Defence
Safety Authority

DSA 03.OME Part 2 (JSP 482) - Defence Code of Practice (DCOP) and Guidance Notes for In-Service and Operational Safety Management of OME

Defence OME Safety Regulator

DOSR

DSA VISION

Protecting Defence personnel and operational capability through effective and independent HS&EP regulation, assurance, enforcement and investigation.

PREFACE

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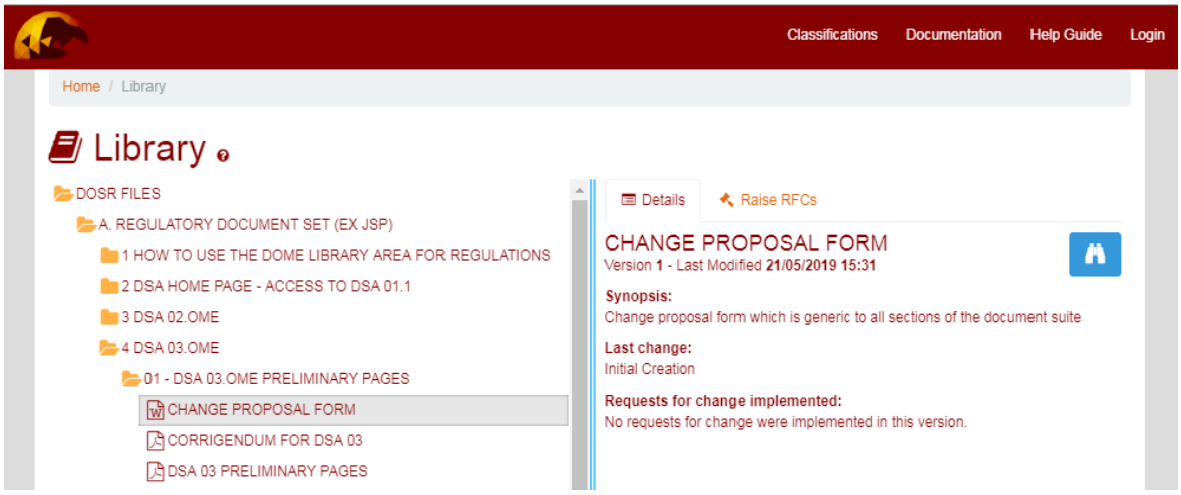

Figure 1. Change Proposal Form (Word version) Location

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AMENDMENT RECORD

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CHAPTER 28

STORAGE AND TRANSPORT OF DEPLETED URANIUM AMMUNITION

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Paragraph

1 STORAGE AND TRANSPORT OF DEPLETED URANIUM AMMUNITION

1.1 Introduction

1.1.1 This chapter, issued by the Chief Inspector of Explosives (MOD), describes the arrangements for the safe storage and transport of Depleted Uranium (DU) ammunition. The requirements are applicable to all personnel, both Service and MOD civilians (including supporting contracted staff) engaged in work with DU munitions.

1.1.2 The general arrangements which are applicable to routine operations are described, in addition to those arrangements required during a limited number of operational applications. The guidance given within this chapter is of a general nature and is supplemented by separate detailed Prescriptions for each type of ammunition containing DU.

1.1.3 Regulations, guidance and controls, additional to those identified within other chapters of this publication, are identified here to allow munitions to be safely managed with regard to their properties as explosives and radioactive substances and, in particular, to ensure that radiation exposure of personnel is kept as low as reasonably practicable (ALARP). Further details are given within the Radiation Safety Handbook (JSP 392, Leaflet 30) which relate specifically to the radiological controls applicable to DU. Where Crown exemption from regulation in relation to safety and transport arrangements is applicable, it is the Secretary of State’s policy that, where reasonably practicable, Departmental standards will be at least as good as those required by Statute.

1.2 Description of Depleted Uranium

1.2.1 Uranium is a naturally occurring, radioactive metal, which emits alpha and beta particles, gamma and x-radiations. Uranium in an 'enriched' form is used as fuel in nuclear reactors. It is called enriched because, through processing, it contains a higher concentration of one of its isotopes (uranium-235) than natural uranium. The by-product of

the enrichment process is depleted uranium (DU), which has a reduced concentration of uranium-235. DU is slightly less radioactive than natural uranium, but exhibits the same chemical properties and, being a heavy metal, is chemically toxic to about the same extent as lead. DU metal has approximately the same density as tungsten and is often alloyed with low concentrations of other metals, such as molybdenum or titanium. DU is dense, strong and machines well, making it an ideal material for use in the manufacture of kinetic energy rounds.

1.3 **Depleted Uranium Munitions**

1.3.1 The 120mm Tk APFSDS L27A1 round comprises a DU penetrator (sometimes referred to as the “shot”) within a sabot, accompanied by a propellant charge. The DU penetrator has a protective coating, which minimises corrosion during storage and provides some protection against surface abrasion. The 20mm Phalanx round consists essentially of a DU penetrator, a sabot, a "pusher" and a cartridge case containing propellant with an electric primer. The armour-piercing ability of a DU penetrator stems from its high mass, which delivers a great deal of energy to the target. The effectiveness of DU ammunition is further enhanced by a secondary, incendiary effect.

1.4 **Radiological Hazards**

1.4.1 Radiation hazards may be defined as “internal” where radioactive material is taken inside the body (following, for example, inhalation or ingestion) or “external” where radiation exposure arises from sources outside the body.

1.4.2 There is unlikely to be any internal radiation hazard from intact DU munitions as loose contamination is unlikely to arise during normal storage and transport activities. However, fine particles of DU and DU oxide will be produced if DU metal is involved in a fire or explosion. These particulates can enter the body by inhalation, ingestion or via uncovered wounds. The form of these particulates is such that they are only likely to result in an individual exceeding a radiation dose limit in the impact area immediately after the use of DU munitions.

