possible DU contamination. All personnel should conduct personal decon when the mission permits.

If you have to enter a potentially-contaminated area or vehicle to save a life, then save the life. Avoid breathing unmasked in a DU-contaminated area if possible, and leave the area when you can. If you do not have your protective mask, use a field-expedient mask. TB 9-1300-278, Appendix 7, has a list of possible field expedient protective clothing you can wear. We will cover that topic in another lesson.

CONDUCT CHECK ON LEARNING

Ask your students the following questions to see if they understood your lecture. If they seem unsure, or can not answer the questions, you should review the material with them.

What are the three hazards associated with DU strikes on vehicles?
A: See paragraph a(1)(a), (b), (c)

What are the three locations expended DU ammunition will be found on the battlefield?
A: See paragraph a(2)(b)1, 2, 3

What does DU oxide look like after a munition strike on a hard target, or after a fire?
A: See paragraph a(3)

What does DU oxide look like after a strike on a soft target?
A: See ELO#2, paragraph a(1)(c)

What are the three situations where you may become contaminated as a result of DU munition strikes?
A: See paragraph b

ENABLING LEARNING OBJECTIVE #6

ACTION:

Identify Depleted Uranium Munition Strikes

CONDITION:

Given a training environment or a suspected DU threat on a non-nuclear battlefield and you encounter a disabled U.S. or foreign armored vehicle or aircraft.

STANDARD:

Identify DU penetrator strikes on armored vehicles

REFERENCES:

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is 0.1 hrs.

Media Vugraph/slides

NOTE: Show OPT 23 (Potential for DU strikes)
So far we have identified DU and its properties. We investigated how it affects the environment, and how we will find it on the battlefield. during our mission we may have to analyze, recover, destroy, or repair a vehicle. We must recognize and react to the DU threat.

We state continually throughout our training program that the only positive way to identify DU contamination is to survey the equipment or individual with radiacmeters. It may be more import to recognize the type of vehicle rather than the specific munition strike, which by itself may not be conclusive.

Our research indicates that identifying DU munitions strikes will not be cut-and-dried. The primary tank-killing munition in the U.S. inventory is a DU round, as is the primary APC-killing round (the M919 25mm Bradley AP round). This could lead us to assume that any enemy vehicle destroyed or disabled by fire may be contaminated with DU since it was likely destroyed with a U.S. DU round. Likewise, in the world market, DU penetrators and high-explosive anti-tank (HEAT) rounds are readily available. It is likely that DU may also become the primary tank-killing munition for our potential enemies. In any case, a U.S. fighting vehicle, tank or BFV, that is destroyed will likely be destroyed by DU munitions, or will contain DU munitions when it is destroyed. This will probably cause DU contamination.

In addition, the variety of the munitions, along with the enhancements to armor packages such as composites and explosive reactive armor, may cause a vastly different visual signature than we saw during the Gulf War. We can't limit our focus to the last battle; that will handicap our ability to protect ourselves in future engagements. We must anticipate the next battle.

These factors have lead us to conclude that visual means may not be the primary method of determining a DU strike. These factors have lead us to suppose that in the next battle, potentially all stricken tanks or fighting vehicles will possibly contain DU contamination. We should tailor our training programs now to account for these potentialities by teaching that only a radiacmeter can positively identify a DU strike, even though visual indicators can alert us to potential DU contamination.

If we continue to forecast the increasingly-widespread use of DU, then we must assume that more and more vehicles will become DU-contaminated. Intelligence data indicates that DU use for ground combat vehicles and ammunition will increase. The presence of various types of DU munitions on the world market reinforces our statement. We currently teach assumption of contamination in other areas of this lesson plan and in other types of CW/BW training. Doing so here maintains consistency.

If you see a disabled or destroyed vehicle, it may be DU-contaminated. Because of DU s increasing use as KE penetrators, let us discuss the indicators of kinetic energy strikes.

a. DU penetrators are long and thin, and are normally much denser than the targets. We have described earlier how the rounds may pass completely through their targets. Identifying vehicles hit by DU kinetic energy weapons is therefore simple: the holes will be small, neat, and round.

NOTE: Show OPT 24 (Visual indicators of a DU strike)
b. In some cases fin lines may surround the hole if the metal was soft or thin, such as the skin of a personnel carrier or a tank ammunition compartment. These fin lines may also be present with non-DU KE penetrators.

c. Frequently you will see the results of spalling around the edge of the hole. The heat generated by the strike causes spall. The results of spalling looks like melted and rehardened solder.

d. If the penetrator goes through the target without breaking up, the exit hole will also be small and round, and slightly larger than the entry hole.

e. You may see oxide residue as we described earlier.

f. In contrast, conventional high-explosive anti-tank (HEAT) munitions make larger entrance holes than KE penetrators, and their exit holes appear noticeably larger than the entrance hole. DU HEAT munition strikes will contain the same residue as KE strikes.

g. You may see many piles of soot or ash after DU has hit a vehicle. You get black piles from the DU being subjected to intense heat and oxidizing. Black piles in an ammunition storage area of a combat vehicle may be considered DU. This is not always true since rubber and other petroleum products often leave blackish residue.

h. The only way to tell if the hole is radioactive is by testing with survey equipment. If you suspect that the hole is a DU strike, wear your mask, and check the hole with a radiacmeter.

NOTE: Show OPT 25 (Positive identification)

CONDUCT A CHECK ON LEARNING

Ask your students these questions to see if they understood the material. You may have to review if they can not answer these questions.

What are the visual characteristics of KE penetrator strikes on armored vehicles?
A: See paragraph b, c, d, e

What is the only sure way to detect DU contamination?
A: See paragraph h

ENABLING LEARNING OBJECTIVE #7

ACTION:

Identify Physiological (Radiological and Toxicological) Hazards of Depleted Uranium

CONDITION:

Given a classroom or field environment.

STANDARDS:

Without reference, identify three methods of exposure to DU contamination
Without reference, identify the primary radiation hazard from DU
Without reference, identify the primary toxicological hazard from DU

REFERENCES:

AEPI page 5-1
Env OV pages 17-18

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is 0.3 hrs.

Media Vugraph/slides

NOTE: Show OPT 26 (General Hazards)
Depleted uranium poses two health hazards: first, there is a primarily alpha radiation hazard. Second, as a heavy metal, there is a toxicological hazard, or poisonous effect, from DU. The second hazard is greater. The risk is from internal metal fragments and oxides. They are created by munition strikes, fires involving DU munitions, or oxidation of DU penetrators in the environment. We directly relate the level of risk to the amount of DU, its form, and the time and method of exposure.
DU fragments and oxides can enter the body through a wound, ingesting or swallowing, or inhaling or breathing. The skin does not absorb DU. The body can absorb particles that are inside you. The principal hazard is inhaling DU. When we inhale insoluble DU, the particles collect in the lungs. Radiation damage to the lungs is a concern. With soluble compounds, damage to the kidney is possible. Because humans have a long life span, damage to the kidneys or lungs may become apparent with time. Basic methods of controlling inhalation are enclosure, ventilation, and respiratory protection.

This portion of our lesson will describe the radioactive and toxic hazards of depleted uranium.

NOTE: Show OPT 27 (Radiological hazards)
a. DU s Radiation hazards

(1) In sufficient quantities, DU in the body presents a radiation hazard. Large amounts of DU, with large surface areas, very close to the body for a long time, also present a radiation hazard.

DU's radioactivity is quite low and overexposure is rare. It is easily prevented by maintaining adequate safety controls and providing proper training. DU munitions that have not been fired or tampered with present no serious external radiation hazard.

(2) The radiation hazard from inhaled DU particles (dust) is the damage to the tissue caused by alpha

particles. Tissue absorbs the alpha particle energy in the closest one-tenth millimeter. This results in localized cellular damage.
Beta and gamma radiation emissions spread their energies in large volumes of tissue and produce comparatively little damage.

Think of it this way: because alpha particles travel a short distance inside the body, all of the tissue within one-tenth of a millimeter is exposed. Beta and gamma emissions, with their greater range, spread their concentration into a greater area. This dilutes their effects in a given area, while alpha particles are full-strength. Also, there are many more alpha particles released than beta or gamma.

