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for mine action

TNMA

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Clearance of Depleted Uranium (DU) hazards

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Foreword

Management practices and operational procedures for humanitarian mine action are constantly evolving. Improvements are made, and changes are required, to enhance safety and productivity. Changes may come from the introduction of new technology, in response to a new mine, UXO or ERW threat, or from field experience and lessons learned in other mine action projects and programmes. This experience and lessons learned should be shared in a timely manner.

Technical Notes provide a forum to share experience and lessons learned by collecting, collating and publishing technical information on important, topical themes, particularly those relating to safety and productivity. Technical Notes complement the broader issues and principles addressed in International Mine Action Standards (IMAS).

Technical Notes are not formally staffed prior to publication. They draw on practical experience and publicly available information. Over time, some Technical Notes may be 'promoted' to become full IMAS standards, while others may be withdrawn if no longer relevant or if superseded by more up-to-date information.

Technical Notes are neither legal documents nor IMAS. There is no legal requirement to accept the advice provided in a Technical Note. They are purely advisory and are designed solely to supplement technical knowledge or to provide further guidance on the application of IMAS.

Technical Notes are compiled by the Geneva International Centre for Humanitarian Demining (GICHD) at the request of the United Nations Mine Action Service (UNMAS) in support of the international mine action community. They are published on the James Madison University (JMU) website (http://www.hdic.jmu.edu/) and the GICHD website (http://www.gichd.ch/).

Introduction

Since depleted uranium (DU) first came to public attention, there has been a lot of interest in the potential hazards presented by DU contamination in post-conflict environments. Some material online and in the media about the possible risks to health from DU has been speculative and not supported by the existing scientific knowledge of the real health hazards posed by DU.

This Technical Note has been written, as an advisory document, to remind mine action managers and field staff of all the potential hazards of DU, and to provide guidance on the establishment of safe operating environments and procedures. This updated version includes more information on the different rounds which contain DU as well as drawing on work by the United Nations Environment Programme (UNEP) undertaken since the technical note was originally published in 2002

The DU clearance tasks should only be undertaken by appropriately qualified EOD personnel or other qualified staff; they are not a task for basic deminers or other field staff.

Clearance of depleted uranium (DU) hazards

1. Scope

This Technical Note establishes principles and provides guidance on the clearance of depleted uranium (DU) hazards encountered during demining operations in a permissive post-conflict environment.

2. References

A list of normative references is given in Annex A. Normative references are important documents to which reference is made in this Technical Note and which form part of the provisions of this Technical Note.

3. Terms and definitions

A list of terms and definitions used in this Technical Note is given in Annex B. In the Technical Notes series, the words 'should' and 'may' are used to indicate the intended degree of compliance. This use is consistent with the language used in International Mine Action Standards (IMAS) and guides.

a) 'should' is used to indicate the preferred requirements, methods or specifications.

b) 'may' is used to indicate a possible method or course of action.

4. Background

The primary use of DU in ammunition is as a penetrator material in armour-piercing rounds. The development of DU ammunition began in the 1970s, and the first confirmed use in conflict was during the1991 Gulf War.

Platforms firing DU ammunition can be found in ground, air and sea forces, and although it was developed for use against armoured targets, the use of DU ammunition against non-armoured targets has also been documented. Legacy contamination from the use of DU ammunition may require clearance by demining organisations operating in places where they have been used. At present these are known to include Afghanistan, Bosnia and Herzegovina, Kuwait, Kosovo, Iraq, Montenegro and Serbia.

Decontamination work has been undertaken in some affected states, but residual contamination will remain at strike sites in the above territories. The undocumented use of DU ammunition may also have occurred in other conflicts, and may also occur in future conflicts.

Ammunition including DU is thought to be in the arsenal of around 20 countries worldwide, but is only known to be produced by six countries: China, France, Russia, Pakistan, the UK and US. A full list of DU rounds, states known to possess DU munitions and conflicts where they have been used can be found in Annex C. DU is known to have been used in the following types of ammunition:

a) Armour Piercing Fin Stabilised Discarding Sabot (APFSDS) tank and armoured fighting vehicle (AFV) ammunition in calibres including 25mm,105mm, 115mm,120mm and 125mm;

b) 20mm cannon rounds for the U.S. Navy's Close-In Weapons System (CIWS), commonly referred to as "Phalanx";

c) Cannon rounds, both 25mm and 30mm cannon rounds, for U.S. ground attack aircraft, including the A-10 "Warthog" and the AV-8B "Harrier";

d) At least one Russian 125mm High Explosive Anti-Tank Fin Stabilised (HEAT-FS) round;

e) Some variants of a Russian infrared guided air to air missile; and

f) US-made M86 and Area Denial Artillery Munition (ADAM) anti-personnel mines.

It should be emphasised that in many cases the DU element of the munition is a sub-calibre long rod penetrator, so even intact pieces of DU encountered in the field will have a smaller diameter than the calibre size. The calibre size refers to the complete round prior to firing.

DU is also used as a component in the armour fitted to some US tanks. Modern tank armour is typically comprised of a number of layers of different materials and DU is known to be used as one layer in the armour of US M1 Abrams tanks manufactured after 1988. It is not known if other nations have also included DU in their tank armour. Sites where tanks with DU armour have been damaged should be treated in the same way as sites struck with DU munitions.

5. Reasons for DU hazard clearance

There are numerous reasons why the clearance of DU hazards may be desirable in a post-conflict setting. These include:

a) to reduce risks to human health;

b) to allow destruction of unserviceable or unstable ammunition;

c) to safeguard the environment;

d) to permit environmental clearance of the area;

e) to allow EOD clearance of armoured fighting vehicles (AFV); and

f) to provide reassurance to local people that risks from contamination have been minimised.

6. The DU threat

6.1 Physical and chemical properties of uranium and DU

Natural uranium is a material of low radioactivity, which can be handled, worked and stored with simple safety precautions. When enriched uranium is manufactured from natural uranium, a residue of DU is left,[1] which is less radioactive than the initial uranium; and is chemically toxic.