1.4.3 The use of suitable shielding, packaging and handling techniques will ensure that external radiation exposure is kept ALARP during normal storage and transport activities. However, significant external radiation dose rates may exist very close to bulk assemblies of unpackaged DU ammunition (1mSv/hr contact and approximately 50µSv/hr at 1m). In these circumstances, additional controls are required to ensure that radiation exposure remains ALARP**.**

1.5 **Risk Assessment**

1.5.1 The Ionising Radiations Regulations (IRR 17) (2017) require that a Prior Risk Assessment (PRA) should be carried out before storing, handling or transporting radioactive material. Guidance on preparing a PRA is provided in JSP 392 (Radiation Safety Handbook, Leaflet 2). In addition, where quantities of DU ammunition exceeding 120kg are stored or transported by rail, there is a requirement to undertake a Hazard Identification and Risk Evaluation (HIRE) assessment, under The Radiation (Emergency Preparedness and Public Information) Regulations. Again, guidance on completion of a HIRE assessment is provided at JSP 392, Leaflet 2.

1.5.2 While the requirement for a full PRA does not apply in operational situations, it is still possible to identify the major hazards and to produce safe systems of work to mitigate the risks in an operational environment. Where practicable such measures should be implemented, providing operational capabilities are not compromised.

1.5.3 Risk assessments should cover all hazards associated with the use of DU ammunition, including everyday hazards such as trips and falls, as well as the special hazards associated with radioactivity, toxicity and explosives. Measures for dealing with the hazards from radioactivity are detailed in subsequent paragraphs of this chapter.

1.6 **Contingency Planning**

1.6.1 Where the risk assessment demonstrates the need for a contingency plan this is to be produced in accordance with the requirements of the Ionising Radiations Regulations (IRR 17) 2017 For DU ammunition, MOD considers it prudent to produce contingency plans even though their requirement or implementation may not be reasonably foreseeable, to ensure that MOD's interests are best protected.

1.6.2 In the event of a fire involving DU ammunition, the elimination of the immediate explosive hazard will take precedence over the elimination of radiation hazards arising from DU material.

1.6.3 Contingency plans should be developed in close consultation with the establishment Radiation Protection Adviser (RPA).

2 **STORAGE REQUIREMENTS FOR DU MUNITIONS**

2.1 **Unit Load Containers**

2.1.1 Complete L27A1 round assemblies are stored (and transported) in purpose-built, Unit Load Containers (ULCs), which offer a significant degree of shielding from the radiation emitted from DU. The ULC has been designed to ensure that the radiation levels at the external surface are As Low As Reasonably Practicable (ALARP) and are low enough for it to be transported and stored in a safe, legally compliant, condition. However, to ensure that radiation exposure remains ALARP, personnel are required to minimise the time spent in the immediate vicinity of the ULC.

2.2 **Limitations on Quantities**

2.2.1 In any external stack of L27A1 rounds, or within any storage building (assuming a suitable building could be used in a field storage situation), the number of shot must not exceed 12,800. In the case of 20mm Phalanx, rounds are limited to 1,000,000.

2.3 **Hazard Classification Code**

2.3.1 The L27A1 and 20mm Phalanx ammunition are classified as 1.3C and 1.2C respectively.

2.4 **Mixing by Hazard Division (HD)**

2.4.1 L27A1 ammunition may be stored with other ammunition of HD 1.3 and HD 1.4, but not with HD 1.1 or 1.2. 20mm Phalanx ammunition may be stored with HD 1.2. However, it is preferable that all stocks of DU ammunition are stored separately, in view of the additional hazards it may present and for ease of control.

2.5 **ULC Stack Heights**

2.5.1 DU Ammunition held in the open or within a building, should not be stored more than two ULCs high. If DU ammunition is held in ISO containers, this should be limited to one ULC high.

2.6 Quantity Distances

2.6.1 The Inside Quantity Distances (IQDs) applied under normal storage conditions, are those specified for Storage Sub Division (SsD) 1.33.

2.6.2 The Outside Quantity Distances (OQDs) applied under normal storage conditions, are those specified for SsD 1.33. However, it is recommended that a minimum safe distance of 500m be applied, due to the potential radiological hazards that may arise in the event of fire or explosion.

2.6.3 Additional requirements for the Field Storage of DU ammunition are covered in A&ER Vol 1, Pam 12, under Special Storage Requirements for DU Ammunition.

PUBLICATION NOTE: This reference is under investigation.

2.7 Siting of Stock

2.7.1 Under exercise or battlefield conditions, the direction of the prevailing wind should be ascertained. Stock must be situated downwind from areas of occupation and other sites that may be at risk.

2.8 ISO Containers

2.8.1 It is probable that, under field storage conditions, DU ammunition will be stored in ISO Containers. These must be vented regularly, especially during the summer months. The distance between each ISO container should be that required for a module of ammunition (10 Pallets) within a Field Storage Site. Ideally, this distance is 25m, though ground restrictions may dictate a lesser distance. However, consideration should be given to preventing fire spreading from one ISO container to the next and the greater the separation between ISO containers the better. In a Field Storage Site, ISO containers (and Flatracks) equate to one module and will be deployed either side of a track, normally 10 on each side.

2.9 Lightning Protection

2.9.1 Lightning protection is required for ISO Containers when used for the storage of DU ammunition. ISO containers should be bonded to earth to provide a lightning protection system as follows:

(1) The ISO container frame, side panels, top panels, end panels and door are all to be electrically bonded together.

