

GAO

Report to the Chairman, Subcommittee
on Regulation, Business Opportunities,
and Energy, Committee on Small
Business, House of Representatives

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OPERATION DESERT STORM

Army Not Adequately Prepared to Deal With Depleted Uranium Contamination



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United States
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National Security and
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The Honorable Ron Wyden
Chairman, Subcommittee on Regulation,
Business Opportunities, and Energy
Committee on Small Business
House of Representatives

Dear Mr. Chairman:

At your request, we recently completed a performance assessment of the Bradley Fighting Vehicle and the Abrams Main Battle Tank during the Persian Gulf War.¹ As a result of that review, you expressed concerns that a number of destroyed or damaged U.S. combat vehicles had been contaminated by depleted uranium (DU). In this follow-on report, our objectives were to determine (1) whether U.S. soldiers were exposed to DU during the Persian Gulf War, (2) to what extent the Army had provided guidance and training to its personnel in the proper handling and risks involved with DU and thereby prepared them to minimize their exposure, (3) how extensively the Army had medically evaluated personnel exposed to DU radiation during the Persian Gulf War, and (4) how effectively the Army planned for and carried out the decontamination and disposal of combat vehicles contaminated by DU.

Background

Depleted uranium, a by-product of the uranium enrichment process, has a lower content of fissionable material than natural uranium. In addition to being radioactive, DU is a chemically toxic metal—much like lead. In recognition of these potentially harmful properties, the Nuclear Regulatory Commission (NRC) and the Army regulate personnel's exposure to uranium. The NRC's regulations provide standards of radiation protection for radiation workers and the general public that apply to individuals and to private and public organizations licensed by the NRC to use radioactive material in the United States and its territories. The NRC also regulates the intake of soluble uranium based on uranium's toxic effects rather than on its radioactivity.² The Army's regulations afford protection to military and civilian employees and parallel the NRC's standards for the protection of

¹Operation Desert Storm: Early Performance Assessment of Bradley and Abrams (GAO/NSIAD-92-94, Jan. 10, 1992).

²NRC regulations related to uranium toxicity are based on levels established by the Occupational Safety and Health Administration.

radiation workers and the general public both in the United States and at Army commands overseas.

Because DU is extremely dense, it can be used to protect against penetration by less dense metals or to pierce other metals such as armored targets. U.S. tanks and the Air Force's A-10 close air support aircraft fire DU munitions, and some M1A1 Abrams tanks have DU in portions of their armor. According to the Army, during the Persian Gulf War, 29 U.S. Army combat vehicles—15 Bradley Fighting Vehicles and 14 Abrams tanks—were contaminated after being hit by DU rounds from Abrams tanks or after experiencing the ignition of stored DU ammunition caused by accidental on-board tank fires or being struck by a Hellfire missile fired by a U.S. helicopter.

Results in Brief

Although the Army does not know the full extent to which personnel were exposed, our review showed that at least several dozen U.S. soldiers, some unknowingly, were exposed to DU by inhalation, ingestion, or shrapnel during the Persian Gulf War. Army and NRC officials believe, however, that these personnel were not exposed to levels of DU that exceeded allowable limits established by the NRC. Because there may be some risk involved with any exposure to radiation, Army regulations require that personnel's exposure to radiation be minimized.

Army and NRC officials believe that DU protective methods may not be appropriate during combat and other life-threatening situations. However, officials from both agencies agreed that personnel in noncombat situations should take precautions to ensure that their exposure to DU is as low as can reasonably be achieved.

Although the Army's stated policy is to minimize personnel's exposure to radiation, it has not effectively educated its personnel in the hazards of DU contamination and in proper safety measures appropriate to the degree of hazard. What little information is available is not widely disseminated, and training on DU is basically limited to Abrams tank personnel, munitions handlers, and explosive ordnance disposal personnel.

The Army has begun to identify and test crew members who were injured in Abrams tanks and Bradley Fighting Vehicles that were contaminated by DU as a result of penetration by DU munitions. The Department of Veterans Affairs has also begun to test personnel from an Army National Guard unit who claim they were exposed to DU while working with contaminated

vehicles in the Persian Gulf. At this time, however, the Army has no plans to medically evaluate other personnel who might have been exposed to DU contamination—for example, those involved in recovering damaged and destroyed vehicles.

Prior to the Persian Gulf War, the Army did not have a formal plan or adequate facilities to decontaminate, dispose of, and quickly repair DU-contaminated vehicles. Moreover, since the war, it has not prepared a formal plan to ensure that, in future conflicts, the decontamination, disposal, and repair of vehicles contaminated with DU are handled efficiently.

While our work was limited to the Army, these issues may be applicable to the other services because they also employ DU in their combat systems and could encounter similar problems in the proper handling of and preparation for the decontamination and disposal of DU-contaminated equipment.

Extent of Exposure to DU Contamination Unknown

The Army does not know the full extent to which its personnel were exposed to DU contamination during the Gulf War. However, according to the Army Surgeon General's Office, 35 soldiers received some form of injury while inside Bradley Fighting Vehicles or Abrams tanks that were penetrated by DU ammunition. On the basis of an examination of these soldiers' medical records, the Army Surgeon General's Office determined that 22 of the 35 were likely to have been wounded by DU shrapnel. Moreover, according to the Army Surgeon General's Office, all of these personnel could have inhaled or ingested oxidized DU particles. In addition, at the two units we visited—the 24th Infantry Division-Mechanized and the 144th Army National Guard Service and Supply Company—we found that soldiers had worked in and around DU-contaminated combat systems without being aware of the characteristics of DU ammunition, the potential risks from DU contamination, and precautions necessary to prevent DU exposure.

Risk Low, but Precautions Necessary

According to NRC and Army officials, troops externally exposed to DU radiation during the Persian Gulf War were unlikely to have been exposed to levels that exceeded the NRC's annual regulatory limits for radiation exposure for the general public. This position appears to be borne out by records of the radiation levels inside 20 of the 29 contaminated vehicles.

Radiation measurements were not recorded for the other nine contaminated vehicles.

While Army and NRC officials believed personnel in the Persian Gulf War were not exposed to external radiation or internal levels of DU that exceeded NRC limits for radiation exposure and toxicity, they said the relationship between radiation dosage and health risks at low levels of exposure is not clearly understood and compliance with the NRC limits does not eliminate the risk of future health problems. The Army's stated goal is to ensure that personnel's exposure to radiation is minimized to the extent possible.

What is considered appropriate action to minimize radiation exposure differs, depending on the situation. For example, Army officials believe that DU protective methods can be ignored during battle and other life-threatening situations because DU-related health risks are greatly outweighed by the risks of combat. However, radiation experts from the Army Armament, Munitions and Chemical Command (AMCCOM); the Tank-Automotive Command; the Army Surgeon General's Office; and the Army Environmental Hygiene Agency agree that personnel working with contaminated vehicles in noncombat situations should take appropriate precautions such as wearing dust masks and gloves and washing their hands after completing their work. NRC officials also noted that DU protective measures applicable in noncombat situations may not be appropriate during combat.

Army Efforts to Educate Personnel on DU Limited

The Army's efforts to educate personnel on the characteristics, risks, and proper handling of DU-contaminated equipment do not extend to all members of military occupations that might come into contact with contaminated equipment. According to officials from the Army's Training and Doctrine Command, training on DU is basically limited to Abrams tank personnel, munitions handlers, and explosive ordnance disposal personnel. An Army Materiel Command official told us that some Army radiation and safety personnel also receive DU training.

Officials at the Training and Doctrine Command acknowledged that training should be provided to all soldiers who may be involved in the recovery process or who otherwise could be tasked with working on contaminated systems. While they felt that such training should be included in the curricula of Army schools that train these individuals, they noted that such a change to current training plans would probably require

new course outline development and instruction and that the direction to make such a change would have to come from the Department of the Army.

Army officials and personnel we interviewed pointed out that a technical bulletin dealing with DU contamination from accidental tank fires is the primary written source of guidance on DU to personnel in the field. Although Army officials told us that this document should have been widely available to troops, most of the personnel we interviewed told us that they had not seen it.

Testing of Some Gulf War Veterans for DU Exposure in Process

Officials in the Army Surgeon General's Office told us that 35 soldiers injured in combat vehicles penetrated by DU munitions would be notified and medically evaluated. The personnel inside these vehicles were at risk from being hit by DU shrapnel and from inhaling DU oxide dust from the DU round as it penetrated the vehicle. According to an Army health official, 22 of the 35 soldiers were likely to have been wounded by DU shrapnel. The Armed Forces Radiobiology Research Institute (AFRRI), in conjunction with other Department of Defense (DOD) scientists and physicians, has drafted DU testing policy for evaluating the health effects on soldiers who were inside vehicles at the time the vehicles were penetrated by DU munitions. This draft policy recommends the implementation of monitoring procedures to track individuals whose test results show the presence of DU in excess of the standards adopted in the recommended test policy. The draft policy also recommends that all of the soldiers wounded by DU shrapnel be tracked over time, because little is known about the effect of DU fragmentation in humans. At a December 1992 meeting, officials from AFRRI, the Department of the Army, and the Department of Veterans Affairs tentatively agreed that testing of these personnel would begin in July 1993.