Natural uranium exists as three isotopes with different half-lives and different levels of radioactivity in the following proportions:

[1]For more details, see http://www.world-nuclear.org/info/nuclear-fuel-cycle/uranium-resources/uranium-and-depleted-uranium/

ISOTOPE	ABUNDANCE (ATOM %)	RADIOACTIVITY (Bq/mg)	HALF-LIFE (YEARS)	REMARKS
^{238}U	99.200%	12.44	10^9	The parent of the natural uranium series.
^{235}U	0.720%	80	10^8	The parent of the natural actinium series.
^{234}U	0.006%	2.31×10^5	10^5	A daughter product of ^{238}U decay.

Of the isotopes, ^{235}U and ^{234}U are more radioactive and are therefore more useful to the nuclear industry. The standard used by the commercial uranium industry considers uranium containing 0.711 weight% (wt%) of ^{235}U to be natural uranium. ^{235}U was chosen for this standard because it is the most relevant isotope for use as fuel in nuclear reactors.

To be sufficiently radioactive to be commercially useful, uranium requires processing to concentrate the more radioactive isotopes. The process is known as “enrichment”, with the end product being called “enriched uranium" and containing more than 8.0wt% of ^{235}U. The remaining uranium is DU, because it is depleted in ^{235}U compared to natural uranium. Enrichment is usually carried out on uranium which has first been converted to a gas. DU used in weapons has to be converted back into a solid metallic form and is usually alloyed with a small quantity of other metals. DU in munitions is typically 0.75% titanium.

Not all countries that produce DU ammunition have access to metallurgical facilities that can undertake this kind of work, and ammunition produced by France and the UK use DU metal sourced from the US. Laboratory analysis of material from UK and US- produced DU weapons has shown a ^{235}U content of 0.2wt% or less[2]. This analysis has also shown that DU material from US stocks contains small amounts of other radioactive elements, because it contains reprocessed uranium from nuclear reactors. Much less is known about the composition of DU used in the munitions produced by other countries, and it may not conform to the above description.

Historically DU metal has also been used as ballast or counterbalances in ships and aircraft and, while it is no longer widely used for this purpose, vehicles containing DU counterweights will remain in service for some time. DU is also used as radiation shielding and in non-nuclear civil applications requiring high-density material.

DU is comprised almost entirely of the isotope ^{238}U; it is initially 60% as radioactive as natural uranium but increases in radioactivity as its ages. DU behaves chemically and physically in the same way as natural uranium. Nevertheless DU metal is a far more concentrated form of uranium than exists in nature.

The uranium industry has been operating for more than 50 years and the experience gained from handling uranium in its raw, enriched and depleted state over this period provides the basis for recommendations that reduce the potential hazards of handling and using DU to a minimum.

6.2 Advice and international responsibilities

Advice on radiation safety and on the disposal of radioactive waste can be obtained from either:

International Atomic Energy Agency (IAEA)
Vienna International Centre

[2]McLaughlin et al., ‘Actinide Analysis of a Depleted Uranium Penetrator from a 1999 Target Site in Southern Serbia’.

PO Box 100
1400 Vienna, Austria

Tel: (+43) (1) 2600-0 Fax: (+43) (1) 2600-7
E-Mail: Official.Mail@iaea.org

http://www.iaea.org/newscenter/features/du/du_qaa.shtml
World Health Organisation (WHO)
Avenue Appia 20
1211 Geneva 27
Switzerland

Tel: (+ 41) 22 791 21 11 Fax: (+41) 22 791 3111
http://www.who.int/en/

United Nations Environment Programme (UNEP)
United Nations Avenue, Gigiri
PO Box 30552, 00100
Nairobi, Kenya

Tel: (254-20) 7621234
E-Mail: unepinfo@unep.org

http://www.unep.org/disastersandconflicts/CountryOperations/UNEPsPastActivities/DepletedUranium/tabid/54619/Default.aspx

The IAEA has statutory responsibilities for establishing standards for the protection of health against exposure to ionising radiation, and for providing for the application of these standards at the request of any state. In fulfilment of these functions, the IAEA has established a comprehensive corpus of radiation safety standards in close collaboration and consultation with other relevant organisations in the UN system.

The International Basic Safety Standards for Protection against Ionising Radiation and for the Safety of Radiation Sources (Basic Safety Standards), which were established jointly with the International Labour Organisation (ILO) and other international organisations, including the WHO, are the authoritative radiation protection standards for assessing the potential radiological impact of the uses of DU.

The exposures to which the requirements of the Basic Safety Standards apply are any occupational exposure, medical exposure or public exposure. However, they only cover risks of radiation and do not cover the toxic risks that may be associated with uranium intake. In the past, the IAEA, based on its statutory mandate and competence has prepared comprehensive scientific radiological impact assessments.

UNEP has led a number of field investigations at sites where DU weapons have been used, with a team including staff from both the IAEA and WHO. The findings and recommendations from those investigations have been used to inform the recommendations in this Technical Note.

6.3 DU ammunition

DU is used in kinetic energy projectiles because of its metallurgical properties; it is metallurgical similar to steel, thereby allowing similar production and processing techniques to be used. The very high density[3] of DU allows for much higher kinetic energy[4] levels to be delivered to the target than an equivalent projectile made of, for example, steel. When hitting an armoured target, a DU penetrator deforms in such a way that the point remains sharp – an effect known as 'adiabatic sheer'. A secondary effect is that the DU oxidises readily, meaning that pieces of DU ignite upon striking a target. This effect is known as pyrophoricity, and the burning DU often causes additional damage to the target.

The combination of design, high mass and high velocity allows the DU round to penetrate the target using the principle of hydrodynamic penetration. The pressures involved are so high that the armour of the target flows away from the DU penetrator.

Despite its radiological and chemically toxic properties it should be emphasised that DU is not a nuclear, radiological or chemical weapon; DU is used because of its high atomic mass/density and metallurgical properties.