(2) Robust earthing points are to be provided on each container at diametrically opposite corners. This is the minimum requirement and more earthing points may be fitted down the sides, if necessary.

(3) Each Container earthing point is to be connected to a separate earth electrode.

(4) The collective resistance to earth of each container is to be less than 10 Ohms.

2.10 Storage of Individual Shot

2.10.1 Individual shot, unaccompanied by a propellant charge, should be stored in accordance with JSP 392.

2.11 **Fire Precautions**

2.11.1 During operational deployments, additional first-aid, fire-fighting measures should be considered and the advice of a Fire Safety Adviser should be sought. Further details on the actions required in the event of fire are provided within this Chapter.

2.12 **Supplementary Fire Symbols**

2.12.1 Under normal peacetime conditions there is a legal requirement to display the Supplementary Fire symbol for radioactive material (i.e. radiation hazard trefoil), such that it is readily visible to attending emergency services. Under operational conditions, alternative measures of alerting may be necessary (e.g. close liaison with fire-fighters or the use of hand-written warning notices).

3 **RADIOLOGICAL SAFETY**

3.1 **Radiological Controls**

3.1.1 Although exposure to radiation emitted by DU ammunition stored and transported within the Service environment is unlikely to result in statutory dose limits being approached, there is a statutory obligation to keep all exposures to ionising radiation As Low As Reasonably Practicable (ALARP). This is achieved by designing safety measures into the equipment and through administrative controls.

3.1.2 As a design safety measure, the ULC incorporates shielding to reduce the radiation dose to personnel. The protective coating on the shot also provides a means of reducing the hazard from corrosion and the potential spread of radioactive material. Arrangements are to be put in place to ensure that effectiveness of the radiation shielding provided by the ULC does not deteriorate due to damage or the effects of ageing.

3.1.3 Administrative controls include the appointment of a Radiation Protection Adviser and the requirement to account for the radioactive material at all times. There is also a requirement to monitor the radiation levels around the stored stacks.

3.2 **Radiation Protection Advisers**

3.2.1 Commanding Officers & Heads of Establishments are required to appoint a Radiation Protection Adviser (RPA) for each unit holding DU ammunition. The Defence Science & Technology Laboratory (Dstl),, is the Appointed RPA for MoD and will act as the RPA for all units and establishments unless, exceptionally, a separate RPA is appointed.

3.2.2 The RPA must be consulted on the implementation of the requirements for Controlled and Supervised Radiation Areas. The RPA must also be consulted regarding the radiation monitoring programme, including the type and frequency of radiation monitoring to be undertaken and the instrumentation to be used. (JSP 392, Leaflet 8 refers)

3.3 **Radiation Protection Supervisors**

3.3.1 Commanding Officers & Heads of Establishments must ensure that appropriately trained Radiation Protection Supervisors (RPSs), who are part of the management chain, are appointed in writing. In peacetime, the RPS has the statutory duty to ensure that local radiation safety rules are followed. Additionally, the RPS has a duty to ensure that tasks such as monitoring and recording radiation levels, collecting samples, storage and control of DU stocks etc., are carried out to the required standards.

4 MANAGEMENT OF OCCUPATIONAL RADIATION EXPOSURE

4.1 External Radiation Hazard

4.1.1 Risk assessments undertaken by Dstl have shown that personnel will not be exposed to significant levels of external radiation whilst working with DU in munitions depots. The storage procedures outlined above mitigate the external radiation hazard identified in the Prior Risk Assessment and will be supported by a establishing a programme of radiation monitoring.

4.2 Internal Radiation Hazard

4.2.1 An internal radiation hazard is posed by the potential to inhale and/or ingest DU dust arising from vehicles or other objects contaminated with DU following a strike from a DU penetrator, or from fires in DU storage sites. Under these conditions, internal radiation doses may be significant and will be the dominant radiation hazard. Procedures for minimising the intake of radioactive material are given in subsequent paragraphs of this Chapter.

4.3 Monitoring Radiation Levels

4.3.1 The monitoring of radiation levels is necessary to indicate any breakdown in controls and to ensure that areas are correctly designated. While comprehensive radiation monitoring will be possible under peacetime conditions, the scope of radiation monitoring under battlefield conditions will be more limited.

4.4 Peacetime Conditions

4.4.1 The RPS is to ensure that radiation levels in storage locations are monitored and recorded at least once per month. Additionally, on receipt and during loading operations, each ULC should be monitored and the details recorded, to confirm that the packaging has not been damaged. Further monitoring of individual ULCs is required only if damage is suspected.

4.4.2 Routine monthly monitoring may be limited to those areas where personnel are frequently moving or working, e.g. at the entrances to the Explosives Store House (ESH), in the gangways and between stacks of ULCs. It is normal practice to establish background radiation readings outside the ESH. For these tasks, radiation monitors such as the MiniRad 1000 & PDR1 (or equivalent) are the instruments of choice.

4.4.3 It is recommended that a scale drawing be made of the ESH, showing the location and quantity of DU material stored. To minimise paperwork, monitoring points can be marked on the drawing and the readings recorded on a separate sheet. Readings are normally taken at a distance of 50 to 75mm (2 to 3 inches) from the side of the ULC. The radiation level at the external surface of the ULC should not exceed 5 µSv/h. If higher readings are recorded, Inspector of Explosives (DE&S) should be informed as this implies incorrect loading.

