



## DEPLETED URANIUM – OVERVIEW OF CURRENT RESEARCH

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## INTRODUCTION

Depleted uranium (DU) is a very dense metal that has been used by the U.S. military in ammunition and tank armor for nearly three decades. DU was first used in combat during the Persian Gulf War and has since been deployed in the Balkans and Iraq as well. Although some news stories during the past 20 years have included DU among suspected causes for unexplained illnesses in veterans and service members, extensive research has suggested that routine “exposure” to DU – such as sitting inside armored vehicles or handling DU munitions – poses no significant health threats. In general, true exposure occurs only when fine particles of DU or bits of metal enter the body when a DU projectile penetrates metal armor or a DU-armored tank is penetrated. A number of prestigious independent scientific organizations, including the Institute of Medicine (IOM) in the United States and the Royal Society in Great Britain, have examined the possible health effects of these “exposure events.” So far, the research shows little to no evidence of an association between military exposure to DU and adverse health effects. This paper offers a brief history of DU and an overview of the current research.

## ABOUT URANIUM AND DU

Uranium is a weakly radioactive element found naturally in soil, water and mineral deposits. Since it exists in the air we breathe and the food we eat, everyone has some level of uranium in their bodies. There is little reason for concern about natural ingestion of uranium because our bodies are very efficient at eliminating it.

Depleted uranium (DU) is what remains after the two most radioactive isotopes of uranium are removed for use as enriched uranium in nuclear fuel or in nuclear weapons. As a result of this process, DU’s properties are very similar to natural uranium, except that DU is 40 percent less radioactive than natural uranium (Harley, Foulkes, Hilborne, Hudson, & Anthony, 1999).

DU’s high density allows it to penetrate metals of lower density and to resist penetration by those same metals. For this reason, DU is a valuable component for armor-piercing munitions and is also used in enhanced armor protection for some tanks. DU has been used in all branches of the U.S. military since the 1980s (Fulco, Liverman & Sox, 2000). DU is also used in civilian industry, primarily for radiation shielding and aircraft balance control.

## 10 FAST FACTS ABOUT U AND DU

### *Uranium (U)*

- Uranium is in the air we breathe and the food we eat — we all have some level of uranium in our bodies.
- The body is naturally very efficient at eliminating many forms of uranium after exposures occur.
- Since uranium’s radiation poorly penetrates the skin or clothing, uranium is not a health threat outside the body.
- Fifty years of extensive research on workers who mine and process uranium has not revealed significant adverse health effects associated with exposure.

### *Depleted Uranium (DU)*

- Depleted uranium (DU) is left over when the two most radioactive isotopes of natural uranium are removed to make enriched uranium.
- DU is significantly less radioactive than natural uranium. The behavior of DU in the body is the same as that of natural uranium.
- Working with DU munitions or in a tank with armor reinforced by DU does not pose a health risk.
- An exposure event may occur if DU has been inhaled or ingested or if a fragment has been embedded in the body.
- DU health effects have been reviewed by the National Academy of Sciences, Institute of Medicine, The Royal Society and numerous academic and government scientists.
- Minnesota veterans who wish to be evaluated for possible DU exposure should contact their local VA environmental health coordinator.

## DU EXPOSURE AND HEALTH EFFECTS

### *Defining and Measuring Exposure*

Over the last three decades, thousands of military personnel have worked near or directly with armor or munitions that contain DU.

Does working with or around DU munitions or tanks constitute an opportunity for exposure that could have health implications? According to most studies, the answer is “no.” Despite its radioactivity, DU outside the body does not generally pose a threat to the health of service members because the type of radiation given off by DU penetrates poorly through surfaces, such as intact skin or clothing.

As a result, working near DU is not enough to constitute a potential “exposure event” that could result in adverse health effects. Even sitting day after day inside tanks with DU-reinforced armor or working with DU munitions is generally not enough for a service member to be “exposed” to DU in a manner that will harm their health (Department of Defense, 1998). A 2003 study found urine uranium levels in Swedish soldiers who served in the Balkans actually decreased during their deployment. The study attributed this to relatively high levels of uranium in Swedish drinking water versus the consumption of bottled water while deployed (Lagercrantz, 2003). These data suggest that for the vast majority of service members, the use of DU in munitions or armor poses very little health risk.

