DEPLETED URANIUM

—What is it? Is it dangerous?

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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 US Army and Marine Corps Abrams M1A1 and M60 tanks, and the US Air Force A10 attack aircraft fired DU kinetic energy penetrators with deadly results. In all cases, DU 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 US forces had DU munitions. Even though targets were carefully identified, some US tanks and vehicles were hit as a result of friendly fire by DU munitions. Some US soldiers were exposed to DU contamination from burning or destroyed US and Iraqi vehicles.

DU 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 munition problems may occur during storage, transportation, combat, testing, or manufacturing. 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 it. Soldiers need more information about the use, hazards, and proper handling of DU.

DU presents a moderate hazard to exposed soldiers; however, if handled correctly, it poses little risk.

Fundamentals

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

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 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 as a kinetic energy penetrator and for use as armor plating.

Military Uses

The US military uses DU in many weapons systems, primarily armor plates in the M1-series heavy Abrams tank and as kinetic energy penetrators. A kinetic energy penetrator is a non-explosive 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 it 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 DU in munitions and other pieces of equipment. Other nations use it in the form of a kinetic energy penetrator and also as the shaped charge liner in high explosive anti-armor projectiles.

Health Hazards

Abrams tanks, Bradley fighting vehicles, light armored vehicles, and other equipment may be damaged, destroyed, or contaminated by DU in the future. Although materiel may be contaminated with DU, low-level radioactive materials, or mixed waste, actual health hazards are small.

Soldiers may be—

- Exposed to DU particulates during a DU penetrator impact
- Exposed to smoke plumes containing DU or mixed waste
- Exposed to DU contamination during processing operations

Health hazards 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.

DU, like lead, is a heavy metal poison and may cause kidney damage, tissue decay, and affect body processes if it remains in the body. Health effects depend on DU's solubility and whether

DU kinetic energy impact entry hole with spalling on Soviet BMP.

the DU is ingested, inhaled, or enters the body through open wounds. Soluble DU can mix with body fluids and 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 DU 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 that 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 uranium deposited within the body carries some risk, 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 the type of radiation and if the radioactive material is inside or outside the body.

Alpha radiation is the least penetrating 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 the 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.

DU is primarily an alpha particle hazard although beta particles and gamma rays also are emitted from radioactive decay products. Radioactivity emitted by DU and 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 work continuously (over 1100 hours a year) in vehicles containing a full load of DU munitions. Estimated total annual exposures for Bradley crew members with a full load of DU rounds is 265 mrem per year.

Although above regulatory limits for the general public, this 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 issued only to units in combat or to a few forward deployed armor and Bradley equipped units. Consequently, radiation exposure hazards are very small and involve only specified individuals.

Impact 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 leave a small round hole and a shaped charge leaves large blown out sections, only a DU impact leaves a distinctive detectable radioactive signature. The only way to identify the DU radioactive contamination with certainty is with a radiac meter.

The DU penetrator may pass 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 vehicle interior 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 that 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-green, 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—

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

The installation or command Radiation Protection Officer, NBC Preventive Medicine, or medical personnel can help identify hazard avoidance procedures. When requesting assistance:

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

Remember, keep people away from contaminated equipment or terrain unless they must complete an assigned task.

If you must work on or near equipment contaminated with DU, 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 decon concerns. You do not have to stop the mission just because you are exposed to DU or other low level radioactive materials.

Protective Clothing

Using appropriate safeguards will reduce exposure. Choose protective clothing based on actual physiological hazards, the weather, and METT-T. 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 to work on the equipment for only a few minutes, a cloth or 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 still may get hurt during impacts, fires, or maintenance. If a soldier is injured while working on equipment containing or contaminated with DU, perform first aid. First aid for the actual injury will take precedence over any radiological or heavy metal concerns.

Decontamination

DU contamination is not an immediate health hazard even though it is radioactive and a heavy metal. Consequently, base all decon decisions on actual physiological hazards from DU contamination and METT-T considerations. The commander should evaluate when, where, and how to complete operational decon. If contamination is present, follow the three principles of decon: decon only what is necessary, decon as far forward as possible, and decon by priority.

If you find DU contamination, follow these steps:

- Select an area away from water sources, food storage or eating area, and occupied bivouac sites.
- Brush, scrape, or wash off the loose radioactive contamination from yourself or equipment.
- Maintain control of the removed contamination.
- Clean up or mark the area as necessary.
- 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 decon the equipment, evaluate for actual physiological hazards, operational status, and unit mobility needs.

The 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/year, if the level of measured general radioactive contamination within a vehicle is .005 centigray/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 decon. It is important to understand that this limit is for regulatory purposes but does not reflect the threshold for health hazards.

Emergency First Aid/Threshhold

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

- 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.
- If available use an AN/VDR 2 or AN/PDR 77 radiac meter to check each wound for radiological contamination if the soldier was injured around DU or other radioactive materials.
- Wash out all 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.
- Contact the medics immediately for all major wounds. Provide first 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

The two primary advisors on management of low-level radioactive materials are the unit chemical and medical personnel.

If you find contaminated equipment—

- Notify the unit NBC and medical officer/NCO.
- Put on protective clothing.
- Complete a visual inspection to identify any explosives hazards IAW FM 21-16.
- Isolate the suspected piece of equipment.
- Perform radiological survey using tactical radiac equipment to identify and verify radioactive contamination.
- Segregate contaminated equipment from non-contaminated equipment.
- Decon as necessary in accordance with commander's guidance.
- Repair equipment if possible using battle damage assessment and repair procedures IAW FM 9-43-2 and TB 9-1300-278. If you can't repair or decon clothing, load bearing equipment, and other small pieces of individual or unit equipment, bag and return them to your supply section for proper disposal.
- Decide whether to release equipment for combat use or to initiate retrograde operations. Remember, unless the vehicle is destroyed or otherwise inoperable, DU contamination will not interfere with mission completion.
- Prepare and submit after-action reports

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. The Division Contaminated Materiel Assistance Team will help evaluate equipment status and whether or not further retrograde is required.

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.

If you have any questions concerning depleted uranium contact:

US Army Chemical School
ATTN: ATZN-CMN-B
Fort McClellan, AL 36205-5000
DSN 865-4489; Comm (205) 848-4489
or
Commanding General
AMCCOM
ATTN: Chief, Radioactive Waste Disposal Office
Rock Island, IL 61299-6000
DSN 793-2933 or Comm (309) 793-2933

NOTE: US Army Chemical School recently completed a videotape on depleted uranium. See your local Training Service Center for TVT 3-92, Depleted Uranium Hazard Awareness, PIN 710493.