4.4.4 Full instructions for the use of the monitoring equipment should be incorporated in local orders and should include details of battery testing, function checks, background readings, calibration and any additional details, as recommended by the RPA. All electrical test equipment and its use must comply with the requirements of this document. All radiation monitoring equipment must have proof of in-date calibration from an accredited Test Authority (usually Dstl). Radiation monitoring equipment typically available for monitoring around ULCs include:

Description	Type of Monitor	NATO Stock Number
Monitor Mini 900 + 44B probe	Contamination	6665-99-801-3983
Monitor Chamber Ion RO2	Radiation	6665-01-243-5942
Monitor Chamber Ion RO10	Radiation	Not Codified
Nuclear Enterprises Meter Portable Dose Rate PDR 1	Radiation	6665-01-444-2778
MiniRad 1000	Radiation	6665-99-728-9785

Table 1 - Typical Radiation Monitoring Instruments

4.4.5 Prior to use all radiation monitoring instruments should be subject to a functional check using a radiation check source. The recommended source is the UAC 1623 (NSN Z8/6665-99-193-3906). The check source should be stored in a secure container, should be accounted for, and must be tested for leakage at intervals not exceeding two years. The necessary arrangements for the control of radioactive check sources are provided in JSP 392 (Leaflet 21).

4.5 **Battlefield Conditions**

4.5.1 Monitoring of radiation levels on a monthly basis is inappropriate for the battlefield situation. The monitoring requirement is therefore reduced to monitoring and recording each ULC/ISO container on receipt, to confirm that the packaging has not been damaged in transit. Further monitoring of individual ULCs is required only if damage is suspected, and during loading operations for transportation. Routine, monthly monitoring is to be limited to those areas where personnel are frequently moving or working, e.g. within ISO containers/rows of ULCs. Readings are normally taken on the top and sides of the ULC. It is recommended that readings are also taken at the sides and ends of the ISO container, with the doors closed. The radiation level at the external surface of the ULC should not exceed 5 μSv/h and, for ISO containers, should not exceed 2 μSv/h. If higher readings are recorded, Defence Munitions should be informed.

4.6 **Monitoring Contamination Levels**

4.6.1 DU ammunition is to be monitored on receipt into Depots[1], to ensure that the level of loose contamination on the external surfaces does not exceed 0.4 Bq/cm^2, when averaged over any area of 300 cm^2. This testing is undertaken by wiping the external surfaces of the ULC with a filter paper and forwarding the filter paper(s) to DSTL. Each container involved is to have a certificate, provided by DSTL, duly dated, to confirm that the results of this monitoring are satisfactory. Provided this is done, there is no need for further smear testing of the ULCs before they are transported, unless the containers are damaged.

4.7 **Personal Monitoring**

4.7.1 The main hazard from DU arises from the inhalation of DU particles generated as a result of firing DU shot. Personal dose meters, which are used to measure external doses, are therefore not routinely issued for peacetime or battlefield conditions. Estimates of external radiation dose are normally carried out using the procedure outlined below. However, where an individual has been issued with a personal dosemeter, it must be worn when working with DU, or when entering DU storage areas.

4.7.2 Entry to ESH containing DU ammunition is to be strictly controlled. A register is to be maintained by the RPS, listing all personnel by name, date, times of entry and exit from the ESH and their calculated dose. The potential exposure to radiation in DU ammunition storage and transport operations is, however, very low and for most situations personal dosimetry will not be required. In these circumstances, the dose to personnel entering the

[1] This is not required if the consignment is in transit and intact, i.e. the package has net been breeched.

ESH, or involved in transport operations, can be calculated using the following formula, which has been approved by the Dstl Radiation Protection Advisory Body:

Dose to individual (µSv) = Time of occupation (hours) x 10

4.7.3 For the purpose of the dose calculation the time of occupation should be rounded up and counted as whole hours (e.g. 1 hr 20 minutes = 2 hrs). The figure of 10 represents 10 µSv/h, which has been advised by the Dstl RPA Body as the probable maximum reading at a location between two ULCs. The radiation doses estimated by this method are therefore likely to be significantly higher than the actual radiation dose.
4.7.4 The RPS is to monitor the exposure of individual personnel and the dose records are to be kept indefinitely. Advice on monitoring techniques, instrumentation and the monitoring programmes will be given by the RPA and is to be used as the basis for producing local rules and written systems of work.

4.7.5 Radiation dose limits are defined in UK legislation and are provided in JSP 392 (Leaflet 4). Current statutory dose limits restrict the whole-body radiation dose to 20mSv in any calendar year. The dose limit for the hands in any calendar year is 500mSv. A dose assessment, undertaken by the Dstl RPA, has shown that unshielded DU ammunition would have to be handled with bare hands, for at least 200 hours, for this limit to be exceeded.

4.7.6 MOD has set investigation levels to ensure that exposures to ionising radiations are kept ALARP. Details of these investigation levels are provided in JSP 392 (Leaflet 4).

4.8 **Biological Monitoring**

4.8.1 It is MOD policy that biological monitoring of Military personnel (and MOD civilians) will be undertaken where they have been exposed to DU, or where there is a high probability that they have been so exposed. Treatment and monitoring of personnel injured by, or closely associated with strikes from DU ammunition will be dictated by the medical staff and the conditions in the field at the time.

4.8.2 Personnel that have participated in clean up and recovery operations for vehicles, or other hard objects struck by DU munitions, or who have attended an accident involving DU ammunition, are encouraged to comply with requests for monitoring. Personal biological monitoring will be coordinated by medical staff and may include the techniques given in Table 2.

EXPOSURE WITHIN 7 DAYS	**EXPOSURE 7+ DAYS AGO**
24 hr urine collection (soluble U) Faecal collection daily (insoluble U) Early whole-body monitoring by Dstl Approved Dosimetry Service	24 hr urine collection (soluble U) Early whole body monitor by Dstl Approved Dosimetry Service.

