Depleted Uranium Exposures to Personnel Following the Camp Doha Fire, Kuwait, July 1991

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Summary

On July 11 and 12, 1991, a fire engulfed a motor pool at the U.S. Army's Camp Doha, in Kuwait. This fire engulfed combat-ready military vehicles, including M1A1 tanks, Bradley Fighting Vehicles, and ammunition carriers, as well as stacks of stored ammunition. After the fire was out, this area remained extremely hazardous because some of the ammunition had caught fire or exploded from the heat and distributed unexploded ordnance (UXO) over a wide area. Although this UXO was far more hazardous and seriously life threatening, another type of potentially hazardous material was also left behind: the partially oxidized remains of DU penetrators from 120-mm series anti-armor rounds and the DU oxide dust generated by the heat of the fire. Depleted uranium is a mildly radioactive material and a heavy metal. This analysis of the Camp Doha fire focuses on the levels of DU to which workers may have been exposed and the resulting radiological and chemical toxicological risks to personnel from this exposure.

This report describes scenarios of how Army and contractor personnel may have been exposed to DU during and after the fire. The scenarios are based primarily on reports that described the conditions and activities that occurred during and after the fire. The assumptions and uncertainties used in constructing the scenarios are documented. The scenarios attempt to describe conservative but reasonable exposure conditions that may have existed at Camp Doha. During the fire, personnel may have inhaled DU that was entrained in the smoke plume from the fire. After the fire, personnel may have handled DU penetrators and ingested or inhaled DU-containing dust during the decontamination and cleanup activities that occurred in the months following the fire. The exposure scenario for the decontamination and cleanup activities consists of four major activities. The first activity involved the recovery work that preceded decontamination and cleanup. During this activity, DU was suspended in the air by wind erosion. The second activity involved the removal of DU oxide piles formed from burned DU penetrators. The third activity involved sweeping of the contaminated area, an action that would have caused DU dusts to be suspended in air. The fourth activity involved sweeping of the contaminated area a second time, during which, remaining DU would again have been suspended in the air by the sweeping action. After the second sweeping, essentially all DU was removed from the area.

This report also contains the results of dose calculations, both chemical and radiation doses, that may have been received by personnel who were downwind of the fire, and by personnel who participated in the decontamination and cleanup activities. Two types of calculation were performed for this study: exposure calculations and dosimetry calculations. The exposure calculations estimate the air concentrations of DU to which the personnel may have been exposed. The chemical dosimetry calculations estimate the maximum concentration of uranium in the target organ due to the exposure scenario activities. For uranium, the target organ is usually identified as the kidney. The radiation dosimetry calculations estimate the CEDE that would have been received from activities described by the exposure scenario.

The results of the calculations of concentrations and doses from the scenarios during the fire and from post-fire activities, uncertainties encountered, and estimated doses are described below.

Exposure from DU Oxides in the Fire Plume

- During the phase of the fire that produced the highest uranium air concentrations, the estimated average air concentration was 3.5×10^{-7} g-U/m^3 at the location of highest concentration. This concentration is well below the ACGIH limit of 2×10^{-4} g-U/m^3 for workers exposed daily to uranium in air and represents a low concentration. This air concentration is also below the NRC limit for exposures of the general public to insoluble uranium. No workers were reported to have been present (or remained) in or near this area during the fire.

- The maximum radiological dose to a worker located in the position of highest air concentration for the full duration of the fire was calculated to be 0.000003 rem (CEDE), well below the annual limit of 0.10 rem for exposure by a member of the public.

- The chemical dose assessment estimated the maximum concentration to the kidney of a person located at the position of highest air concentration for the duration of the fire would have been approximately 2.8×10^{-7} µg-U/g of kidney. This concentration is well below 3 µg-U/g of kidney, which is the concentration of uranium in the kidney thought to cause kidney damage in humans.