NOTE: Show OPT 28 (Radiation effects deterministic and stochastic)
(3) We divide radiation s health effects into two broad categories: deterministic effects and stochastic effects. Deterministic effects are related to cell death. A burn is a deterministic effect. Stochastic effects are related to cell change. Cancer is a stochastic effect.

(a) Deterministic effects:

Deterministic effects have a threshold dose below which we do not see the effects. We relate the severity of the effects to the radiation exposure received. These are similar to heat on the skin. There is a point when a burn is first noticed. As we increase the temperature or the time, we increase the severity of the burn.

(b) Stochastic effects:

Stochastic means "containing a random variable." Stochastic events involve probability and chance. When we describe the stochastic effects, we mean increasing the chance of tissue damage. Increasing the radiation exposure increases the probability of disease. This does not increase the severity of the disease. A radiation-induced cancer or mutation will have the same health effect despite the radiation exposure received.

There is another significant difference for stochastic effects: no exposure limit exists below which the effect does not occur. Currently, we assume that any radiation exposure, however small, will result in an increased health risk over an individual s lifetime.

NOTE TO INSTRUCTOR

Point out that it is this statistic that leads to the inappropriate conclusion that no level of radiation is "safe." Whether this increased risk is "safe" or acceptable is a separate issue.
Because stochastic events involve probabilities, we can t tell if a cancer or mutation occurred naturally, or because of exposure.

(c) Both deterministic and stochastic risks from acute, high-dose radiation exposure are well established. However, no data can be used to directly establish the cancer and hereditary risks from the low-level/low-dose-rate exposures that may occur from DU.

NOTE: Show OPT 29 (Toxicological hazards)
b. Toxicological Hazards of DU

Like most heavy metals, uranium is chemically toxic in sufficient quantities. Once in the body, DU concentrates in the kidney, liver, and bones. The kidney is the organ most sensitive to uranium's toxic effects. If your kidneys fail, you may die.

Uranium toxicity in man is not well known because of the lack of experimental data involving humans. However, from limited human and laboratory studies, we know that the degree varied. The variation is due mostly to the specific uranium compound in the body, soluble or insoluble, large particle or small.

Of the possible health risks from DU contamination, the chemical toxic hazard is a greater threat than radiation hazards. Depleted uranium is a heavy metal, and heavy metals are poisons. DU is a poison and it is present on today's battlefield in many forms. You must avoid breathing or swallowing DU because it may damage your internal organs, especially your kidneys.

NOTE: Show OPT 30 (Observations)
(1) The vugraph shows some observations about DU toxicity:

(a) Uranium is more toxic than pure tungsten which is also used in some penetrators.

(b) In soluble form, uranium and lead have comparable toxicities. In insoluble form lead is more toxic than uranium.

(c) The solubility of the inhaled metal controls the toxicity of the metal.

(d) Risks are dependent on the particle size distribution.

(2) We do not define the level at which chronic (lifetime) exposures can produce significant results. We have done some long-term studies. The results are inconclusive. What they have concluded is that uranium exposure could act to damage normal kidney functions.

(3) We lack data concerning the placental transfer of uranium from a mother to her child. Only one report was conducted using rats and one particular form of uranium. It concluded that transfer did occur, and that adverse effects were evident at higher doses.

(4) These uncertainties associated with chronic kidney damage are particularly important because of the Desert Storm veterans who still have imbedded DU fragments. DU fragments will probably result in elevated blood uranium levels for as long as they remain in the body.

(5) Keep in mind that proper medical care will reduce associated symptoms or illness from DU contamination.

CONDUCT CHECK ON LEARNING

Ask your students these questions to see if they understood what you taught them. If they can not answer the questions, you should review the material.

What are the three methods of exposure to DU contamination?
A: See paragraph 2 of ELO introduction

What is the primary radiation hazard from DU?

A: See paragraph a(1)(2)

What is the primary toxicological hazard from DU?
A: See paragraph b

ENABLING LEARNING OBJECTIVE #8

ACTION:

Identify Radiological Hazards on Foreign Equipment

CONDITIONS:

Given a training environment or given a suspected DU threat on a non-nuclear battlefield with any of the following situations:

1. You encounter a disabled U.S. or foreign armored vehicle or aircraft
2. You find expended or damaged DU penetrators or rounds.
3. You find damaged foreign chemical agent or radiation detection or monitoring set.
4. You find a foreign night sight or night sight component, or a weapon mounting night sight components.
5. You find a foreign vehicle with damaged dials or gauges.

STANDARDS:

Identify foreign equipment containing radiological hazards

REFERENCES:

AST-1500Z-100-93 Identification Guide for Radioactive Sources in Foreign Material (F-Mat Guide)

Learning Activity 1

Type of instruction: Slide presentation Instructor to student ratio is __:__

Time of instruction is .3 hrs.

Media Vugraph/slides (Figures 1-18)

Show OPT 31 (Sources of radiation in foreign materiel)
Some foreign equipment contains radioactive material. Commonly, only a very small amount of radioactive material is involved. It is in a container called a "source." These radioactive materials do not present a hazard to personnel working close to them unless we unwittingly tamper with or damage the radioactive source. Avoid a hazardous situation by properly handling radioactive sources on foreign materiel.

Foreign equipment containing a radiation hazard is not always clearly labeled and shielded. This is especially important where radium is used, as in luminous dials and switches. This is a significant difference between U.S. and foreign sources. Another difference is the packaging. Foreign equipment is often packed in wooden boxes. They are easily broken, and do not protect the equipment inside very well.

Practically all radioactive sources found on foreign materiel are not sealed. Exceptions to this are munitions containing DU, and instrument dials painted with luminous paints containing radium, tritium, or promethium. Sealed sources are either alpha, beta, or gamma, as we discussed earlier in the lesson.

NOTE: Show OPT 32 (Types of radioactive sources)
Types of radioactive sources.

(1) Alpha sources. These are found in various kinds of instruments and detectors, such as chemical detectors, icing monitors, or smoke detectors. An alpha source may also have a weak gamma. An alpha source is a slight external risk since we can totally stop or absorb alpha particles by a sheet of paper or one or 2 inches of air. The hazard from alpha sources is the internal radiation exposure that occurs if we ingest or inhale radioactive material.

(2) Beta sources. These are found in thickness gauges, nuclear batteries, static eliminators, and luminous dials and devices. Beta radiation is moderately penetrating and is rarely detectable outside the casing of a sealed source. It presents a risk of local skin exposure. It is not a significant internal hazard if inhaled or ingested. Thin steel can shield beta particles.

(3) Gamma sources. These are found in radiation test and measurement equipment. Gamma radiation is highly penetrating, and it requires substantial shielding to prevent external exposure. How much shielding required is dependent on the source strength and the energy of the gamma rays. High-density materials such as lead are often used to shield one from gamma rays.

Let s take the next few minutes looking at some foreign equipment with radioactive components. Pay attention to the types of equipment you see.

Instructor notes on slides: see following pages
Figure: 1

Item: Typical Radiation Symbols

Origin: International

Location:

Radioactive items:

Source:

Symbols: Universal symbol. Often we identify radioactive sources with one of these symbols. In the United States, the radiation symbol normally consists of a magenta (reddish purple) trefoil or "propeller" on a yellow background.

Variations. Red, purple, or black may replace the magenta coloring. Occasionally we may replace the yellow background with an orange background. Sometimes we find the "propeller" symbol without a separate, distinct background.

Figure: 2

Item: NSB-3 Mortar Sight Kit

Origin: Former Yugoslavia

Location: In separate metal case, which may accompany mortars

Radioactive items: (1) NT-M70 Sighting Point (2 per set)
(2) NSB-3 Sighting Device

Source: (1) NT-M70 Sighting Point contains tritium
(2) NSB-3 Sighting Device contains tritium (amt. unk.)

Symbols: Both contain the international radiation symbol. In addition, the NT-M70 has the radioactive material name abbreviation "T" for tritium and the amount of radioactive material.

Figure: 3

Item: PAB-2 Artillery Aiming Circle

Origin: Former Soviet Union

Location: Can be separate in case or accompany howitzers, etc.

