

Leukemias from Military Use of Depleted Uranium

Bernard L. Cohen

There has been a great deal of media publicity recently about leukemias induced by military use of depleted uranium (DU) in Bosnia and Kosovo. DU is used in anti-tank shells because of its high density (1.7 times the density of lead) allows it to penetrate tank armor; the principal alternative, tungsten, is more expensive. The high density and abundant availability of DU leads to other uses where packing a lot of mass into a small volume is advantageous, like counterweights in missiles and in airplanes (including the Boeing 747), in sailboat keels, and as protective armor for tanks. It is especially useful for radiation shielding as its high atomic number makes it much more effective than lead for X-rays and low energy gamma rays.

When a shell tipped with DU penetrates the armor of a tank, it often becomes heated to 500-1000 °F at which uranium ignites and burns, producing a very fine dust which may be inhaled. Inhalation of this dust is the principal source of potential radiation exposure from DU. Maximum exposure would occur immediately after, and close to, the burning, but the dust disperses for possible inhalation at distant locations, it settles on surfaces from which it can later be resuspended leading to additional inhalation, contaminate vegetation later used for food, or migrate down into the ground to be picked up by plant roots to get into food supplies.

There has been extensive publicity about trace amounts of plutonium and other transuranics in the DU. These arise from the fact that the isotope enrichment plants from which the DU was derived were used to enrich uranium in reprocessed spent fuel from the government production reactors at Hanford and Savannah River. The transuranics were chemically removed in the reprocessing, and were further reduced in the conversion of uranium to the hexafluoride gas used in the enrichment process, but tiny traces may have remained. The United Nations Environmental Program (UNEP) reported that four samples of DU from Kosovo contained Plutonium levels between 0.8 and 12.9 Bq/Kg; the latter corresponds to less than one alpha particle emitted from Pu per million alphas from the DU, and a fraction of Pu by mass of about 5 parts per trillion. The health impacts of this slight contamination would add far less than one percent to those of the DU., so I ignore the Pu contamination here.

I begin by explaining how Health Physicists evaluate hazards of this type, and will present the findings of various investigations as reported in the media. UNEP considers the maximum credible quantity of DU inhaled to be 100 mg. Inhalation of 1000 mg of any dust causes death by choking; the highest air pollution levels in cities (15 times the alert level) are 1 mg/m³ which would lead to inhalation of about 20 mg per day. I therefore accept the UNEPs 100 mg of DU inhaled.

Health Physics is heavily concerned with determining radiation exposures from inhaled and ingested radionuclides, and for this purpose acquire data to determine their behavior in the human body. This information is continuously collected and evaluated by task groups of the International Commission for Radiological Protection (ICRP), and I will use their numbers [1]. When the very fine particulates of uranium oxide formed from burning DU are inhaled, 25% of the inhaled deposits in the nose and pharynx, 8% deposits in the trachea and bronchi, and 25% deposits in the pulmonary region. From the pulmonary, 40% goes to the G-I tract within about 1 day, another 40% goes to the G-I tract after an average time of 500 days, 5% goes into the blood stream with a 500 day time constant, and the remaining 15% goes into lymph nodes from which 90% eventually gets into the blood stream after about 1000 days. Of the DU deposited in the nose, pharynx, trachea, and bronchi, 99% rapidly goes into the G-I tract and only 1% gets directly into the blood stream. Of the material that goes into the G-I tract, only 0.2% goes through the intestine walls into the blood stream. Putting these numbers together tells us that about 5 mg of DU get into the blood stream. According to ICRP, 2.3% of this, 0.12 mg, deposits in the bone where it stays for an average of 5000 days.

