DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF STAFF
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WASHINGTON DC 20310-0200

REPLY TO
ATTENTION OF

Army Safety Office

25 July 2005

FOR MEMORANDUM FOR Nuclear Regulatory Commission, Division of Industrial and Medical Nuclear Safety, Office of Nuclear Material Safety and Safeguards, Washington, D.C. 20555-0001

SUBJECT: Receipt of 10 CFR 2.206 Petition

Dear Ms. Holahan,

The U.S. Army manages radioactive material, included depleted uranium, under the authority of several Nuclear Regulatory Commission (NRC) licenses. These include licenses authorizing testing, storage, transportation, and use of depleted uranium. Instead of inundating the NRC with comments from each licensee, the Army has consolidated comments in reply to the allegations stated in the NRC letter dated 10 June 2005, subject: Receipt of 10 CFR 2.206 Petition. Rather than reply to each allegation, especially since many were repeated several times in various forms, the Army is responding to what we believe is the intent of the petition. Our major substantive & technical comments are attached.

We have also attached a copy of the DU Capstone Fact Sheet that provides specific answers to many of the questions surfaced in the 2.206 petition.

Please contact me at 703-601-2405 if you have any further questions.

2 Enclosures

GREGORY R. KOMP, CHP
Army Radiation Safety Officer

17 Jul 05

US Army Review and Comments
on
10 CFR 2.206 Petition to the U.S. Nuclear Regulatory Commission (NRC)
from
Mr. James Salsman
16 March 2005 [as amended 18 April 2005]

The U.S. Nuclear Regulatory Commission (NRC) has received a petition from James Salsman requesting "that all licenses allowing the possession, transport, storage, or use of pyrophoric uranium munitions be modified to impose enforceable conditions on all such licensees in order to rectify their misconduct..." Additional information is described in detail in the petition.

It is the policy of the NRC under Section 2.206 of Title 10 of the Code of Federal Regulations (10 CFR 2.206) to provide members of the public with the means to request action to enforce NRC requirements. The NRC has determined that the petition meets the criteria for handling under 10 CFR 2.206.

The NRC has requested the Army respond to the petitioner's safety concerns within each Army organization's areas of responsibility which fall under NRC jurisdiction. For those concerns which do not fall under NRC jurisdiction, the Army need not respond to the NRC, but may take other action as it deems appropriate.

The US Army has reviewed Mr. Salsman's petition and provides the following comments regarding his allegations:

Major Substantive & Technical Comments

1. Issue: Mr. Salsman cites many scientific research studies on DU health effects throughout the document. However, the most relevant medical surveillance program involving depleted uranium (DU) exposure and the results of this program is not mentioned at all in the petition.

Comment: Many research studies and data are mentioned throughout the document; however, the most relevant cohort of individuals with depleted uranium fragment injuries from Operation Desert Storm who are undergoing long-term medical surveillance at the Department of Veterans Affairs (VA) Baltimore Medical Center have not been mentioned. These individuals with retained fragments that contain DU also had to have had inhalation exposures to the DU compounds formed when the DU penetrator interacted with their armored vehicles. Additionally, and more recently, individuals from Operation Iraqi Freedom with fragment injuries and elevated levels of DU in their urine have also been referred to the VA DU Medical Surveillance and Follow-Up Program run by Dr. Melissa McDiarmid at the Baltimore Veterans Administration Medical Center.

The key point regarding the clinical assessments on these individuals is that no health effects attributable to DU have been observed in the cohort. Dr. McDiarmid's publications regarding this medical surveillance of our Gulf War Veterans include:

- Melissa A. McDiarmid A2, Susan Engelhardt A1, Marc Oliver A2, Patricia Gucer A2, P. David Wilson A3, Robert Kane , Michael Kabat , Bruce Kaup , Larry Anderson A6, Dennis Hoover A6, Lawrence Brown , Barry Handwerger A2, Richard J. Albertini A7, David Jacobson-Kram A8, Craig D. Thorne A2, Katherine S. Squibb, **Health Effects of Depleted Uranium on Exposed Gulf War Veterans: A 10-Year Follow-Up**, Journal of Toxicology and Environmental Health Part A, Taylor & Francis, Volume 67, Number 4 / February 27, 2004, Pages: 277 – 296.
- McDiarmid MA, Squibb K, Engelhardt S, Oliver M, Gucer P, Wilson PD, Kane R, Kabat M, Kaup B, Anderson L, Hoover D, Brown L, Jacobson-Kram D; **Depleted Uranium Follow-Up Program, Surveillance of Depleted Uranium Exposed Gulf War Veterans: Health Effects Observed in an Enlarged "Friendly Fire" Cohort**, Journal of Occupational Environmental Medicine, 2001 Dec; 43(12):991-1000.
- McDiarmid MA, Hooper FJ, Squibb K, McPhaul K, Engelhardt SM, Kane R, DiPino R, Kabat M., **Health Effects and Biological Monitoring Results of Gulf War Veterans Exposed to Depleted Uranium**, Journal of Military Medicine, 2002 Feb; 167 (2 Suppl): 123-4.