Radioactive items: (1) PAB-2 Sight
(2) Sighting Point

Source: Each item contains a small, unknown amount of radium

Symbols: No radioactive symbols. Sight has hammer, sickle, and star.

NOTE: Yellow tape with a radioactive material symbol added in the United States.

Figure: 4 - 5

Item: GVJ-1 Chemical Agent Detector

Origin: Hungary

Location: In a separate wooden box

Radioactive items: 2 sources

Source: Each source contains americium

Symbols: They mark both the other wooden box or carrying case and the instrument itself with the magenta radiation symbol on a yellow circular background. Notice the warning label below the radiation symbols:

"Dismounting the detector of the equipment is strictly forbidden and noxious to the health"
Figure: 6 - 7

Item: RAM 63 Radiation Detection Instrument

Composed of:

(1) Wooden Carrying Case
(2) Electronic Detection Instrument
(3) RAM 63/2 Probe
(4) RAM 63/3 Probe

Origin: Former Democratic Republic of Germany

Location: In a separate wooden box or carrying case

Radioactive items: (1) RAM 63/2 Probe
(2) RAM 63/3 Probe

Source: Each contains plutonium and cesium as check sources

Symbols: A radiation symbol is on the RAM 63/2 probe

Figure: 8

Item: Dials and Switches

Origin: Former Soviet Bloc Countries

Location: Dials and switches containing radioactive materials can be found on various types of vehicles and weapon systems.

Radioactive items: Dials and switches

Source: Radium, tritium, and promethium have all been used in paints on dials and switches. Tritium has also been used as a gas in glass vials to "back light" gauge dials. Promethium has also been used. The amount of radioactive materials has generally been small.

Symbols: Generally, they do not label dials and switches with the radiation symbol.

CONDUCT CHECK ON LEARNING

Ask your students the following question to see if they understood the material you presented. If they can not answer the question, they may need to have the information explained again.

What types of foreign equipment contain radiation sources?
A: Sights, gauges, dials, night vision devices

ENABLING LEARNING OBJECTIVE #9

ACTION:

Identify Radiological Hazards on U.S. Equipment

CONDITION:

Given a training environment or given a suspected DU threat on a non-nuclear battlefield with any of the following situations:

1. You find damaged U.S. chemical agent or radiation detection or monitoring set.
2. You find U.S. night vision equipment.
3. You find U.S. fire control equipment.
4. You find U.S. small-arms weapons (rifles, pistols, light and medium machine guns).

STANDARD:

Without reference, identify four types of U.S. equipment with radiation sources.

REFERENCES:

TB 43-0116
F-Mat Guide

Learning Activity 1

Type of instruction: Slide presentation Instructor to student ratio is __:__

Time of instruction is .3 hrs.

Media Vugraph/slides

NOTE: Show OPT 33 (U.S. Army Radiation Sources)
The United States also uses equipment containing radioactive materials. The vugraph shows just one page, page 80, of the technical bulletin which lists all the items in the Army inventory that have radioactive components. There are over three thousand items in this training bulletin. We usually mark and shield U.S. equipment that contains radioactive materials, and pose no threat if properly used and are not damaged. Natural radioactive materials that are not machined or processed do not require marking.

U.S. equipment which contain radioactive sources are usually chemical agent monitors and detectors, night vision equipment, and fire control equipment. Fire control equipment helps sight or compute for weapon systems. Mortar or artillery sights are an example.

If you find any of these items to be damaged, treat them as you would the foreign materials described earlier, and inform your unit NBC and Medical officer or NCO.

Let s spend a few minutes looking at some slides of U.S. equipment with radioactive sources. Remember the different types of equipment.

Instructor notes for slides: see following pages.

Figure: 1

Item: M8/M43A1 Chemical Agent Detector

Origin: United States

Location: The radioactive source is found inside the housing of the detector

Radioactive items:

Source: The chemical agent detector contains americium

Symbols: We stamp the source with an international radiation symbol

Figure: 2

Item: Chemical Agent Monitor (CAM)

Origin: United States

Location:

Radioactive items:

Source:

Symbols: We stamp the source with an international radiation symbol

Figure: 3

Item: Night Vision Devices:

(1) AN/PVS-4
(2) AN/PVS-5
(3) AN/TAS-6

Origin: United States

Location: The radioactive source in these night vision devices in contained in the housing. The radioactive material is used to intensify the image collected by the night vision device.

Radioactive items:

Source: Each contains thorium

Symbols: We stamp the source with an international radiation symbol

Figure: 4

Item: Fire Control Equipment

Origin: United States

Location:

Radioactive items:

Source: These devices contain tritium

Symbols: We stamp the sources with an international radiation symbol

Figure: 5

Item: MC-1 Moisture Density Gauge

Origin: United States

Location:

Radioactive items:

Source: This item contains americium and cesium

Symbols: We stamp the source with an international radiation symbol

Figure: 6

Item: M1, IP M1, M1A1 Collimator (MRS)

Origin: United States

Location: End of main gun tube (top)

Radioactive items: We completely encase radioactive material within the unit and it poses no external radiation threat.

Source: Contains tritium

Symbols: We stamp the source with an international radiation symbol

CONDUCT CHECK ON LEARNING

Ask your students the following question to see if they understood the material. If they can not answer the question, review the material with them.

What are the three types of U.S. equipment with radiation sources?
A: Night vision devices, chemical agent detectors and monitors, and fire control equipment

ENABLING LEARNING OBJECTIVE #10

ACTION:

Identify Equipment Processing Procedures

CONDITION:

Given a classroom or tactical environment

STANDARD:

Without reference, identify the individual procedures taken to process DU/LLR-contaminated equipment
Identify the collective or unit equipment processing procedures.

REFERENCES:

AR 385-XX
DA PAM 385-XX
TB 9-1300-278
FM 9-43-2

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is 0.2 hrs.

Media Vugraph

NOTE: Show OPT 34 (DU contamination prevention procedures)
We have spent the last two hours describing DU, its properties and effects, and how it will be found on the battlefield. If you find DU or other low-level radiological hazards there are certain procedures you should take to prevent contaminating yourself.

Individual Procedures:

1. Notify your unit NBC and medical officer or noncommissioned officer.

2. Put on protective clothing.
3. Complete a visual inspection to identify any explosive hazards from any unexploded ordnance (UXO).

NOTE: Show OPT 35 (Procedures Pt 2)
Your unit would perform the rest of these steps as part of deliberate remediation activities:

4. Isolate the suspected piece of equipment.

5. Perform radiological survey using tactical survey equipment.

6. Segregate contaminated equipment from non-contaminated equipment.

7. Decontaminate the equipment as necessary.

8. Repair if possible using Battlefield Damage Assessment and Repair techniques.

9. Decide whether to release the equipment for combat use or to commence retrograde removal of the equipment.

10. Prepare and submit an After-Action Report (AAR).

NOTE: Show OPT 36 (Personal Protection)
We will discuss many of these activities in greater detail in another lesson. What we ll discuss now are a few simple guidelines you can follow to protect yourself in a DU-contaminated environment.

Maximum personal protection is always best and safest. Yet, during emergencies or combat immediate and rapid action may be required to save lives and win battles. The focus of the personal protection must be to prevent DU inhalation, ingestion or injection.

Maximum solider combat protection is wearing your complete overgarment, mask, boots, and gloves. Minimum solider protection would be holding your breath. A realistic approach is fast, sensible, and affords significant protection: wear your protective mask, roll down your uniform sleeves, blouse your trousers into your boots, and wear a hat and gloves.

DU is not so hazardous that you could not cover your nose and mouth with a bandanna or towel and work in a DU contaminated environment for a short time to save a life or win a battle. When the work is finished, dust off your uniform and equipment. Wash your face and hands before eating, smoking or going to the latrine. As a double check, have your uniform and body surveyed with a radiacmeter when time allows. The individual protective mask, work coveralls and overboots could be added as additional protection. We must also check the protective mask filters after use. DU won't affect their ability to filter chemical agents, but a lot of dust may clog them. At a minimum, survey the mask and filters to make some DU dust is not present.