Exposures and Doses from Recovery and Cleanup Activities

- During the recovery and cleanup activities, the estimated air concentrations ranged from 3.8×10^{-5} g/m^3 to 4.2×10^{-4} g/m^3. These air concentrations, when averaged over the course of a year, are below the NRC limit when adjusted for particle size distribution for occupational exposure to airborne uranium, but they are greater than the NRC limits for exposure of the general public to uranium. These estimated air concentrations are greater than 2×10^{-4} g/m^3, which is the ACGIH limit for continuous exposure to uranium (the TWA), but are lower than 6×10^{-4} g/m^3, the ACGIH limit for short-term exposures (TLV-STEL). The ACGIH air concentration limit was exceeded for only three weeks.

- The chemical assessment estimated that the maximum concentration of uranium in the kidney of the most highly exposed workers was 9.5×10^{-2} µg-U/g of kidney. This concentration is below 3 µg-U/g of kidney, which is the concentration of uranium in the kidney that is thought to cause kidney damage in humans. The estimated chemical dose is low even though the air concentrations were high because only small amounts of the uranium would be deposited in the lung; most of the dust particles were too large to be inhaled.

- The estimated radiological dose received by the most highly exposed workers was 0.065 rem. This dose is less than 0.1 rem, which is the NRC annual dose limit for individual members of the public.

Uncertainties Encountered

This study relied primarily on eyewitness accounts, some of which were conflicting. Also, because there was no air monitoring performed during these activities, it was necessary to estimate many quantities that were used to calculate the doses received.

- Although the total inventory of DU munitions was known, the quantity of DU oxide formed during the fire was not known. There were no measurement data to assist in this determination.

- The day-by-day location of each recovery worker was also not known. Only general descriptions of job categories and type of work performed were available.

- No resuspension factors have been measured specifically for DU. It was necessary to use resuspension factors from studies done with different materials.

- Particle size distribution greatly influences the chemical and radiological doses received by workers. The particle size distribution of the DU oxides that remained close to a burned penetrator was based on dust samples from two penetrators that were burned in a wood and diesel fuel fire. It is assumed, but not certain, that the particle size distribution of DU oxides from the test burn is similar to that of the Camp Doha fire oxides.

Estimated Doses

The estimated chemical and radiation doses to personnel who were at Camp Doha during the fire and who participated in the decontamination and cleanup activities following the fire are low. The estimated doses are all below the limits set by U.S. regulatory agencies. The estimated air concentrations of DU oxide to which the workers may have been exposed were high, but only for a few weeks rather than for a full year. The estimated chemical exposures that occurred during decontamination of the area and the first sweeping exceeded the ACGIH limits, but for only 2 weeks. The estimated chemical dose, represented by the concentration of uranium in the kidney, did not exceed the recommended limits. The radiological exposures did not exceed the limits for occupational exposure to airborne uranium. The radiological exposure limits for exposure of members of the general public were exceeded but only for approximately 3 weeks. The radiological dose received by the most highly exposed group of individuals did not exceed the dose limit for members of the general public.

Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ALI	annual limit on intake
AMAD	activity median aerodynamic diameter
AMCCOM	Armament Munitions and Chemical Command
ARF	airborne release fraction
BDAT	Battle Damage Assessments Team
CEC	Combat Engineer Company
CECOM	Communications-Electronics Command
CEDE	committed effective dose equivalent
CHPPM	Center for Health Promotion and Preventive Medicine
DAC	derived air concentration
DIL	derived investigation level
DU	depleted uranium
ECC	Environmental Chemical Corporation
EOD	Explosive Ordnance Disposal
gsd	geometric standard deviation
GI	gastrointestinal
ICRP	International Commission on Radiological Protection
MEPAS	Multimedia Environmental Pollutant Assessment System
NBC	Nuclear-Biological-Chemical
NCRP	National Council on Radiation Protection and Measurements
OSAGWI	Office of the Special Assistant for Gulf War Illnesses
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
PPE	personnel protective equipment
RADCON	radiological control
TLV	threshold limit value
TLV-STEL	threshold limit value – short-term exposure limit
TLV-TWA	threshold limit value - time-weighted average

UN	United Nations
UXO	unexploded ordnance

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