According to an AFRRI official, preliminary tests conducted on two of the personnel wounded by DU shrapnel showed the presence of uranium in their urine in excess of the level in NRC Regulatory Guide 8.22 that, when exceeded, triggers preliminary administrative or investigative actions to ensure that exposure is reduced. However, the consensus of a panel of nonmilitary radiation and toxicity experts was that these levels were far below the amounts that would cause toxic effects.

In addition to the 35 personnel injured when their vehicles were penetrated by DU rounds, 27 Army National Guard soldiers from the 144th Service and Supply Company who were involved with the damage

assessment and readying for shipment of damaged and destroyed combat vehicles subsequently have claimed they were unknowingly exposed to DU. As of November 1992, 12 of the 27 had received radiological testing at the Nuclear Medicine Branch of the Veterans Hospital in Boston, Massachusetts. We were informed that test results from these 12 appear negative in that none of these individuals had any measurable increase in internal radiation levels when compared to a control group. The remaining 15 are to be tested in February 1993.

Army health officials told us that personnel from the 144th are not being included in the DU testing policy because they were not subject to the same exposures as those who were inside the vehicles when the vehicles were penetrated by the DU rounds. They stated that personnel from the 144th were not wounded by DU shrapnel and were unlikely to have stirred up and inhaled enough DU dust when working with contaminated vehicles to present health problems.

The maintenance personnel from the 24th Infantry Division who worked on Bradley Fighting Vehicles penetrated by DU ammunition have not been tested for DU exposure. An official from the Army Surgeon General's Office said that, since test results thus far from soldiers from the 144th who might have inhaled DU show that the presence of uranium is within applicable regulatory limits or that uranium is not present at all, there is no compelling reason to identify and recall for radiological testing all of the soldiers who might have inhaled DU during the vehicle recovery process.

Vehicle Decontamination Planning Inadequate

While an Army radiological team was able to oversee the central collection and readying for shipment of the contaminated vehicles back to the United States after the war, at the time of the war, the Army did not have an effective strategy for decontaminating ground combat vehicles so that they could be quickly repaired or scrapped. During the war, 29 vehicles were contaminated with DU. The first tank was shipped back to the Defense Consolidation Facility in Snelling, South Carolina. Of the remaining 28 contaminated vehicles, 6 Bradley Fighting Vehicles were decontaminated and buried in Saudi Arabia. Twenty-two—13 Abrams tanks and 9 Bradley Fighting Vehicles—were sent back after the war to the Defense Consolidation Facility for decontamination. Decontamination of these vehicles, however, has been delayed because a new, larger decontamination building had to be constructed. Construction of this building at the facility was completed in June 1992, and work began in

October 1992—20 months after the war ended. According to the Army, decontamination of the remaining vehicles is scheduled to be completed in August 1994.

While an official from AMCCOM told us that in January 1993 the Army Materiel Command would evaluate procedures for DU, including the recovery and control of contaminated vehicles and DU materials, the Army has not prepared a formal plan on how it will handle DU-contaminated vehicles in the future.

Recommendations

We recommend that the Secretary of the Army

- ensure that the appropriate Army training schools provide adequate information and training to personnel who could come in contact with DU-contaminated equipment,
- develop time frames to implement the proposed DU testing policy involving the testing of all crew members inside vehicles penetrated by DU munitions,
- expand testing to include personnel involved in the vehicle recovery process should the testing of the Army National Guard personnel show that uranium is present in excess of the standards being applied in the medical tests, and
- develop a formal plan for dealing with the recovery of DU-contaminated equipment.

We also recommend that the Secretary of Defense ensure that the other military services are prepared to decontaminate and dispose of DU-contaminated equipment and have appropriate training and guidance for personnel who may be exposed to DU.

Agency Comments

In commenting on a draft of this report, DOD concurred with all of our findings and recommendations. DOD stated that the Secretary of the Army will provide guidance by March 31, 1993, to implement courses of instruction on DU in appropriate Army training schools. DOD also stated that the Army is performing medical evaluations on all soldiers likely to have been wounded by depleted uranium during the Persian Gulf War. In December 1992, the Army, in conjunction with officials from AFRRRI and the Department of Veterans Affairs, established tentative time frames for implementing the proposed testing policy. DOD noted that, pending the outcome of the current testing program, personnel involved in the vehicle

recovery process may be included in further, expanded testing. DOD acknowledged the need to plan for the recovery of contaminated equipment and noted that the Army is expected to develop such a plan by May 31, 1993. Finally, DOD said it would provide a service-by-service plan of action for handling depleted uranium-contaminated equipment in response to our recommendation.

The Department of Veterans Affairs stated that sections in our draft report pertaining to it are accurate. In addition, the Department told us that information from a special examination program would assist in conducting long-range health surveillance of Persian Gulf veterans, including those exposed to depleted uranium.

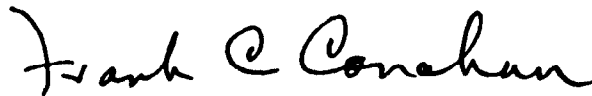
The NRC provided suggestions to more accurately and precisely define technical terms and regulatory requirements. We have incorporated these suggestions where appropriate in our report.

We conducted our review between February and November 1992 in accordance with generally accepted government auditing standards. Further details on our findings appear in appendix I; our scope and methodology appear in appendix II; and comments on this report from DOD, the Department of Veterans Affairs, and the NRC are presented in appendixes III, IV, and V.

We are sending copies of this report to the Chairmen, House and Senate Committees on Armed Services, on Appropriations, on Veterans Affairs, the House Committee on Government Operations, and the Senate Committee on Governmental Affairs; the Secretary of Defense; the Secretary of the Army; the Secretary of Veterans Affairs; the Chairman of the Nuclear Regulatory Commission; and other interested parties. We will also make copies available to others upon request.

This report was prepared under the direction of Henry L. Hinton, Jr., Director of Planning, who may be reached at (202) 275-6226 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix VI.

Sincerely yours,



Frank C. Conahan
Assistant Comptroller General

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Abbreviations

AFRRI	Armed Forces Radiobiology Research Institute
AMCCOM	Army Armament, Munitions and Chemical Command
DCF	Defense Consolidation Facility
DOD	Department of Defense
DU	depleted uranium
NRC	Nuclear Regulatory Commission
TRADOC	Training and Doctrine Command

Exposure of Personnel to DU Contamination During the Persian Gulf War

Background

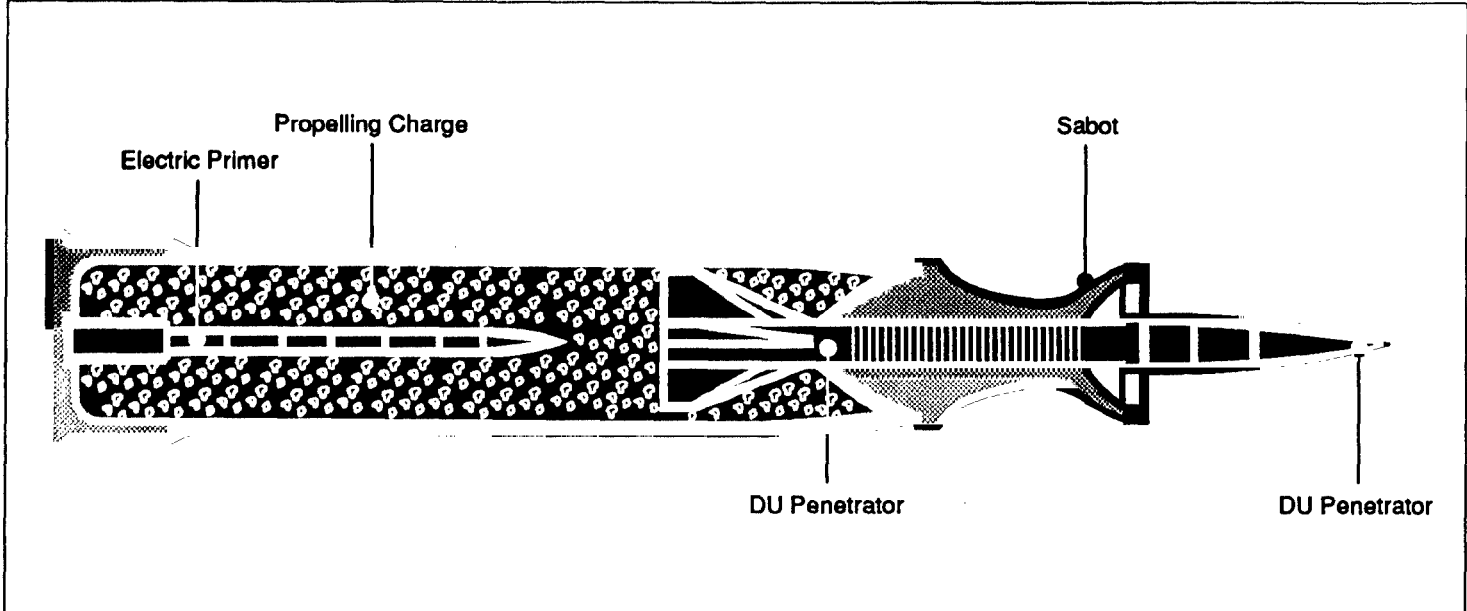
Depleted uranium (DU) is a by-product of the uranium enrichment process. During this process natural uranium is separated into two products. One product contains a higher content of the fissionable uranium isotope U-235 and is used for nuclear reactor fuel and nuclear weapons. The other product contains a lower content of U-235 and is referred to as "depleted uranium." DU is extremely dense, making it a good material for protecting against penetration by less dense metals or for piercing other metals such as armored targets.