An additional journal article is by Dr. JPG Bolton:

- Bolton JPG; Foster CRM; **Battlefield Use of Depleted Uranium and the Health of Veterans**, Hodder Arnold Journals, Trauma, 1 June 2002, vol. 4, no. 1, pp. 1-10(10).

In response to Mr. Salsman's allegations, potential health effects do depend on the amount and physiochemical form of the material reaching the organs and tissues of interest. Data exist from uranium miners, millers, processors, and perhaps populations living in areas with high levels of background uranium and whose body burdens of uranium were/are much higher than all but, perhaps, the fragment patients.

The Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile for Uranium (Update), 1999, is a comprehensive review, but it may be viewed as out-of-date by some and it does not seem to cover residents in areas with a high natural uranium background. The profile states in Section 2.5, Relevance to Public Health, on page 205 that, based on the findings for uranium miners, millers, and processors, it is "doubtful that human exposure to uranium compounds at or near hazardous waste sites could result in interference with normal reproduction... [or] normal development." The ATSDR profile is less clear on genotoxic effects. Dr. Melissa McDiarmid of the Baltimore Veteran Administration has reported 65 to 70 healthy babies parented by Soldiers with confirmed DU shrapnel injuries from the first Gulf War.

2. Issue: Another significant source of DU aerosol information and data is the Army's Capstone DU Aerosol Study and Human Health Risk Assessment, which Mr. Salsman does not mention in his petition. This report can refute many of Mr. Salsman's allegations that there is a lack of knowledge on the chemical composition of DU aerosols and can provide other references for literature searches in its extensive bibliography (report is available at http://www.deploymentlink.osd.mil/ du library/du_capstone/index.pdf).

Comment: Nationally and internationally recognized aerosol physics experts designed and reviewed the aerosol sample collection systems and results. The Capstone aerosol samples underwent x-ray diffraction analyses to identify the uranium compounds in the aerosols based on crystalline structure. Crystalline structures from the DU aerosols were compared to the Inorganic Crystalline Structure Database (ICSD). Specific uranium compounds for which the aerosol patterns were compared included UO_3 and U_3O_8; however, the UO_3 pattern overlaps with the U_3O_8 pattern. Therefore, U_3O_8 was definitely in the DU aerosol; however, it could not be determined if UO_3 was in the aerosol. The results were reported as U_3O_8/UO_3. Chemical form may be used to assign expected lung dissolution factors if tests are not performed to determine solubility in lung fluid; however, the Capstone aerosols were used for *in vitro* dissolution tests. These tests determined the solubilities of the various particle-sized aerosols in simulated lung fluid. The particle size separated aerosol dissolution factors were then used in the modeling of the chemical and radiological doses to Reference Man. Using the results of the *in vitro* dissolution tests takes into account the solubilities of the aerosol regardless of the chemical form and is more accurate than predicting the solubility(ies) solely on the chemical form(s), especially for heterogeneous aerosols as produced in the Capstone DU Aerosol Study. Mr. Salsman appears to be unaware of the many studies conducted by the National Laboratories evaluating DU at the DTC (formerly TECOM) test centers between 1979 and 2001. Although, Mr. Mishima was a primary researcher in the studies he cited in his complaint, Mr. Mishima was not the primary researcher studying DU on our test ranges.

3. Issue: Cloud behavior or colligative effect of high concentration aerosols. Even though very small particles may be formed, they may behave as a much larger particle due to their very high concentration and close proximity when they are initially formed.

Comment: When very high concentrations of aerosols are generated, they are likely to behave initially as a cloud rather than an aerosol. Work by Phalen et al. (**Cigarette Smoke Deposition in the Tracheobronchial Tree: Evidence for Colligative Effects**, Aerosol Science and Technology, 20(2) 215-226) on cigarette smoke indicates that mainstream smoke, consisting of 0.45 micrometer (μm) particles, deposited as if it consisted of 6.5 micrometer (μm) particles when highly concentrated in the mainstream puff. These effects were due to what was termed cloud behavior of colligative effects, where particles are close enough to one another to affect

particle motion. Very high initial DU concentrations were measured in the Capstone Aerosol Study.