The next step is to calculate the dose to the bone. For beta or gamma rays, the dose in rem is defined as an energy deposit of 0.01 joules/kg, but alpha particles are taken to be 20 times more biologically effective, so 1 rem is 0.0005 j/kg. As the average mass of the bone is 5 kg, the dose in rem is 0.0025 times the energy deposit. Calculating the

energy deposit is straightforward physics: from the half life, DU emits 39 alphas/s-mg; the alpha energy is 4.2 MeV; the residence time is 5000 days; multiplying these and conversion factors, MeV to J, days to seconds, we find that the 0.12 mg deposited gives a dose to the bone of 0.6 rem. From measurements on natural uranium, which is found in all our bodies, the dose to the bone marrow is found to be 15% of the dose to the bone, or about 0.1 rem. The lifetime risk of leukemia from exposure to bone marrow is known from the Japanese A-bomb victims to be 10^{-4} /rem, so our final result is that inhalation of 100 mg of DU would give a lifetime leukemia risk of $0.1 \times 10^{-4} = 10^{-5}$, of which only about 10% would be expected after such a short time. Since there were far less than one million NATO soldiers stationed in Bosnia and Kosovo, we would expect less than one case of leukemia by now even if all of them were exposed at our maximum credible level of DU.

Health Physicists have procedures for calculating exposures from clouds of dust as they are blown by the wind, from deposition on the ground and later resuspension, for migrating down into the ground, for pick-up by plant roots and accumulation in food, etc but there is not space to describe them here. UNEP has gone through such analyses, and I will quote their results for maximally exposed individuals [2]:

- Inhalation*: effective dose including all body organs
 < 1 rem, which corresponds to a lifetime cancer risk of <0.001.
 None except leukemia would be experienced for at least 10 years.
- Resuspended inhalation* (assuming all time spent in the most contaminated area)
 0.1 rem first year, decreasing rapidly thereafter.
- Ingestion via contaminated food, water, hands in mouth*
 <1 rem/y (Note that it would be easy to detect this and avoid further exposure)
- Picked up pieces of solid DU carried in pocket for several weeks*
 ·*No skin burns, no important health problems*

All of the above discussion is based on paper studies; I now turn to experimental studies with measurements. UNEP sent teams of investigators to Bosnia and Kosovo in 1999 and again in 2000. They reported no elevated radiation near destroyed military vehicles or along the roads they traveled. In response to publicity about their soldiers who had served in the Balkans suffering from leukemia and other diseases, Italy, Germany, Portugal, and the Czech Republic each sent teams of investigators and each reported in press releases that they had found no increased levels of radiation in areas where their troops had operated. In a Jan. 24, 2001 press conference, NATO stated that more than a dozen nations tested soldiers or sent teams to Bosnia and Kosovo, and none of them found any indication of increased radioactivity. NATO further stated that they had convened a committee of 50 nations and that committee concluded that there was no evidence for DU causing cancer, and that soldiers who had served in Bosnia and Kosovo were no sicker than soldiers who had not served there. Investigators for the German and Portuguese governments each concluded that there was no link between DU and diseases reported by soldiers. An investigation by the United Nations in collaboration with World Health Organization concluded that there is no evidence for DU related medical cases in Kosovo, and that there was no excess of leukemia cases in Kosovo hospitals; it also pointed out that there had been no excess of leukemia among those exposed in the Chernobyl accident where tens of thousands of people had been exposed to far more radiation than anyone got from DU in Kosovo.

Two U.S. studies are relevant to this issue. A group of 50 American soldiers who were hit by friendly fire involving DU in the Gulf War have been followed for the past 10 years by researchers from University of Maryland. They have DU fragments in their bodies that are still dissolving, and they have high DU levels in their urine. They have had no leukemias or other cancers, and aside from hormonal problems that have not disappeared, they have had no unusual health problems. They have fathered 38 children, all without birth defects.

The other U.S. Study involves following 78,000 workers involved in milling and processing uranium since the 1940s;

there has been no excess leukemia among them. The World Health Organization stated that these were exposed, on average, to more than twice as much radiation as the most exposed soldiers in the Balkans.

Bernard L. Cohen
University of Pittsburgh
blc+@pitt.edu

References:

1. Limits for intakes of radionuclides by workers, ICRP Publication 30, Pergamon Press (Oxford); 1979. There have been more recent updates but they have increased complexity that would not be appropriate for the discussion here.
2. J.O. Snihs and G. Akerblom (Swedish Radiation Protection Institute) in SSI News, Dec. 2000, available at www.ssi.se)