In recognition of these properties, the Army and Marine Corps have installed DU on some M1A1 Abrams tanks to provide additional protection in selected areas. The DU armor packages are completely surrounded by thick, rolled homogeneous steel armor, which blocks out most of the radiation. In addition, 120-mm armor-piercing rounds for the M1A1 Abrams tank and 105-mm armor-piercing rounds for the M1 Abrams tank and the M60 series tank have penetrators made of DU.¹ When the round is fired and the propellant ignites, the round flies down the gun barrel, stabilized by the sabot wrapped around the penetrator. After the round leaves the gun barrel, the sabot jacket around the DU penetrator peels off or discards in flight. The DU penetrator then continues on to the target, aided by fins to keep the penetrator stabilized in flight. In essence, a DU penetrator resembles a metal spear and acts like an armor-piercing arrow. (See fig. I.1.)

¹The Air Force's A-10 close air support aircraft is also capable of firing DU ammunition.

Appendix I
Exposure of Personnel to DU
Contamination During the Persian Gulf War

Figure I.1: 120-mm Armor-Piercing Round With DU Penetrator



Source: U.S. Army.

The Nuclear Regulatory Commission (NRC) and the Army have regulations that are designed to limit exposure to uranium and offer a gauge of the risk of health problems. The NRC's regulations provide standards of protection for radiation workers and the general public and apply to individuals and private and public organizations, such as the Army, that are licensed by the NRC to use radioactive material in the United States and its territories. These standards limit a member of the general public's annual whole body exposure to radiation to 500 millirems.² The NRC also has additional standards for radiation exposure other than whole body. The Army's policy is to ensure that its military and civilian personnel worldwide are afforded radiation safety at least equal to the NRC's requirements. As such, the Army has regulations for its personnel both in the United States and Army commands overseas that parallel NRC standards for radiation workers and the general public.

²A "rem" (roentgen equivalent man) is a measurement unit used to quantify the effect of radiation on humans. One thousand millirems equal one rem. A chest X-ray provides an average exposure of about 16 millirems.

According to Army studies, under normal operating conditions, Abrams crew members are not exposed to radiation that exceeds NRC standards from either ammunition or armor. A 1988 Army study of radiation levels inside a DU-armored Abrams loaded with DU ammunition concluded that crew members inside the crew compartment receive no measurable dose of radiation because the vehicle's armor and thick ammunition doors effectively block any radiation from the armor and ammunition. The driver is exposed to some external DU radiation if the hatch is kept open while the vehicle is operating. However, another 1988 Army report estimated that even with the hatch open, the driver's maximum annual exposure would be 1/25th of the NRC's 500 millirem annual radiation exposure limit for the general public.

The potential for internal and higher levels of external radiation exposure exists if a vehicle's DU armor is damaged, if a vehicle is penetrated by a DU round, or if on-board ammunition ignites and burns. For example, when a DU penetrator cuts through armor and into the vehicle's crew compartment, it fractures, oxidizes, and burns, contaminating the vehicle with DU oxide dust. DU ammunition also oxidizes and contaminates the vehicle in the heat of a vehicle fire. Personnel who later work with the contaminated vehicles can be exposed to this DU oxide dust. In addition, personnel can be wounded by shards of DU shrapnel when the DU round penetrates a vehicle.

U.S. Combat Vehicles Contaminated by DU in the Persian Gulf War

According to the Army, during the Persian Gulf War, 29 U.S. Army combat vehicles—15 Bradley Fighting Vehicles and 14 Abrams tanks—were contaminated after being hit by DU rounds from Abrams tanks or after experiencing the ignition of stored DU ammunition caused by accidental on-board tank fires or being struck by a Hellfire missile fired by a U.S. helicopter. Six of the tanks had DU armor. However, the DU armor on these vehicles was not penetrated and did not contribute to the vehicles' contamination. All affected Bradleys were contaminated as a result of friendly fire, since Bradleys did not carry DU ammunition during the war, and Iraqi forces did not have DU ammunition.

**Appendix I
Exposure of Personnel to DU
Contamination During the Persian Gulf War**

**Table I.1: U.S. Army Combat Vehicles
Contaminated by DU in the Persian
Gulf War**

Vehicles damaged or destroyed	Vehicles contaminated solely from ignition of stored DU munitions	Vehicles impacted by DU munitions	Total
Abrams tanks	6 ^a	8	14
Bradley Fighting Vehicles	0	15	15
Total	6	23	29

^aThree Abrams were contaminated after a fire at an Army motor pool and ammunition storage area in Doha, Kuwait, in July 1991. Two Abrams burned as the result of accidental on-board fires. One Abrams was set afire after being struck by a Hellfire missile fired by a U.S. helicopter. In all six cases, these vehicle fires set off stored DU ammunition, contaminating the vehicles.

Source: U.S. Army Office of the Deputy Chief of Staff for Operations and Plans.

According to the Army, six of the contaminated Bradley Fighting Vehicles were buried in Saudi Arabia after the contaminated portions had been removed and shipped to the United States for disposal. The other nine Bradleys were returned to the United States for decontamination. All 14 Abrams tanks were returned to the United States for decontamination.

**Abrams and Bradley
Crews Exposed to DU
Contamination**

According to the Army Surgeon General's Office, 35 soldiers received some form of injury while inside Bradley Fighting Vehicles or Abrams tanks that were penetrated by DU ammunition fired by Abrams tanks. On the basis of an examination of these soldiers' medical records, the Army Surgeon General's Office determined that 22 of the 35 were likely to have been wounded by DU shrapnel. Moreover, all of these personnel could have inhaled or ingested oxidized DU particles.

**Maintenance
Personnel Potentially
Exposed to DU
Contamination**

According to personnel we interviewed from the 24th Infantry Division-Mechanized, in one action during the war, the unit had three of its Bradleys hit by friendly fire from Abrams tanks using DU ammunition—two were destroyed, and the other was badly damaged. After the battle was over and the combat units moved on, maintenance personnel from the 24th arrived to recover the two destroyed Bradleys. After unloading all the ammunition and personal items, the maintenance personnel stripped off usable parts and highly sensitive equipment. The maintenance sergeant in charge of the recovery operation told us that he had had no prior knowledge of the potential for DU contamination in these vehicles. He told us that at the time he believed the vehicles had been hit by Abrams tanks and that he was aware of rumors that the tanks fired DU rounds, but

information on the use of DU, its risks, and necessary precautions had not been a part of his training or included in guidance provided to him. He said he had not been provided at the time of the incident, or since then, a medical evaluation for radiation exposure. While he could not remember the exact number of people involved in the recovery operation, he was not aware of anyone else involved receiving any medical attention. During our June 1992 interview, the maintenance sergeant told us that this was the first time that he had been informed that these combat vehicles had been contaminated by DU and that he might have been exposed to some level of radiation.

The one damaged Bradley from the same incident was repaired in the field. Another maintenance sergeant who had helped repair this vehicle told us he believed the damaged vehicle had been hit by Abrams tank fire, but he did not know it had been contaminated. He said he was unaware that Abrams tanks fired DU ammunition. This maintenance sergeant told us that after the vehicle was repaired, he had stayed in it, along with other personnel, for several days until the ground war was over. He said that he had never been told that he might have been exposed to DU; nor had he been provided a medical evaluation for radiation exposure.

At our exit conference, command officials from the 24th acknowledged that, in retrospect, division personnel who were tasked with recovering these vehicles should have been trained in the characteristics of DU, its potential hazards, and the precautions necessary to safeguard themselves from exposure. Although they believed that troops face much greater risks on the battlefield, they also believed that after the battle is over it is reasonable to take precautions. They thought that training and guidance, including information on what risks DU poses and what precautions should be taken to prevent unnecessary exposure, should be provided to all soldiers who may come into contact with contaminated vehicles on the battlefield.

