MATERIALS LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 36, 39, 40, and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

301358

Licensee	
1. Department of the Army Commander Crane Army Ammunition Activity 2. ATTN: SIOCN-SF 300 Highway 361 Crane, IN 47522-5099	3. License Number SUB-1578 4. Expiration Date August 31, 2001 5. Docket or Reference No. 040-09045

6. Byproduct, Source, and/or Special Nuclear Material	7. Chemical and/or Physical Form	8. Maximum Amount that Licensee May Possess at Any One Time Under This License
A. Uranium (depleted in U-235)	A. Solid metal alloy	A. 10,000,000 Kilograms

9. Authorized Use:

A. For possession incident to the transportation, storage, inspection, performance of minor maintenance and demilitarization of depleted uranium munitions as define in application dated April 18, 1996.

CONDITIONS

10. Licensed material shall be used and stored only at Crane Army Ammunition Activity, 300 Highway 361, Crane, Indiana.

11. Licensed material shall be used by, or under the supervision of, Walter F. Shearin, Robert D. Roach or Richard W. Murphy.

12. The Radiation Safety Officer for this license is Walter F. Shearin.

13. This license does not authorize the firing of ammunition containing licensed material.

14. The licensee is authorized to transport licensed material only in accordance with the provisions of 10 CFR Part 71, "Packaging and Transportation of Radioactive Material."

License Number SUB-1578

MATERIALS LICENSE SUPPLEMENTARY SHEET

Docket or Reference Number 040-09045

15. The licensee may not possess and use materials authorized in Items 6, 7, and 8 until:

    A. The licensee has constructed the facilities and obtained the equipment described in the application and supporting documentation; and

    B. The U. S. Nuclear Regulatory Commission, Region III, ATTN: Chief, Materials Licensing Branch, 801 Warrenville Road, Lisle, IL 60532-4351 has been notified that activities authorized by the license will be initiated.

16. Within 30 days of the date of a decision not to complete the facility, acquire equipment, or possess and use authorized material, the licensee must notify the Commission in writing, of the decision.

17. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents, including any enclosures, listed below. The U.S. Nuclear Regulatory Commission's regulations shall govern unless the statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.

    A. Application dated April 18, 1996; and

    B. Letter dated August 15, 1996.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Date August 27, 1996

By Loren J. Hueter
Materials Licensing Branch, Region III

COPY

BETWEEN:

LICENSE FEE MANAGEMENT BRANCH, ARM
AND
REGIONAL LICENSING SECTIONS

(FOR LFMS USE)
INFORMATION FROM LTS

PROGRAM CODE:
STATUS CODE: 3
FEE CATEGORY:
EXP. DATE: 0
FEE COMMENTS:
DECOM FIN ASSUR REQD:

LICENSE FEE TRANSMITTAL

A. REGION

1. APPLICATION ATTACHED
   APPLICANT/LICENSEE: ARMY, DEPARTMENT OF THE
   RECEIVED DATE: 960528
   DOCKET NO: 4009045
   CONTROL NO.: 301358
   LICENSE NO.:
   ACTION TYPE: NEW LICENSEE

2. FEE ATTACHED
   AMOUNT: 0
   CHECK NO.: 0

3. COMMENTS

SIGNED D. Hersey
DATE 5-29-96

B. LICENSE FEE MANAGEMENT BRANCH (CHECK WHEN MILESTONE 03 IS ENTERED /__/)

1. FEE CATEGORY AND AMOUNT:

2. CORRECT FEE PAID. APPLICATION MAY BE PROCESSED FOR:
   AMENDMENT
   RENEWAL
   LICENSE

3. OTHER

SIGNED
DATE

FEE EXEMPT

NRC FORM 313 (6-93) 10 CFR 30, 32, 33, 34, 35, 36, 39 and 40

U. S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR MATERIAL LICENSE

APPROVED BY OMB: NO. 3150-0120
EXPIRES 6-30-96

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 9 HOURS. SUBMITTAL OF THE APPLICATION IS NECESSARY TO DETERMINE THAT THE APPLICANT IS QUALIFIED AND THAT ADEQUATE PROCEDURES EXIST TO PROTECT THE PUBLIC HEALTH AND SAFETY. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555-0001, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0120), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

APPLICATION FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

DIVISION OF INDUSTRIAL AND MEDICAL NUCLEAR SAFETY
OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS:

IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

LICENSING ASSISTANT SECTION
NUCLEAR MATERIALS SAFETY BRANCH
U.S. NUCLEAR REGULATORY COMMISSION, REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406-1415

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

NUCLEAR MATERIALS LICENSING SECTION
U.S. NUCLEAR REGULATORY COMMISSION, REGION II
101 MARIETTA STREET, NW, SUITE 2900
ATLANTA, GA 30323-0199

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

MATERIALS LICENSING SECTION
U.S. NUCLEAR REGULATORY COMMISSION, REGION III
801 WARRENVILLE RD
LISLE, IL 60532-4351

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:

NUCLEAR MATERIALS LICENSING SECTION
U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
611 RYAN PLAZA DRIVE, SUITE 400
ARLINGTON, TX 76011-8064

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:

RADIOACTIVE MATERIALS SAFETY BRANCH
U.S. NUCLEAR REGULATORY COMMISSION, REGION V
1450 MARIA LANE
WALNUT CREEK, CA 94596-5368

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S.NUCLEAR REGULATORY COMMISSION JURISDICTIONS.

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*
   - [X] A. NEW LICENSE
   - [ ] B. AMENDMENT TO LICENSE NUMBER ______
   - [ ] C. RENEWAL OF LICENSE NUMBER ______

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include Zip code)*
   Commander
   Crane Army Ammunition Activity
   ATTN: SIOCN-SF
   300 Highway 361
   Crane IN 47522-5099

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED
   Crane Army Ammunition Activity
   300 Highway 361
   Crane IN 47522-5099

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION
   Walter F. Shearin
   TELEPHONE NUMBER
   (812) 854-1246/3404

SUBMIT ITEMS 5 THROUGH 11 ON 8-1/2 X 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL
   a. Element and mass number; b. chemical and/or physical form; and c. maximum amount which will be possessed at any one time.
6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.
7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING EXPERIENCE.
8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.
9. FACILITIES AND EQUIPMENT.
10. RADIATION SAFETY PROGRAM.
11. WASTE MANAGEMENT.
12. LICENSEE FEES *(See 10 CFR 170 and Section 170.31)*
    FEE CATEGORY ______ AMOUNT ENCLOSED $ ______
13. CERTIFICATION. *(Must be completed by applicant)* THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, 36, 39 AND 40, AND THAT ALL INFORMATION CONTAINED HEREIN IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

CERTIFYING OFFICER – TYPED/PRINTED NAME AND TITLE	SIGNATURE	DATE
J. C. King COL, OD Commanding	[signature]	18 Apr 96

FEE EXEMPT

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	AMOUNT RECEIVED	CHECK NUMBER	COMMENTS
			$		RECEIVED MAY 28 1996 REGION III
APPROVED BY				DATE	301358

DEPARTMENT OF THE ARMY
CRANE ARMY AMMUNITION ACTIVITY
300 HIGHWAY 361
CRANE INDIANA 47522-5099

REPLY TO
ATTENTION OF

May 23, 1996

Safety Office

Materials Licensing Section
U.S. Nuclear Regulatory Commission, Region III
801 Warrenville Road
Lisle, Illinois, 60532-4351

Dear Sir,

Enclosed are two copies of our Depleted Uranium Storage and Demilitarization License Application for your approval.

If additional information is required, please contact the undersigned at (812) 854-1246.

Sincerely,

Walter F. Shearin

Walter F. Shearin
Chief, Safety Office

Enclosure

Copies Furnished:

U.S. Army Material Command ATTN: AMCSF, 5001 Eisenhower Avenue, Alexandria, VA 22333-0001 (w/enclosure)

U.S. Army Industrial Operations Command ATTN: AMSIO-DMW (Mr. Jesse Granger), Rock Island IL 61299-6000 (wo/enclosure)

MAY 2 8 1996

RECORD OF ENVIRONMENTAL CONSIDERATION

To: Doug Johnson, Environmental Protection Specialist, Crane Army Ammunition Activity (CAAA)

From: Walter F. Shearin, Radiation Protection Officer, Crane Army Ammunition Activity

Project Title: Demilitarization of Small Arms Projectiles Containing Depleted Uranium (Staballoy) Penetrators.

Brief Description: Demilitarization, Maintenance, Storage and Transportation of Various Depleted Uranium Munitions as Listed in the Attached NRC License Application.