6.4 Identification of DU fragments

DU fragments have the following physical characteristics:

a) non-magnetic;
b) extremely heavy. In relation to size DU is 60% more dense than lead;
c) jet-black lumps or dust;
d) they retain heat. DU fragments will retain heat to the point where they will cause serious burns for three to four hours after firing. A red hot core may be coated with black dust and therefore appear cool;
e) honeycombed. The fragment will have an aerated texture;
f) the surface of a fragment which has been in the field for any length of time will not appear metallic. Corrosion will begin in cracks caused by the round impacting a hard surface and will spread from there. Corrosion is light yellow in colour; and
g) sparking. When cold, if struck with a metallic object such as a pick or shovel, they will spark in a similar fashion to a cigarette lighter. IMPORTANT: PERSONNEL SHOULD NEVER STRIKE ANY OBJECT FOUND IN THE FIELD UNLESS THEY CAN BE ABSOLUTELY CERTAIN THAT THE OBJECT CONTAINS ONLY INERT METAL

7. Hazards and risk reduction

7.1 Overview of exposure pathways and risks

In demining or EOD clearance work, the key factors determining the risks to health are:

a) the route of exposure, (i.e. external radiation or DU entering the body through inhalation, ingestion or contact with wounds);

b) the magnitude of exposure; and

c) the particle size and solubility of any DU that enters the body.

[3]Density (D) = Mass (M) / Volume (V).

[4]Kinetic Energy (KE) = ½ Mass (M) x Velocity $(v)^2$.

Effects due to external exposure are limited to radiological effects, whilst the effects due to internal exposure include both radiological and chemical toxicity effects. In practice the effects of external radiation are negligible except in cases of long-term physical proximity.

A number of detailed risk assessments on DU have been carried out. These have drawn upon laboratory studies on both DU and natural uranium, which has the same chemical behaviour as DU. Although these assessments have shown that DU does present a hazard, there is general agreement that if appropriate safety precautions are taken and followed, the risks are minimal.

7.2 External risks - radiation dose rate

DU emits alpha, beta and gamma radiation. Alpha radiation will not penetrate clothing or even skin. The radiation dose rate at the surface of unshielded DU is approximately 2.3 millisieverts per hour (mSv/hr). A large proportion (98%) of this dose rate is attributable to beta radiation.

The density of DU means that only radiation emitting from the surface is a factor, as the DU itself shields the internal emissions.

There are two types of health effect associated with exposure to radiation: 'acute' effects following a high dose ("radiation sickness"), and an increased risk of 'stochastic' effects, such as the occurrence of cancer.

The radiation doses from DU are far too low to result in acute effects, and in practice the increased risk of stochastic effects from external exposure will be negligible except for cases of prolonged contact with exposed skin.

7.3 Internal risks - chemical toxicity and radiation

As with all heavy metals, DU is chemically toxic. On the basis of current evidence, the main health problem associated with DU's chemical toxicity is damage to the kidney. However, former soldiers known to have high levels of DU in their bodies have not suffered from serious damage to their kidney functions.

DU may enter the body through inhalation, ingestion or through wounds. Within the body it can cause damage due to both chemical toxicity and the effects of radioactivity. It is not known whether the danger from heavy metal poisoning exceeds the radiation hazard, as most laboratory studies do not attempt to distinguish between the two effects.

The International Agency for Research on Cancer has classified all sources of alpha particle radiation within the body as carcinogenic. As DU primarily emits this type of radiation, DU within the body probably carries an increased risk of cancer.

Some studies on animals have shown other health problems following exposure to DU, however these findings have not been seen in all studies and these health effects have not been observed in the limited number of humans known to have been exposed to DU. A full overview of the literature about the health effects of uranium can be found in the US Agency for Toxic Substances Disease Registry toxicological profile for uranium.[5]

Additionally, inhaled insoluble DU particles can cause damage to the respiratory system.

According to the risk assessments that have been carried out, individuals would only receive a high enough dose to suffer adverse health effects if they had been exposed to DU dust particles for a significant period of time without any form of personal protection. The simple risk reduction measures

[5] Agency for Toxic Substances and Disease Registry, 'Toxicological Profile For Uranium', 2013, http://www.atsdr.cdc.gov/toxprofiles/TP.asp?id=440&tid=77

recommended in this Technical Note, if followed correctly, prevent DU from entering the body and are adequate to provide protection.

7.4 Contamination types and exposure pathways for DU dust

A slightly increased hazard to those undertaking EOD clearance arises from the presence of DU dust produced as a result of fire or explosion. Particles may be re-suspended in the air by the presence of teams at the site and by EOD activities, many of the particles may be of respeirable size.

The exposure pathways which might occur with DU dust are: inhalation; ingestion, which may follow hand to mouth contact or involve particles that are inhaled but then cleared to the digestive system; and the passage of DU particles through an open wound or abrasion.

7.5 Risk reduction – external risks

Bare DU material (either as a complete round or as pieces of a fired penetrator) would have to be handled for in excess of 200 hours before the UK Safe Exposure Limit (SEL) of 500mSv (for the hands) is exceeded. This SEL is extremely conservative. The external radiation hazard to the hands can be significantly reduced by the wearing of gloves. Gloves decrease the beta dose, giving safe exposure times of up to 5000 hours per year.

This Technical Note stipulates that DU material should not be directly handled at all, or if handling cannot be avoided, that two layers of gloves should be worn (see section 7.7 below). Following these procedures means that an already low risk can be considered negligible.

7.6 Risk reduction – internal risks

In addition to the measures for minimising external risks, all personnel working in areas where DU ammunition has been used should use the personal protective equipment listed below. Wearing a face mask will prevent inhalation and ingestion of re-suspended DU dust. Covering all exposed skin will prevent contamination through cuts and grazes. If this is done, the main risk is through unintentional ingestion of DU through contamination of surfaces or clothes. Ensuring that the procedural measures listed below (sections 7.7-7.8) are thoroughly complied with will ensure that this risk is also negligible.