Some National Guard Personnel Potentially Exposed to DU Contamination

According to personnel we interviewed from the 144th Army National Guard Service and Supply Company, the unit was responsible for establishing a central vehicle receiving and storage point for all damaged and destroyed combat vehicles. Its mission involved assessing battle damage to the vehicles and preparing the vehicles for shipment back to the United States. Prior to the company's deployment to the Persian Gulf, most of its experience with combat vehicles involved M109 and M110 howitzers. Consequently, the company's personnel had limited experience

with the Abrams tanks or Bradley Fighting Vehicles they encountered in the Persian Gulf and were unaware of the use of DU in Abrams tank armor and ammunition and the potential for contamination.

Among the vehicles the company received at the central collection site were several Abrams and Bradley vehicles contaminated by DU resulting from friendly fire incidents involving Abrams tanks or from the ignition and burning of on-board DU ammunition due to accidental fires or being struck by a missile from a U.S. helicopter. Unit personnel told us that 20 to 25 soldiers from the unit had worked on the contaminated Bradleys and Abrams vehicles without prior knowledge of the existence of DU contamination or radiation hazards and without any protective gear. They said that, although they could not be sure, they believed that it was not until about 3 weeks later that a radiological team informed them they were working with DU-contaminated vehicles and instructed them on proper precautions for handling DU. The Department of the Army had deployed this team from the Army Armament, Munitions and Chemical Command (AMCCOM) to the Persian Gulf to assist with the preparation of contaminated vehicles for shipment to the United States.

Thirteen members of the 144th Service and Supply Company told us that after they had become aware of their exposure to DU radiation they had requested radiological testing once they had returned to the United States. They expressed a strong view that they should have been informed about DU prior to their exposure. They pointed out that if information on the risks and necessary precautions had been made available to them at the time of their tours of duty, they could have taken precautions to protect themselves.

Risks Low, but Precautions Necessary

DU is both a radioactive and a chemically toxic heavy metal—much like lead. When a DU round penetrates armor, the area around the penetration site emits low levels of radiation. Moreover, DU oxide dust, which is formed as a result of the DU being subjected to the intense heat that results from the round's penetration of the vehicle or from on-board vehicle fires, poses both a radioactive and a toxicity risk. Personnel working on or inside contaminated vehicles can come into contact with the DU dust by either inhaling or ingesting it. The primary risk from inhaled DU depends, in part, on the solubility of the oxide. More soluble oxides enter the bloodstream quicker and primarily pose a toxicity risk to the kidneys. Inhaled insoluble oxides stay in the lungs longer and pose a potential cancer risk due to radiation. Ingested DU dust can also pose both a

**Appendix I
Exposure of Personnel to DU
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radioactive and a toxicity risk, although, according to a radiation specialist from the Army Materiel Command, more than 99 percent of ingested DU passes through the body without causing harm. However, Army and civilian radiation specialists told us that depleted uranium's toxic nature poses a greater potential health risk than its radioactivity.

According to NRC and Army health officials, troops externally exposed to DU radiation during the Persian Gulf War were unlikely to have been exposed to levels that exceeded the NRC's annual regulatory limits for external radiation exposure for the general public. This position appears to be borne out by records of the radiation levels inside 20 of the 29 contaminated vehicles. Before shipping the vehicles back to the United States, members of an Army radiological team took radiation measurements for all 29 vehicles. These radiation measurements were recorded for all 15 contaminated Bradleys, but only 5 of 14 contaminated Abrams tanks. Radiation measurements were not recorded for the other nine contaminated Abrams tanks. The highest level measured directly at the surface of any of the 20 vehicles for which records were available was 14 millirems per hour. According to an NRC official, standards for skin exposure to radiation would apply, since personnel would not receive whole body radiation exposure from the localized DU contamination. At 14 millirems per hour, it would have taken more than 53 hours of direct contact with this portion of the vehicle to exceed the Army's quarterly 750 millirem nonoccupational limit on radiation exposure to the skin. Actual exposure was probably much less, since the highest radiation levels, which were measured directly at the points where DU munitions had penetrated the armor, decreased significantly 6 inches from the points of impact.

The NRC has also established standards for maximum permissible concentrations of uranium in the air. For uranium materials with a lower content of U-235, such as DU, the NRC regulates the intake of soluble, airborne compounds based on uranium's toxic effects rather than on its radioactivity. Officials from the Army Environmental Hygiene Agency, the Army Surgeon General's Office, and the NRC told us that while working on contaminated vehicles, personnel are not likely to inhale quantities of the heavy DU dust formed after a fire or penetration that are sufficient to exceed these NRC standards. They told us that DU dust is very heavy and does not easily resuspend into the air where it can be inhaled. As a result, they believed personnel in the Persian Gulf were unlikely to have inhaled sufficient amounts of DU dust to cause health problems related to toxicity and internal radiation. This conclusion is supported by numerous prewar

studies conducted by the Army to investigate potential DU hazards. In a series of test results published between 1977 and 1991, DU munitions were burned or fired into tanks or armor plate, and the amount of uranium in the air and on the ground was measured. These studies concluded that personnel were unlikely to inhale or ingest quantities of DU dust that exceeded NRC limits.

Army and NRC officials also told us that, while they believed personnel in the Persian Gulf War were not exposed to internal or external levels of DU that exceeded NRC limits, compliance with these limits for radiation exposure does not eliminate the risk of health problems. The relationship between radiation dosage and health risks at low levels of exposure is not clearly understood. The working assumption is that there may be some risk involved with any exposure to radiation. In recognition of this unquantifiable risk from low levels of radiation, the National Council on Radiation Protection and Measurements³ recommends that users of radioactive material ensure that personnel's exposure to radiation is as low as is reasonably achievable, given economic and societal constraints. Officials from the NRC told us that this approach is currently not a regulatory requirement but rather is an internationally recognized approach to radiation safety that NRC encourages its licensees to adopt. Army regulations to minimize personnel's exposure to radiation also adopt this approach.

Appropriate actions to minimize radiation exposure differ, depending on the situation. For example, Army officials believe that, because the risks of combat greatly outweigh the low DU-related health risks, DU protective methods can be ignored during battle and other life-threatening situations. However, radiation experts from AMCCOM, the Tank-Automotive Command, the Army Surgeon General's Office, and the Army Environmental Hygiene Agency believe that personnel working with contaminated vehicles in noncombat situations should take appropriate precautions. These precautions could involve wearing dust masks and gloves and washing their hands after completing their work. NRC officials also noted that DU protective measures applicable in noncombat situations may not be appropriate during combat.

³The National Council on Radiation Protection and Measurements is a congressionally mandated corporation that studies radiation, its health effects, and radiation protection measures. The Council periodically issues recommended levels of radiation exposure.

Army Efforts to Educate Personnel on DU Limited

The Army's efforts to educate personnel on the characteristics, risks, and proper handling of DU-contaminated equipment do not extend to all members of military occupations that might come in contact with contaminated equipment.

According to officials from the Army's Training and Doctrine Command (TRADOC), training on DU characteristics and risks is limited to Abrams tank personnel, munitions handlers, and explosive ordnance disposal personnel. TRADOC is the Army agency that oversees all individual training of Army personnel conducted at Army training schools and centers. An Army Materiel Command official also told us that some Army radiation and safety personnel receive DU training.

In response to our request, TRADOC queried its training schools to determine whether training on DU is provided to combat vehicle personnel and other military occupations likely to be involved in the recovery of DU-contaminated systems. TRADOC's survey showed that only the Armor School at Fort Knox, which trains Abrams tank personnel, offered some limited training on DU characteristics and risks. The Armor School warns entry-level soldiers going into Abrams tank units that DU is used in the ammunition and armor but provides no details on potential risks and necessary precautions. More detailed information, although still limited, is provided in master gunner and advanced officer training courses. For example, personnel in these courses are taught that they should wear gloves and breathing apparatuses when inside a contaminated vehicle to avoid breathing particles of DU and that in the event of a fire on a tank loaded with DU ammunition, personnel should stay upwind of any smoke. If it is necessary to get near the fire, personnel are told to wear breathing apparatuses to avoid inhaling DU particles. Personnel are also informed that the greatest danger from a DU tank fire comes from unexploded ammunition and not the radiological or toxicological properties of the DU.

TRADOC's survey showed that its other schools that trained personnel who could be involved in the recovery of damaged DU-contaminated vehicles did not include training on the risks and hazards of DU contamination. These schools included the Infantry Center and School, which trains Bradley personnel; the Ordnance Center and School, which trains maintenance personnel; and the Transportation and Aviation Logistics School, which trains transport drivers.

Officials at TRADOC acknowledged that training should be provided to all soldiers who may be involved in the recovery process or who otherwise

could be tasked with working on contaminated systems. While they felt that such training should be included in the curricula of Army schools that train these individuals, they noted that this type of training would not be included by the schools without direct instruction to do so. Since such a change to current training plans would probably require new course outline development, materials, and instruction, officials from TRADOC Headquarters indicated that the direction to incorporate training on DU into TRADOC's current curricula would have to come from the Department of the Army.