Reason for using a record of environmental consideration--

This project is categorically excluded under the provisions of CX A-11, AR 200-2, Appendix A, (and no extraordinary circumstances exist as defined in paragraph 4-2), because:

1. Operations in this established laboratory are within an enclosed facility and has external radiation levels that are in compliance with existing Federal, State, local laws, and regulations.

2. No environmentally controversial change is being made to existing environmental conditions.

3. This action has been evaluated IAW AR 200-2, Appendix A, paragraph A-31, and all requirements for categorical exclusions are true.

20 May 1996
Date

Walter F. Shearin
WALTER F. SHEARIN
Radiation Protection Officer

20 May 1996
Date

Doug Johnson
DOUG JOHNSON
Environmental Coordinator

CRANE ARMY AMMUNITION ACTIVITY
CRANE INDIANA 47522-5099

ITEM 5

RADIOACTIVE MATERIAL

a. Element and Mass: U-238 -Depleted Uranium)

b. Chemical and
Physical Form: Solid Metallic Alloy (STABALLOY) not less than 95% U-238

c. Maximum Quantity
to be possessed
at any one time: 10 million Kilograms

CRANE ARMY AMMUNITION ACTIVITY
CRANE INDIANA 47522-5099

ITEM 6

PURPOSES FOR WHICH LICENSED MATERIAL WILL BE USED

SECTION I - DESCRIPTION

1. Depleted Uranium (DU) controlled by this license will be used in the following activities:

a. Transportation. Individual containers and pallets of DU munitions will be received from or shipped to other authorized depots, using units, and manufacturers.

b. Inspection. DU munitions and packaging will be inspected for safety and serviceability during storage and transportation activities according to applicable Army, Navy, or Air Force guidelines.

c. Storage. Bulk quantities of DU munitions will be kept in permanent structures for long term storage.

d. Maintenance. Various types of maintenance are performed to repair and/or modify DU munitions and packaging. The exposure of depleted uranium is not incidental to these operations. Typical maintenance operations may include corrosion removal, repainting, restenciling, 100 percent inspection for critical defects, and the replacement or refurbishment of packaging material.

e. Demilitarization. The DU component of the munition will be disassembled and segregated from the other components of the assembly. The DU components will be stored at Crane Army Ammunition Activity pending authorization to ship them to a licensed recycling agent or to an NRC or Agreement State licensed disposal site.

See Supplement 6, Item 10, Radiation Safety Program, for a further description of these activities.

2. The Depleted Uranium controlled by this license will not be chemically, physically, or metallurgically altered. DU munitions controlled by this license will not be fired or made commercially available.

3. The following are interservice DU munitions typically handled at Crane Army Ammunition Activity:

a. Cartridge, 20mm, U.S. Navy, MK 149 series, also controlled under NRC license 45-16023-01NA, issued to the U.S. Navy.

b. Cartridge, 25mm, U.S. Navy, PGU-20/U series, also under NRC license 45-16023-01NA.

c. Cartridge, 25mm, U.S. Army, M919 series, also under NRC license SUC-1380, issued to the U.S. Army Armament, Munitions, and Chemical Command, Rock Island, IL.

d. Cartridge, 30mm, U.S. Air Force, PGU-14 series, under this license.

e. Cartridge, 105mm, U.S. Army, M774, M833, and M900 series, also under NRC license SUC-1380.

f. Cartridge, 120mm, U.S. Army, M827, M829, and M829A1 series, also under NRC license SUC-1380.

g. Cartridge, 7.62mm, U.S. Army, no model number available, under this license.

h. Cartridge, .50 caliber, U.S. Army, no model number available, under this license.

4. In addition to the items listed above, DU munitions and components handled at Crane Army Ammunition Depot Activity may also include prototype items generated from research and developement projects, as well as foreign or captured items.

SECTION II - OPERATIONAL PROCEDURES

1. Transportation. DU munitions will be transported, packaged, marked, and labelled in accordance with applicable DOT regulations unless specifically exempted.

a. Receiving. The following operations are performed during receiving operations involving DU munitions:

(1) Quality Assurance (QAS) personnel are notified by Depot Operations Personnel of the arrival of a loaded inbound vehicle.

(2) The vehicle is checked by QAS personnel for serviceability and for unauthorized or suspicious articles on the exterior of the vehicle.

(3) The seals are checked by QAS personnel against the bill of lading for the proper seal number. If the seal is broken, missing, or a foreign seal is found, the carrier is treated as a suspect vehicle and is moved to the Suspect Vehicle inspection area. The Security Officer and Depot Operations Office are immediately notified.

(4) QAS personnel cut and remove the seals and open the door. Personnel opening the door exercise caution to prevent being struck by any cargo which may have become displaced during transit. The load is then inspected for suspicious articles or any damage caused by improper blocking and bracing.

(5) If an unauthorized or suspicious article is discovered, non-essential personnel are removed from the inspection area a minimum of 2,000 feet. QAS personnel then conduct a thorough inspection of the article.

(6) If any damage to the load is discovered, QAS personnel evaluate the extent of the damage to determine if an explosive hazard exists and what remedial measures are required. The RPO or designate is notified to determine if any radiological contamination is present.

(7) If no discrepancies are detected during the QAS inspection, the doors are secured and the vehicle is sent to a holding point or directly to the storage site.

(8) Storage personnel receive the incoming vehicle, remove and store the load. The item quantity listed on the shipping documents is checked during unloading operation by a physical count of the applicable unit pack.

(9) DU munitions, if not attended by authorized depot personnel, will be secured in a locked storage building and/or vehicle(s) with a numbered seal.

(10) DU munitions will be received at Crane Army Ammunition Activity in accordance with 10 CFR 20.205.

b. Shipping. The following operations are performed during shipping operations involving DU munitions:

(1) Storage personnel remove the munitions from the storage site and load it onto the carrier vehicle in accordance with the applicable drawings.

(2) QAS personnel inspect the vehicle, the loading method, the blocking and bracing used, and the general physical condition of the unitized load to ensure suitability for transport. Any discrepancies detected or conditions not in accordance with the applicable drawing will be corrected prior to shipment.

(3) QAS personnel verify that the items being shipped are as specified on the shipping documents, i.e., stock number, lot/serial number, unit quantity, etc.

(4) QAS personnel verify that the shipping papers, marking, placarding, and emergency response information provided are in accordance with 49 CFR 172. Radioactive labels are not required on packages of DU munitions when the conditions established in DOT-E-9649 are met. The latest revision of DOT-E-9649 is attached as enclosure 1

(5) After all inspections are successfully completed, QA personnel secure and seal the door of the transport vehicle.

(6) The RPO or designated representative will verify that the level of non-fixed (removable) contamination on packages of DU munitions offered for shipment is less than the limits established in 49 CFR 173.443.

2. Storage. DU munitions are stored in standard ammunition storage structures in accordance with applicable U.S. Army regulations.

3. Inspection. Samples of DU munitions are periodically removed from storage, unpacked, inspected for defects or evidence of deterioration, and then repacked for shipment or return to storage. Typical inspections are as followed:

a. Periodic Inspections (PI) are conducted at fixed intervals on munitions held in storage to confirm their serviceability status and determine if any deterioration in storage has occurred. The inspection interval and any swipe testing requirements are detailed in the technical manual applicable to each type of DU munition.

b. Receipt Inspections (RI) are conducted on munitions returned from using units (field return) and munitions received from other storage depots. Receipt inspections for field return munitions consist of a 100 percent inspection of all ammunition items in containers with out a depot or factory seal. Field return munitions with proper seals and munitions received from other storage depots are randomly sampled and inspected per PI standards if the interval since their last Periodic Inspection has expired.

c. Initial Receipt Inspections (IRI) determine if munitions received from the manufacturer are serviceable, comply with contractual requirements for new production, and are acceptable for entry into the stockpile.

d. Safety in Storage Inspections (SIS) are conducted at specified intervals on unserviceable stocks to verify that they are safe for continued storage.

4. Maintenance. Various types of maintenance are performed to repair and/or modify DU munitions and packaging. The exposure of depleted uranium is not incidental to these operations. Typical maintenance operations may include corrosion removal, repainting, restenciling, 100 percent inspection for critical defects, and the replacement or refurbishment of packaging material.

5. Demilitarization. Various types of DU munitions may become obsolete or inspections may reveal non-repairable deterioration or defects. In these instances demilitarization will eventually have to be performed. Crane Army Ammunition Activity has a two-fold mission in this regard:

a. Testing Mission. In this activity Ammunition Peculiar Equipment (APE), specifically engineered to handle munitions during maintenance or demilitarization operations, is subjected to operational testing. The APE is first extensively tested using inert munitions (no DU or explosive components) but the final phase of testing will involve live DU munitions.