If you need equipment components from DU-contaminated end items to make other vehicles or equipment fit for combat, use them. Dust or wash them off, scrape off known DU contamination, mark them for later identification in some fashion, survey them if possible and then put them to use. Follow up with a survey and further decontamination if required later when time permits.

CONDUCT CHECK ON LEARNING

Ask your student these questions to see if they understood the material. If they can not answer the questions, you should review the material with them.

What are the three equipment processing procedures you take on your own?
A: See numbered items 1, 2, 3

What are the equipment processing procedures you perform as part of collective equipment processing?
A: See numbered items 4-10

What are the personal protection measures you can take?
A: See OPT 37

ENABLING LEARNING OBJECTIVE #11

ACTION:

Identify Documents Describing Procedures for Management of Radiologically Contaminated Personnel at the Platoon and Company Level

CONDITION:

Given a classroom or tactical environment

STANDARD:

Identify the documents describing DU and LLR-contaminated personnel and equipment.

REFERENCES:

Learning Activity 1

Type of instruction: Lecture Instructor to student ratio is __:__

Time of instruction is 0.1 hrs.

Media Vugraph

NOTE: Show OPT 37 (Documentation) (Also student handout 1)
Several manuals describe in greater detail the guidelines for the safe handling and use of depleted uranium and other radioactive materials. They are:

1. TB 9-1300-278, Guidelines for Safe Response to Handling, Storage, And Transportation Accidents Involving Army Tank Munitions Or Armor Which Contain Depleted Uranium.

2. AR 385-XX, Retrograde Plan for Damaged Radioactive Materials Or Materials Contaminated With Radioactive Materials (Proposed).
3. TM 55-315, Transportability Guidance for Safe Transport of Radioactive Materials.

4. DA Pamphlet Retrograde of Low-Level Radioactive Materials.

5. TC 5-400, Unit Leaders' Handbook for Environmental Stewardship.

6. FM 9-43-2, Battlefield Damage Assessment and Repair.

7. TM 92350-200-BD-1 Battlefield Damage Assessment and Repair for Tank, combat, Full-tacked M105mm Gun, M1, Tank, Combat, Full-tracked M105mm Gun, IMPI, and Tank, Combat, Full-tracked 120mm Gun M1A1, General Abrams (Hull).

8. FM 3-220 Decontamination Procedures.

9. Security Guide for Depleted Uranium Ammunition.

10. Security Guide for M1-Series Tanks.

11. Security Guide for M2/M3 Bradley Fighting Vehicles.

TB 9-1300-278 is the Army s principal handbook in describing how to handle DU. Another important document is the Battle Damage and Assessment manuals, which are identified by the letters B-D at the end of the manual number.

SECTION IV - SUMMARY

Type of instruction: Lecture Instructor to student ratio is ___:___.

Time of instruction is: 0.1 hrs.

REVIEW/SUMMARIZE:

NOTE: Show OPT 38 (Summary/review of lesson objectives)
In this lesson we have learned about the hazards of depleted uranium and from other low-level radiation sources.

We learned that depleted uranium is a heavy metal that is a by-product of the uranium enrichment process. The properties of DU are almost the same as for natural uranium, except that it is much less radioactive.

We learned that DU is a radioactive silvery-white metal about one point six times as dense as lead. It is toxic, and it is pyrophoric, which means that very small particles of it can burn by themselves. DU oxidizes very quickly, and the oxide is normally a heavy, dull black dust.

The U.S. Army uses DU as armor in M1 tanks and as penetrators of armor-piercing munitions. The Army munitions are tank ammunition for M1-series tanks, and in 25mm Bradley ammunition.

The primary hazard from DU is when it is found internally through inhalation, ingesting, or injecting. DU may settle in the kidneys and cause serious damage to them. The radiological hazard from DU is through alpha particle emission, but this threat is less than the heavy metal toxicity.

We have discovered that DU can contaminate the environment, and its effects are long-lasting because of the half-lives of its radioactive elements. DU, however, does not migrate well from the site of contamination. The effects on plants and animals are slight.

We saw that when DU KE penetrators strike a hard target, the impact signature is a small, neat, round hole. Entry and exit holes are quite similar. When DU strikes a hard target, the penetrator often aerosolizes and burns immediately. However, DU munitions may not always be KE penetrators. DU HEAT shaped charges are being distributed by foreign governments. Consequently, the only sure way to identify a DU munition strike is to check it with a meter.

The places most likely to find DU contamination are in and around destroyed vehicles. Most of the contamination remains within 50m of the target, except that large fragments of the penetrator may travel up to a mile away.

We identified many foreign and U.S. types of equipment containing other radioactive materials. We learned that they do not label foreign equipment as radioactive. Foreign gauges, dials, and switches are frequently illuminated with tritium or radium paints. Both U.S. and foreign chemical agent detection equipment contains radioactive components, and U.S. night vision devices often contain radioactive sources.

Lastly, we identified procedures to follow when dealing with contaminated equipment, and identified the manuals that govern the safe use of DU.

TRANSITION TO THE NEXT LESSON:

In this lesson we learned how to recognize a depleted uranium or other low-level radiological hazard. These hazards will not go away. The use of DU is on the rise, and will spread to other nations soon because of their observed effectiveness during combat in Southwest Asia. We must learn how to continue our mission because of the hazards. In the next lesson we will identify and describe the protective actions you must take to work safely and fight in a DU/low-level radiologically contaminated environment.

NOTE TO INSTRUCTOR

Give the exam prior to starting lesson [DU2]. Put the students on break before beginning [DU2].

SECTION V - STUDENT EVALUATION

TESTING REQUIREMENTS:

Performance test: NONE

Written test:

A reproducible written exam is attached as pages Exam 1-3. The answer key is at the bottom of this page.

The students must correctly answer eight of the eleven questions to achieve a passing score on this exam. The students have ten minutes to complete this exam.

Answer Key:

1. A
2. C
3. A
4. A
5. B
6. D
7. D
8. A
9. D
10. C
11. C

FEEDBACK REQUIREMENT:

After the students have completed the exam, go over the answers with them. Students that do not receive a passing score should be allowed an opportunity for a retest.

Name:
SSN:
Section:
Date:

WRITTEN EXAMINATION
RECOGNIZE A DEPLETED URANIUM/LOW-LEVEL RADIOLOGICAL HAZARD

Instructions:

Circle the best choice from among the answers provided.

1. Depleted uranium is:

a) The byproduct of the uranium enrichment process
b) Spent nuclear fuel rods
c) Natural uranium found in the soil or in mines
d) Weapons-grade uranium

2. Depleted uranium is NOT:

a) an Alpha (Â) radiation emitter
b) a Beta ( ) radiation emitter
c) a neutron
d) a Gamma ( ) radiation emitter

3. Depleted uranium is most often found on the conventional battlefield in:

a) Armor plate
b) Nuclear weapons
c) Radiation shielding
d) Counterweights in Army helicopters

4. What is the greatest health hazard from ingestion, inhalation, or injection of depleted uranium?
a) heavy metal poisoning
b) external radiation
c) there is no health hazard
d) internal radiation

5. DU is considered to be hazardous to the environment because it:

a) is easily spread by the wind
b) is a toxic, heavy metal
c) is highly radioactive
d) causes mutations in animals

6. Which of the following best describes the visual signature of a DU-round impact:

a) A large, jagged exit hole
b) Small, regular entry and exit holes
c) Green powder burns around the entry hole
d) Cannot be positively identified by visual signature

7. DU contamination can be visually detected by:

a) Glowing piles of charcoal
b) Bright green residue
c) Silver-white flakes
d) Piles of blackish dust

8. Which group of foreign equipment contains a low-level radiological hazard?

a) Night sights
b) NBC protective masks
c) Portable communication equipment
d) Munition casings

9. U.S. equipment with low-level radiological hazards would not include which of the following categories?

a) Chemical detectors
b) Tank turrets
c) Machine guns
d) Battle Dress Overgarments

10. What handling procedure is used for a DU/low-level radiologically contaminated item in peacetime?

a) Blow it in place
b) Bury it
c) Segregate, tag, and secure it
d) Leave it for the enemy

11. What is the document that describes procedures for handling depleted uranium-contaminated items?

a) TM 3-250
b) TB 9-1300-278
c) AR 50-5
d) FM 3-100

TSP XXXXXXXX

APPENDIX A: OVERHEAD PROJECTION TRANSPARENCIES

TSP XXXXXXXX

APPENDIX B: INSTRUCTOR READ-AHEAD

This appendix contains an information paper which introduces the general issues surrounding depleted uranium and its implications for military use by the United States; and a set of instructor notes to accompany each of the overhead projections used in this Training Support Package.