Some Personnel Not Familiar With DU Guidance

Army officials and personnel we interviewed pointed out that a technical bulletin dealing with accidental tank fires is the primary source of guidance on DU. However, many of the soldiers we interviewed said they had not seen this bulletin.

An updated September 1990 version of this bulletin—Department of the Army Technical Bulletin 9-1300-278, entitled “Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium”—discusses proper procedures for handling fires involving DU ammunition. Although Army officials told us that this document should have been widely available to troops, personnel we interviewed at the 24th Infantry Division-Mechanized told us they were not familiar with the bulletin or its contents. We spoke with an Abrams Tank Battalion Executive Officer, an Abrams Platoon Commander, and an Abrams Master Gunner who told us they did not have the bulletin and were not familiar with its contents. The Battalion Executive Officer appointed to handle the preparations for our visit told us that he had come across the document in pulling together available information on DU, but that was the first he had known of the bulletin's existence. None of the Bradley Fighting Vehicle maintenance and recovery personnel we talked with had seen the document.

Abrams organizational maintenance personnel we spoke with told us they were aware of the bulletin and its contents because earlier in their careers they had experienced on-board tank fires involving DU ammunition when they had been stationed in Germany. Maintenance personnel from the direct support level who are responsible for maintaining both the Abrams tanks and the Bradley vehicles told us that they had only recently been given copies of the bulletin. In their view, the sheer volume of technical manuals, bulletins, and instructions covering all the vehicles they were responsible for maintaining made it impossible for them to have ready

access to these documents when they were in the field or to even be aware of all of them. They expressed the view that such guidance needed to be reinforced with unit training. Additionally, soldiers we interviewed from the Army National Guard's 144th Service and Supply Company said they had never heard of or seen the technical bulletin.

Testing of Some Gulf War Veterans for DU Exposure in Process

According to the Army Surgeon General's Office, it plans to notify all 35 soldiers injured while inside combat vehicles penetrated by DU during the war and have them medically evaluated by the Department of Veterans Affairs. The personnel inside these vehicles were at risk from DU shrapnel and inhaling DU oxide dust from the DU round as it penetrated the vehicle. The Army Surgeon General's Office identified these soldiers through medical records. An Army Surgeon General's Office official told us that 22 of the 35 soldiers were likely to have been wounded by DU shrapnel.

The Armed Forces Radiobiology Research Institute (AFRRI), in conjunction with other DOD scientists and physicians, has drafted DU testing policy for evaluating potential DU health effects for those soldiers inside vehicles penetrated by DU munitions. This group invited comments on the draft policy from nonmilitary radiation and chemical toxicology experts. The draft policy, discussed at a meeting on September 10, 1992, with these experts and representatives from the Department of Veterans Affairs and the Army Surgeon General's Office, recommends the evaluation of all soldiers who were inside vehicles at the time the vehicles were penetrated by DU munitions—not just the soldiers who were injured in these vehicles. According to an AFRRI official, this policy further recommends the implementation of monitoring procedures to track individuals whose test results show the presence of uranium in excess of the standards adopted in the testing policy. All identified soldiers who were wounded by DU shrapnel would be tracked over time, because little is known about the effect of DU fragmentation in humans. At a December 1992 meeting, officials from AFRRI, the Department of the Army, and the Department of Veterans Affairs tentatively agreed that testing of these personnel would begin in July 1993.

According to an AFRRI official, preliminary tests of urine samples conducted by the Army Environmental Hygiene Agency on two personnel who were wounded by DU shrapnel indicated that these two soldiers had 15 to 17 micrograms of uranium per liter of urine. This exceeds the urinary uranium action level set out in the NRC's Regulatory Guide 8.22. Under this guide, if a worker has urine uranium levels between 15 and 35 micrograms

per liter, the NRC recommends that the company examine its worker protective measures to ensure exposure to uranium is as low as is reasonably achievable. According to an AFRRRI official, an "action level" is a level that is set below the regulatory standard for a specified set of exposure conditions. It is designed to trigger administrative or investigative actions to ensure that the standard is not exceeded and to reduce exposure. He also noted that exceeding the action level does not mean that a standard was exceeded; nor does it indicate that the person will suffer adverse health effects. The consensus of a panel of nonmilitary radiation and toxicity experts that was convened to advise the military on testing soldiers' wartime exposure to DU was that toxic effects would not be evident until uranium concentrations exceeded 250 micrograms per liter.

In addition to the group of soldiers who were inside vehicles penetrated by DU munitions, 27 Army National Guard personnel from the 144th Service and Supply Company who claim they were exposed to DU will receive radiological testing at the Nuclear Medicine Branch of the Department of Veterans Affairs Medical Center in Boston, Massachusetts. Of these, 12 had been tested as of November 1992 for low-level radiation exposure. These individuals were given radiological tests, including urine, fecal, and breath tests. According to a physician involved in the testing, test results from these 12 individuals appear negative in that when compared to a control group, none of the 12 individuals tested had any measurable increase in internal radiation levels due to DU exposure during the Persian Gulf War. The remaining 15 were due to be tested in February 1993.

According to officials from the Army Surgeon General's Office and AFRRRI, personnel from the 144th Service and Supply Company will not be covered under the draft DU testing policy because they were not subject to the same risks as those who were inside the vehicles when the vehicles were penetrated by DU munitions. Personnel from the 144th were not wounded by DU and, in the officials' view, were not likely to have stirred up and inhaled enough DU dust to suffer health problems. In addition, an official from the Army Surgeon General's Office told us that since test results for soldiers from the 144th who might have inhaled DU dust show that the presence of uranium is within applicable regulatory limits or that uranium was not present at all, there is no compelling reason to identify and recall for testing all soldiers who might have inhaled DU dust during the vehicle recovery process, such as maintenance and transportation personnel.

Vehicle Decontamination Planning Inadequate

At the time of the war, the Army did not have an effective strategy for decontaminating ground combat vehicles so that they could be quickly repaired or scrapped. Prior to the war, there had been only two tank fires involving DU ammunition since the ammunition was fielded in 1980. In 1988, two fire-damaged M60A3 tanks were shipped from Europe to the United States, where they were buried intact at a low-level radioactive waste site in Barnwell, South Carolina.

In March 1991, personnel from the Radioactive Waste Disposal Division of AMCCOM's Safety Office were sent to Saudi Arabia to oversee the collection and preparation for shipment back to the United States of DU-contaminated vehicles from the Persian Gulf War. This division has responsibility for handling low-level radioactive waste for the Department of Defense. Upon arrival, the AMCCOM radiological team found that the contaminated vehicles were scattered throughout the collection site and that measures to limit personnel's exposure had not been established. The team separated the contaminated vehicles, established a security perimeter to limit personnel access, and instructed personnel from the 144th Service and Supply Company who staffed the collection site in the proper precautions for handling DU.

The radiological team also had to develop a new strategy to determine what it would do with the contaminated vehicles. A member of this team told us that the prewar strategy of burying the vehicles intact at a disposal site in the United States was inappropriate for the war-damaged vehicles because (1) a large number of vehicles were contaminated, and radioactive waste burial, which is charged by the cubic foot, is costly and (2) the more lightly damaged vehicles could be repaired once the contaminated portions were cut out. Consequently, the team adopted a strategy for dealing with the DU-contaminated vehicles from the war that called for

- decontaminating the exterior of the vehicles;
- shipping the vehicles to the Army's contractor for consolidating low-level radioactive waste, Chem-Nuclear Systems, Incorporated's, Defense Consolidation Facility (DCF), located in Snelling, South Carolina, where the contaminated portions of the interior of the vehicles would be cut out and buried at South Carolina's low-level radioactive waste disposal site; and
- when possible, repairing the decontaminated vehicles at an appropriate repair facility or, if they were not repairable, removing repairable and classified components and selling the rest as scrap.

As discussed earlier, 29 vehicles were contaminated with DU in the Persian Gulf. The first incident, involving an accidental tank fire, occurred in December 1990, prior to the start of the ground war. An AMCCOM team decontaminated the exterior of the vehicle in Saudi Arabia, and the tank was shipped back to DCF in Snelling, South Carolina. The contaminated areas on the interior of the tank were removed and sent to the South Carolina low-level waste disposal site for burial, while the tank itself minus reparable and classified components was cut up and sold as scrap. Of the remaining 28 contaminated vehicles, 6 Bradley Fighting Vehicles, according to the Army, were decontaminated and buried in Saudi Arabia. Twenty-two vehicles—13 Abrams tanks and 9 Bradley Fighting Vehicles—were sent back after the war to DCF for decontamination. As of November 1992, 2 of these 13 tanks and none of the Bradleys had been decontaminated. These two tanks will be sent to the Anniston Army depot, where they will be repaired and returned to service.