(1) The APE allows for the disassembly of live munitions with a minimum of human involvement. For example, the APE used in the 30 millimeter DU demilitarization project is loaded and operated remotely. See the accompanying drawing.

(2) Standing Operating Procedures proposed for Army-wide use in demilitarization operations involving DU munitions and APE are also verified. Written procedures are developed to account for known hazards and how to deal with them. See Enclosure 2 for an example.

(3) As other equipment and procedures are developed, they will be similarly tested and worded to maintain compliance with the 10 CFR. A license amendment will be sought for any procedure that involves a significant change from established, license approved procedures.

b. Production Mission. At CAAA bulk quantities of DU munitions scheduled for demilitarization are separated into their component parts for recycling, reuse, or disposal.

c. The depleted uranium core of the DU projectile is not normally removed from the projectile assembly during either the testing or production phase of demilitarization at Crane Army Ammunition Activity. If depleted uranium cores need to be separated from projectile assemblies as part of a special test or evaluation, specific written procedures will be established in accordance with paragraph 5.a.(2) above prior to removal. Production demilitarization involving the removal of depleted uranium cores from the projectile assemblies will only be performed after a formal review of activity facilities and equipment by HQ IOC health physics staff. In no instance will depleted uranium be subjected to grinding, sanding, milling, or any other physical or chemical alteration.

CRANE ARMY AMMUNITION ACTIVITY
CRANE, INDIANA 47522-5099

ITEM 7

RADIATION PROTECTION PERSONNEL
TECHNICAL QUALIFICATIONS

Walter F. Shearin, Chief, Safety Office, Radiation Protection Officer (RPO), Crane Army Ammunition Activity (CAAA)

Training:

General:

B.S. Engineering Operations, North Carolina State University, 1981

Certificate, Safety Engineering, U.S. Army School of Engineering and Logistics (SEL), 1982

Masters of Public Affairs, Indiana University, 1994

Radiation Specific:

Radiological Safety Course, Fort McClellan, AL, 1986,120 hours

Principals of Radiolical Safety, SEL, 1981, 100 hours

Radiolical Safety and Hazards Evaluation II, SEL, 1981, 100 hours

Radiography, Level I, 1990 40 hours, Stavely Schools

Radiation Safety Refresher Classes, 6 hours each, 1991, 1992, 1993 1994, 1995

Radiography, Level II, 1993, 40 hrs, U.S.Army Research Lab, Watertown, Ma.

Experience:

RPO, CAAA, September 1986 to Present

Nine years experience with a picker X-ray Exposure Device using a CO-60 Source.

Nine years experience with storage of DU munitions.

Robert D. Roach, Metals Inspector, Production Inspection Branch, Quality Control and Proceedures Division, Industrial Operations Directorate, Crane Army Ammunition Activity (CAAA)

Mr. Roach serves as co-alternate RPO with Mr. Murphy.

Training:

Radiation Specific:

Radiographic Inspection, Level I, 40 hours, Stavley Schools, 1990

Radiographic Inspection, Level II, 40 hours, U.S. Army Research Lab, Watertown, Ma, 1993

Radioactive Material Transportation, 8 hours, CAAA, 1993

Linear Accelerator Operations, 40 hours, Schomberg Radiation Corporation, CAAA, 1994

Radiation Safety Refresher, 6 hours, 1990, 1991, 1992, 1993, 1994, 1995

Experience:

Six Years experience with a Picker Gamma Ray Exposure Device using a Co-60 source.

Six years experience with various x-ray machines: 160, 300, 320, 420KV, and 6 Mev Linear Accelerator.

Six years experience with storage of DU munitions.

Richard W. Murphy, Metals Inspector, Production Inspection Branch, Quality Control and Inspection Division, Industrial Operations Directorate, Crane Army Ammunition Activity (CAAA).

Mr. Murphy serves as co-alternate RPO with Mr. Roach.

Training:

Radiation Specific:

Radiographic Inspection, Level I, 40 Hours, Stavely Schools, 1990

Radiographic Inspection, Level II, 40 Hours, U.S. Army Research Lab, Watertown, MA, 1993

Radioactive Material Transportation, 8 Hours CAAA, 1993.

Linear Accelerator Operations, 40 Hours, Schomberg Radiation Corporation, CAAA, 1994

Radiation Safety Refresher, 6 Hours each 1990, 1991, 1992, 1993, 1994, 1995

Experience:

Three Years experience with a Picker Gamma Ray Exposure Device using a Co-60 source.

Three years experience with various x-ray machines: 160, 300, 320, 420KV, and 6 Mev Linear Accelerator.

Three years experience with storage of DU munitions.

CRANE ARMY AMMUNITION ACTIVITY
CRANE, INDIANA 47522-5099

ITEM 8

TRAINING FOR PERSONNEL WORKING IN "RESTRICTED AREAS"

I TRAINING OUTLINE:

A. Types of Radiation

1. Alpha
2. Beta
3. Gamma and X-rays
4. Neutron

B. Units of Radiation

1. Roentgens
2. Rads - Gray
3. REM - Sieverts
4. Curies - Bequerels

C. Biological Effects

1. Acute
2. Chronic
3. Somatic
4. Genetic
5. Target Organs

D. ALARA - As Low As Reasonably Achievable. Procedures to Minimize Exposure.

1. Exposure Limits

   a. Radiation Workers
   b. General Public
   c. Prenatal
   d. Typical Exposure Levels at CAAA

2. Protective Measures

   a. Time
   b. Distance
   c. Shielding

3. Dosimetry - Thermoluminescent Devices (TLDs)

   a. Types: Body, Wrist, Finger
   b. Analysis Program
   c. Medical Documentation
   d. DD Form 1952
   e. Local Requirements
   f. Employee Access to Dosimetry Records

4. Surveys

   a. Background
   b. Monitoring with Radiac Equipment
   c. Wipe tests
   d. Air Sampling

5. Bioassays

6. Personal Hygiene

   a. Wash prior to breaks
   b. No eating, drinking, smoking, etc. in Radiation Areas
   c. No food storage in Radiation Areas
   d. Uncovered wounds

7. Protective Clothing and Equipment

   a. Need, use, approval
   b. Replacement and Disposal
   c. Types: Gloves, Coveralls, Respirators, etc.

8. Restrictive Area Signs

E. Depleted Uranium (DU)

1. Description

   a. Dense Solid Metallic Alloy
   b. Chemically Toxic
   c. Low Radioactivity
   d. All feasible U-235 removed
   e. Explosive Hazard predominant as a complete round

2. Uses

   a. History
   b. As Projectiles for Ammunition (7.62mm through 120mm)
   c. As Armor

F. Regulatory Requirements

1. 10 CFR Parts 19, 20, 21, 40, and 71

2. Nuclear Regulatory Commission (NRC) Guides

   a. 7.1, Admin guide for packaging and transporting radioactive material
   b. 7.3, Procedures for picking up and receiving packages of radioactive material
   c. 8.10, Operating philosophy for maintaining occupational exposures ALARA
   d. 8.13, Instructions concerning prenatal radiation exposure
   e. 8.29, Instructions concerning risks from occupational radiation exposure

3. Army Regulations

   a. AR 385-11, Ionizing Radiation Protection
   b. AR 40-14, Control and Recording Procedures for the Exposure to Ionizing Radiation and Radioactive Materials

4. U.S.ARMY, INDUSTRIAL OPERATIONS COMMAND NRC License SUC-1380

   a. Quantity Limits
   b. Munitions Licensed
   c. Individuals Responsible
   d. Licensed Operations:
      (1) Transportation
      (2) Storage
      (3) Inspection
      (4) Maintenance
      (5) Demilitarization
   e. Radiation Safety Program

5. Dept. of Transportation Exemption for DU Munitions, DOT-E-9649.

F. Waste Management
   1. Types of Waste
   2. Waste Storage
   3. Waste Disposal

G. Standing Operating Procedures (SOPs)

   1. Routine Procedures

      a. Explosives Safety
      b. Industrial Safety and Hygiene
      c. Radiation Safety

   2. Emergency Procedures

      a. Accidents
      b. Firefighting guidelines
      c. Evacuate upwind

   3. Reporting Unsafe Acts and Conditions

      a. Employees
      b. Supervisors
      c. Safety Office

   4. Safe Use of Radioactive Materials

II DURATION AND FREQUENCY OF TRAINING

A. Initial training will last approximately two hours.

B. Annual refresher training will last approximately one hour.

C. Testing may consist of a written exam (see attached sample), an oral exam, or proficiency testing.

D. Training records will be maintained in the Safety Office and in the Official Personnel File for each individual involved.