7.7 Personal protective equipment (PPE)[6]

When working in areas possibly contaminated with DU the following PPE should be used by the EOD technician or qualified staff member until the presence of DU can be positively discounted:

a) disposable plastic gloves of the type used in a hospital;
b) a high quality face mask that meets European standard EN149 FFP3 or a comparable standard; and
c) an outer layer of clothing and footwear that covers the whole body, for example full body cotton overalls and sturdy boots.

The aim of the PPE is to provide complete overall protection from inhaled or skin-contact dust, and cuts from sharp fragments. As stated in section 8.1, metallic fragments should not be handled in an area where DU is present. If there is any risk of hand contact with DU then inner cotton gloves and outer heavy PVC gloves should be worn.

[6]This PPE is additional to the PPE requirements contained within IMAS 10.30.

7.8 Risk reduction procedures

Having taken all precautions to prevent injury, and to prevent direct exposure, it should also be remembered that clothing and footwear may have become contaminated. Excess material should be shaken from boots, clothing and equipment when leaving the site. Any item suspected of being contaminated may be checked using a portable contamination meter (PCM) and all clothing and equipment should be regularly cleaned. Regular checking of face-masks using a PCM may also be helpful as a reassurance measure.

Good personal hygiene, such as the covering of cuts and grazes before work commences should be observed. After work, normal personal hygiene of washing the face and hands or taking a shower will overcome any further possibility of cross contamination

Care should be taken not to touch the mouth and face after removal or handling of the outer layer of clothing until hands and other exposed skin have been washed. ‘Dirty’ areas, where equipment and outer layers of clothes are left should be kept separate from ‘clean’ areas, where staff can wash. Staff should keep face masks on while in the dirty area and remove them immediately before leaving. Normal washing of hands and clothing should be considered sufficient to negate any risk from cross contamination.

Managers unable to obtain equipment to the recommended standards should use the best available materials, and ingenuity, to offset the risks as outlined above.

8. Working in areas potentially contaminated with DU

8.1 Personal protection

WARNING 1: DU fragments. Do not let DU residue or fragments come into contact with exposed unprotected skin. DU fragments are not to be picked up by hand; a scoop or other such tool is to be used.

DU contamination is relatively harmless unless inhaled, ingested or absorbed into the bloodstream through open cuts. Fragments of DU penetrators are extremely sharp and liable to cause cuts if handled carelessly.

8.1.1 Simple precautions

The following simple precautions will reduce the risk of DU contamination and serious risks to health:

a) sleeves are to be rolled down and gloves are to be worn. Care is to be taken to avoid sharp objects that may rip the gloves and expose the skin;
b) allow a minimum of four hours to elapse after firing before attempting to carry out clearance. Fragments of DU penetrators are red hot internally for up to four hours after firing;
c) a medical or industrial face mask is to be worn at all times. This will protect against the ingestion of any DU oxide particles that are released due to the movement of fragments. In the absence of an appropriate mask or a respirator, a damp face veil tied around the nose and mouth should be used;
d) do not use your boot to turn over or move fragments. Always use a CV Tool, stick, scoop or similar item as a remote tool; and
e) in order to prevent contamination of personal clothing and footwear, coveralls and overboots are to be worn.

In addition, all working procedures should be designed in accordance with the risk reduction advice in sections 7.5-7.8.

8.1.2 Casualties and exposed personnel

The appropriate medical authorities are to be informed of any casualties that occur whilst in a DU contaminated area.

If any of the precautionary measures set out in this note fail, or for any reason personnel have worked in a DU contaminated area without proper protection, there is a possibility that they may have been exposed. Personnel who have potentially been exposed to DU should have the risks of exposure, as set out in this note, explained to them in a non-alarmist manner.

While there are no medical interventions to mitigate these limited risks once exposure has occurred, exposed personnel should have the opportunity to consult medical personnel with expertise in radiation physics or toxicology, and be offered regular monitoring that is standard for workers who may be occupationally exposed to radiation.

8.2 Radiation detection equipment

8.2.1 Thermoluminescent Dosimeter (TLD)

Although the low radiation count from DU munitions is unlikely to register on a personal dosimeter, as a precaution, an EOD technician may wear a TLD during work in contaminated areas to ensure that they are not exposed to high levels of external radiation, as described in section 8.3. Personal dosimetry and health checks should be co-ordinated with a local and appropriately qualified medical facility. TLDs can be obtained from a variety of sources. The following have been identified from an Internet search; there will be many others:

a) LANDAUER. (http://www.landauer.com/);

b) Proxtronics Incorporated. (http://www.proxdose.com/); or

c) Mirion Technologies. (http://www.mirion.com/).

Information on how a TLD works can be found at http://www.ab.ust.hk/sepo/tips/rp/rp002.htm.

8.2.2 Portable Contamination Meter (PCM)

A Portable Contamination Meter (PCM) - Type Mini Monitor fitted with a B-6-H GM Tube, is a small, sensitive but rugged instrument used for the purpose of detecting DU contamination. Although most of the contamination emitted by DU is alpha radiation, this type of radiation is difficult to detect in the field as it is easily blocked by a layer of grass or dust and only has a short range in air. Instead, field measurements should be taken of gamma or beta radiation.

For detecting DU, highly sensitive instruments are required, and readings must be taken very close to the ground. The following PCMs were used by UNEP field teams:

a) the Saphymo-SRAT S.P.P.2 NF scintillometer, which measures gamma radiation and was the most effective instrument for surveys;
b) the Inspector, manufactured by S.E. International, which was lighter and measured beta radiation; and
c) the Exploranium GR-130G/BGO which is a gamma spectrometer and is able to identify the radioactive isotope which is emitting the radiation.

Instruments from other manufacturers are also available. For effective field work, instruments of an equivalent sensitivity to those listed above should be used.