INTRODUCTION TO DEPLETED URANIUM

CPT Doug Rokke, Ph.D, CPT John Shank,
David O. Lindsay, COL (Ret.), and MSG Susan Wright
United States Army Chemical School

BACKGROUND:

Depleted uranium (DU) is an extremely dense metal used in munitions to penetrate heavy armor or as protective shielding. Operation Desert Storm revealed the lethality and benefits of using DU. The U.S.

Army and Marine Corps Abrams M1A1 and M60 tanks, and U.S. Air Force A10 attack aircraft fired DU kinetic energy penetrators easily destroyed Iraqi armor, and battlefield survivability was substantially improved because of the DU armor in some of the M1 series tanks.

During Operation Desert Storm only U.S. forces had depleted uranium munitions. Even though targets were carefully identified, some U.S. tanks and vehicles were hit as a result of friendly fire by DU munitions. Consequently, some U.S. soldiers were exposed to DU contamination from burning or destroyed U.S. and Iraqi vehicles.

Depleted uranium exposure and incidents may occur anytime there is damage to the DU armor package or the vehicle is hit with DU munitions. The DU armor can be damaged during vehicle maneuvers, on board fires, maintenance activities, or ballistic impacts. DU munitions problems may occur during storage, transportation, combat, testing, or manufacturing. Soldiers must understand the hazards and know how to handle these problems to reduce risks.

Although depleted uranium munitions have been in the Army s arsenal and in the hands of some combat units in Europe and elsewhere for years, there is a general lack of information and training on the characteristics and hazards associated with DU. Half truths and misconceptions have surfaced. Consequently, soldiers need more information about the use, hazards, and proper handling of DU.

PURPOSE:

Depleted uranium presents a moderate hazard to exposed soldiers; however, if handled correctly, it causes little risk. This paper dispels the myths concerning DU by describing associated hazards and the precautions you should take if you must handle equipment containing or contaminated with DU.

DEPLETED URANIUM FUNDAMENTALS:

Depleted uranium comes from uranium ore found throughout the world. In the United States it is mined in New Mexico, Colorado, Wyoming, Utah, and Arizona.

The term depleted uranium (DU) means that the amount by weight of U-235 and U-234 has been substantially reduced. Uranium ore contains, by weight, 99.28% U-238, .71% U-235, and .0058% U-234. This means that U-238 is the largest part of uranium ore, while the part that is most useful for nuclear fuel and nuclear weapons, U-235, is only a very small part of the actual ore. Uranium ore is run through a complex enrichment process. During this enrichment process U-234 and U-235 are removed, leaving only U-238 (99.8%) and a very small quantity of U-235 (.2%) as by-products. Consequently, U-238 (DU) is readily available for use in manufacturing various products.

DU, which is easy to machine or form into various products, has two important physical properties. It is pyrophoric, which means that very small particles of DU may spontaneously ignite when they come in contact with air or during impact with armor or other hard materials. It is also a very dense material and very hard to penetrate. DU is about 1.6 times as dense as lead and denser than tungsten when both are alloyed. These two properties make it ideal for use a kinetic energy penetrator and for use as armor plating.

MILITARY USES:

The U.S. military uses DU in many weapons systems. DU is primarily used as armor plates in the M1 series heavy Abrams tank and as kinetic energy penetrators. A kinetic energy penetrator is a nonexplosive projectile made of high density material formed into a small diameter rod. The DU kinetic energy penetrator focuses its energy on the small area that it impacts and punches through the target. The self sharpening effect of DU allows greater penetration. As DU punches through, DU particles or spalling are formed which ignite resulting in secondary fires and explosions. This enhances its destructive nature.

All branches of the military use depleted uranium in munitions and other pieces of equipment. As a munition it is used in the Air Force A10's 30mm gun, the Army and Marine Corps 20mm chain gun on the Bradley and LAV, the 105mm gun on the M60 and M1 tanks, and the 20mm gun on the M1 series Abrams tank. The Navy has switched from a 20mm DU to a 20mm Tungsten-Carbide kinetic energy penetrator for use in the Phalanx. It may be used as radiation shielding, counter weights for aircraft, vibration dampers, and as ballast replacement for nuclear warheads in missiles and artillery projectiles. DU is also used as a catalyst in forming structural compounds such as the body of the M86 Pursuit Deterrent Munitions and the Area Denial Artillery Munition (ADAM). Other nations use DU in the form of a kinetic energy penetrator and also as the shaped charge liner in high explosive anti-armor projectiles.

DEPLETED URANIUM HEALTH HAZARDS:

In the future Abrams Tanks, Bradley Fighting Vehicles, Light Armored Vehicles, and other pieces of equipment may be damaged, destroyed, or contaminated by depleted uranium. Although materiel may be contaminated with DU, low level radioactive materials, or mixed waste the actual health hazards are small. Health hazards for soldiers who are:

(a) Exposed to depleted uranium particulates during a DU penetrator impact,
(b) Exposed to smoke plumes containing depleted uranium or mixed waste,
(c) Exposed to depleted uranium contamination during processing operations,

may include inhalation or ingestion of radioactive particulates or wound contamination.

The primary health hazard of DU is its heavy metal toxicity. The secondary health hazard is from ionizing radiation. This negates the popular belief that radiation is the greatest hazard.

Depleted uranium, like lead, is a heavy metal poison and if it remains in the body may cause kidney damage, tissue decay, and affect body processes. The health effects depend on whether the DU has been ingested, inhaled, or enters the body through open wound, and its solubility. Solubility is like mixing sugar and water. Sugar when mixed in water is still there but it is not a visible solid. Soluble DU can mix with body fluids and thus move around in the blood or tissue. DU dust formed during impacts is more soluble than DU dust formed during fires. While the critical organ for depleted uranium in soluble form is the kidney, uranium may be deposited in other body organs as well. Of the insoluble uranium that reaches the deep lung, about 60% is retained about 500 days, irradiating lung alveoli. Some of the uranium which reaches the blood will be deposited in and retained in the bone for from 1,500 to 5,000 days. For chronic exposure over long periods of time, the bone may become the critical organ. Although there are some risks associated with uranium deposited within the body, current medical procedures can effectively minimize the physiological effects.

Radioactivity is the spontaneous emission (spitting out) of particles or energy (ionizing radiation) from an unstable atom resulting in the formation of a new element. Ionizing radiation consists of alpha particles, beta particles, and gamma rays. The health effects of ionizing radiation depend on what type

of radiation it is and it the radioactive material is inside or outside the body.
Alpha radiation is the least penetrating form of radiation because it is the most ionizing and expends all of its energy within a very short distance. It can travel only a few centimeters in air and is stopped by even a very thin material like plastic, cardboard, or the dead, outer layers of a person s skin. Even though it is the least penetrating, alpha radiation is the most ionizing. When the alpha particle gets inside the body, the internal tissues absorb the energy causing mass destruction of the cells near the particle. In contrast, beta and gamma are more penetrating but do not cause as many ionizations resulting in less damage within the body.

Depleted uranium is primarily an alpha particle hazard although beta particles and gamma rays also are emitted from radioactive decay products. Radioactivity emitted by depleted uranium an other low level radioactive materials dissipates rapidly, usually within two to three feet. The primary radiation hazard will be exposure to bare penetrators or radioactive shrapnel.

The beta particles and gamma ray radiation hazards may interest Abrams or Bradley crew members who handle DU munitions or continuously work (over 1100 hours/yr) in vehicles containing a full load of DU munitions. Estimated total annual exposures for Bradley crew members with a full load of M DU rounds is 265 mrem/year. Although this dose is above regulatory limits for the general public, this expected annual dose is still below the naturally occurring annual background radiation exposure in many parts of the United States. Crew member exposure is substantially less in Abrams series and M60 tanks because of the design of the vehicle ammunition storage compartment which acts as a radiation shield. DU munitions are only issued to units in combat or to a few forward deployed armor and Bradley equipped units. Consequently, radiation exposure hazards are very small and only involve specified individuals.