E. Training may be provided by the installation RPO, alternate RPO, or competent third party specifically designated by the RPO.

CRANE ARMY AMMUNITION ACTIVITY
CRANE, INDIANA 47522-5099

ITEM 9

FACILITIES AND EQUIPMENT

I. LOCATION

The Crane Army Ammunition Activity (CAAA) is a tenant of the Naval Systems Warfare Center (NSWC) in Crane Indiana. Located in south central Indiana, it is 85 miles southwest of the state capital, Indianapolis, and 95 miles northeast of Lousville, Kentucky. The center comprises an area approximately 63,000 acres of rugged forested terrain, with 52,000 acres, (82%) under control of the CAAA for ammunition production and storage facilities.

II. STORAGE FACILITIES

The Depleted Uranium (DU) munitions will be stored in either earthcovered igloo type or Navy block type magazines. Both of these structures are designed for the storage of ammunition items. The positioning of these structures within a storage block is designed to prevent sympathetic detonation from one structure to another. All magazines containing DU munitions will be locked except during authorized operations, and the keys will be maintained under positive control at all times. Entrance to any buildings or areas containing DU ammunition is restricted to employees with appropriate authorization.

III. DEMILITARIZATION FACILITIES

Demil facilities at CAAA consist of various buildings originally used for the production of assorted explosive munitions. These facilities are selected on a case by case basis for the setup of demil lines based upon the characteristics and Quantity-Distance requirements of the item being processed. Explosive operating buildings are fabricated of hardened concrete, with internal cells and bays separated by substantial dividing walls. Due to scheduling conflicts and limited building availability, selection of a particular site will be defered until the assets are on hand. At that time, a facility will be selected, equipment installed and baseline surveys performed. This site will remain the only facility for DU demil until the project is completed and decommisioning requirements are met.

IV. EQUIPMENT

1. Fire Prevention and Protection: Fire extinguishers will be present during all operations involving DU ammunition. Self-contained breathing apparatus and protective clothing are standard equipment for center fire fighting personnel.

2. Personnel Monitoring and Detection Equipment: The following is a list of the radiation detection instruments currently available to support the depleted uranium mission at Crane Army Ammunition Activity. The instrument types and numbers available may vary due to maintenance and calibration requirements and as older equipment is replaced.

Type of Instrument	Number Available	Radiation Detected
a. Model AN/PDR-77, Portable Meter, with Accessory Survey Kit or equivalent.	4 (four)	Alpha Beta & Gamma
b. Eberline Model E-520 Geiger Counter	4 (four)	Beta & Gamma
c. Thermoluminescent Devices (TLDs)	As required	Beta & Gamma
d. IM 235PD Pocket Dosimeter or equivalent	As required	X-ray/ Gamma

Note: TLDs are not normally used for shipping, receiving, storage, or inspection operations, but will be issued and worn by personnel directly involved in new demilitarization projects, until the RPO can confirm that their use is not required.

3. Equipment Calibration Program:

a. Calibration services are currently performed by U.S. Army Training and Support Group for Test, Measurement and Diagnostic Equipment (TMDE) Activity, Redstone Arsenal, AL. Calibration may also be performed at any accredited and certified calibration facility.

b. Radiac instruments labeled "ACTIVE" are used for health and safety surveys and are calibrated at intervals not to exceed 240 days. The specific calibration interval for each instrument is determined by TMDE and is based on the calibration history for each model of instrument. Radiac instruments labeled as "INACTIVE" are used for contingency purposes only and will be calibrated on an annual basis.

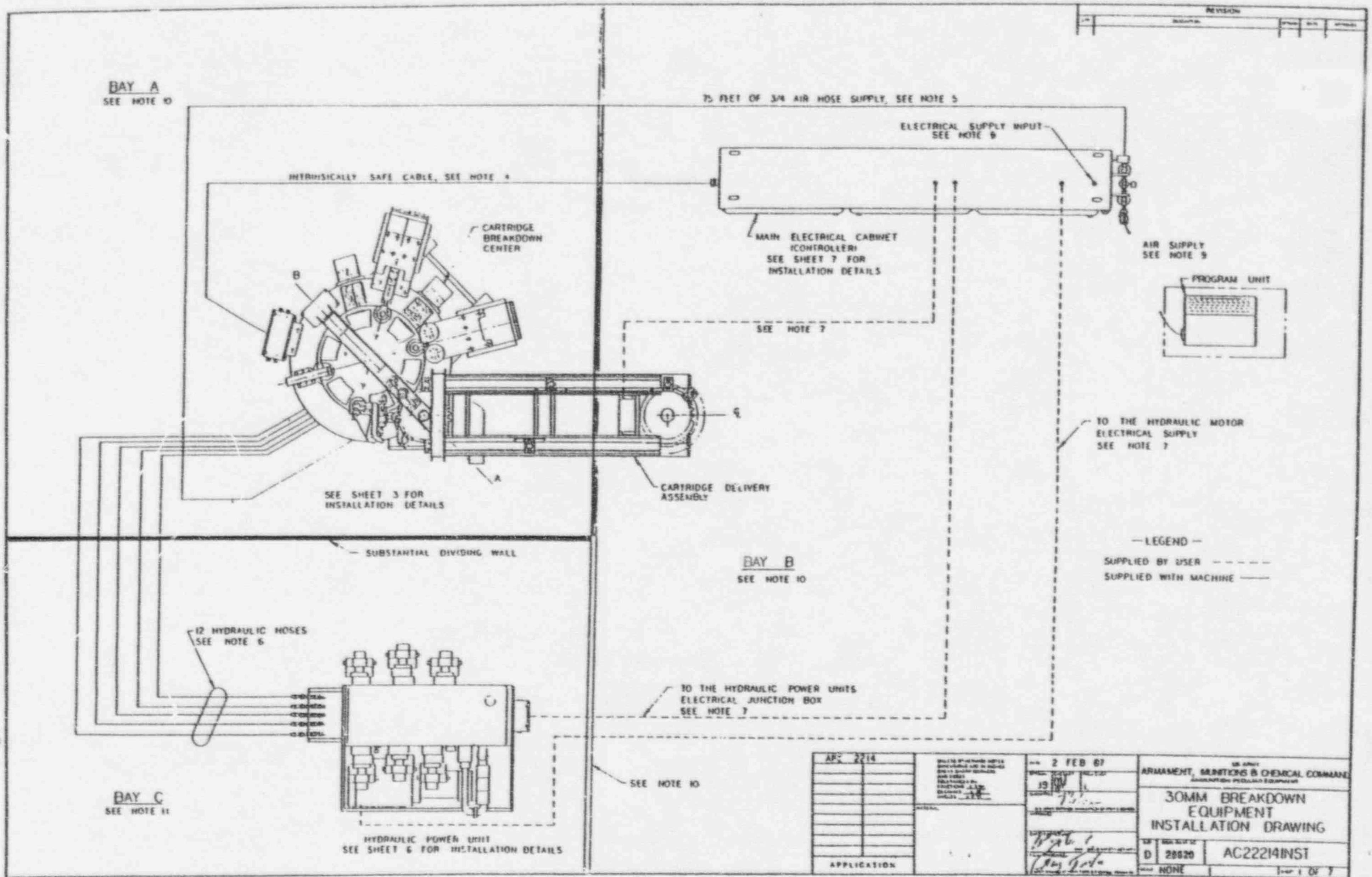
4. References:

AR 750-43, Army Test, Measurement and Diagnostic Equipment Program.

DA PAM 738-750, Army Maintenance System (TAMMS).

TB 43-180, Calibration and Repair Requirements for the Maintenance of Army Material.

TB 750-25, Maintenance of Supplies and Equipment: Army Test, Measurement and Diagnostic Equipment (TMDE) Calibration and Repair Support Program.