Most studies focus on assessing the health effects of DU that has entered the body. The U.S. Army estimates that a few hundred soldiers were involved in incidents during the Persian Gulf War (information on Iraq War incidents remains classified) in which DU entered their bodies. In nearly all cases, such incidents were the result of “friendly fire,” in which a U.S. or allied vehicle was mistakenly struck by U.S.-made DU munitions. Upon impact, about 30 percent of the penetrating munition turns to dust or fragments, which fills the vehicle’s interior (DU Capstone Report, 2005). Service members inside the vehicle when it is struck may be hit by DU fragments, some of which may remain embedded in their bodies. They and those who enter the vehicle afterwards, as part of a rescue, investigatory or cleanup operation, may breathe in DU dust or ingest it when it covers their hands or face; it may also enter their bloodstream through open wounds. Relatively quickly, however, the DU dust settles into the ground and the potential for inhalation exposure decreases.

In 1998, the Department of Defense’s Office of the Special Assistant for Gulf War Illnesses defined three levels of exposure of military personnel to DU in “friendly fire” incidents:

- Level I -- military personnel on, in or near vehicles struck by DU rounds;
- Level II -- those whose job duties involved recovery, repair or salvage of the vehicles after the vehicles were struck;
- Level III -- those whose exposure was brief or incidental, such as being downwind from a tank that has been struck by DU munitions.

In order to estimate the level of DU exposure a soldier might be subjected to during one of these incidents, in 2005 the U.S. Army commissioned the DU Capstone Report, which included a series of experiments to provide information on the amount and characteristics of aerosols generated in or near vehicles hit by DU munitions (Department of Defense, 2005). The experiments involved firing 12 large caliber DU cartridges into Abrams tanks (with and without DU armor) and a Bradley fighting vehicle. The DU Capstone experiments allowed the Army to more accurately estimate the amount of DU a soldier might inhale or ingest in any of several possible scenarios, including the length of time spent in the struck vehicle, when it was entered after the strike, and whether or not it was ventilated.

### *DU Dust*

The second part of the DU Capstone report used health risk assessment models to estimate the risk these various exposure scenarios might pose for soldiers. The research focused on the lungs and kidneys, the organs most likely to be affected. The Report concluded that only soldiers with the most severe Level I exposures – those who remained in a struck unventilated vehicle for an extended period of time, such as one to two hours after the incident, had the potential to absorb a DU dose large enough to possibly have short-term adverse effects on the kidney.

Although DU Capstone was the first to quantify the potential exposure to DU faced by soldiers, earlier reports by the Institute of Medicine (2000) and the Royal Society (2001, 2002) had concluded it was unlikely service members would face adverse health effects from such exposure. These reports relied, in part, on the extensive health research done on workers who mine and process uranium (Harley, Foulkes, Hilborne, Hudson, & Anthony, 1999). The workers were exposed to uranium on a daily basis over many years or decades, working in proximity to it as well as breathing in or ingesting uranium-laden dust, at much higher levels and for much longer time periods compared to service members. No peer-reviewed studies have yet shown an association between this type of exposure and cancers, kidney disease or dysfunction, respiratory problems, neurological disorders or a host of other diseases and disorders (IOM, 2000). This is mainly because the body is very effective at eliminating ingested and inhaled natural uranium (Harley, Foulkes, Hilborne, Hudson, & Anthony, 1999). These study results suggest that DU, which has a similar toxicity profile to that of natural uranium, poses very little health threat when inhaled or ingested (Agency for Toxic Substances & Disease Registry, 1999).

While these uranium mining and processing studies are relevant to the DU exposure issue, they also have their limits. For instance, they are not directly comparable for several key reasons:

- Miners' exposure to cigarette smoking and radon in mines are known to have influenced their health outcomes;
- The intensity and duration of the exposure events experienced by service members briefly exposed to DU versus those who mined or processed natural uranium every day over a period of many years was different (IOM, 2000);
- While DU is as chemically toxic as natural uranium, it is 40 percent less radioactive, which reduces the radiological risks proportionately (Harley, Foulkes, Hilborne, Hudson, & Anthony, 1999).

All three factors suggest that service members exposed to DU would be less likely to experience illness related to their exposure than the subjects of the studies of occupational exposure to uranium. In fact, the latter studies, as documented in the 2000 IOM report, tested the hypothesis that occupational exposure to uranium caused serious disease – such as lung cancer – but found no convincing evidence that it did.