Decontamination of the remaining 20 vehicles has been delayed because the DCF facilities were not large enough to handle the vehicles and the regular work load of low-level radioactive waste. A new facility had to be built to decontaminate the heavy tanks and fighting vehicles. Construction of a new \$4 million building at DCF to accommodate the larger, heavier vehicles was completed in June 1992. Chem-Nuclear Systems, Incorporated, began work in the new building in October 1992 after the building was approved by a Safety Review Board audit mandated by the State of South Carolina. Decontamination of the remaining vehicles is estimated by the Army to be completed in August 1994—22 months from when work began in the new building in October 1992. The Army currently estimates that, in total, four tanks and all nine of the Bradley Fighting Vehicles will be restored to service. The remaining nine tanks at DCF are currently believed to be too badly damaged to be repaired. The unclassified contaminated portions of these vehicles will be decontaminated when possible and sold as scrap along with the uncontaminated portions. Portions that cannot be decontaminated will be removed from the vehicle and will be buried at South Carolina's low-level radioactive waste disposal site at Barnwell, South Carolina, which is near DCF.

Although it now has a new building for decontamination capable of handling heavy tanks, the Army has not prepared a formal plan on how it will handle DU-contaminated vehicles in the future. An official from AMCCOM told us that in January 1993 the Army Materiel Command would

**Appendix I
Exposure of Personnel to DU
Contamination During the Persian Gulf War**

evaluate procedures for DU, including the recovery and control of contaminated vehicles and DU materials.

Scope and Methodology

To obtain information on the numbers and disposition of vehicles contaminated during the Persian Gulf War, we reviewed documentation on the number of destroyed and damaged Bradley Fighting Vehicles and Abrams tanks that was provided by the Office of the Deputy Chief of Staff for Operations and Plans and the Army Armament, Munitions and Chemical Command. We also held interviews with officials from the Office of the Project Manager for Survivability Systems, the Army Congressional Liaison Office, and the Defense Consolidation Facility.

To obtain information on the health risks associated with depleted uranium, we interviewed officials from the Nuclear Regulatory Commission; the Environmental Protection Agency; the National Council on Radiation Protection and Measurements; Battelle Pacific Northwest Laboratories; the Army Environmental Hygiene Agency; the Army Surgeon General's Office; the Army Materiel Command; the Army Armament, Munitions and Chemical Command; the Army Armament Research, Development, and Engineering Center; and the Department of Veterans Affairs.

To follow up on crew comments regarding policies and procedures for minimizing the risks associated with DU, we met with officials from the Army Training and Doctrine Command responsible for designing and implementing Army training programs. We obtained information from officials of this Command on the level of DU training its subordinate schools offered. With officials from the following organizations, we discussed the level of DU training provided to Army personnel, the information provided about DU, and the availability of equipment used in the Army for radiation detection:

- the Abrams Tank System Program Office, Warren, Michigan;
- the Army Materiel Command, Alexandria, Virginia;
- the Army Armor School, Fort Knox, Kentucky;
- the Army Infantry School, Fort Benning, Georgia;
- the Army Ordnance School, Aberdeen Proving Grounds, Maryland;
- the Army Tank-Automotive Command, Warren, Michigan;
- the Army Training and Doctrine Command, Fort Monroe, Virginia;
- the Office of the Deputy Chief of Staff for Operations and Plans, Department of the Army, Washington, D.C.;
- the Office of the Project Manager for Nuclear, Biological, and Chemical Defense Systems, Aberdeen, Maryland; and
- the Army Communication and Electronics Command, Fort Monmouth, New Jersey.

We interviewed soldiers from the 24th Infantry Division-Mechanized, Fort Stewart, Georgia, to determine whether they were aware of the characteristics of DU, the risks associated with handling DU-contaminated equipment, and proper precautions necessary to safeguard themselves against exposure to DU. We also interviewed personnel from the 144th Army National Guard Service and Supply Company, New Jersey Army National Guard, when it came to our attention that they had requested radiological testing after alleging that they had been unknowingly exposed to DU contamination. Both these units had served in the Persian Gulf War.

We obtained information on the Army's efforts to decontaminate vehicles from a number of organizations, including

- the Anniston Army Depot, Anniston, Alabama;
- the Red River Depot, Texarkana, Texas;
- the Army Armament, Munitions and Chemical Command, Rock Island, Illinois;
- the Office of the Project Manager for Survivability Systems, Warren, Michigan;
- the Abrams Tank System Program Office, Warren, Michigan; and
- the Chem-Nuclear Systems, Incorporated's, Defense Consolidation Facility, Snelling, South Carolina.

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, DC 20301-3010

15 JAN 1993

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and International
Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "OPERATION DESERT STORM: Army Not Adequately Prepared to Deal With Depleted Uranium Contamination", dated November 25, 1992 (GAO Code 933493, OSD Case 9266). The DoD concurs with the GAO findings and recommendations.

The Department recognizes the hazards associated with the use of depleted uranium in tank armor and in armor-piercing munitions. Because of the toxic nature of uranium and because it is prudent to assume there is some risk associated with low level depleted uranium radiation, the DoD will implement precautions for personnel working with contaminated equipment in noncombat situations. The Department is actively addressing the medical evaluation and testing policy issues discussed in the draft GAO report through self-initiated actions on the part of the Army and the Armed Forces Radiobiology Research Institute. In addition, as a result of lessons learned in Operation Desert Storm, the Army will develop plans for future recovery of depleted uranium contaminated equipment, and will implement appropriate training for all personnel who could be tasked with working on this equipment.

The DoD detailed comments are provided in the enclosure. The Department appreciates the opportunity to comment on the draft GAO report.

Sincerely,


Victor H. Reiss

Enclosure

Appendix III
Comments From the Department of Defense

DOD RESPONSE TO GAO DRAFT REPORT--DATED NOVEMBER 25, 1992
(GAO CODE 393493) OSD CASE 9266

"OPERATION DESERT STORM: ARMY NOT ADEQUATELY PREPARED TO
DEAL WITH DEPLETED URANIUM CONTAMINATION"

DEPARTMENT OF DEFENSE COMMENTS

* * * * *

FINDINGS

o FINDING A: Depleted Uranium Contamination During the Persian Gulf War. The GAO explained that depleted uranium--a by-product of the uranium enrichment process--is about half as radioactive as natural uranium. The GAO further explained that depleted uranium is extremely dense, and is a good material for protecting against penetration by less dense metals or for piercing other metals such as armored targets. The GAO observed that the Army and Marine Corps installed depleted uranium on some M1A1 ABRAMS tanks to provide additional protection--the armor packages are completely surrounded by thick rolled homogeneous steel armor, which blocks out most of the radiation. The GAO found that the following Army systems have penetrators made of depleted uranium:

- the 120-mm armor-piercing rounds for the M1A1 ABRAMS tank; and
- the 105-mm armor-piercing rounds for the M1 ABRAMS tank.

The GAO noted that, in addition, the M60 series tanks have penetrators made of depleted uranium.

The GAO pointed out that the Nuclear Regulatory Commission and the Army have regulations designed to limit exposure to uranium and offer a gauge of the risk of health problems. The GAO noted that the regulations provide standards of protection for the general public and apply to individuals and private and public organizations licensed by the Nuclear Regulatory Commission to use radioactive material. The GAO further noted that the standards limit individual annual whole body exposure to radiation to 500 millirems. The GAO found that Army policy is to ensure that military and civilian personnel worldwide are afforded radiation safety at least equal to the Commission requirements; therefore, Army regulations parallel Nuclear Regulatory Commission standards for the general public.

The GAO reported that, according to Army studies, under normal operating conditions, ABRAMS crew members are not exposed to radiation exceeding the Nuclear Regulatory Commission standards from either ammunition or armor. The GAO concluded,

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Comments From the Department of Defense

however, that the potential for higher levels of exposure exists (1) if a vehicle's depleted uranium armor is damaged, (2) if a vehicle is penetrated by a depleted uranium round, or (3) if on-board ammunition ignites and burns. As an example, the GAO cited a scenario where a depleted uranium penetrator cuts through armor and into the vehicle's crew compartment, which could result in the following:

- the penetrator would fracture, oxidize, and burn--contaminating the vehicle with depleted uranium oxide dust;
- the depleted uranium ammunition would also oxidize--thus, contaminating the vehicle in the heat of a vehicle fire;
- the personnel who later work with the contaminated vehicles can be exposed to the oxide dust; and
- the personnel can be wounded by shards of depleted uranium shrapnel when the depleted uranium round penetrates a vehicle. (pp. 1-2, pp. 16-19/GAO Draft Report)

DoD Response: Concur.

o FINDING B: U.S. Combat Vehicles Contaminated by Depleted Uranium in the Persian Gulf War. The GAO determined that, during the Persian Gulf War, 29 Army combat vehicles-- 15 BRADLEY Fighting Vehicles and 14 ABRAMS tanks--were contaminated by depleted uranium after being hit by depleted uranium rounds from ABRAMS tanks or after experiencing accidental on-board tank fires that caused the ignition of stored depleted uranium ammunition. According to the GAO, six of the tanks had depleted uranium armor; however, the armor on the vehicles was not penetrated and did not contribute to the vehicle contamination. The GAO concluded that all affected BRADLEY Fighting Vehicles were contaminated as a result of friendly fire, since the Vehicles did not carry depleted uranium ammunition during the war and Iraqi forces did not have depleted uranium ammunition. According to the GAO, six of the contaminated BRADLEY Fighting Vehicles were buried in Saudi Arabia after the contaminated portions had been removed and shipped to the United States for disposal--the other nine were returned to the United States for decontamination. The GAO further reported that all 14 ABRAMS tanks were returned to the United States for decontamination. (pp. 3-4, pp. 19-20/GAO Draft Report)

DoD Response: Concur.

o FINDING C: ABRAMS and BRADLEY Crews Exposed to Depleted Uranium Contamination. The GAO found that 35 soldiers received some form of injury while inside BRADLEY Fighting Vehicles or ABRAMS tanks that were penetrated by depleted uranium ammunition fired by ABRAMS tanks. The GAO concluded that 22 of the 35

Now on pp. 1-2 and
12-14.