BAY A
SEE NOTE 10
75 FEET OF 3/4 AIR HOSE SUPPLY, SEE NOTE 5
ELECTRICAL SUPPLY INPUT
SEE NOTE 9
INTRINSICALLY SAFE CABLE, SEE NOTE 4
CARTRIDGE BREAKDOWN CENTER
B
MAIN ELECTRICAL CABINET (CONTROLLER)
SEE SHEET 7 FOR INSTALLATION DETAILS
AIR SUPPLY
SEE NOTE 9
PROGRAM UNIT
SEE NOTE 7
TO THE HYDRAULIC MOTOR
ELECTRICAL SUPPLY
SEE NOTE 7
A
SEE SHEET 3 FOR INSTALLATION DETAILS
CARTRIDGE DELIVERY ASSEMBLY
SUBSTANTIAL DIVIDING WALL
BAY B
SEE NOTE 10
— LEGEND —
SUPPLIED BY USER
SUPPLIED WITH MACHINE
12 HYDRAULIC HOSES
SEE NOTE 6
TO THE HYDRAULIC POWER UNITS
ELECTRICAL JUNCTION BOX
SEE NOTE 7
SEE NOTE 10
BAY C
SEE NOTE 11
HYDRAULIC POWER UNIT
SEE SHEET 6 FOR INSTALLATION DETAILS
ARC 2214
APPLICATION
2 FEB 67
ARMAMENT, MUNITIONS & CHEMICAL COMMAND
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CRANE ARMY AMMUNITION ACTIVITY
CRANE, INDIANA 47522-5099

ITEM 10

CAAAR 385-7

16 APR 1996

IONIZING RADIATION SAFETY

Applicability. This regulation applies to all elements of Crane Army Ammunition Activity (CAAA). This procedure establishes minimum requirements for all personnel working with an ionizing radiation source. This procedure applies to any CAAA employee working with such a source whether it be in an x-ray or radiographic operation, a quality assurance operation, or a storage operation.

Suggested Improvements. The proponent of this regulation is the Safety Office (SIOCN-SF). Users are invited to send comments and suggested improvements to SIOCN-SF, building 13.

Distribution. A, B, AFGE.

Official:

J. C. KING
COL, OD
Commanding

ORIGINAL SIGNED

Contents

1. PURPOSE. The purpose of this regulation is to establish requirements to ensure the protection of Crane Army Ammunition Activity (CAAA) personnel against the effects of ionizing radiation.

2. REFERENCES:

a. 10 Code of Federal Regulations (CFR) Parts 0 to 50, Energy.

b. 49 CFR Parts 171 to 177, Transportation.

c. AR 40-14, Medical Services, Control and Recording Procedures of Exposure to Ionizing Radiation and Radioactive Materials, 15 Mar 82.

d. AR 385-11, Safety, Ionizing Radiation Protection, (Licensing, Control, Transportation, Disposal, and Radiation Safety), 1 May 1980.

e. MIL-STD-410E, Military Standard, Nondestructive Testing Personnel Qualification and Certification, 25 Jan 91.

f. SB 742-1, Supply Bulletin, Inspection of Supplies and Equipment, Ammunition Surveillance Procedures, Nov 90.

g. NRC License 13-18235-01, CAAA License for Radioactive Material, Issued 26 Jun 90, Expires 31 Mar 95. Renewal Submission Docket Number, 030-14708 SUB-1995

h. NRC License SUC-1380, IOC License for Receipt, Storage and Transfer of Depleted Uranium Munitions, Original Issue, 1 June, 1980, Expires 30 November, 1995. Renewal Submission Docket Number 040-08767, SUB-1995.

3. DEFINITIONS OF TERMS.

a. Licensed material. Source material, special nuclear material, or by-product material received, possessed, used, or transferred under a general or specific license issued by the Nuclear Regulatory Commission (NRC).

b. Absorbed dose. The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray.

c. Radiation area. An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (5 millirem (mrem) or 0.05

milliSievert (mSv)) in 1 hour at 30 centimeters (cm) from the radiation source or from any surface that the radiation penetrates.

d. High radiation area. An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (100 mrem or 1 mSv) in 1 hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

e. Very high radiation area. An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at one meter from a radiation source or from any surface that the radiation penetrates.

f. Unrestricted area. An area to which access is not restricted or controlled for the purpose of protection of individuals from exposure to radiation and radioactive materials.

g. Restricted area. Any area where access is controlled for the purpose of protection of individuals from exposure to radiation and radioactive materials.

h. ALARA. An acronym for "as low as reasonably achievable". Every reasonable effort must be made to maintain exposures to radiation as far below the dose limits in this regulation as is practical.

i. Background or natural radiation. Radiation from cosmic sources; naturally occurring radioactive materials, including radon and global fallout as it exists in the environment from testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear material regulated by the NRC.

j. Declared pregnant women. A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

k. Occupational dose. Dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material. Occupational dose does not include dose received from background radiation, as a patient from medical practices, or as a member of the general public.

l. Permanent Radiographic installation. A shielded installation or structure designed or intended for radiography and in which radiography is regularly performed.

m. Radiographer. Any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic or x-ray operations and who is responsible for ensuring compliance with NRC and license requirements.

n. Radiographer's assistant. Any individual who under the personal supervision of a radiographer, uses radiographic exposure or x-ray devices, sealed sources or related handling tools, or radiation survey instruments in radiography.

o. Level I and II radiographers. Quality level designators for radiographers who have been trained IAW reference e. These individuals will have a minimum of 40 hours of classroom training for each level.

p. Termination. The end of an individual's employment with CAAA or the end of permanent work assignment in radiography with no anticipation of the individual ever working in radiography again.

q. Radiography. The examination of a specimen using a sealed source or electronically generated (x-ray) gamma rays.

r. Ionizing radiation. Radiation capable of producing ionization, including energetic charged particles such as alpha and beta particles, or nonparticulate radiation such as x-rays and gamma rays.

s. Radiation Protection Officer/Radiation Safety Officer (RPO/RSO). A person appointed by the Commander to give advice on the hazard of ionizing radiation and to supply effective ways to control these hazards. This individual is approved on the NRC license and has knowledge of, responsibility for, and authority to ensure compliance with appropriate radiation protection rules, standards, and practices on behalf of the Commander.

4. IONIZING RADIATION CONTROL COMMITTEE (IRCC).

a. The IRCC is an advisory body to the Commander. It should consist of the:

(1) Commander.

(2) The RPO.

(3) Medical Officer.

(4) Safety Officer.

(5) Or representatives of (1) through (4)

(6) Representatives of employee organizations

b. The committee will advise the commander involving local rules and procedures for procurement, storage, and safe use of radiation sources. It is to evaluate incident reports and look at all radiation exposures.

c. The IRCC must meet quarterly, but can meet more often if the Commander so desires.

d. Minutes are to be kept of the Committee meetings.

5. GENERAL RADIATION SAFETY.

a. No minor (person under 18 years of age) should be allowed in a restricted area nor will he be allowed in any area with ionizing radiation that could lead to an exposure of 0.125 rem or greater within a calendar quarter. If circumstances require that a minor enter a restricted area, the RPO must be notified and the minor must be provided with a thermoluminescent dosimeter (TLD) to monitor exposure to ensure that it is less than 0.125 rem per quarter.

b. The dose to an embryo/fetus during the entire pregnancy, due to occupational exposure, of a declared pregnant woman cannot exceed 0.5 rem (5 mSv). If circumstances require that a declared pregnant woman enter a restricted area, the RPO must be notified and the woman must be provided with a TLD to monitor exposure.

c. Except for planned special exposures, the occupational dose to a radiation worker shall not exceed 1.25 rem per quarter to the whole body; head and trunk; active blood-forming organs; lens of the eye; or gonads. Exposure will be monitored by the RPO by means of a TLD. Any exposure greater than 0.5 rem (5 mSv) (considered an action level) will result in the following:

(1) The individual and supervisor will be notified.

(2) The individual will be removed from work with ionizing radiation sources pending a positive response to a memorandum from the supervisor, through the RPO, to the Commander. This memorandum will request the individual be allowed to continue work with ionizing radiation sources and will state the specific steps that will be taken to minimize future exposures.

d. Prior to long-term assignment as a radiographer's assistant or first entry of any individual into a restricted area during each employment or work assignment in which the individual could receive in excess of 0.3125 rem in any quarter, the RPO must be contacted. The RPO must ensure the following is done:

(1) The individual's prior occupational dose for the quarter must be determined and documented to ensure the occupational limit will not exceed the maximum specified in 5.c.

(2) All prior occupational exposure must be documented in the individual's medical file.

(3) The person is to be included in the radiation program by Medical Department who will ensure that a periodic radiation physical is scheduled and that individual's exposure is tracked IAW NRC requirements.

e. All occupational radiation exposures will be tracked by means of a TLD. The results will be posted in the individual's medical record after being viewed by the RPO.

f. No radioactive material shall create, in any unrestricted area, radiation levels which, if an individual were continually present in the area, could result in an exposure in excess of 2 mrem in 1 hour or 100 mrem in any 7 consecutive days.

g. Radiation areas must be posted with a sign bearing the words:

CAUTION
RADIATION AREA

h. High radiation areas will be:

(1) Posted with a sign bearing the words:

CAUTION
HIGH RADIATION AREA

(2) Equipped with a control device that will cause the level of radiation to be reduced below 100 mrem/hour if someone should enter the area; and/or:

(3) Equipped with a control device which shall energize a conspicuous visible or audible alarm signal that will warn an individual entering the area of the hazard.