Table 2 - Monitoring of DU Intakes

5 **ACCIDENTS INVOLVING DU AMMUNITION**

5.1 **Personnel Requirements**

All personnel working with DU ammunition must be aware of both the explosive and radiological hazards associated with the ammunition and must be instructed in the actions to be taken in the event of an accident or fire. Drivers and escorts of vehicles transporting DU ammunition must be trained and equipped to undertake appropriate remedial action to protect people in the immediate vicinity of an accident or fire.

6 ACTIONS IN THE EVENT OF FIRE

6.1 Evacuation

6.1.1 The uranium alloy used in DU shot may ignite when heated in air to between 600 and 1000° C, a temperature range that is easily attainable in a petrol or propellant fire. If the shot becomes involved in such a fire, there is the potential for uranium oxide to be dispersed as an aerosol, though recent information suggests that this is unlikely. However, as a precautionary measure, an area downwind, within 22.5° sectors either side of the plume centreline, to a distance of 500m (or at least the radius of the relevant SsD 1.33 Inhabited Building Distance (IBD)), must be evacuated.

6.2 Fire Fighting

6.2.1 Fires in the vicinity of ammunition must be fought immediately to prevent the fire spreading to the ammunition, see also Chapter 15. External fire-fighting teams must be warned of the hazards. The immediate explosive hazards from munitions must take precedence over the elimination of the radiological hazards of DU. In the event of a fire involving DU ammunition, the advice of the RPA must be sought as soon as is practicable.
6.2.2 Once uranium metal has ignited and a vigorous self-sustaining oxidation reaction has started, the application of small quantities of water are not likely to be effective and may even add to the spread of the fire by dispersing the burning uranium. Dry powder smothering agents may be used, but when explosives are present, the close approach necessary to deliver them to the seat of the fire would create additional hazards for the fire-fighters. **Fire extinguishers containing Halon should not be used for fighting fires involving DU.**

6.2.3 The most practicable method of fighting the fire is to drench the burning items with copious quantities of water from a safe distance and position, up-wind if practicable, with the intention of rapidly cooling the DU. Self-Contained Breathing Apparatus (SCBA) should be worn and personal decontamination procedures should be implemented as soon as possible, once the fire is completely extinguished. The remaining ashes and debris must be cold and thoroughly saturated with water, prior to being bagged in strong polythene, pending appropriate disposal.

6.3 Actions in Event of Damage to DU Ammunition

6.3.1 In the event of an accident resulting in damage to the protective coating of the penetrator, it must be assumed that particles of DU may have been released.

6.3.2 Fragments of DU penetrator may be extremely sharp, which may cause radioactively contaminated cuts in the skin. The following precautions are therefore to be taken to reduce the risk of handling damaged DU ammunition:

(1) DU residues or fragments must not be allowed to come into direct contact with bare skin. Personal Protective Equipment (PPE), for example full NBC kit, including Service respirator and over-boots, are to be worn. Further information on protective clothing and respiratory protective equipment is contained in ESTC Guidance Notes No. 5.

(2) The direct handling of DU fragments or contaminated items is to be avoided. Remote handling tools (e.g. Cee-Vee reachers) or similar should be used where practicable.

(3) Where possible all PPE and clothing, which may be contaminated, must be removed using standard NBC undressing procedures and bagged for future monitoring, decontamination or disposal.

6.3.3 Procedures for the clearance of DU from ranges or vehicles that may have suffered a DU strike, or a vehicle containing DU ammunition that has been subjected to a vehicle fire, are provided at paragraph 6.9. Further information is available in JSP 364.

6.3.4 Monitoring of Personnel Following a Fire or Accident

6.3.5 The main risk to health arises from the potential to inhale or ingest DU dust whilst clearing vehicles contaminated with DU, or from fires involving DU ammunition. The simple precautions given in EOD Procedure No. 8, supplemented by paragraphs 6.3.2 (1) to 6.3.2 (3) above, reduce this risk to a minimum. The essential precautions are to cover the body in disposable clothing and to wear a respirator. Individual Protective Equipment (IPE) is a readily available clothing system that achieves this. The use of protective breathing apparatus significantly reduces work output and regular rest breaks are required.

6.3.6 All potentially exposed personnel should have a full medical history taken and be counselled appropriately. They should be made aware that uranium dust inhalation carries a long-term risk to health. Following exposure, biological monitoring is advised and should be arranged with local medical authorities. Exposed personnel should be encouraged to comply with these arrangements.

6.4 **Contingency Plans and Exercises**

6.4.1 Guidance on contingency planning and alerting procedures are contained in ESTC Guidance Note No. 5. MOD policy requires that a medium level exercise be carried out every two years. These exercises are co-ordinated within the Major/Medium exercise calendar maintained by the Directorate of Safety & Claims (D S&C). A medium level exercise may take the form of a Command Post Exercise (CPX) with a limited amount of field play. Local civilian authorities and emergency services should participate and MOD's Nuclear Accident Response Organisation (NARO) must be represented. A minor exercise does not involve local authorities or emergency services.

6.4.2 Contingency plans for matters relating to compliance with the Ionising Radiations Regulations 2017, are required to address the issues identified in the Prior Risk Assessment and must be included in local rules. While the majority of the issues identified in the risk assessment have been addressed in this Chapter, it is important to identify and address issues relating to specific sites where DU ammunition is stored.

6.4.3 Reference should be made to ESTC Standards 10 and 11 (formerly ESTC Prescriptions Nos. 4 and 5) for Predictions and Countermeasures relating to exposure to a plume of DU smoke and to unfixed (loose) DU surface contamination.

6.5 **Health Risk to Members of the Public**

6.5.1 A potential radiation health risk to the public resulting from a fire in an explosives site containing DU ammunition, or in transit, may result from:

(1) The inhalation of a uranium oxide aerosol, in the form of smoke escaping from the site or vehicle;

(2) The contamination of property, foodstuffs and livestock by the deposition of uranium oxide particulate from the smoke plume, leading to long-term inhalation and ingestion risks.