8.2.3 Locating contamination

All available data should be used to identify sites where the use of DU munitions is known or suspected. Often the probable location of contamination within a site can be determined using visual clues and other information. If a large area is suspected to be contaminated, then measurements should be taken at random using a PCM and a combination of visual clues and other information should be used to identify areas which should be subject to a systematic survey.

The method that should be used to systematically search for contamination in a small area, when safe and appropriate to do so, is a line-up survey. Personnel should systematically walk in a line across the site with 1-2 metres between them, sweeping the ground in front of them with their instruments to make sure that no surface contamination is missed.

A detailed description of the methodology used by UNEP to survey sites can be found in their report on DU in Bosnia and Herzegovina.[7]

8.2.4 Alternative methods

Where PCMs are not available, and one party to the conflict is believed to have fielded DU munitions, caution should be exercised at all sites until the use of DU can be ruled out.

All AFVs are to be considered suspect and full precautions taken accordingly. As the use of DU munitions against non-armoured targets has also been documented, the absence of AFVs should not be taken as a guarantee that DU is not present. To assess the likelihood that DU has been used at a site, all information about the types of munitions used there should be compared to munitions listed in Annex C of this Technical Note. Other munitions fired by planes or vehicles which are known to field DU ammunition may also be evidence of DU use. Any activities at a site should be undertaken with precautions appropriate to the likelihood that DU munitions have been used there.

8.3 Personal dosimetry and health checks

Although the low radiation count from DU munitions is unlikely to register on a personal dosimeter, the following process may be adopted to monitor the external radiation exposure of teams working in an area where DU ammunition has been fired.

At least one member of each EOD or specialist team is nominated as a Control Member and issued with a Thermoluminescent Dosimeter (TLD), which is to be worn whenever EOD duties are being carried out in the area. In addition to wearing a TLD, which is to be exchanged each month, collection of a urine sample from the same Control Member of each team is to be arranged, again on a monthly basis. The samples can then be analysed for the presence of DU. This should be coordinated with an appropriately equipped local medical facility.

The demining organisation should ensure that personal medical records are annotated to record that they have worked in a potential DU environment to allow for regular monitoring in the future.

9. Demining and EOD work in areas potentially contaminated with DU

9.1 In-situ detonation

If landmines and UXO are detonated in DU contaminated areas during clearance work, there is potential for re-suspension of contamination, causing an inhalation hazard. Where feasible, detonation should be carried out away from contaminated areas, or contamination should be removed before detonation. Where this is not possible, or to do so would convey excessive risk, attention

[7] United Nations Environment Programme, *Depleted Uranium in Bosnia and Herzegovina: Post-Conflict Environmental Assessment*.http://www.unep.org/disastersandconflicts/portals/155/disastersandconflicts/docs/dup/BiH_DU_report.pdf

should be paid to the wind direction and speed. The immediate area down-wind of the detonation should be kept clear of people, and face masks as detailed in section 7.7 should be worn by all persons in the vicinity.

9.2 Community liaison

As the risks from DU can be a significant cause for public alarm in areas where they have been used, operators carrying out risk education programmes as part of demining or EOD operations should consider incorporating education about the actual risks from DU and the risk reduction strategies described in this technical note. Information should also be provided on any decontamination activities that have been undertaken.

10. DU clearance methodology

10.1 Detection of DU contamination

It may not always be possible to identify DU contaminated areas visually. A sensitive Portable Contamination Meter (PCM) such as those listed in section 8.2.2, and the methodology listed in section 8.2.3, should be used to locate contamination.

10.2 Collection

10.2.1 Box preparation

The container used must be a robust metal box of suitable size and without holes. The box must be strong enough to carry the heavy weight produced by even a small quantity of DU, and it must be capable of being secured so as to prevent any leakage of the contents. Wooden or cardboard boxes are not to be used as they will absorb contamination.

A 20 mm lining of a suitable material such as sand or earth is to be inserted into the box. This lining is used as a packing medium to hold the DU fragments, absorb any DU oxides and prevent fire. The 20 mm lining should be built up around the sides and on top of each layer of fragments as the box is filled. A final layer of sand or earth is to be added to the top before the box is closed.

10.2.2 Box marking

Once filled with fragments and topped with sand or earth, the box is to be closed and sealed to prevent leakage. The box is to then be marked **CAUTION RADIOACTIVE MATERIAL - DU FRAGMENTS** and the appropriate Trefoil (radiation) sign applied.

10.2.3 Manual transportation

Although DU fragments are not highly radioactive, filled boxes should not be carried close to the body. They should be held away from the body, as far as is reasonably possible. Two or three boxes may be carried between two persons using a robust 6 ft pole through the handles.

10.2.4 Disposal

Filled boxes should be moved to a collection point, (fenced off and suitably marked and signed), and stacked ready for removal by a specialist hazardous and radiological waste disposal company, in accordance with the IAEA Basic Safety Standards. Guidance about appropriate companies and the appropriate procedure should be sought from the IAEA or a national regulator.

It should be noted that because DU is so dense, it acts as radioactive shielding, as a result the internal boxes in a stack are shielded by the outside boxes. In addition the dose rate at the surface is reduced by distance based on the Inverse Square Law. A relatively small distance will reduce the level of absorbed radiation appreciably and therefore fencing need only be 1 m from the stack.

10.3 Principles of decontamination

It should be recognised that in most cases it will not be practicable to remove all traces of DU from a site. However, the significant risks from contamination depend upon the contamination being sufficiently concentrated that exposure would lead to a dose high enough to cause health problems. As such, the aim of decontamination work should be to remove all high concentrations of contamination that people might come into contact with, in order to eliminate this risk. However, care must also be taken to minimise additional risks to those undertaking decontamination work, and others, for example by the re-suspension of contamination into the air.

Because DU material corrodes in the field, and may become mobile in groundwater or air, early removal of intact pieces of DU will result in the removal of the largest amount of DU material from a site. As such, early decontamination work should always be preferred in terms of risk reduction. In most cases, early decontamination will usually also be the most simple in procedural terms and incur the lowest cost.