(4) The controls in (2) and (3) shall be established in such a way that no individual will be prevented from leaving a high radiation area (i.e. panic hardware on doors).

i. Ensure survey meters are calibrated at least quarterly and that pocket dosimeters are calibrated semi-annually.

j. The RPO and all radiation workers will follow the ALARA principle. All radiation exposures will be kept as low as reasonably achievable.

6. ISOTOPE RADIOGRAPHY AND X-RAY OPERATIONS. All isotope radiography and x-ray operations will be conducted by at least one radiographer. This radiographer will normally have a Level II certification but, can be an experienced Level I radiographer with concurrence of the RPO. The radiographer will be assisted by another radiographer or by a radiographer's assistant.

a. Training.

(1) Radiographers:

(a) Trained prior to expiration of NRC license (Mar 95), reference g, will receive training IAW the requirements of that license.

(b) Trained after renewal of this license will:

<1> Receive 40 hours of safety training. This training will cover the subjects listed in Appendix A. This training can be developed on-station or can be given by a contractor.

<2> Receive Level I and, if required, Level II training per the requirements of the American Society for Nondestructive Testing (ASNT).

<3> Have, at a minimum, 13 weeks on-the-job training.

<4> Will take and pass a written safety certification examination from an NRC approved certifying agency (i.e. ASNT) within 2 years after final publication of NRC Proposed Rule Change for Parts 34 and 150, published in the Federal Register on 28 Feb 94.

<5> Will receive 8 hours of refresher training in radiation safety principles, applicable regulations, and emergency procedures annually.

<6> Will always work with another Radiographer or Radiographers Assistant. Radiographers will never work alone.

(2) Radiographer's Assistants will work with and under the direct supervision of the radiographer. They will never be allowed to perform radiography operations alone. They will:

(a) Receive 3 hours of initial training as outlined in Appendix B. This training may be given by the RPO or by a qualified radiographer.

(b) Take an written exam administered by either the RPO or a qualified radiographer.

(c) Take a field test on the equipment, safeguards, etc., given by the RPO or a qualified radiographer.

(d) Will receive 8 hours of refresher training in radiation safety principles, applicable regulations, and emergency procedures annually.

(3) Radiographers and Radiographer's assistants will receive copies, or have copies made available at the worksite, of applicable NRC regulations, including 10 CFR Parts 30.7, 30.9, 30.10, the sections of Part 34 that apply to radiography operations, and NRC Regulatory Guide 8.29, Instructions Concerning Risks From Occupational Radiation Exposure..

(4) Women of childbearing age, acting as radiographers or assistants, will also receive instructions on the effects of prenatal radiation exposure and the definition of declared pregnant women. They will be given a copy of NRC Regulatory Guide 8.13, Instructions Concerning Prenatal Radiation Exposure.

(5) Radiographers and Radiographer's assistants must demonstrate understanding of NRC regulations, license requirements, emergency procedures, and competence in the use of radiographic exposure devices, sealed sources, and survey instruments. This will be demonstrated by a written and field exam administered by the RPO or Assistant RPO (see 5.a.(2) above).

(6) The RPO will conduct an annual inspection program of the job performance of each radiographer and radiographer's assistant. This will consist of:

(a) Observation of the performance of each radiographer and radiographers assistant during an actual radiographic operation. This should be done at least one time throughout the fiscal year.

(b) If a radiographer or assistant has not worked in radiography for more than 6 months, the RPO must ensure that his performance is observed and recorded the next time he participates in a radiography operation. This observation can be done by the RPO or by a qualified representative of the RPO (i.e. another radiographer).

b. <u>Dosimetry.</u>

(1) Personnel assigned to radiography operations will wear two pocket dosimeters and one TLD. The dosimeter gives an immediate indication of exposure. The TLD is the <u>only</u> permanent record of the exposure that is received. The following rules apply:

(a) Do not take these items home. If for some reason they aren't removed at work, do not store them in your car or in direct sunlight. Do not take them to the doctor or hospital when you are going to get an x-ray as they will record your non-occupational exposure.

(b) Store them in the designated storage areas only. Do not store them where they can receive a dose when not in use.

(c) Wear them on your upper torso area (i.e shirt pocket).

(d) Do not share TLDs. They are to be assigned to one person and utilized only by that person. If a TLD is lost, report it to the RPO immediately.

(2) Pocket dosimeters give an immediate indication of dose. There are many different brands that can be used, but they must have a scale of 0 to 200 mrem. They can be made to show a reading by jarring or dropping them. Handle them with care. The following rules apply:

(a) Record the initial and final reading for both dosimeters in the utilization log daily.

(b) Zero each pocket dosimeter daily. If it cannot be brought to read less than 10 mrem, reject it and return it for recalibration.

(c) Read the dosimeters periodically throughout the day (i.e. at each break and at lunch).

(d) Report any incident of loss or breakage to the RPO.

(3) Pocket dosimeters found to be off-scale after radiography operations require immediate action to evaluate and minimize possible personnel exposure. The following steps should be taken:

(a) If either pocket dosimeter shows a reading more than a few mrem, contact the supervisor and the RPO. While this is not an indication of a high exposure, it is an indication that there may be a procedural problem in the radiography area. The RPO will evaluate the situation and determine if any corrective action is necessary.

(b) If even one dosimeter shows a reading of 100 mrem or more, stop operations, conduct an immediate survey of the area to establish a safe perimeter, secure the area, and call the RPO immediately. This could indicate a serious situation. If the possibility of radiation exposure cannot be ruled out, the RPO will send the TLD to be processed immediately. The decision to allow the individual to return to work with the isotope prior to receiving the results of the TLD will be up to the RPO or his designated representative.

(c) If even one dosimeter goes off-scale - becomes totally discharged - this is an indication of a possible emergency situation. Take the following steps:

<1> <u>IMMEDIATELY CEASE OPERATIONS.</u>

<2> Conduct an immediate survey.

<3> Establish a safe perimeter.

<4> Secure the area.

<5> Contact the RPO.

If the possibility of radiation exposure cannot be ruled out, the RPO will send the TLD to be processed immediately. The decision to allow the individual to return to work with the isotope prior to receiving the results of the TLD will be up to the RPO or his designated representative. The RPO will determine if a reportable incident has occurred. If it has, it will be reported IAW with paragraph 10 of this regulation. A local incident report (NSWCC 5100/13) will be filed, either by the supervisor or the RPO. A copy of this report will be maintained in the Safety Office. NOTE: If you bump or drop your dosimeter, immediately check it to see if it off-scale. If it is off-scale or shows a high reading (i.e. in excess of 100 mrem), call the RPO and ask for instructions. Do not continue to work in the radiography area without his clearance.

c. Daily Start-up Procedures. The following procedures are to be implemented prior to startup daily.

(1) Upon entering the radiography area, verify the gamma lights above the control door are not flashing. If they are flashing, take precautions.

(2) All radiography personnel are to don two pocket dosimeters and one TLD immediately upon entering the area. Pocket dosimeters should be zeroed daily.

(3) Verify the survey meter has been calibrated and the battery is charged. If meter is not working properly, obtain another one before proceeding any further.

(4) Using a calibrated survey meter, check the area above the lead-lined lattice doors to the Cobalt 60 (Co-60) area to ensure the source is not in an exposed condition. If meter indicates source is in an exposed condition, attempt to close the cyclops with the controls. If this is ineffective, close it manually. Use the minimum number of personnel for the manual closing. Notify the RPO.

(5) Start the Co-60 cycle; observe the lights on the control console and gamma lights above both doors. If any of the lights are out, replace the bulbs. If this is not effective, close the Cyclops and contact an electrician. (Do a survey to ensure the source is closed prior to allowing any maintenance work in the area.)

(6) Open the door slightly (just enough to activate alarm) to the Co-60 area while the source is exposed to ensure door interlocks are working. The alarm bell should ring and the Cyclops should turn itself off. If the interlock is not working as designed, close the Cyclops, do a survey to verify the source is not exposed, and contact maintenance.

(7) Turn on x-ray machine, ensure x-ray imminent light comes on prior to the 7 second delay and that gamma light comes on when x-rays are being produced. Verify the interlocks are functioning properly. Survey over door to ensure head pointed the right direction.

d. Operating Procedures.