6.6 **Consequences of a Major Fire Involving DU Material**

6.6.1 Assessments have been carried out to evaluate the radiological consequences of a major fire involving DU material (Dstl Report 348/2003 December 2003). The dose to personnel and members of the public in terms of the significant exposure pathways have been estimated for a fire involving 1 tonne of DU and are given in Table 3.

Exposure Pathway	Personal Dose (μSv) / tonne of DU burned		
	100 m	200 m	300m
Inhalation Dose (direct plume)	3.870	1.450	0.726
Ground Shine	0.680	0.255	0.128
Ingestion Dose	0.020	0.001	0.000
Resuspension Inhalation Dose	0.122	0.046	0.023
TOTAL DOSE	**4.67**	**1.76**	**0.876**

Table 3 - Estimated dose consequences following a major fire within an ESH

6.6.2 The data given in Table 3 is indicative of the dose consequences of a major fire within an ESH and may be scaled up for fires involving larger DU inventories. The data is extracted from a larger data set and is based on a number of very pessimistic assumptions in terms of release characteristics and weather conditions. The use of this data in consideration of accident contingency planning should be accompanied by advice from the appropriate establishment RPA.

6.7 **Protective Clothing**

6.7.1 Where NBC clothing is unavailable or inappropriate, other Personal Protective Equipment may be used following an incident where DU has been dispersed. This may include filter masks, gloves and coveralls.

6.7.2 The Control of Substances Hazardous to Health Regulations (2002) require that all masks, including disposable masks, need to be fit tested, to ensure that satisfactory protection is achieved. Respirators issued to Service personnel are normally individually fit tested and should be used in preference to disposable or other masks. Disposable or industrial masks should only be used where there is no alternative.

6.8 **Clearance of DU Contaminated Vehicles**

6.8.1 Procedures for the clearance of DU from range areas are contained EOD Procedure No 8. The guidance given also applies to the clearance of vehicles that may have suffered a DU strike, or a vehicle containing DU ammunition that has been subjected to a vehicle fire. The following additional advice is given to supplement EOD Procedure No. 8:

(1) As there may be uncertainty as to the presence of radioactive material, it is essential that all approaches to a suspect vehicle/site are made in full IPE. In the event that radiation monitoring confirms the presence of radioactive material, on return to an uncontaminated area, the IPE must be removed (except respirator), double bagged and sealed, and returned to the UK for appropriate disposal. Respirators may be

removed when there is no likelihood of contamination being present and may require decontamination prior to reuse.

(2) Radiation dose rate instruments (e.g. the MiniRad 1000) must be used as the vehicle is approached. This will indicate the presence of bulk DU, though it is unlikely to detect DU contamination on the vehicle surfaces. Surface contamination will only be detected by careful use of a contamination monitor, such as the Mini 44B. Dose rate and contamination measurements are to be made, both inside and outside the vehicle.

7 TRANSPORT OF DU AMMUNITION

7.1 Transport Regulations

7.1.1 International Regulations for the safe transport of radioactive materials are published by the International Atomic Energy Agency (IAEA No. ST-1 revised 2005). The objective of the IAEA Regulations, which apply to all modes of transport, is to protect persons, property and the environment from the effects of radiation during the transport of radioactive materials. Statutory UK Regulations are in place for the transport of radioactive materials by road (SI 2002 No. 1093) and rail (SI 2004 No. 568) and the International Maritime Dangerous Goods (IMDG) Code applies to transport by Sea. Transport of explosives, by road and rail, is regulated by The Carriage of Dangerous Goods & Use of Transportable Pressure Equipment Regulations 2004 (SI 2004 No. 568). These latter regulations will be amended to incorporate regulations for the transport of radioactive materials by road in 2007, whereupon SI 2002 No. 1093 will be revoked. As international and civil Regulations consider explosives and radioactive materials under separate categories of dangerous goods, compliance with each of these regulatory areas is necessary for shipments of DU ammunition. While UK regulations (SI 2002 No. 1093 and SI 2004 No. 568) may be disapplied in relation to the transport of radioactive munitions as “instruments of war”, MOD policy is to do “as good as” that required by statute.

7.1.2 While transport of DU munitions by the MOD is carried predominantly by road, transport by other modes is possible and reference to specific modal regulations will be required.

7.1.3 MOD policy and procedures for the transport of radioactive materials by all surface modes are contained in the Dangerous Goods Manual (DGM) which, in addition, includes procedures for explosives transport. Arrangements for the transport of DU ammunition by MOD are described in Prescriptions, for each ammunition type, published by DOSR which reflect the requirements of the national and international Regulations.

7.2 Classification of Transport Consignments

7.2.1 For all modes of transport, radioactive items may be transported under the IAEA system as “Radioactive Excepted” subject to meeting a number of conditions. Within this category, compliance with the various modal regulations are simplified. The detailed criteria for classification of radioactive materials as “Radioactive Excepted” are described in the DGM. In, summary, the conditions relevant to DU consignments are:

(1) No explosives are present.

(2) The radiation level on the outside of the package does not exceed 5 μSvh-1.

(3) The outer surface of the DU material should be enclosed in an inactive sheath made of metal or some other substantial material.

(4) Loose contamination on the outside of the container should not exceed 4 $Bqcm^{-1}$ for beta/gamma emitters and 0.4 $Bqcm^{-1}$ for alpha emitters.

