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Radiation from Depleted Uranium

Depleted uranium (DU) has been used by the USA military and other NATO forces as a kinetic projectile and as armour plate in tanks. DU also has had a number of civilian applications, such as use as a counterweight in aircraft. Depleted uranium potentially is a health hazard to humans due to its chemical nature as a heavy metal and due to its radioactivity.

The purpose of this SOP bulletin is to consider the issue of potential exposure to radioactivity from DU in Australian Defence Force (ADF) personnel.

Activities such as handling DU munitions or being in close proximity to DU armour may result in low level irradiation of the skin, but will not cause significant internal exposure to ionising radiation.

Potential risk to internal organs and structures comes from exposure to aerosolised, particulate or fragmented DU generated by the impact of DU projectiles or an impact upon DU armour. Such exposure potentially occurred in some ADF personnel with service in the Middle East (Iraq in particular) or the Balkans.

A number of Repatriation Medical Authority (RMA) SOPs include factors for exposure to ionising radiation. These factors specify a minimum dose (in Sieverts) of ionising radiation and may also include a necessary latency period. For example, the SOPs for malignant neoplasm of the brain, Nos 37, 38 of 2011, require exposure to a cumulative equivalent dose of ionising radiation to the brain of at least 0.1 Sievert at least two years before clinical onset (reasonable hypothesis standard), or at least 0.5 Sievert at least two years before clinical onset (balance of probabilities standard).

This cumulative dose excludes normal background radiation but covers ionising radiation from other sources, including any exposure to radiation from depleted uranium. As such, at issue is the probable ionising radiation dose accumulated by a veteran at the target organ in excess of normal background radiation, as a result of depleted uranium exposure (on the surface of the skin, inhaled, ingested, and embedded in the body tissue through shrapnel).

Note that this assessment of the ionising dose accumulated from depleted uranium to the target organ would need to be combined with other sources of ionising radiation, being:

- Diagnostic radiation to the organ – Xrays, CT scans, radionucleotide bone scans but not MRI scans or Ultrasound scans.
- Therapeutic radiation to the organ – usually for the treatment of cancer.
- Cosmic radiation
- Nuclear bomb radiation
- Nuclear accident radiation
- Occupational radiation to the organ

Note also the 2011 SOP bulletin 151 on 'ionising radiation', SOP bulletins 42 (2000) and 106 (2006) on 'Atomic radiation' and the 2010 SOP bulletin 145 'Atomic radiation update: British nuclear test participants'.

Depleted uranium is a by product of uranium enrichment or uranium reprocessing of fuel for nuclear reactors. Sztajnkryer and Otten (2004, pp. 212-213)[1] states "DU typically contains 70% less ^{235}U and 80% less ^{234}U than naturally occurring uranium" and thus "By its very nature DU contains only 50 to 60% of the radioactivity of naturally occurring uranium". Depleted uranium is chemically the same as uranium but is 40-50% less radioactive than non-depleted uranium.

Uranium with its different isotopes and with the decay products, provides alpha particle emissions, beta particle emissions and gamma ray emissions. The predominate emission is alpha particles.

With the external exposure of the human body to uranium, Marshall (2008, p. 101) states "alpha particles from external sources cannot penetrate the dead skin layer of the body and do not present a health hazard to humans" and the beta particles do not penetrate beyond the skin but can cause skin burns or increase the risk of skin cancer.

However the human body can also be internally exposed to uranium, via inhalation of uranium particles, ingestion of particles, or by embedding of uranium shrapnel fragments within body tissue. Again the major effect of internally exposed uranium is via alpha particle emissions and the range of alpha particle emission in the body tissue is very small. Cember(1989, p. 107)[2] states "In air, even the most energetic alphas from radioactive substances travel only several centimeters, while in tissue, the range

[1] Sztajnkrycer, M. and Otten, E. 2004, 'Chemical and radiological toxicity of depleted uranium', **Military Medicine**, March, vol. 169, pp. 212-216.
[2] Cember, H. 1989, **Introduction to Health Physics**, Pergamon Press, New York.

of alpha radiation is measured in microns (1 $\mu = 10^{-4}$ cm)" and Bomford *et al* al (1993, p. 60)[3] states "The maximum range of alpha particles in tissue is always less than 0.1 mm".

The current 'Fact sheet' provided by the Australian Government Department of Defence titled 'Depleted Uranium'[4] (also appended to this SOP bulletin) states that "The ADF has deployed a Hazard Assessment Team to Iraq to identify and evaluate the environmental and occupational threats, including DU, to ADF personnel within the Al-Muthanna Province". "On the basis of this information, Defence considers that there is very low risk of adverse health effects from DU in Al-Muthanna" and "based on this risk assessment, Defence Health Services did not require ADF personnel to wear radiation dosimeters". Additionally, "The ADF directly monitors the health of Australian troops and offers elective post-deployment Uranium screening tests, primarily to allay concerns that may otherwise arise of perceived risk of exposure to DU" and "all tests conducted have returned negative results".

The ADF Policy on depleted uranium health screening (2003)[5] (also appended to this SOP bulletin), states "Personnel in categories 1 and 2 are considered to be at higher risk and should be offered urinary screening" and "this urinary screen can indicate whether a person has been exposed to uranium beyond the expected background environmental exposure".