DU IMPACTS AND HAZARDS IDENTIFICATION:

It s easy to tell if a vehicle has been hit with a DU kinetic energy penetrator. The entry hole in armor or other hard materials hit by a kinetic energy penetrator will be small and round. In some cases you may see fine lines surrounding the entry hole if the metal was soft or thin such as the aluminum sheet around the outside of the Abrams turret ammo compartment. In most cases there will be spalling around the edges of the hole as well. In contrast a DU shaped charge will resemble a conventional impact.

While all kinetic energy penetrator impacts have a small round hole and a shaped charge will leave large blown out sections, only a DU impact will leave a distinctive detectable radioactive signature. To detect radioactivity emitted by DU, use an AN/PDR 27, AN/PDR 77, or an AN/VDR 2 radiac meter, reading its Beta signature. This is the only was to identify the DU radioactive contamination with certainty.

The DU penetrator may go completely through the vehicle with about a 15% loss of material and only minimal deformation. The exit hole will be slightly larger in diameter than the entry hole and retain a radioactive signature. In contrast, conventional high explosive anti-tank munitions leave large entrance and large blown out exit holes and no radioactive signature.

If there is a well defined hole with a radioactive signature, then DU contamination must be suspected. The reported new use of DU as a liner in shaped-charge high explosive munitions means that the usual small entrance and exit holes may not exist. Therefore, the radioactive signature will be the only way to confirm the presence of DU contamination.

DU shrapnel, spalling, and oxides form and release into the interior of the vehicle or surrounding environment during impacts or upon combustion. DU spalling looks like melted and rehardened solder. DU oxide (dust) is a very heavy black dust. Dust particles may be as small as a cigarette ash or as big as a pea. Suspended DU oxide looks like a dark dust cloud which moves with the wind but usually drops within 50 meters of a fire.

DU metal is silver in color, but after exposure to air it quickly oxidizes and turns black or black and yellow-greenish, or a blackish gold. Shrapnel from the DU penetrator could be in many shapes, sizes, colors, and forms. The only positive method to identify DU is to use survey equipment to detect radiation. Spalling from a DU kinetic energy or high explosive (HE) impact or penetration may be contaminated with other types of materials and be in various shapes which again requires a radiation survey to determine contamination.

HAZARD AVOIDANCE:

The three principles of radioactive hazard avoidance are time, distance, and shielding. In combat or if involved in a peacetime incident, do the following:

1. Minimize time near the radioactive source.
2. Maximize the distance between you and the radioactive source.
3. Improve shielding (use cardboard, tape, etc.).

The installation or command Radiation Protection Officer (RPO), and NBC, Preventive Medicine, or Medical personnel can help identify hazard avoidance procedures. When requesting assistance, provide the following information:

1. Describe what the equipment is or looks like,
2. Tell if it is broken or intact,
3. Report if you detect any radioactivity,
4. Report what equipment you have available to perform suggested tasks.

REMEMBER: Always keep people away from contaminated equipment or terrain unless they need to complete an assigned task.

Safety comes from knowing what to do, when to do it, and how to perform a given task or set of tasks. You can not safely and effectively complete the mission without knowledge and skill mastery. If you must work on or near equipment contaminated with DU, you need to know how to protect yourself, your equipment, and the environment while performing required tasks. Again the objective is to avoid contaminating soldiers or equipment, or spreading DU contamination. Bear in mind that the DU health hazards are insignificant when compared to other battlefield hazards. During combat, mission completion overrides decontamination concerns. You do not have to stop the mission just because you are exposed to depleted uranium or other low level radioactive materials.

PROTECTIVE CLOTHING:

Using appropriate safe-guards will reduce exposure. Base selection of protective clothing on actual physiological hazards, the weather, and METT-T. TB 9-1300-278 Guidelines For Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium , FM 3-3 Chemical and Biological Contamination Avoidance , FM 3-3-1 Nuclear Contamination Avoidance , and FM 3-4 NBC Protection provide practical guidance to help select appropriate protective clothing. Mechanics coveralls, BDUs/BDOs, and gloves provide adequate radiological protection for the body.

Use military issue protective masks to avoid inhaling DU oxide (dust). However, if you plan on working on the equipment for only a few minutes, a cravat (handkerchief) worn over the mouth and nose or a dust mask will provide adequate respiratory protection for very short exposures. Wear gloves to avoid picking up and ingesting dust. Wash off dust before eating, drinking, or using the latrine. Brush off clothing before returning to non-contaminated areas.

Even using hazard avoidance procedures, soldiers may still get hurt during impacts, fires, or maintenance. If a soldier is injured while working on equipment containing or contaminated with DU, perform first aid or buddy aid. First aid for the actual injury will take precedence over any radiological or heavy metal concerns.

DECONTAMINATION PRINCIPLES:

DU contamination is not an immediate health hazard even though it is radioactive and a heavy metal. Consequently, it s probably not necessary to conduct immediate decontamination procedures like those done for chemical agents. Base all decontamination decisions on actual physiological hazards from DU contamination and mission, enemy, troops, terrain, and time (METT-T) considerations. The commander needs to evaluate when, where, and how to complete operational decontamination. If contamination is present, follow the three principles of decontamination described in FM 3-5 based on METT-T:

1. Decontaminate only what is necessary,
2. Decontaminate as far forward as possible, and
3. Decontaminate by priority.

By carefully evaluating each incident and following these basic principles to complete operational decontamination, you can complete the mission while preserving fighting strength and protecting the environment. For operational radiological decontamination, see FM 3-5 and TB 9-1300-278. Use AN/PDR 27, AN/VDR 2, or AN/PDR 77 to verify DU contamination. If you find DU contamination, follow these steps:

1. Select an area away from water sources, food storage or eating area, and occupied bivouac sites.
2. Brush, scrape, or wash off the loose radioactive contamination from yourself or equipment.
3. Maintain control of the removed contamination.
4. Clean up or mark the area as necessary.
5. Report location, type, and level of contamination with an NBC-4 report up the chain of command.

If you find fixed or imbedded DU contamination, cover it with duct tape or cardboard. Remember, DU emits primarily alpha radiation. By covering it and using adequate shielding, you substantially reduce radioactive exposure. If you can t decontaminate the equipment, evaluate for actual physiological hazards, operational status, and unit mobility needs.

Th NRC has set the standard for maximum level of radiation exposure that the general public may receive in the United States. Although, NRC standards do not apply during combat operations, use them for planning purposes to follow the ALARA (As Low As Reasonably Achievable) principle. Using current Federal standards of 100 mrads/yr., if the level of measured general radioactive contamination within a vehicle is .005 centrigray/hr (5 mrads/hour) or less, you can use the vehicle for 20 hours without exceeding standards. Crew members can be rotated to minimize individual exposure and increase the time before needing operational decontamination. It is important to understand that this limit is for regulatory purposes but does not reflect the threshold for health hazards.

If the equipment is to remain within the combat zone, complete thorough decontamination as described in TB 9-1300-278 and DA PAM: Management of Contaminated and Damaged Materiel. Unit maintenance personnel under the direction of the Division Contaminated Materiel Assistance Team (DCMAT) should conduct this. The DCMAT consists of NBC, medical, explosive ordnance disposal, logistics, and maintenance experts.

You may need to remove equipment to either the communication zone or back to CONUS. If so, contact one of the U.S. Army Contaminated Materiel Retrograde Teams who will decontaminate and package equipment for shipment. The team consists of technical experts in health physics, transportation, medicine, and maintenance.

EMERGENCY FIRST AID/BUDDY AID:

First aid/buddy aid procedures for injuries involving DU are the same as described in the Soldier's Manual of Common Tasks, STP 21-1-SMCT for injuries that do not involve DU, with minor changes.

1. When removing injured soldiers from a damaged or burning vehicle contaminated with DU, put on respiratory protection and gloves, check for immediate ordnance or fire hazards, and then remove the casualty. Realize that standard medical needs override any DU hazards because DU is not an immediate health concern.