7.2.2 Details of the classification, packaging and transport arrangements for Excepted Packages are given in the DGM

7.2.3 DU penetrators and munition components that do not contain explosives where the package cannot be sent as an Excepted Package, shall be transported as Low Specific Activity Material Group I (LSA-I) as long as the articles meet the definition of LSA-I. Details of the classification, packaging and transport arrangements for LSA-1 consignments are given in IAEA No. ST-1 (revised 2005).

7.2.4 DU penetrators and munitions that contain explosives and where the package fulfils the criteria for an Excepted Package shall be transported as UN Class 1 (explosives) in accordance with the DGM).

DU penetrators and munitions that contain explosives and where the package cannot be sent as an Excepted Package shall be transported as Low Specific Activity Material Group I with a subsidiary risk of UN Class 1 (explosives) provided that the articles meet the definition of LSA-I.

7.3 **Transport in Unit Load Container (ULC)**

7.3.1 DU munitions are commonly transported by road, rail, and sea modes. In all modes, complete DU round assemblies are transported in purpose-built Unit Load Containers (ULCs). The ULC has been designed to ensure that radiation levels at the external surface are As Low As Reasonably Practicable (ALARP) and are sufficiently low to allow transport in a safe, legally compliant condition.

7.3.2 Within the ULC, DU shot and explosives are considered to be suitably partitioned such that they may be considered to be separately packaged. Designation of the package as UN Class 1, either primary or subsidiary, is therefore not required. Further, under normal circumstances, the ULC is sufficiently shielded to be regarded as an Excepted Package in accordance with Paragraph 7.2.1(2). Should a protective base plate not be fitted, however, radiation levels may exceed 5 $\mu Sv h^{-1}$ outside the ULC and designation as Class 7 LSA-1 as indicated in Paragraph 7.2.5 will be required.

7.4 **Transport Procedures and Documentation**

7.4.1 The responsibilities of Consignor, Carrier and Consignee with respect to the generic Dangerous Goods transport requirements are defined in the DGM. Consignors are to ensure that the DU consignment has been correctly classified, packed, marked and documented. Within the MOD, the same agency (or person) may fulfil the roles of Consignor and Carrier.

7.4.2 Whether the ULC is an Excepted Package or an LSA-1 Package, the following measures are always to be adopted when transporting DU ammunition.

(1) SITPRO Dangerous Goods Note. The SITPRO (DGN) is the principal document used for surface movements of Dangerous Goods and constitutes the Shipping Instruction, the Dangerous Goods Declaration and the Packing Certificate and must be completed for all DU munitions consignments transported by road, rail or sea. The SITPRO (DGN) is to be completed only by persons suitably trained in accordance with the DGM.

(2) Supplementary Hazardous Load Warning Sheet (SHLWS). Risks in addition to those indicated by the UN classification are included on a SHLWS for Depleted Uranium. Crews of road vehicles are required to be briefed on these risks and are to be issued with a SHLWS as detailed in the DGM

(3) Other ammunition and explosives (Class 1) are not to be carried in the same vehicle as the DU ammunition, except where ULCs contain shot only, when they may be transported with other explosives of HD 1.3 or 1.4.

(4) Each ULC is to be inspected to ensure that it is in good condition and is legibly and durably marked with its permitted gross weight.

(5) Prior to shipping, radiation and contamination monitoring will be carried out to demonstrate compliance with transport regulations. Monitoring for loose contamination on the outside of a ULC should be carried out by an indirect smear method as indicated in Paragraphs 4.3 and 7.2.1(4). Monitoring and the interpretation of monitoring results should be undertaken by suitably trained persons in consultation with a Dangerous Goods Safety Adviser or Radiation Protection Adviser.

7.5 **Transport as LSA-1 Material**

7.5.1 In addition to the general requirements for transport already indicated, additional measures are required where ULCs cannot be classified as Excepted.

7.5.2 The maximum radiation dose rate at a distance of one metre from the external surface of the ULC is to be measured. Converting this dose rate into µSv/h and dividing the figure obtained by 10 will give the Transport Index (TI) of the ULC. If the TI is less than 0.05 (i.e. the dose rate is less than 0.5 µSv/h) it can be regarded as zero. The Transport Index should be marked on the transport label.

7.5.3 The maximum radiation dose at any point on the external surface of the ULC is to be measured in order to determine the Category and thus the appropriate label according to the table below. If the Transport Index satisfies the conditions for one category and the surface dose rate those of another, the ULC is to be assigned to the higher of the two categories. DU ammunition will normally be Category II - YELLOW.

Category	**Surface Dose Rate**	**Transport Index**
Category I – WHITE	Not more than 5 µSv/h at any point	0
Category II – YELLOW	More than 5 µSv/h but not more than 500 µSv/h	More than 0 but not more than 1.0
Category III – YELLOW	More than 500 µSv/h but not more than 2mSv/h	More than 1.0 but not more than 10.

Table 4 - Categories of Package

7.6 **Transport by Rail**

7.6.1 The transport of DU munitions by rail in the UK is governed by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2004 (SI 2004/568). These regulations refer directly to international regulations (Regulations concerning the International Carriage of Dangerous Goods by Rail (RID)) are, therefore, valid for movements within and outside the UK. While exemptions to the UK Regulations may be permitted for the movement of military explosives, compliance with all UK and international regulations will normally be expected for consignments of DU munitions by MOD.

7.6.2 Should transport by rail be required, this should be carried out following reference to the MOD Regulations for the Transport of Dangerous Goods (the DGM) and consultation with a Dangerous Goods Safety Adviser.

7.7 **Transport by Sea**

7.7.1 Transport of DU munitions by sea is governed by the International Maritime Dangerous Goods (IMDG) Code and the Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997. The latter Regulations require the provision and maintenance of equipment and management systems to ensure that satisfactory health and safety is maintained on board.