Now on pp. 2 and 14-15.

Now on pp. 3 and 15.

soldiers were likely to have been wounded by depleted uranium shrapnel--and all of the personnel could have inhaled or ingested oxidized depleted uranium particles. (pp. 4-5, pp. 20-21/GAO Draft Report)

DoD Response: Concur. The 35 soldiers injured inside combat vehicles that were penetrated by depleted uranium ammunition are being medically evaluated by the Army or Department of Veterans Affairs to determine the presence of uranium.

o **FINDING D: Maintenance Personnel Potentially Exposed to Depleted Uranium.** According to personnel the GAO interviewed from the 24th Infantry Division-Mechanized, in one action the unit had three BRADLEY Fighting Vehicles hit by friendly fire from ABRAMS tanks using depleted uranium ammunition--two were destroyed, and the other was badly damaged. The GAO noted that after the battle was over and the combat units moved on, maintenance personnel from the 24th arrived to recover the two destroyed BRADLEYS. In other interviews with 24th personnel, the GAO found that soldiers had worked in and around depleted uranium-contaminated combat systems without being aware of the characteristics of depleted uranium ammunition, the potential risks from depleted uranium contamination, and precautions necessary to prevent depleted uranium exposure. (p. 5, pp. 21-23/ GAO Draft Report)

Now on pp. 3 and 15-16.

DoD Response: Concur. The DoD recognizes that maintenance, service, and supply personnel worked inside the contaminated vehicles without being aware of the presence of depleted uranium and/or without being aware of precautions recommended for working with depleted uranium contaminated equipment in noncombat situations.

o **FINDING E: Some National Guard Personnel Potentially Exposed to Depleted Uranium Contamination.** According to personnel the GAO interviewed from the Army National Guard 144th Service and Supply Company, the unit was responsible for establishing a central vehicle receiving and storage point for all damaged and destroyed combat vehicles. The GAO explained that the mission of the 144th involved assessing battle damage to the vehicles and preparing the vehicles for shipment back to the United States. The GAO determined that 27 soldiers from the 144th (who were involved with the damage assessment and preparation of damaged and destroyed combat vehicles for shipment) subsequently claimed they were unknowingly exposed to depleted uranium. The GAO pointed out that as of November 1992, 12 of the 27 had received radiological testing--with the test results for the 12 negative. The GAO noted that the remaining 15 will be tested in December 1992. The GAO further noted, however, that according to Army health officials, personnel from the 144th are not being included in the depleted uranium testing policy because they were not subject to the same exposures as were those who were inside the

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Now on pp. 3 and 16-17.

vehicles when the vehicles were penetrated by the depleted uranium rounds. (pp. 8-9, pp. 23-25/GAO Draft Report)

DoD Response: Concur. Radiological testing of the personnel from the 144th will be completed in January 1993. Except for the control group, the DoD does not intend to include individuals in the uranium testing policy who test negative for the presence of uranium.

o **FINDING F: Risks Low, But Precautions Necessary.** The GAO observed that depleted uranium is both a radioactive and a chemically toxic heavy metal--much like lead. According to the GAO, when a depleted uranium round penetrates armor, the area around the penetration site emits low-level radiation and a depleted uranium oxide dust, which is formed as a result of the depleted uranium being subjected to the intense heat that results from the round penetration of the vehicle or from on-board vehicle fires--thus, posing both a radioactive and a toxicity risk. The GAO concluded that depleted uranium poses a greater potential health risk because of its toxic nature than due to its radioactivity.

The GAO reported that, according to both Nuclear Regulatory Commission and Army health officials, troops externally exposed to depleted uranium radiation during the Persian Gulf War were unlikely to have been exposed to levels that exceeded the annual regulatory limits for radiation exposure. The GAO agreed that that position appeared to be borne out by records of the radiation levels inside 20 of the 29 contaminated vehicles. The GAO concluded, however, that the relationship between radiation dosage and health risks at low levels of exposure is not clearly understood and compliance with the Nuclear Regulatory Commission limits does not eliminate the risk of future health problems. (pp. 5-6, pp. 25-28/GAO Draft Report)

Now on pp. 3-4 and 17-19.

DoD Response: Concur. The DoD recognizes the hazards associated with depleted uranium contamination caused by fires involving vehicles up-loaded with depleted uranium munitions or by penetrations of vehicles by depleted uranium rounds. The contamination may be a combination of uranium oxide dust, uranium fragments, and uranium firmly attached to the vehicle, at a site of penetration and to objects inside the vehicle. The DoD agrees that the toxicity of the uranium contamination poses a much greater hazard to personnel than the low level depleted uranium radiation.

The DoD recognizes the relationship between radiation dosage and health risks at low levels of exposure is not clearly understood because the health effects and dosage are so low that direct measurement is difficult. The working assumption is that there is some risk involved with any exposure. This risk is estimated by using the results from exposures much greater than the Nuclear Regulatory Commission limits (approximately 20 to 400

times greater) to predict the risks at low exposures. The DoD estimates the risks from depleted uranium to be much smaller than naturally occurring risks and other occupational risks.

In order to remain on the side of caution, however, the DoD assumes there is some risk associated with exposure to depleted uranium. Therefore, the DoD agrees that precautions should be taken in noncombat, nonemergency situations to limit exposure to depleted uranium to levels that are as low as reasonably achievable. The DoD agrees that compliance with Nuclear Regulatory Commission regulations and efforts to reduce exposure to levels that are as low as reasonably achievable does not eliminate the risks associated with radiation exposure, but it reduces these risks to acceptable levels.

o **FINDING G: Army Efforts to Educate Personnel on Depleted Uranium Limited.** The GAO reported that Army efforts to educate personnel on the characteristics, risks, and proper handling of depleted-uranium-contaminated equipment do not extend to members of all military occupations that might come in contact with contaminated equipment. The GAO found that training on depleted uranium characteristics and risks is limited to ABRAMS tank personnel, munitions handlers, and explosive ordnance disposal personnel.

In response to an inquiry on the availability of depleted uranium training, the GAO learned that only the Armor School at Fort Knox, which trains ABRAMS tank personnel, offered some limited training on depleted uranium characteristics and risks. The GAO found that other schools involved in training personnel who could be involved in the recovery of damaged depleted-uranium-contaminated vehicles did not include training on the risks and hazards of depleted uranium contamination. The GAO noted that such schools included the Infantry School, which trains BRADLEY personnel; the Ordnance School, which trains maintenance personnel; and the Transportation School, which trains transport drivers.

The GAO noted that, according to officials at the U.S. Army Training and Doctrine Command and the Department of the Army Safety Office, such training should be provided to all soldiers who may be involved in the recovery process or who otherwise could be tasked with working on contaminated systems. The GAO was advised, however, that direction to incorporate training in depleted uranium into the current curricula would have to come from Department of the Army headquarters. (pp. 6-7, pp. 29-30/GAO Draft Report)

DoD Response: Concur. Existing training courses that include depleted uranium characteristics, risks, and handling have been attended primarily by ABRAMS tank, munitions, explosive ordnance disposal, radiation, and safety personnel. These courses have been available to, but not mandatory for other specialties.

Now on pp. 4-5 and
20-21.

Based on experiences in Desert Storm, the DoD agrees that similar training should be provided to all soldiers who may be tasked with working on equipment contaminated by depleted uranium.

o **FINDING H: Guidance on Depleted Uranium Not Widely Available.** The GAO reported that, according to Army officials and personnel, a technical bulletin dealing with accidental tank fires is the primary source of guidance on depleted uranium. The GAO noted that an updated September 1990 version of the bulletin--Department of the Army Technical Bulletin (TB 9-1300-278), entitled--Guidelines for Safe Response to Handling, Storage, and Transportation Accidents Involving Army Tank Munitions or Armor Which Contain Depleted Uranium--discusses proper procedures for handling fires involving depleted uranium ammunition. The GAO reported that although Army officials indicated that the Technical Bulletin should have been widely available to troops, most of the personnel interviewed had not seen it. (p. 7, pp. 31-32/GAO Draft Report)

DoD Response: Concur. Existing training and literature that includes depleted uranium characteristics, risks, and handling has not been mandatory for all soldiers who may be tasked with working on equipment contaminated by depleted uranium.

o **FINDING I: Testing of Some Gulf War Veterans for Depleted Uranium Exposure in Process.** According to the GAO, the Office of the Army Surgeon General plans (1) to notify all 35 soldiers injured while inside combat vehicles penetrated by depleted uranium during the Persian Gulf war (who were identified through medical records) and (2) to have them medically evaluated by the Department of Veterans Affairs. The GAO concluded that the personnel inside the vehicles were at risk from depleted uranium shrapnel and inhaling depleted uranium oxide dust from the depleted uranium round as it penetrated the vehicle. The GAO was advised by the Office of the Army Surgeon General indicated that 22 of the 35 soldiers were likely to have been wounded by depleted uranium shrapnel.