2. If available use an AN/VDR 2, AN/PDR 77, or an AN/PDR 27 radiac meter to check each wound for radiological contamination if the soldier was injured around DU or other radioactive materials.

3. Wash out all minor cuts to hands, arms, or legs in which you verify or suspect radioactive or heavy metal contamination to remove any loose contamination as soon as possible. Leave imbedded particles in place and inform the medic that a radioactive or heavy metal material was involved so that appropriate advanced medical care can be provided.

4. Contact the medics immediately for all major wounds. Provide buddy aid for all major wounds IAW STP 21-1-SMCT. Mark the field medical card (DD 1380) to indicate radioactive and heavy metal contamination.

In summary, when treating DU casualties, perform each first aid task to standard. Remove the DU contamination only if doing so will not cause further damage or complications to the injured person.

OPERATIONAL PROCEDURES:

This paper has discussed how to identify DU, what to do to protect soldiers and equipment, and how to treat casualties. If you understand these basic concepts and can perform the tasks described above, then you are ready to work on equipment containing or contaminated with depleted uranium or other low level radioactive materials.

Mission completion is the number-one priority. If you encounter DU or other radioactive material on the battlefield or during training, reduce radioactive or heavy metal exposure hazards as low as reasonably achievable (ALARA) while performing assigned tasks. The two primary advisors on management of low level radioactive materials are the unit chemical officer or NCO and the unit medical team.

If you find contaminated equipment, do the following:

1. Notify the unit NBC and medical officer/NCO.
2. Put on protective clothing.
3. Complete a visual inspection to identify any explosives hazards.

CAUTION: Abrams, Bradleys, and other vehicles that have been hit with munitions may contain unexploded and unstable ordnance. This ordnance may retain its normal shape or look different, so be very careful when working on damaged equipment or removing casualties because of the possibility of munitions exploding.

If you find destroyed or damaged equipment which may contain damaged, unexploded, and unstable ordnance, mark, secure, and report the status and location of the equipment. Only explosives trained personnel should handle damaged or unexploded ordnance (UXO) or work in or around equipment containing UXO. The Division Contaminated Materiel Assistance Team (DCMAT) will help evaluate equipment status and whether or not further retrograde is required.

4. Isolate the suspected piece of equipment.
5. Perform a radiological survey using tactical radiac equipment to identify and verify radioactive contamination.
6. Segregate contaminated equipment from non-contaminated equipment.
7. Decontaminate as necessary in accordance with commanders guidance.
8. Repair equipment if possible using battle damage assessment and repair procedures IAW FM 20-30, TB 9-1300-278, and the DA PAM Management of Contaminated Equipment . If you can t repair or decontaminate clothing, load bearing equipment (LBE), and other small pieces of individual or unit equipment, bag and return them to your supply section for proper disposal.
9. Decide whether to release equipment for combat use or to initiate retrograde operations.

REMEMBER: Unless the vehicle is destroyed or otherwise inoperable, depleted uranium contamination will not interfere with mission completion.

10. Prepare and submit after action reports.

RADIOACTIVE EQUIPMENT HAZARDS:

Other radioactive hazards, besides DU, may exist on the battlefield. Both the U.S. and foreign nations use radioactive materials as equipment components. U.S. equipment that contains radioactive materials includes (a) M8A1/M43A1 Chemical Agent Detectors, (b) chemical agent monitors, (c) night vision equipment, (d) fire control equipment, and (e) MC-1 Moisture Density Gauges. We currently have over 3800 items in the inventory that contain radioactive components. Foreign equipment with radioactive components includes (a) dial assemblies, (b) night vision equipment, and (c) NBC equipment. The radioactive materials used in these items may emit alpha particles, beta particles, or gamma rays. If you encounter this equipment, consider the potential hazards of the radioactive materials and take appropriate precautions. However, the total amount of radioactive material in these items is so low that risk from their release is minimal during combat. These hazards should only be a priority after cessation of hostilities.

EQUIPMENT RECOVERY:

Use hazard avoidance procedures when completing retrograde operations on a radiologically contaminated vehicle or piece of equipment. Transfer vehicles to the brigade, division, or corps maintenance collection points. At these collection points, specialists in handling radioactive materials will take charge and complete recovery or removal operations.

DOCUMENTATION:

Guidelines and operational procedures for management of equipment containing or contaminated with depleted uranium are in existing documents. If you have equipment containing depleted uranium or may be exposed to depleted uranium munitions, obtain, read, and be able to perform the procedures described in these references.

1. TB 9-1300-278 Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium currently provides the operational guidance for incidents involving depleted uranium munitions, armor, and battlefield damage.

2. AR 385-xx Management of Contaminated and Damaged Materiel and the companion DA PAM Procedures for Management of Contaminated and Damaged Materiel will be published in 1995.

3. AR 385-11 Ionizing Radiation Protection .

4. AR 40-14 Control and Recording procedures for Exposure to Ionizing Radiation and Radioactive Materials .

5. TM 55-315 Transportability Guidance for Safe Transport of Radioactive Materials describes the procedures for packaging and transporting radioactive materials.

6. FM 9-43-2 Battlefield Damage Assessment and Repair describes emergency maintenance procedures that can be used to put equipment back into combat as soon as possible.

7. FM 21-16 Unexploded Ordnance (UXO) Procedures describes the procedures that soldiers can use to protect themselves from UXO hazards.

SUMMARY:

This presentation has described some of the hazards of DU exposure and introduced procedures you can use to safely handle equipment containing or contaminated with depleted uranium or other low level radioactive materials. Depleted uranium is used as armor, munitions and ballast. Although DU is radioactive and a heavy metal, unless personnel have been directly involved in a detonation or fire, the HAZARDS ARE NOT SIGNIFICANT.

Vehicles involved in an incident, unless immobilized, are still usable to complete the assigned mission. Operational decontamination can be completed based on METT-T and commanders assessment. This consists of designated soldiers removing loose radioactive contamination and taping over the fixed contamination. Vehicles can then be released for continued use by combat.

If you have any additional questions concerning Depleted Uranium contact:

COMMANDING GENERAL, U.S. ARMY CHEMICAL SCHOOL
ATTN: DIRECTOR, EDWIN R. BRADLEY RADIOLOGICAL LABORATORIES
FT. MCCLELLAN, AL 36205-5020
DSN: 865-4489 OR COMMERCIAL (205) 848-4489

OR

COMMANDING GENERAL, AMCCOM
ATTN: CHIEF, RADIOACTIVE WASTE DISPOSAL OFFICE
ROCK ISLAND, IL 61299-6000
DSN: 793-2933 OR COMMERCIAL (309) 793-2933

The following is the text of an unclassified Army sectional message transmitted from HQDA to United States forces operating in Somalia in October of 1993 (141130Z Oct 93).

UNCLASSIFIED

SUBJECT: Medical Management of Unusual Depleted Uranium Exposures

1. REFERENCE:

A. AR 40-5, Preventive Medicine
B. AR 40-400, Patient Administration
C. TB 9-1300-278, Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium.
D. UNCLAS MSG, CDRAMCCOM, AMSMC-SF, 081515Z OCT 93, SUBJECT: Depleted Uranium (DU) Contamination.

2. This message is being sent to provide advice and guidance to medical personnel who may be confronted with soldiers who have received unusual exposures to depleted uranium (DU).

3. Routine exposures to DU, in the course of normal duties, pose no medical problems. Examples of routine exposures include transportation, handling, storage, firing, etc., of munitions or armor containing DU. Safety guidance is provided in the appropriated user technical manuals.

4. Unusual exposures to DU are also expected to cause no medical problems, but in the interest of documenting the expected minimal exposures, the exposures should be documented and specimens taken. Unusual exposures include situations which could result in ingestion/inhalation of DU dust, or the contamination of wounds by DU dust or fragments. These unusual exposures could result from:
A. Being in the midst of the smoke from DU fires resulting from the burning of vehicles uploaded with DU munitions or depots in which DU munitions are being stored.
B. Working within environments containing DU dust or residues from DU fires.
C. Being within a structure or vehicle while it is struck by a DU munition.