(1) Fill out the isotope utilization log, or the x-ray log, whichever applies, with, at least the following information:

(a) radiographers name

(b) date

(c) type of radioactive material (or x-ray machine)

(d) dosimeter serial numbers and beginning daily readings,

(e) survey type, serial number, and calibration date

(f) person securing source in evening

(2) A survey meter will be carried with the radiographer or assistant each time the radiography bay is entered during isotope radiography. This meter must be calibrated and should be set on the X1 setting. This procedure is not required for x-ray operations, but is recommended.

(3) Any time the bay is left unattended, the door to the radiography area is to be locked and the key is to be in the possession of the radiographer or put in the safe in the film viewing area.

e. Shutdown Procedures.

(1) Survey the area to ensure that the Co-60 source is secure.

(2) Verify that all keys to the radiography area are accounted for.

(3) Fill out utilization log with ending dosimeter readings and total dose for the day. Sign log book. Person securing area must verify all log entries have been completed.

(4) Lock keys for the Co-60 Cyclops in the safe in film reading room.

(5) Lock the radiography/x-ray bay. Secure the key in security safe in the Lunchroom of Building 104.

f. Portable X-ray Operations.

(1) All portable x-ray operations will require a written, signed Quality Control Instruction that contains safety precautions and procedures.

(2) A barricade will be placed at the 2 mrem per hour limit and marked to ensure the public cannot enter. A survey will be done to ensure this limit is accurate.

(3) The RPO will be notified prior to any portable x-ray operation. He will assist the radiographer in making calculations to determine a safe working area.

(4) The Security Department will be notified prior to start of operations. All effected departments will also be notified to ensure that personnel are kept clear of the area.

7. STORAGE AND SURVEILLANCE OPERATIONS OF MUNITIONS WITH RADIOACTIVE COMPONENTS.

a. TRAINING:

(1) All DU workers and emergency responders must receive annual radiation training. This training will include, as a minimum; why the Army uses DU, the hazards of DU, the rights of the worker, and what to do in an emergency. A video tape is available from the Radiation Protection Officer (RPO) to meet this requirement. A roster must be signed to verify training was received. A copy of this roster must be forwarded to SIOCN-SF, for filing purposes.

(2) No one will handle DU munitions unless they have received the proper training.

b. INVENTORIES:

(1) Inventory records must be checked and recorded annually to verify that the installation DU storage limit is not exceeded. A record of such inventory checks must be kept on file by the RPO. The RPO will conduct the annual records check.

(2) The IOC license limits CAAA's storage to 10 million kilograms of DU, as contained in the following ammunition items (by model number): M774, M833, M900, M829, M829A1, M829A2, and M919. The Navy items at the current time are licensed separately, thus, separate maximums must be kept.

(3) Invent. ry spot checks will be conducted by the RPO during the annual survey of DU storage magazines.

c. POSTING:

(1) A current copy of NRC Form 3, per Title 10, CFR 19.11, must be posted in each magazine containing DU munitions. The current copy is dated January 1996. A sign saying "Caution - Radioactive Material" must be posted on the outside of each magazine containing DU munitions. This requirement is in accordance with Title 10 CFR 20.1902(e).

(2) A copy of NRC Form 3 and NOTICE TO EMPLOYEES on additional information will be posted on all official bulletin boards in DU work areas and magazines containing DU munitions (building 2532 and building 3149 as a minimum).

d. SURVEYS:

(1) Surveys to check for contamination must be performed at locations where DU ammunition rounds are handled, such as the Quality Assurance Workshop. This survey will be performed monthly by the RPO or assistant RPO. During the months when DU ammunition rounds are not being handled, this survey need not be performed. This survey will include the taking of smears. Smears should be taken from work tables, tools, etc. Records must be kept. It is recommended that DU rounds be limited to one or two workbays to avoid the spread of contamination.

(2) The DU ammunition must have wipe samples taken if there is visible indication of damage or corrosion on the rounds when being inspected. Wipe tests can be accomplished by the RPO or by the local Quality Assurance Specialist in Ammunition Surveillance, according to procedures in appendices to SB 742-1, 12 November 1990, Ammunition Surveillance Procedures.

(3) Instrument surveys must be made of structures storing DU ammunition. A convenient time is when DU ammunition is moved in or out of those structures. An instrument survey will be conducted of each magazine containing DU ammunition annually, at a minimum. Records will be kept by the RPO.

(4) The Depot Operations Directorate must notify the RPO when a magazine will be loaded with radioactive material. A baseline survey must be conducted prior to loading the magazine. When radioactive material is removed (all radioactive material), a termination survey must be done by the RPO. The SIOCN-DO must notify the RPO when this is required.

(5) Baseline/termination surveys of magazines will be conducted by the RPO using a grid system as follows: Using a tape measure, section off the magazine floor into 10 by 10 foot sections and walls into 10 by 6 foot sections, survey each grid with a survey instrument, take one or two swipes within each section, and have the swipes analyzed. Mark the location of each swipe, meter reading, and the results of both on a sketch of the magazine interior. The RPO will maintain these records.

(6) The individual doing the survey shall determine the need for the different type of instrumentation surveys (i.e. alpha, beta, or gamma). The alpha survey instrumentation will be held less than .5 cm away from the surface to be surveyed. The alpha probe shall be held in place for a reading (do not scan with the alpha probe). All alpha readings will be recorded on a data collection form in units of counts per minute (per probe surface area) and converted to disintegrations per minute, per 100 square centimeters. The beta-gamma survey instruments will be held at approximately 1 cm from the surface to be surveyed. Scanning should be done slowly at about 2 cm/sec. All beta readings will be recorded on the data collection form in units of millirad. The gamma survey instruments will be held about 1 meter from the surface to be surveyed. The readings will be recorded in micro roentgens per hour along with the distance at which the measurement was taken.

(7) Incoming shipments of DU munitions will be surveyed within 3 hours during normal duty hours and within 18 hours after duty hours by the RPO or assistant RPO. If there is no package damage then no wipes of the packages are required. The interior of the truck will be surveyed with a radiac meter and by taking three wipes (minimum).

(8) Outgoing shipments will be wipe tested (one smear per pallet) and checked for contamination with a radiac meter. The truck will be surveyed before loading on the interior. After loading the truck will be checked on the exterior. The DOT exemption 9649 states that DU shipments will be shipped according to explosive hazard. No RAD markings are required.

(9) The Installation Radiation Protection Officer (RPO) or a designated alternate RPO, shall be notified of all incoming/outgoing shipments containing radioactive material. This includes, but not limited to, DU ammunition.

(10) The Installation RPO shall maintain a log of survey results for a minimum of 3 years for each DU ammunition shipment leaving the installation.

d. <u>WIPE TEST PROCEDURES:</u>

(1) A wipe test can be used on most surfaces where radioactive contamination is suspect. The type of material used to take a wipe is dictated by the isotope suspected of contaminating the device or surface. The two most common materials used in wiping are Nu-con Smears and Metrical Filters.

(2) Blank wipes should be submitted to the laboratory for use in determining background for the wipe survey.

(3) Use a separate wipe for each surface area wiped. Tile area wiped should be approximately 100 square centimeters or a 4 inch x 4 inch area. For radioactive commodities, all accessible surfaces suspected of contamination should be wiped. The use of more than one wipe per commodity is acceptable. Each wipe should be positively identified by placing in a separate folder or envelope and positively identifying with a wipe number and the following information:

(a) Date and time wipe taken.
(b) Technician taking wipe.
(c) Isotope of interest, if known.
(d) Name and telephone number of individual responsible for conducting test.

(4) The requesting organization will be responsible for maintaining a record of each wipe. Using a back and forth motion, wipe the area of suspected contamination. Wipe the area only once. Avoid touching the wipe contact surface when placing the wipe in the folder or envelope. Place the wipe folder(s) inside an envelope (or small ziploc bag), seal, and mark the envelope or bag: LABORATORY SAMPLE-DO NOT OPEN. Place this envelope, inside another envelope and mail to the following activity:

DIRECTOR
U.S.ARMY TMDE ACTIVITY
ATTN: AMSMI-TMDE-SR-DR
BLDG 5417
REDSTONE ARSENAL,AL 35898-5400

(5) All environmental samples must be labeled or tagged with the following information:

(a) Identification of sample by area or description.
(b) Type of analyses(es) desired.
(c) Isotopes of interest, if known.
(d) Date and time of collection.
(e) Address for forwarding results and POC.
(f) Telephone numbers, DSN and/or Commercial of POC.
(g) Any known or suspected chemical and/or biological contaminants.

e. <u>DECONTAMINATION PLAN:</u>

(1) Contamination control is the utmost priority when handling DU munitions. Contamination controls are as follows:

(a) Upon arrival of EOD, render safe operations will be performed. The radiation protection personnel should not approach the area prior to EOD declaring the area safe from an explosive standpoint. The EOD personnel should not approach the area without appropriate clothing and respiratory protection. After the EOD has declared the area safe from an explosive standpoint, radiation protection personnel will conduct a radiological survey of the ground. Areas noted to be contaminated should be marked and decontamination should be performed.