10.4 Decontamination procedure

10.4.1 DU fragments and rounds

Pieces of DU or intact penetrators and rounds represent the greatest concentration of DU material in the field, and care should be taken to remove all such pieces from the site. The pieces should be placed in a box as described above and disposed of by a specialist company, see sections 10.2.1-10.2.4 above.

DU fragments and penetrators which have been present at a site for any length of time will have undergone corrosion and weathering, meaning that residues will be present in the soil surrounding any intact pieces of DU. For this reason, when any piece of DU is collected, the10cm^3 of earth or sand surrounding it should be collected at the same time as the fragment.

10.4.2 Surface decontamination

Any contaminated soil or material that can be identified with a PCM should be removed from the site with a trowel or similar tool, placed in a box as described above and disposed of by a specialist company, see sections 10.2.1-10.2.4. Where contamination is on hard surfaces, such as concrete or asphalt and cannot be easily removed, the contaminated area should be covered with a layer of asphalt or concrete.

10.4.3 Sub-surface decontamination

In the case of DU fired from a high angle relative to the ground, or from the air, DU material may be buried some distance below the ground, depending on the soil composition. In many cases this contamination will not be detectable from the surface. In this situation the risk of re-suspension from disturbing the soil outweighs the risk presented by buried contamination, unless the site is likely to be used in such a way that the soil would be disturbed by future activities, or where the presence of DU may compromise water or agricultural resources.

If the future use of the site requires sub-surface decontamination, then the recommended procedure is complete removal of the topsoil up to a certain depth. In these circumstances, a survey should be undertaken to locate all points of contamination. All contaminated soil should be dug out at each point of contamination, following the trajectory of the round until no further contamination can be found. The depth of topsoil to be removed will depend upon the soil type, and advice should be sought from UNEP or another agency with experience of DU decontamination.

Sites where sub-surface decontamination has been left undisturbed should be recorded. Detailed location information should be logged with an appropriate agency that can maintain a register of affected sites and monitor land use to ensure that no disturbance of the soil will take place at these sites. Environmental monitoring of the sites and nearby water sources may also be desirable.

10.4.4 Contaminated vehicles

The interiors of vehicles which have been targeted with DU munitions may contain quite high levels of contamination, and should be dealt with by an operator specialising in hazardous and radiological waste in accordance with the IAEA Basic Safety Standards. If collection by a suitable operator cannot be immediately arranged, a warning about the presence of DU and the Trefoil (radiation) symbol should be painted on the outside of the vehicle in bright weatherproof paint, and an appropriate national or international authority should be notified. If the vehicle can be sealed without extra risk to staff, this should also be done.

Where the risks from leaving the vehicle in place are unacceptable, for example if the vehicle is in a built-up area, it should be moved to the nearest secure area that can be identified. If this is done, all possible measures should be undertaken to prevent the spread of debris and other contaminated material from the vehicle. The exterior of the vehicle should be cleaned of contamination and sealed before transit and steps should be taken to make sure that any contamination dislodged during transit is contained. The original location of the vehicle should be decontaminated and the transit route should be treated as potentially contaminated and surveyed using the techniques described in section 8.2.3.

10.4.5 Contaminated buildings

Within a building that has been contaminated by DU munitions, there may be significant airborne DU and a higher potential risk of re-suspension of particles in the air. All areas and surfaces should be thoroughly cleaned using an industrial strength vacuum cleaner, and the material placed in a box and disposed of as described in sections 10.2.1-10.2.4. If required, surfaces can be further cleaned using pressurised water.

10.4.6 Jammed penetrators

Occasionally a partial penetration of a target may occur, resulting in a jammed penetrator. If the penetrator cannot be removed, then it is to be left for between 7 to 14 days, after which it will shrink slightly due to weathering and can then be removed with a sharp knock. Because weathering involves some spread of DU material into the environment, it is preferable to remove penetrators as soon as possible.

10.4.7 Cross contamination

Having taken all precautions to prevent injury and contamination in the area of operations it should be remembered that clothing and footwear may have become contaminated. Any item suspected of being contaminated should be cleaned immediately and checked using a PCM, and personnel should follow all the risk reduction procedures outlined in sections 7.8 above.

11. Safety brief

Demining organisations should ensure that all of their managerial, demining, administrative and support staff are briefed as to the hazards of DU if they have to operate in a potential DU environment. (Their EOD or specially qualified personnel should already be trained in the hazards of

DU). Although such personnel will not be actively involved in the clearance of DU hazards, they may inadvertently place themselves in a potentially hazardous situation by examining targets hit by DU munitions.

The following safety brief should be made available to such personnel:

DU is a heavy metal, which is used primarily in anti-armour ammunition in the main armament of battle tanks, and in the cannon of some ground attack aircraft. It is slightly radioactive and it has a chemical toxicity similar to lead.

There is no appreciable hazard when the DU round is intact, even after firing, but there is a minor hazard when the DU round strikes a hard target. This can result in DU dust and fragments around the target to a radius of 50m. There is only a risk if particles are eaten, breathed in or enter the body through an open wound. If this occurs there may be a small increase in risk of cancer or other ill effects in the future.

You should be aware that it will not be possible, without special instruments, to detect whether a damaged target has been struck by DU. The following precautions should be taken:

a) Do not enter or climb onto a damaged hard target, or loiter within 50m, unless you are working in co-operation with an EOD technician.
b) If your work requires you to work within 50m, wear a facemask and gloves, and roll your sleeves down. Cover any cuts and abrasions with waterproof dressings. Spend as little time as practicable on the task.
c) Do not eat, drink or smoke near the damaged target. After completing your task, wash and shower as soon as is practicable. Remove your outer clothing and, if feasible, replace it. Otherwise, have it laundered. Do not eat, drink or smoke until you have done so.
d) Do not, under any circumstances touch fragments of DU or unidentified metal. Do not use your boot to turn over or move fragments. Always use a CV Tool, stick, scoop or similar item as a remote tool.