7.7.2 Should transport by sea be required, this should be carried out following reference to the MOD Regulations for the Transport of Dangerous Goods (the DGM) and consultation with a Dangerous Goods Safety Adviser.

CHAPTER 28

ANNEX A

GLOSSARY

The following are definitions used throughout this chapter.

ALARP As Low As Reasonably Practicable

Becquerel (Bq) The SI unit of activity defined as one nuclear disintegration per second.

Contamination The unintended presence of radioactive material on surfaces, areas, personnel or objects or in gases or liquids.

Contingency Plan A plan designed to protect persons who may be affected by ionising radiation arising from any foreseeable accident or incident to which the plan relates.

Dangerous Goods Safety Adviser A person, suitably qualified and experienced, to advise on the transport requirement for the consignment of Dangerous Goods (such as DU munitions).

Depleted Uranium Uranium containing less than 0.72% uranium-235 by weight.

Dose Limits Limits of radiation dose to the whole body or individual tissues or organs or extremities of the body in a specified period.

Dose Rate The rate at which a person or part of a person would receive a dose of ionising radiation.

Dosimetry The measurement of radiation doses. It applies to both the devices used and the assessment technique.

Excepted Package This is a package containing radioactive materials within the limits described for excepted packages in International Atomic Energy Agency (IAEA) Safety Series No. TS-R-1, Regulations for the Safe Transport of Radioactive Material

Hazard Identification and Risk Evaluation (HIRE) An evaluation of risk to members of the public resulting from accidents during storage, use or transport of radioactive materials.

Ionising Radiation Gamma (γ) rays, X-rays, alpha (α) particles, beta (β) particles and neutrons, the latter causing ionisation indirectly.

Low Specific Activity Low Specific Activity (LSA) material is a system of categorisation for radioactive material defined in IAEA Safety Series No. TS-R-1, Regulations for the Safe Transport of Radioactive Material.

Low Specific Activity Group I (LSA-1)

LSA-1 material is either:

(1) Ores containing naturally occurring radionuclides (e.g. uranium, thorium) and uranium and thorium concentrates of such ores.

(2) Solid unirradiated natural uranium or depleted uranium or natural thorium or their solid or liquid compounds or mixtures.

(3) Radioactive material other than fissile material, for which the A value is unlimited.

Natural Uranium Uranium containing the naturally occurring distribution of uranium isotopes (approximately 99.28% uranium-238 and 0.72% uranium-235 by weight).

Prior Risk Assessment An assessment of radiological risk carried out before commencement of work to identify measures needed to restrict radiation exposure.

Radiation Protection Adviser (RPA) A person or corporate body appointed by the Commanding Officer (or equivalent head) to advise on the observance of the Ionising Radiations Regulations 2017 and on other health and safety matters in connection with ionising radiations.

Radiation Protection Supervisor (RPS) A person appointed in writing by the Commanding Officer (CO) (or equivalent head) in respect of a particular process or processes to ensure that work is carried out in compliance with these instructions.

Radiation Safety Officer (RSO) An officer appointed by the CO (or equivalent head) for the purpose of administering his responsibilities under these instructions.

Radioactive Material Includes closed sources, articles containing radioactive substances, unsealed radioactive substances and non-radioactive articles contaminated with radioactive substances.

Radioactive Substance There are three definitions for a substance that must be regarded as radioactive for the purposes of radiation protection, dependent upon which regulations are applicable:

(1) The Ionising Radiations Regulations 2017 (IRR 17)
Any substance which contains one or more radionuclides whose activity cannot be disregarded for the purposes of radiation protection.).

(2) The Radioactive Substances Act 1993 (RSA 93)
A substance containing an element specified in Schedule 1 (of RSA93) in such a proportion that the number of becquerels of that element contained in the substance, divided by the number of grams which the substance weighs, is a number greater than that specified in relation to that element in the appropriate column of that Schedule; or,
A substance that has become radioactive through bombardment by neutrons or ionising radiations.

Where there is any doubt about whether a substance is radioactive, seek the advice of the Radiation Protection Adviser.

(3) Regulations for the Safe Transport of Radioactive Material (IAEA No. TS-R-1)
Any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in paras 401-606 (of TS-R-1).

Radiological Safety Assessment An assessment to confirm that equipment is fit for purpose and to identify the nature and magnitude of the radiation hazard to employees or other persons associated with the introduction of new equipments, installations or working practices which is likely to arise during normal operating conditions.

Radionuclide A radioactive species of atom characterised by its mass number, atomic number and nuclear energy state.

Sievert (Sv) The SI unit of dose equivalence; defined as the product of the absorbed dose, in Gray (Gy) and the quality factor of the radiation. It is a measure of biological damage in man.

SITPRO (Dangerous Goods Note) Document used for the consignment of Dangerous Goods (such a DU munitions).

Type A Package A package that contains up to the relevant specified activity limit for any given isotope. Type A packages are designed to prevent the loss or dispersal of the radioactive package contents and prevent any increase in the maximum radiation level recorded at the external surface of the package during normal conditions of transport.

Unit Load Container A container designed for the transport of DU shot and propellant within a single, but segregated, package.

Uranium See Depleted Uranium or Natural Uranium.

Visitors Persons who enter radiological areas other than for purposes of undertaking work.

Women of Reproductive Capacity A woman who is made subject to the additional dose limit for a woman of reproductive capacity specified in paragraphs 5 and 11 of Schedule 4 (to IRR 17) by an entry in her health record made by an appointed doctor or employment medical adviser.

Work with Ionising Radiations Any task entailing the production, processing, handling, use, holding, storage, moving, transport or disposal of any radioactive substance, or entailing the operation or use of any radiation emitting machine or apparatus, including instruction or training in which a person is engaged in as a trainee.

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