The GAO explained that the Armed Forces Radiobiology Research Institute, in conjunction with other Department of Defense scientists and physicians, is currently drafting a depleted uranium testing policy for evaluating potential depleted uranium health effects for those soldiers inside vehicles penetrated by depleted uranium munitions. The GAO noted that according to an official of the Institute, the policy recommends the implementation of monitoring procedures to track individuals whose test results show the presence of uranium in excess of the standards adopted in the testing policy. The GAO further observed that all identified soldiers that were wounded by depleted uranium shrapnel would be tracked over time because so little is known about the effect of depleted uranium fragmentation in humans. The GAO further noted that at a December 1992 meeting,

Now on pp. 5 and 21-22.

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Now on pp. 5-6 and
22-23.

officials from the Department of the Army and the Department of Veterans Affairs agreed that testing of these personnel would begin in July 1993. (pp. 7-8, pp. 32-35/GAO Draft Report)

DoD Response: Concur. The DoD recognizes the importance of medically evaluating personnel who were inside vehicles penetrated by depleted uranium munitions to determine the presence of uranium. These medical tests will be completed by September 1993.

See comment 1.

o **FINDING J: Vehicle Decontamination Planning Inadequate.** The GAO reported that, while an Army radiological team was able to oversee the central collection and readying for shipment of the contaminated vehicles back to the United States after the war, at the time of the war, the Army did not have an effective strategy for decontaminating ground combat vehicles so that vehicles could be quickly repaired or scrapped. The GAO pointed out that 29 vehicles were contaminated with depleted uranium in the Persian Gulf. The GAO found that (1) the first tank was shipped back to the Defense Consolidation Facility in Snelling, South Carolina, (2) of the remaining 28, six were decontaminated and buried in Saudi Arabia, and (3) the remaining 22 were sent back after the war to the facility in South Carolina. The GAO further found that decontamination of the remaining vehicles was delayed for 12 months--pending the construction of a larger facility, which was completed in April 1992. The GAO noted that the decontamination of the first two tanks in the new facility was completed in June (16 months after the war ended); with the decontamination of the remaining vehicles scheduled to be completed in August 1994. The GAO concluded, however, that the Army has not prepared a formal plan on how it will handle depleted-uranium-contaminated vehicles in the future. (pp. 10-11, pp. 36-39/ GAO Draft Report)

Now on pp. 6-7 and
24-26.

DoD Response: Concur. Prior to Desert Storm, the DoD did not anticipate the need to decontaminate a large number of ground combat vehicles. The DoD notes, however, that in the aftermath of Desert Storm, there was no reason to rapidly decontaminate and dispose of the combat vehicles. The DoD accepts the Army schedule to complete decontamination in 1994 as a reasonable goal.

* * * * *

RECOMMENDATIONS

o **RECOMMENDATION 1:** The GAO recommended that the Secretary of the Army ensure the appropriate Army training schools provide adequate information and training to personnel who could come in contact with depleted-uranium-contaminated equipment. (p. 11/GAO Draft Report)

DoD Response: Concur. The Secretary of the Army will identify appropriate training schools (e.g., the Armor, Infantry, Ordnance, and Transportation Schools) and provide guidance to implement courses of instruction in appropriate training curricula. The guidance is expected to be issued by 31 March 1993.

o **RECOMMENDATION 2:** The GAO recommended that the Secretary of the Army develop time frames to implement the proposed depleted uranium testing policy involving the testing of all crew members inside vehicles penetrated by depleted uranium munitions. (p. 11/GAO Draft Report)

DoD Response: Concur. This has been accomplished--the Army plans to begin in July 1993 and complete testing in September 1993.

o **RECOMMENDATION 3:** The GAO recommended that, should the testing of the Army National Guard personnel show uranium is present in excess of the standards being applied in the medical tests, the Secretary of the Army expand testing to include personnel involved in the vehicle recovery process. (p. 11/GAO Draft Report)

DoD Response: Concur. Pending the outcome of the testing, the DoD will expand its testing, as needed, to include personnel in the vehicle recovery process.

o **RECOMMENDATION 4:** The GAO recommended that the Secretary of the Army develop a formal plan for dealing with the recovery of depleted-uranium-contaminated equipment. (p. 11/GAO Draft Report)

DoD Response: Concur. Lessons learned from Operation Desert Storm include the need to develop technical and operational methods to reduce the number of friendly fire incidents, and the need to plan for recovery of contaminated equipment. The Army is expected to complete a recovery plan by 31 May 1993.

Now on p. 7.

o **RECOMMENDATION 5:** The GAO recommended that the Secretary of Defense ensure that the other Military Services (a) are prepared to decontaminate and dispose of depleted-uranium-contaminated equipment and (b) have appropriate training and guidance for personnel who may be exposed to depleted uranium. (p. 12/GAO Draft Report)

DoD Response: Concur. Of the other Services, the Marine Corps has the strongest potential for depleted uranium contamination of combat related equipment similar to the Army. The Department will review the recommendation and provide a Service-by-Service plan of action in response to the final report.

The following are GAO's comments on the Department of Defense letter dated January 15, 1993.

GAO Comments

1. Since our draft report was sent to DOD for comment, we have obtained additional information, which is reflected in this final report. The new, larger building at DCF for vehicle decontamination was completed in June 1992 and licensed to begin work in October 1992. Work in the new building began in October 1992. The two tanks that were decontaminated in June 1992 were decontaminated in preexisting facilities at DCF. As of November 1992, no vehicles had been completely decontaminated at the new building.

Comments From the Department of Veterans Affairs



DEPARTMENT OF VETERANS AFFAIRS
Veterans Health Services and Research Administration
Washington DC 20420

DEC 23 1992

In Reply Refer To: 173C

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and International
Affairs Division
General Accounting Office
441 G Street NW
Washington D. C. 20548


Dear Mr. Conahan:

I have reviewed your draft report, OPERATION DESERT STORM: Army Not Adequately Prepared to Deal With Depleted Uranium Contamination, Report Number GAO/NSIAD-93-90, and the references to the Veterans Health Administration (VHA) in the report are accurate. VHA's Office of Environmental Medicine and Public Health has worked closely with the Department of Defense's (DoD) U. S. Army Surgeon General's Office in dealing with the various health issues raised by the use of depleted uranium (DU) during the Persian Gulf War. This association, which began during the war, continues as examination protocols for veterans exposed to DU are developed. VA and DoD are also working together to compile whole-body counts of the universe of Persian Gulf veterans known to have been exposed or wounded by DU fragments.

VA and DoD will continue their cooperative efforts on this issue. In fact, VA and DoD are currently discussing details of conducting long-range health surveillance of veterans known to have been exposed to DU. In addition, a special Persian Gulf Registry examination program has been established at all major VA health care facilities which includes recording of information on possible exposure to DU during the Persian Gulf War. This information will assist VA in conducting its own long-range health surveillance of Persian Gulf veterans, including those exposed to DU.

Thank you for the opportunity to review this report.

Sincerely,


for James W. Holsinger, Jr., M.D.
Under Secretary for Health

JWH/ps

Comments From the Nuclear Regulatory Commission



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

December 18, 1992

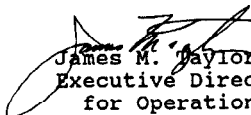
Mr. Frank C. Conahan
Assistant Comptroller General
National Security and
International Affairs Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Conahan:

The Nuclear Regulatory Commission staff reviewed your draft letter to Congressman Ron Wyden and Attachment I (Enclosure 1). Our specific recommended changes and comments are identified by page and line number in Enclosure 2. The NRC staff comments generally suggest language to more accurately and precisely define technical terms and regulatory requirements.

If you have any questions about these comments, please contact Michael A. Lamastra at (301) 504-3416. I trust that this reply responds to your concerns.

Sincerely,


James M. Taylor
Executive Director
for Operations

Enclosures:

1. GAO Draft Ltr to
Congressman Ron Wyden
and Attachment 1
2. NRC Recommended Changes to
and Comments

Note: NRC provided suggestions to more accurately and precisely define technical terms and regulatory requirements. Since these comments do not affect our findings or recommendations, we are including only the cover letter. Copies of NRC's entire comments are available from GAO upon request.

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