4. Issue: A quote by Mr. Salsman states "...Probably monomolecular, UO3" a single gas molecule of UO3. How much deposition/absorption will occur in the lung?

Comment: From International Commission on Radiological Protection (ICRP) Publication 66:

> *"As extremely small, 'ultrafine' particles approach molecular size they tend to behave more like a vapour [sic]. When less than about 1 nm in diameter, ultrafine particles tend not to stick to each other or surfaces on collision. ... Conversely, ultrafine particles larger than about 10 nm generally stick when they contact another surface. ... True gas molecules do not tend to stick to a surface; they immediately rebound to the air upon contact. However, when the surface is a liquid in which the gas is soluble, molecules have some probability of being absorbed."*

There is some question regarding the behavior of "gaseous" UO_3. Will it behave as a "true gas" or will it behave as a molecule or a solid? When this issue is combined with the colligative effects mentioned above, discussion of the behavior of UO_3 becomes complex. With regard to potential health effects, what matters most is how much of the material reaches the tissues or organs of interest.

The simulated lung fluid used in the Capstone *in vitro* dissolution tests was maintained at a pH of 7.3. The UO_3 is soluble in acid and insoluble in water. Therefore, if UO_3 gas molecules are formed and are taken into the respiratory tract, and the pH of the simulated lung fluid is similar to the lung fluids in which the UO_3 gas molecule comes into contact, the UO_3 molecule may not be absorbed.

The paper cited by Mr. Salsman in his petition, **Free Energies of Formation of the Gaseous Uranium, Molybdenum, and Tungsten Trioxides**, by Ackerman et al., determined the vapor densities of the gases by passing oxygen through the powdered solid [U_3O_8]. This may not be an appropriate comparison for the reactions of DU penetrators as they react upon impacts with armored vehicles.

5. Issue: Oxidation state of DU recovered in range and soil samples.

Comment: As stated earlier, Mr. Salsman is unaware of our many DU studies and is not aware that we have examined the oxidation state of the DU recovered from the range and in soil samples. DU metal in the ammunition is in the zero oxidation state, U(0). It is thermodymically

unstable and will oxidize to U(IV) and U(VI) in the natural environment according to the following reactions:

$$U(0)+O_2=U(IV)O_2 \quad (1)$$

$$U(0)+2H_2O=U(IV)O_2+2H_2 \quad (2)$$

$$U(IV)O_2+\tfrac{1}{2}O_2=U(VI)O_3 \quad (3)$$

$$U(IV)O_2+\tfrac{1}{2}O_2+2H_2O=U(VI)O_3\bullet 2H_20 \quad (4)$$

$$U(IV)O_2+2H^++\tfrac{1}{2}O_2=U(VI)O_2^{+2}+H_2O \quad (5)$$

It should be noted that although we expect uranyl oxide, UO_3, to be formed, we have not identified it in samples from the test ranges. Only uranyl oxide hydrate, schoepite, ($UO_2(OH)_2\bullet 2H_2O$), has been identified. Several studies published in journals identified this hydrated mineral in experiments involving UO_2(s) and various uranyl complexes under various conditions (Duff et al. 2002; Finch et al. 1996; Fredrickson et al. 2000; Froideval et al. 2003; Morris et al. 1996; Torrero et al. 1994).

6. Issue: The issue of Iraq environmental clean-up of DU contaminated sites and equipment is outside the jurisdiction of the NRC, DOD, and the Army.

Comment: However, the United Nations Environment Programme (UNEP) has initiated a training program, which has a goal to teach and equip Iraqi scientists to survey, assess, and deal with DU environmental issues. Sensitive analytical equipment, such as ICP-MS, and training in using the equipment, to detect low levels of DU is expected to be provided to the Iraqi scientists in future phases of the UNEP program. The UNEP team, consisting of international scientists, has had an Army subject matter expert, at the U.S. State Department's request, participate and will have him continue to participate in the future in this training of Iraqi scientists.