12. Responsibilities

12.1 National mine action authority

The National Mine Action Authority is responsible for warning all mine action agencies of any armoured conflicts that have taken place, and any history of the use of DU rounds. The Authority should be aware of these Notes, and make copies available, through the National Mine Action Centre, to all mine action agencies, including those involved in mine awareness. The Authority should also seek all available information that can be used to identify contaminated sites, and make it available to these agencies.

12.2 Demining organisations

The manager of any mine action team should also be aware of these Notes, and if the use of DU ammunition is suspected or proved, should include the recommendations of these Notes in SOPs. The manager is also responsible for ensuring the presence of a trained EOD staff member, or for sending a staff member for specific training in DU hazards. Where a National Mine Action Authority or Mine Action Centre has not been established, managers are responsible for establishing amongst themselves a code of practice to ensure the safety of mine action staff and locals.

12.3 Demining personnel

All mine action staff working in areas of potential DU contamination, should make every effort to keep themselves free from DU dust hazards by the conscientious use of protective equipment, strict observation of SOPs and the dictates of common sense.

Annex A
(Normative)
References

The following documents when referred to in the text of this Technical Note, form part of the provisions of this guide.

a) IMAS 04.10 Glossary of mine action terms and definitions.

The latest version/edition of these references should be used. GICHD hold copies of all references used in this Technical Note. A register of the latest version/edition of the IMAS standards, guides and references is maintained by GICHD, and can be found on the IMAS website (www.mineactionstandards.org). National Mine Action Authorities, employers and other interested bodies and organisations should obtain copies before commencing mine action programmes.

The latest version/edition of the Technical Notes can be accessed via the IMAS website (www.mineactionstandards.org).

Annex C
(Informative)
DU munitions, platforms, user states and affected states

1. DU munitions

As mentioned in Section 4, the DU in most of these rounds is a long-rod penetrator of a much smaller diameter than the calibre size, which refers to the diameter of the complete round, prior to firing. Calibres are listed in size from largest to smallest. This list should not be taken as complete, and for some rounds very little information is available in the public domain.

1.1 125mm rounds

a) 3BK-21B High Explosive, Anti-Tank, Fin Stabilised (HEAT-FS) round, produced by Russia/USSR. This round is used by T-90, T-80, T-72 and T-64 tanks.

b) 3VBM-13 Armour Piercing, Fin Stabilised, Discarding Sabot, Tracer (APFSDS-T) round, produced by Russia/USSR. This round is used by T-90, T-80, T-72 and T-64 tanks.

c) 125mm APFSDS-T round produced by China. Chinese Type 99, Type 98 and Type 90 tanks are equipped with DU ammunition. A separate DU round may also be carried by Type 85-III tanks.

d) 125mm Amour Piercing, Fin Stabilised, Discarding Sabot (APFSDS) round, produced by Pakistan. Pakistani T-80UD and Type 90-II tanks are equipped with this round.

1.2 120mm rounds

a) L26 APFSDS round, produced by the UK. Challenger 1 tanks were equipped with this round, but it is no longer in service.

b) L27 APFSDS round, produced by the UK. Used with the Challenger 2 tank.

b) M829 APFSDS-T round, produced by the USA. Used with the M1 Abrams tank.

c) OFL 120 F2 APFSDS-T round, produced by France. Leclerc tanks are equipped with this round.

d) PROCIPAC APFSDS-T round, produced by France. Note that PROCIPAC was the designation of the round during the development phase. It may have subsequently been licensed and given a different designation. When licensed, it will be used in the Leclerc tank.

1.3 115 mm rounds

a) 3UBM-13 APFSDS-T round, produced by the USSR. T-64 and T-62 tanks are equipped with this round.

1.4 105mm rounds

a) M774 APFSDS-T round, produced by the USA. Used with the M60 Patton tank.

b) M833 APFSDS-T round, produced by the USA. Used with the M60 Patton tank.

c) M900 APFSDS-T round, produced by the USA. Used with the M60 Patton tank and the M1128 Stryker Mobile Gun System.

d) OFL 105 F2 APFSDS-T round, produced by France. AMX-30 tanks were equipped with this round, but it is probably no longer in service.

e) 105mm APFSDS-T round, produced by China. Type 85-II, Type 80, Type 79 and Type 59 tanks are thought to be equipped with this round.

f) 105mm APFSDS round, produced by Pakistan. Type 59 tanks are thought to be equipped with this round.

1.5 30mm rounds

a) PGU-14 Armour Piercing Incendiary (API) round, produced by the USA. Used in the A-10 Thunderbolt aircraft and the GPU-5 gun pod (sometimes erroneously known as the GPU-30). The GPU-5 was originally designed for attachment to aircraft such as the F-15 or F-16. It was used on the F-16 for one mission in the 1991. The GPU-5 was subsequently fitted to an amphibious landing craft, the Landing Craft Air Cushion (LCAC)

b) 30 x 113 ammunition for the Apache Helicopter, produced by the USA. A DU round for this platform has not been publically acknowledged, but there is credible information that one has been both produced and fielded.

1.6 25mm rounds

a) M919 APFSDS round, produced by the USA. This round is used in the M2/M3 Bradley Fighting vehicle.

b) PGU-20 API round, produced by the USA. This round was used in the AV-8 Harrier II, but is no longer in service.

1.7 20mm rounds

The original ammunition for the Mk 15 Phalanx Close-In Weapons System (CIWS), produced by the USA contained a DU penetrator. The Phalanx CIWS is a ship-based automatic system which detects and shoots down anti-ship missiles. Production switched to a tungsten round in 1990, but the Phalanx system is widely deployed and the round may still be in service in some countries.

1.8 12.7mm (0.5 inch) rounds

The USA developed munitions at this calibre, but they were apparently never licensed for use. A small quantity may have been used in the 1991 Gulf War.

1.9 7.62mm rounds

The US developed munitions at this calibre, but they were apparently never licensed for use. A small quantity may have been used in the 1991 Gulf War.