As such it is the policy of the ADF, that unless the veteran is in category 1 or 2, the level of DU exposure would not be greater than the normal background exposure.

Category 1 is defined as "personnel who were in, on or near (less than 50 m) an armoured vehicle at the time the vehicle was struck".

Category 2 is defined as "personnel in, or near (within 50 m) a fire involving DU munitions, or personnel who regularly entered damaged/ destroyed vehicles".

If the veteran fulfils the criteria for category 1 or 2 depleted uranium exposure, the ADF will have taken a urine sample post deployment within 180 days of the contended exposure event. The sample would have been sent to the Australian Nuclear Science and Technology Organization Environment Division for assay of the Uranium and the respective isotopes, and the veteran will have been informed of the results and their requirement for follow-up. As such a copy of these results should be sought from the ADF.

Similarly, in the published sound medical scientific literature, Marshall (2008)[6] examined the probable depleted uranium body dose and accumulated ionising radiation using the USA Department of Defence categories (1, 2 and 3) of potential uranium exposure. Marshall (2008, p. 99) states "All but about 10% of the inhaled

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[3] Bomford, C., Sherriff, S., Kunkler, I. 1993, **Walter and Miller's Textbook of Radiotherapy - Radiation Physics, therapy and oncology**, Churchill Livingstone, Edinburgh.
[4] http://www.defence.gov.au/ips/parliament/qons/41st/senate/3001-3500/s3083_factsheet.pdf
[5] Director General Defence Health Service, 2003. 'Australian Defence Force policy on depleted uranium health screening', **Health Bulletin No. 7/2003**, Defence.
[6] Marshall, A. 2008, 'Gulf war depleted uranium risks', **Journal of Exposure Science and Environmental Epidemiology**, vol. 18, pp. 95-108.

DU is either exhaled or rapidly cleared (~1 day) by ciliary action and blood absorption followed by excretion in the urine and feces". "Most of the 10% of DU remaining in the lung after 1 day will eventually be absorbed by the blood, and all but about one third of the DU absorbed by the blood will be excreted rapidly in the urine". "Thus, about 3% of the inhaled DU will be redeposited in the kidney, bones, and other organs". "The DU deposited in these other target organs will be eventually reabsorbed by the blood and excreted in the urine or redeposited among various organs". "Within less than 2 years, only 1% of the inhaled DU is retained".

As such, the ionising radiation suffered by the target organ which is the subject of the veteran's claim, would be the accumulated dose whilst the uranium is being cleared from the body over time. Note that only 1% of the depleted uranium is left in the body after 2 years.

Marshall (2008, pp. 100) state that the overall average equivalent dose of ionising radiation from the depleted uranium exposure for the following 50 years was:

Exposure	**Definition of category**	**Overall average (Sv)**	**Soft tissue, including brain (Sv)**
Level 1 exposure	Crew of targeted vehicle exposed to aerosolized DU particulate; or wounded by DU fragments; immediate rescuer personnel.	Inhalation only 0.015 Inhalation & fragment 0.019	Inhalation only 0.0005 (Max 0.008 Sv) Inhalation & fragment 0.005 (Max 0.035 Sv)
Level 2 exposure	Veterans involved in post combat evaluation of DU damaged vehicles, removal of equipment, preparation of vehicles for transport – dust settled but resuspended by activity.	0.0025 (Max 0.038 Sv)	
Level 3 exposure	Short term, low level inhalation exposures to DU during and following battle; greater than 100 metres from the vehicle during the battle.	2.5×10^{-7} (Max 0.0005 Sv)	
Iraqi civilian exposure downwind of battlefield – inhalation, ingestion, consumption of contaminated food and water.	Downwind exposure from battlefield for 50 years following battle.	4.1×10^{-6}	1.3×10^{-8}

Continued.

Exposure	Definition of category	Overall average (Sv)	Soft tissue, including brain (Sv)
Children playing in battlefield for intermittently for 10 years - inhalation, ingestion, consumption of contaminated food and water.	Playing in the battlefield vehicles after cessation of hostilities.	0.0015 (Max 0.049 Sv)	0.0001 (Max 0.010 Sv)

As a result of this detailed analysis, Marshall (2008, pp. 102)[7] states "as a consequence, veterans and civilians who were never inside DU- contaminated vehicles are unlikely to internalize DU in quantities much in excess of normal intake of natural uranium from the environment". Marshall (2008, pp. 106) states "This study found that the quantity of DU internalized by most exposed veteran and civilians (those who did not occupy DU-contaminated vehicles) was smaller than typical exposure levels to natural uranium in the environment".

Summary and Conclusions

ADF personnel with service in Iraq or the Balkans had potential exposure to ionising radiation from depleted uranium munitions or armour. Personnel in ADF category 1 or category 2 may have had exposure that should be taken into account when considering an ionising radiation cumulative dose factor in a SOP. Results of ADF urine testing for DU exposure should be sought in such personnel.

The available evidence indicates that potential DU radiation exposure in those without category 1 or 2 exposure was at levels below normal background exposure.

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[7] Marshall, A. 2008, 'Gulf war depleted uranium risks', **Journal of Exposure Science and Environmental Epidemiology**, vol. 18, pp. 95-108.