Much of the direct evidence we have of the potential health effects of DU comes from the Depleted Uranium Follow-up Program at the Baltimore VA Medical Center. Since 1993, the DU Follow-up Program has conducted medical surveillance to identify, characterize and monitor individuals over time with known or suspected embedded DU fragments, DU-contaminated wounds or significant amounts of inhaled DU. The DU Follow-up Program now follows approximately 80 participants and serves as a clearinghouse for questions raised by veterans about uranium exposures.

Over the past 15 years, the DU Follow-up Program has not identified any medically significant associations between DU exposure and adverse health effects to the brain, lung, kidneys, reproductive organs or other systems (McDiarmid, 2009). Health surveillance of these veterans is ongoing.

Other research concurs with the DU Follow-up Program's findings related to exposure to DU dust. For instance, an extensive environmental study in Kosovo did not find adverse health effects in service members or others who worked in or near sites where DU dust was present (Oeh, 2007).

### *Embedded DU*

Much of what we know about the health effects of embedded DU fragments comes from the approximately 80 participants of the DU Follow-up Program. About 25 percent of that group, all of whom were involved in "friendly fire" incidents, have evidence of retained DU fragments in their bodies. The remaining participants of the group have a documented inhalation exposure. Although those with retained fragments continue to have elevated levels of uranium in their urine, so far there is no clinically significant evidence of adverse uranium-related health effects in these veterans during the program's 16 years of surveillance. In 2008, the National Academy of Sciences recommended further surveillance of individuals with embedded DU because it concluded the DU Capstone Report may have overestimated how much uranium concentration in the kidneys is required to pose a health risk, and it wanted to see cancer risk estimates. This recommendation is consistent with recent research from the DU Follow-Up Program (McDiarmid, 2009).

### SUMMARY/CONCLUSION

Although some media stories in recent years have suggested DU as a potential cause of various illnesses, exhaustive scientific research on DU as well as human and animal studies conducted to date – including long-term studies on uranium workers – has failed to show an association between uranium exposure and serious health problems. Because DU shares the same chemical toxicity as natural uranium, but is less radioactive, results of studies from these other exposed human populations are pertinent here and support the surveillance findings by VA investigators thus far, which have shown no clear signs of adverse uranium-related health effects.

One concern raised is that the number of service members included in the surveillance cohort of veterans is relatively small. Certainly from an epidemiological perspective, it is desirable to have a sufficiently large population size in the study to make it potentially easier to observe an effect. But an even more important epidemiological requirement is to have a correct (unbiased) assessment of exposure among the population being studied. To meet these requirements, the Baltimore VA DU Follow-up Program has identified and is following about 80 veterans who experienced high levels of exposure. Since veterans with the highest measured exposures comprise this "friendly-fire" cohort, this group includes those who would most likely be the first to display an adverse health effect.

These veterans are being vigilantly monitored in ongoing studies and surveillance at the DU Follow-up Program so that any potential health impact from their DU exposure should be detected early.

Current and emerging health information on DU is available to veterans and their caregivers from their local VA environmental health coordinators, the Minnesota Department of Veterans Affairs Web site and the Baltimore VA DU Follow-up Program.

## DU TESTING

To determine the concentration of uranium in the body, veterans who suspect they may have been exposed to DU are asked to undergo a urine test in which urine is collected over a 24-hour period. The test reflects the total amount of all forms of uranium in the body – that is, DU plus any natural uranium absorbed from consuming food or water. An isotopic analysis can then help determine how much of the uranium level is specifically due to DU.

The DU Follow-up Program is responsible for assembling, distributing and processing kits for urine collection. To date, the program has conducted more than 2,000 urine uranium analyses for U.S. service members.

## RESOURCES FOR VETERANS

*Materials:* There are a number of excellent resources for those who would like to learn more about DU. A bibliography of recommended resources at the end of this paper includes references and suggestions for further reading.