1.10 5.56mm rounds

The US developed munitions at this calibre, but they were apparently never licensed for use. A small quantity may have been used in the 1991 Gulf War.

1.11 Other munitions containing DU

a) R-60 infrared-guided air-to-air missile (NATO designation AA-8 ‘Aphid’) made by Russia/USSR. Carried by numerous aircraft, including the IAR-99, MiG-21, MiG-23, MiG-25, MiG-29, MiG-31, Su-17, Su-22, Su-24, Su-27 and possibly also on the Su-15, Su-25 and Yak-38. In the wars in the former Yugoslavia, some R-60 missiles were apparently adapted for use as ground-to-air missiles, and this practice may have been repeated elsewhere.

b) Area Denial Artillery Munition (ADAM) landmine, produced by the USA.

c) M86 landmines, produced by the USA.

2. User States

These lists should not be considered exhaustive.

2.1 States known to possess tank-based DU munitions

States are listed in alphabetical order. Only rounds thought to be currently in service are listed. Where possible, information about the rounds possessed is also included:

a) Bahrain – 105mm M833 round

b) China – 125mm and 105mm round

c) France – 120 mm OFL 120 F2 and PROCIPEC rounds. 105mm OFL 105 F2 round.

d) Israel – 105mm M833 round. Israel may also have produced a bespoke 120mm round

e) Jordan – 105mm M833 round

f) Pakistan – 105mm M833 round. Also domestically produced 125mm and 105mm rounds.

g) Russian Federation – 125mm 3BK-21B round, 125mm 3VBM-13 round, 115mm 3UBM-13 round

h) Saudi Arabia – 105mm M833 round

i) Taiwan – 105mm M774 round

i) Turkey – 105mm M774, 105mm M833 round

k) United Kingdom – 120mm L7 round

l) United States – 120mm M829 round and 105mm M900 round

2.2 States possibly possessing tank-based DU munitions

There is some credible information to suggest that at one stage India was developing tank-based DU munitions, but it is not known whether an in-service round was ever produced

2.3 Ex-Soviet states

In addition to the above, the following states may have inherited DU munitions following the breakup of the USSR, and so should be considered possible user states:

a) Azerbaijan

b) Belarus

c) Georgia

d) Kazakhstan

e) Kyrgyzstan

f) Tajikistan

g) Turkmenistan

h) Ukraine

i) Uzbekistan

2.4 States which have fielded the R-60 air-to-air missile

As it is not known whether all variants of this missile contain DU, the following states should be considered possible user states:

a) Afghanistan (now apparently withdrawn from service)

b) Algeria

c) Angola

d) Azerbaijan

e) Belarus

f) Bulgaria

g) China

h) Croatia

i) Cuba

j) Czech Republic

k) Egypt

l) Finland

m) Germany

n) Hungary

o) Kazakhstan

p) India

q) Iraq (now apparently withdrawn from service)

r) North Korea

s) Libya

t) Malaysia

u) Montenegro (may have inherited some missile stocks after the end of union with Serbia)

v) Poland

w) Romania

x) Serbia

y) Slovakia

z) Sudan

aa) Syria

ab) Turkmenistan

ac) Ukraine

ad) Uzbekistan

ae) Vietnam

af) Yemen

2.5 States which have fielded the Phalanx Close-In Weapons System

Although the DU round for this system ceased production in 1990, and most states have replaced it with the tungsten round, it is possible that some of the following states still possess some DU rounds in their arsenal:

a) Australia

b) Bahrain

c) Brazil

d) Canada

e) Ecuador

f) Egypt

g) Greece

h) India

i) Israel

k) Japan

l) Malaysia

m) Mexico

n) Morocco

o) New Zealand

p) Pakistan

q) Poland

r) Portugal

s) Saudi Arabia

t) Spain

u) Taiwan

v) Thailand

w) Turkey

x) the UK

y) the USA

3. Affected states

3.1 Territories where the use of DU munitions in conflict has been confirmed

Where information is available, the year and circumstances of use are briefly outlined. Note that in some cases the status of a territory may be disputed:

a) Afghanistan. It is thought that DU munitions have been used both during the Russian war in Afghanistan and by US forces since 2001.

b) Bosnia & Herzegoviana. DU munitions were used in 1994 and 1995 by US A-10 aircraft intervening in the civil war.

b) Iraq. DU munitions were used by US and UK forces in 1991, and again in 2003.

c) Kosovo. DU munitions were used in 1999 by US A-10 aircraft.

d) Kuwait. DU munitions were used by US and UK forces in 1991.

e) Montenegro. DU munitions were used in 1999 by US A-10 aircraft.

f) Serbia. DU munitions were used in 1999 by US A-10 aircraft.

3.2 Territories where the use of DU munitions in conflict is possible but not confirmed

This list is by no means exhaustive. In general any conflict involving a known or suspected DU user state could potentially involve DU munitions. However, the characteristics of the following conflicts mean they are particularly of interest.

a) Georgia. During the 2008 conflict with Russia over South Ossetia it is possible that DU munitions were used.

b) Russia. During the 1994-1996 and 999-2000 Chechen wars it is possible that DU munitions were used.

c) Somalia. It is possible that US forces in Somalia in 1994 used DU munitions.

d) Ukraine. During the conflict beginning in 2014 it is possible that Ukrainian or Russian forces used DU munitions

Amendment record

Management of Technical Notes amendments

Technical Notes (TN) are subject to review on an 'as required' basis. As amendments are made to this TN they will be given a number, and the date and general details of the amendment shown in the table below. The amendment will also be shown on the cover page of the TN by the inclusion under the version date of the phrase *'incorporating amendment number(s) 1 etc.'*

As reviews of TN are made new versions may be issued. Amendments up to the date of the new version will be incorporated into the new version and the amendment record table cleared. Recording of amendments will then start again until a further version is produced.

The most recently amended TN will be the versions that are posted on the IMAS website at www.mineactionstandards.org.

Number	Date	Amendment Details