5. Safety guidance on appropriate soldier response to accidents involving DU is contained in reference A and guidance on appropriate management of potentially DU-contaminated equipment is contained within reference C.

6. In cases such as those described in Paragraph 4, the following steps should be taken:

A. A MED-16 report (RCS MED-16(R4) should be submitted in accordance of paragraph 6-10 of Reference B.
B. Specimens should be collected and forwarded for analysis in conformance with the information provided in subsequent paragraphs and paragraph 9-6 of Reference A.

(1) Nasal swipes could be collected; if collected they should be placed within any protective container (e.g., plastic bag) to preserve the integrity of the specimen. (Nasal swipes can be useful in confirming exposure to DU dust environments, but because of biological clearance mechanisms, are of limited value if collected more than 30-60 minutes, post-exposure: the time of exposure and the time of specimen collection should be documented.) The specimens should be mailed to the address provided in paragraph 6B(3)(D).
(2) Any filters used for respiratory protection (protective mask canister, dust masks, field-expedient cloths placed over the nose, etc.) should be sealed in plastic bags or other protective containers. Each should be labeled with the wearer s name, SSN, and the details of the exposure. The filters should be mailed to the address provided in paragraph 6B(3)(D).
(3) Twenty-four hour urine specimens should be collected (24-hour clock starts after initial voiding). If at least twenty-fours has not passed between the time of exposure and the time of examination, an initial 24-hour urine specimen should be collected to provide a baseline. A second twenty-four collection of urine should be collected twenty-four hours after the baseline specimen is collected. Subsequent specimens will be collected in coordination with this office. The following guidance is provided on collecting and processing the urine specimens:

(A) The urine specimens should be collected in leak-proof, liter bottles (bottled-water bottled could be used if leak-proof sample containers are not available).
(B) The tops of the bottles should be sealed using something similar to parafilm, if available. (If this is not available, any really-sticky tape could be used, e.g., 100 mph tape -- masking or cellophane tape will probably be of little use if the bottles leak in transit).
(C) The leak-proof, primary-container liter bottles should be packaged within leak-proof secondary containers (e.g., 5-quart paint cans) with enough absorbent non-particulate material to absorb the entire sample should it leak (e.g., cloth, tissue, not vermiculite or Styrofoam peanuts).
(D) The secondary containers should be placed in a substantial cardboard box. The box should be marked with three labels (or markings):

(1) TOP: (Address)
Commander
U.S. Army Environmental Hygiene Agency
ATTN: HSHB-ML-A/Laboratory Samples, BLDG E-2100
Aberdeen Proving Ground, MD 21010-5422
(2) TOP and ALL SIDES: (CAUTION)
Clinical specimen/biological products-biohazard
(3) TOP: (CAUTION)
THIS END UP

(E) Preservatives need not be added to the urine specimens.
(F) Information relative to the samples should be provided using miscellaneous Standard Form 577 (if available). The critical information required includes name, SSN, date of exposure, and date of sample collection.

C. If possible, telephonic notification should be made to COL Peter H. Myers, OTSG Radiation Hygiene Consultant, at DSN 471-8168/6612.

7. If DU fragmentation injuries are suspected, standard medical criteria should be used to determine the advisability of the removal of imbedded DU fragments.

A. MED-16 Reports, however, should be submitted and telephonic reporting, if possible, should be made to COL Myers.

B. Urine specimens should be collected from the soldier as soon as medically feasible to establish the soldier s uranium-in-urine baseline. Additional specimens may be required for evaluation depending on the extent and duration of the DU exposure. Further guidance should be obtained from COL Myers. TSP XXXXXXXX

APPENDIX C: GLOSSARY OF TERMS

Abrams Heavy Armor Abrams Heavy Armor refers to armor protection on M1-series tanks that contains depleted uranium.

Alpha Particle An alpha particle is a positively charged particle, indistinguishable from a helium atom nucleus and having two protons and two neutrons.

Beta Particle A beta particle is a high-speed electron or positron given off in radioactive decay.

Biological Half-life Biological half-life refers to the amount of time it takes the body to rid itself, through metabolization, of half of the radiation from a radioactive material.

Depleted Uranium Depleted uranium (DU) is uranium metal that is the by-product of the uranium enrichment process. It is almost entirely (99.8%) U-238.

Deterministic A deterministic effect is an outcome that is the inevitable consequence of an action or series of actions.

Equipment Equipment in this lesson refers to equipment that is issued to you or your unit. It refers to clothing, uniforms, Basic Issue Items, Prescribed Load List items, TOE, and CTA items.

Field-Expedient Field-expedient means using techniques or equipment in a manner not specifically approved by doctrine. A field-expedient repair to a tent may be to patch it with duct tape, instead of the doctrinal method of sewing on a canvas patch. Field-expedient measures are short-lived and are used only until approved methods are available.

Gamma Ray A gamma ray is the electromagnetic radiation or high energy photons emitted by radioactive decay.

Half-life The half-life is the amount of time it takes for a given quantity of radioactive material to deteriorate so that only half of it remains.

Heavy Metal Heavy metals are dense metallic substances, or their salts, which are characterized by their tendency to accumulate in the human body and exhibit toxic effects. Examples of heavy metals are mercury, lead, arsenic, and uranium.

Heavy Metal Poisoning Heavy metal poisoning is the toxic effect on the body's organs as a result of heavy metal contamination.

Ingestion Ingestion means to take in by swallowing.

Injection Injection means to force or drive a substance into another thing; to be pierced or wounded by DU would inject DU into you.

Insoluble Insoluble means incapable of being dissolved.

Kinetic Energy Kinetic Energy (KE) is the force generated by moving objects.

Oxidation Oxidation is the combination of a substance with oxygen.

Oxide An oxide is a chemical compound of an element and oxygen. For example, rust is iron oxide.

Penetrator The penetrator is the part of a munition that is designed to pierce its target. Penetrators are usually associated with kinetic energy munitions.

Pyrophoric Pyrophoric means igniting spontaneously in air, or producing sparks by friction.

Radiation Radiation is the emission and propagation of waves or particles, such as light, sound, radiant heat, or particles.

Radioactive Radioactive means of, exhibiting, or emitting radioactivity.

Radioactivity Radioactivity is the spontaneous emission of radiation, either directly from unstable atomic nuclei, or as a consequence of nuclear reaction.

Radiological   Radiological means pertaining to radioactivity. Radiological hazards are hazards which are associated with radioactivity.

Sabot, Discarding Discarding sabot ammunition is ammunition which contains a sub-caliber projectile with a full-size jacket. The jacket separates from the projectile after leaving the barrel, while the projectile travels on to the target by itself. Discarding sabot ammunition attains very high velocity, and is the primary armor-piercing projectile used by the United States Army.

Shielding Shielding is a mass of material, such as lead or cement, that is placed around a radioactive source in order to reduce the amount of radiation that escapes into the surrounding area.

Soluble Soluble means capable of being dissolved.

Spall Spall is a fragment broken from a piece of material. Spall produced by munition strikes is metal fragments, often molten because of the heat produced by the strike.

Stochastic Stochastic means involving probability or chance.

Survey Survey means to examine in a comprehensive way. Radiation survey is survey which determines the boundaries and extent of radiation.

Toxicological Toxicological means referring to the nature, effects, and detection of poisons and the treatment of poisoning. Toxicological hazards are the hazards from poisonous materials.

Unexploded Ordnance (UXO) Unexploded ordnance (UXO) are munitions that have not exploded. A slang term is "dud." Ammunition in its normal storage or carrying configuration is not called an UXO.

TSP XXXXXXXX

APPENDIX D: STUDENT HANDOUTS

TSP XXXXXXXX

APPENDIX E: SELECTED BIBLIOGRAPHY

Army Publications:

AR 385-XX (Draft) Retrograde Plan for Damaged Radioactive Materials or materials Contaminated with Radioactive Materials.

AST-1500Z-100-93 Identification Guide for Radioactive Sources in Foreign Material.

DA Pam (Draft) Retrograde of Low-Level Radioactive Materials.

FM 3-3 Chemical and Biological Contamination Avoidance.

FM 3-3-1 NBC Contamination Avoidance.

FM 3-4 NBC Protection.

FM 3-5 NBC Decontamination.

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