*Request for evaluation for possible DU exposure:* Any Minnesota service member or veteran who believes he or she may have been exposed to DU may request an evaluation through their local VA Environmental Health Coordinator:

### MINNEAPOLIS VA MEDICAL CENTER

1 Veterans Drive  
Minneapolis, MN 55417  
(612) 725-2000  
[www1.va.gov/minneapolis](http://www1.va.gov/minneapolis)  
Environmental Health Coordinator Deborah A. Walzel  
(612) 467-2320  
[Debbie.Walzel@va.gov](mailto:Debbie.Walzel@va.gov)

### ST. CLOUD VA MEDICAL CENTER

4801 Veterans Drive  
St Cloud, MN 56303  
(320) 252-1670  
[www.stcloud.va.gov](http://www.stcloud.va.gov)  
Environmental Health Coordinator Mary L. Garding, RHIT  
(320) 255-6407  
[Mary.Garding@va.gov](mailto:Mary.Garding@va.gov)

### FARGO VA MEDICAL CENTER

2101 North Elm St.  
Fargo, ND 58102  
Environmental Health Coordinator Cindi K. Nordick  
(701) 239-3700 x2982  
[Cindi.Nordick@va.gov](mailto:Cindi.Nordick@va.gov)

### SIOUX FALLS VA MEDICAL CENTER

2501 W. 22nd St.  
Sioux Falls, SD 57117  
Environmental Health Coordinator Debbie Sands  
(605) 336-3230 x6356  
[Debbie.Sands@va.gov](mailto:Debbie.Sands@va.gov)

## SUMMARIES OF REPORTS BY EXPERT RESEARCH INSTITUTIONS

*The Institute of Medicine (IOM) (2000):* In order to determine the health effects of potential exposure to DU by U.S. troops, the committee examined research conducted over 50 years on workers who mined or processed uranium. While recognizing the limitations of this earlier research, such as the presence of “confounding variables” like cigarette smoking and radon exposure that may have influenced health outcomes, the IOM concluded that there is little evidence to suggest a link between uranium exposure and lung cancer, renal dysfunction, a variety of other cancers, or diseases of the nervous or respiratory systems. The committee recommended long-term follow-up for service members with embedded DU fragments and uranium processing workers, and additional studies to investigate the specific effects of DU on animals.

*The Royal Society (2001, 2002):* In response to persistent reports that illnesses suffered by veterans of conflicts in the First Gulf War and in the Balkans were due to DU, The Royal Society set up an independent committee to review the present state of knowledge on this subject and recommend areas for further research. The first report, *The Health Hazards of Depleted Uranium Munitions, Part I* (2001), addresses “the amounts of DU to which soldiers could be exposed on the battlefield, the risks from radiation, and what we know from epidemiological studies.” The first report considers past and potential future exposures, the most likely exposures, and the “worst-case” exposures. *Part II* (2002) focuses on the possible effects of the use of DU munitions on the kidney and considers whether the use of large amounts of DU in military conflicts will have long-term effects on the environment.

The report concludes that most service members who experienced potential DU exposure would not suffer adverse effects on the kidney, but that some, such as those who survived in tanks hit by DU rounds or were involved in a protracted cleanup of such tanks, could suffer some short-term kidney dysfunction with long-term effects not clear. There are no known cases of kidney failure in service members due to DU exposure.

*U.S. Army Capstone Depleted Uranium Aerosols Study & Human Health Risk Assessment (2005):* The aerosols study analyzed DU particles that became airborne when an Abrams tank and a Bradley Fighting Vehicle were struck by a large-caliber DU projectile. The DU particles were collected and analyzed to determine the air concentration, content and other characteristics that determined their ability to be inhaled and absorbed by the body. The risk assessment used data from the first phase to calculate radiation doses and possible DU concentrations in the body in the second phase.

*National Academy of Sciences (2008):* A committee was convened to review the toxicological, radiologic, epidemiologic and toxicokinetic data on DU, to assess the DU Capstone Report on the toxicological and radiologic risks to service members posed by exposure to DU, and to identify relevant data deficiencies and offer recommendations for future research. The committee found the methods and results of the DU Capstone Report exposure assessment to be appropriate and well done, and agreed with DU Capstone that the kidneys are the most sensitive target of uranium toxicity. However, the committee said the DU Capstone Report may have overestimated how much uranium concentration in the kidneys is required to pose a health risk and wanted to see cancer risk estimates (and, in some cases, health monitoring) for service members with embedded DU fragments and those with Level II or III exposure. (Neither of these topics was covered by the DU Capstone Report.)

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## ABOUT THE MINNESOTA DEPARTMENT OF VETERANS AFFAIRS (MDVA)

MDVA assists Minnesota's 410,000 veterans and their dependents to obtain the benefits and services provided by the United States Department of Veterans Affairs, formerly called the Veterans Administration.

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