7. Issue: Environmental monitoring at Army ranges.

Comment: The Army has environmental radiation monitoring plans (ERM) to monitor the potential transport of DU in the environment at those test ranges. Natural processes appear to attenuate the transport of the DU on the test ranges. Based on our ERM data and the long-term fate study conducted by LANL, the NRC removed ATC from the Site Decommissioning Management Plan list because we showed that DU on the ranges was not migrating to ground water (U.S. Nuclear Regulatory Commission 1996).Current studies at the Johns Hopkins Universtiy that are not yet published, found that DU at APG complexes with and/or sorbs to natural organic matter, clays, and ferric oxyhydroxide minerals in APG soils. We take exception to Mr. Salsman's stating that DU is environmentally toxic and conflicts with study results

(Ebinger et al. 1996; Oxenberg 1997). Additionally studies indicate that removal of residual DU from the test ranges would adversely affect the environment and the health and safety of decommissioning workers by increasing the rate of erosion and causing a detrimental imbalance to the ecosystems and risking life or limb to workers from their exposure to unexploded ordnance (Oxenberg 1997).

8. Issue: Impact of uranyl nitrate on workers exposed to DU..

1. Comment: The petitioner seems overly concerned about the hazards of uranyl nitrate to workers exposed to DU. He states the reaction occurs at 700 °C (1292 °F). The reaction cannot occur between the DU on the test ranges and the nitrogen in the surrounding air because ambient temperatures are well below this temperature. The reaction may occur if there is breach in the gun tube during a failed test firing or after the DU round impacts armor during performance testing. However, a barrier shields the workers during the firing of the test weapon and armor testing is only conducted in our Superbox at the Aberdeen Test Center. All effluents are contained and filtered in the Superbox so that DU is not released to the unrestricted area. Workers cannot enter the Superbox without respiratory protection until DU air concentrations are below concern. Workers wear lapel monitors to monitor their breathing exposure to DU while working in the Superbox. All DU workers at ATC have annual bioassay to measure U concentrations in their urine.

- END OF ARMY COMMENTS -

Fact Sheet

A collaborative effort between the Air Force Institute for Operational Health, the Deployment Health Clinical Center, the Deployment Health Support Directorate, the Navy Environmental Health Center and the U.S. Army Center for Health Promotion and Preventive Medicine

U.S. Army Capstone Depleted Uranium Aerosols Study & Human Health Risk Assessment

For service members and their families

March 10, 2005

Summary:

- The Capstone Depleted Uranium Human Health Risk Assessment determined there would be little or no impact on the health of service members who breathe in DU dust particles while inside tanks or other vehicles hit by DU munitions.
- The Capstone DU Aerosols Study showed that operating vehicle ventilation systems are very effective in reducing DU particle concentrations and, therefore, reducing potential DU exposures to personnel inside the vehicles.
- The Departments of Defense and Veterans Affairs are committed to fully addressing the health concerns of individuals with DU exposures. DoD continues to screen personnel for DU exposure and the VA continues to monitor those with confirmed DU exposures for possible long-term health problems.
- Depleted uranium weapons and armor save U.S. service members' lives by providing more effective weapon systems on the battlefield.

What is depleted uranium? What is different about depleted uranium and natural uranium? How is depleted uranium used?

Depleted uranium is a form of uranium, a naturally occurring, slightly radioactive heavy metal found in many parts of the world. DU is the byproduct of enriching uranium for use in nuclear weapons and nuclear power plants. It is 40 percent less radioactive than natural uranium. People are routinely exposed to natural uranium in food, water, and air. The health effects of natural uranium, which has the same chemical properties as DU, are very well understood and are based on 50 years of scientific research.

The military uses DU in armor penetrating munitions fired by Abrams tanks, Bradley Fighting Vehicles, and several aircraft systems. Depleted uranium is also used as armor for Abrams tanks. Commercial uses of DU include aircraft and sailing ship counterweights and radiation shielding of industrial and medical radiation sources.

How might service members be exposed to DU?

Service members might be exposed to DU when they occupy vehicles hit by DU munitions, rescue occupants from those vehicles, or perform other operational duties involving these vehicles (equipment removal, repair, salvage, etc.). Exposures can occur when someone is wounded and retains fragments that contain DU in his or her body, or breathes air containing DU dust, or transfers DU dust from contaminated surfaces to the mouth or to open wounds. DU must be taken into the body to be a potential health hazard.

What was the Capstone DU Project and why was it done?

The Capstone DU Project was composed of both the Capstone DU Aerosols Study and the Capstone DU Human Health Risk Assessment. The Capstone DU Project was sponsored by the U.S. Army (Heavy Metals Office and USACHPPM) and the DoD Deployment Health Support Directorate. Its purpose was to provide a peer-reviewed, rigorous scientific estimate of any health risks associated with breathing DU particles. The study focused on service members who may have been in or around armored vehicles when hit by large-caliber DU munitions. While the health hazards of DU are well understood, the military recognized that more information was needed about the DU aerosols inside armored vehicles to predict possible health risks from aerosol exposure.

The Capstone DU Project had two major phases:

- The first phase, the Capstone DU Aerosols Study, involved the collection and comprehensive analysis (particle size, air concentration, etc.) of DU aerosols produced in an Abrams tank and a Bradley Fighting Vehicle struck by large-caliber DU munitions. Aerosol particles were collected and analyzed to determine the air concentration, the DU content and other characteristics of the resulting DU particles affecting their ability to be inhaled and absorbed by the body.
- The second phase, the Capstone DU Human Health Risk Assessment, used the data from the first phase to calculate radiation doses and possible DU concentrations in the body. The exposures were based on the amount of time crewmembers were expected to remain inside their vehicles after

it was struck. This information was then combined with comprehensive reviews of uranium's hazards by scientific organizations from around the world to identify any resulting potential health effects.

- The cost of this project was more than $6 million.

Who did the Capstone DU Project?

The Capstone DU Project was conducted by a multidisciplinary team of government (U.S. Army Aberdeen Test Center, U.S. Army Armament Research, Development, and Engineering Center, and USACHPPM) and master scientists from Battelle Memorial Institute, Pacific Northwest National Laboratory, Los Alamos National Laboratory, and the Lovelace Respiratory Research Institute. The test plans, methodologies and scientific reports were all peer-reviewed by an independent team of U.S. nationally recognized experts.

What were the Capstone DU Project results, and what do they mean?

The Capstone DU Human Health Risk Assessment determined that health risks associated with breathing in DU particles would be very low, even for service members inside tanks or other vehicles hit by DU munitions, and that there would be little or no impact on their health. Long-term adverse health effects are not expected in service members with DU exposures comparable to the Human Health Risk Assessment exposures.

The Capstone DU Aerosols Study confirmed the value of ventilation in reducing possible exposures to DU aerosols and clearly showed that simply getting out of DU struck vehicles, if operational conditions permit, provides a way to significantly minimize exposure.

Is medical testing available to service members who were potentially exposed to DU?

Yes. DoD policy requires that all personnel, including those wounded, who were in, on, or near (less than 50 meters) a combat vehicle at the time it was struck by DU munitions and all personnel who entered the vehicle immediately after it was struck (e.g., to attempt rescue of personnel) be tested. These personnel are required to complete a DU exposure assessment form and have a 24-hour urine test as soon as feasible. Also, all service members with specific military occupational specialties, who were required to enter multiple vehicles damaged by DU munitions, are also required to complete a DU exposure assessment form and have a urine test. Most often this occurs at the time of redeployment to the service member's home station. All other personnel with possible contact with DU are categorized as "incidentally-exposed," and no urine DU testing is required because their exposure, if any, will be minimal. Service members with incidental DU exposures, who desire to be tested, may request a test when consulting with a healthcare provider. Active duty personnel may request this test at a military treatment facility. Veterans who are separated may request this test at a VA Medical Center. Service members who test positive for DU are offered referral to the Veterans Affairs Depleted Uranium Medical Follow-up Program at the Baltimore VA Medical Center.

Where can I obtain answers regarding specific technical questions?

The full-text reports from the Capstone DU Aerosols Study & Human Health Risk Assessment, as well as other information about DU, can be found at:
http://deploymentlink.osd.mil/du_library/

For specific technical questions on the Capstone DU Aerosols Study & Human Health Risk Assessment, contact the DoD Health Affair's Deployment Health Support Directorate. For specific military service-related issues with DU policies, operations, and health issues, contact the service points of contact listed below.

Where Do I Get More Information?

Air Force Institute for Operational Health (AFIOH)
Phone: (888) 232-3764
http://www.brooks.af.mil/afioh/

DOD Deployment Health Clinical Center (DHCC)
Phone: (866) 559-1627
http://www.pdhealth.mil/

DOD Deployment Health Support Directorate (DHSD)
Phone: (800) 497-6261
http://www.deploymentlink.osd.mil

Navy Environmental Health Center (NEHC)
Phone: (757) 953-0700
http://www-nehc.med.navy.mil

U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM)
Phone: (800) 222-9698
http://chppm-www.apgea.army.mil

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Enclosure

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