(b) Under the direction of the RPO, radiation protection personnel will set up radiation contamination control lines upon their arrival. A single entry and exit point should be established. The control lines should be "Cold Zone" - free of contamination; "Intermediate Zone" - work area, may be contaminated; and the "Hot Zone - contaminated. Survey instruments should be used by trained personnel to determine levels of contamination and decontamination results.

(c) A person should be assigned to assure that the names, addresses, and telephone numbers of those people who cross over the radiation contamination control line, whether contaminated or not, are recorded along with the results of personnel monitoring. The number of emergency personnel who are to pass over the radiation contamination control line should be kept to an absolute minimum.

(d) The RPO or his designated representative shall establish a decontamination team. Surface decontamination may include washing with detergent and water, vacuuming of surfaces with an approved HEPA filtered vacuum system, wiping with cloths, or actual removal of soil. All waste materials must be contained, including waste water, and disposed of as radioactive waste. Personnel decontamination should include removal of exterior clothing or protective coveralls, including shoes/boots or their covers, and washing with soap and water.

(e) Every effort should be made to contain the spread of contamination to within the radiation control line. Contaminated clothing should be removed, if feasible, at the site. If someone wearing contaminated clothing leaves the site, make sure that the area entered is surveyed and decontaminated. Injured personnel should be wrapped in clean sheet to prevent the possible spread of contamination. Contaminated clothing need not be removed from a seriously injured person. Whenever possible, contaminated casualties shall be accompanied by a person with a radiation survey meter to a medical treatment facility to aid in the control of spreading the contamination and to relieve the anxiety of nonoccupational related personnel.

(f) Emergency response personnel who sustain minor injuries but are also contaminated with DU should be decontaminated prior to treatment of minor injuries, provided concurrence is obtained from medical personnel. Equipment, including vehicles exiting the fire area, are to be monitored and decontaminated by radiation protection personnel.

(g) Vital medical treatment shall always take precedence over decontamination. Radiation Safety personnel shall be available to the medical staff to advise and monitor contamination levels during all treatment phases.

(h) Soap and water is the typical means of removing contamination from personnel, clothing and equipment. Contaminated clothing should be removed from personnel prior to performing decontamination of the persons body. Wash areas of contamination with water (warm, not hot or cold) and a nonabrasive soap. Contaminated hair may have to be removed (clipped). The spread of contamination should be controlled by minimizing exposures and keeping all contaminated personnel, clothing and equipment within specific controlled areas.

(i) Waste receptacles are to be available and located at the radiation contamination control line for disposal of contaminated clothing and equipment. Metal containers with lids should be available with 4 mil plastic bag inner linings for solid waste. Liquids should be collected in plastic, earthenware, or thick-wall glass bottle inner containers. Leak proof metal containers may also be used provided the container is chemically inert to the liquid. All containers shall be marked/labeled as containing radioactive contaminated materials.

(j) N equipment or materials involved in the accident/incident are to be removed from the site for unrestricted use until the item(s) have been monitored by radiation protection personnel and decontaminated as required. Equipment and material release should be adequately documented by radiation protection personnel and proper security procedures should be in force to prevent pilferage. A statement from the RPO should accompany items surveyed and released for unrestricted handling. Items that cannot be decontaminated on site, should be sealed in plastic bags for subsequent decontamination or disposal.

(k) Eating, drinking, chewing or smoking shall not be allowed in a potentially contaminated area or when wearing potentially contaminated clothing. Storage of food in a potentially contaminated area shall not be allowed.

(m) Specific and general methods for equipment and area decontamination shall be in accordance with NRC and Army directives. Additional information is provided in the Department of the Army Technical Bulletin, TB 9-1300-278, September 1990.

f. EMERGENCY PLAN:

(1) In a fire emergency, the basic concern is air-borne contamination carried out of the flames by the heated air and in the smoke. Notify all personnel to evacuate the space/area or building and to remain upwind of the fire, turn off all ventilation equipment which may be present and close all doors and hatches/windows, if possible. Notify the Fire Department and give the location of the fire.

(2) FIREFIGHTERS-- Fire should be fought with firefighting personnel standing upwind of the fire if possible. Firefighters should wear portable air systems.

(3) RECOVERY-- After the fire has been extinguished and EOD has performed render safe procedures, debris must be surveyed for the presence of equipment containing source, as well as contamination which may have been spread by burning. Monitor personnel, the firefighting equipment and the area to determine if decontamination will be necessary.

(4) SURVEY INSTRUMENT(S)-- The Eberline (E-520) or AN/PDR 77 is suitable for detecting the location of the source, however wipes must be taken and evaluated to detect the presence of contamination. Follow-up evaluation of wipes on suitable laboratory equipment must be made.

(5) The Fire Department and Security Office currently receive and must continue to receive storage data showing the location of all stored ammunition. Action: SIOCN-DO.

(6) The IOC, RPO, must be notified immediately in the event DU ammunition is: Involved in a fire, involved in an accident, functioned in or outside a weapon, or lost. This is in addition to reporting incidents through normal Chain-of-Command.

(7) Munitions with radioactive components present little, if any, hazard to personnel. Therefore, unless the license specifically states that TLDs must be worn, they will not be used. Normal precautions will be taken:

8. REPORTS/SURVEYS.

a. Surveys.

(1) A quarterly survey and inventory will be conducted by the RPO for all material used in radiography. A survey of ammunition items with radioactive components will be conducted IAW the individual license requirements. The survey must list the type of radioactive material, the date of the survey, the location of the material, and the name of the person conducting the survey.

(2) The RPO will pull the SDS report that details the radioactive items on inventory. This report is generated monthly, but should be pulled at least quarterly. The RPO will ensure this report correlates with his inventory and that he is licensed to have all the items listed.

(3) Alarms at the permanent radiography facility will be tested quarterly.

(4) Leak tests will be performed at intervals not to exceed 6 months.

(5) Each survey meter will be calibrated at intervals not to exceed 3 months.

b. Reports.

(1) A report of exposure of radiation workers must be submitted to the NRC annually. This report must cover the calendar year and must be submitted by 30 April for the previous year. The report must be in the form required by 10 CFR 20.2206. The report must be sent to:

REIRS Project Manager
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

(2) Incidents will be reported as prescribed in paragraph 12 of this regulation.

9. RECORD MAINTENANCE.

a. Training Records. Records must be maintained of all training, field examinations, and inspections of job performance. The Directorate responsible for radiography operations will forward a copy of these records to the RPO. These records will be maintained by the RPO for 3 years after they are made. The records must contain:

(1) Radiographer certification documents.

(2) Certification status verification documents.

(3) Copies of written tests.

(4) Dates and scores of field examinations and name of individual conducting the exam.

(5) Record of annual safety review. The record must list the topics discussed, the dates of the review, the name of the instructor and attendees.

(6) Record of annual inspection listing what items were checked and what was found. Any discrepancies must be documented.

b. Survey Records. Copies of the quarterly surveys must be maintained for at least 3 years.

c. Dosimetry Records. Dosimetry records (reports from TLDs or film badges) must be retained until the NRC license is terminated. They are maintained in the medical files of personnel.

d. Leak Test Records. Leak test records must be maintained for at least 3 years.

e. Calibration Records. Calibration records will be maintained for at least 3 years after the date of calibration.

f. Records of Material.

(1) A record of receipt of radioactive material (this does not include ammunition items) shall be kept as long as the material is possessed and for 3 years following transfer or disposal of material.

(2) A record of transfer of material shall be retained for 3 years after each transfer.

(3) A record of disposal of material shall be retained until the NRC terminates the license that authorized the disposal.

g. Minutes of the IRCC. Minutes will be kept for a minimum of 3 years.

10. EMERGENCY PROCEDURES.

a. In the event of an incident involving radioactive materials, contact one or more of the following personnel, in the order listed, as required:

(1) RPO

(2) Alternate RPO

(3) Commander

(4) Executive Officer

The RPO will provide a memorandum for the radiography area with the above personnel's name, daytime, and home phone numbers.

b. In the event an incident is reportable to the NRC (see paragraph 11.c.), notify the U.S. Army Industrial Operations Command (IOC) prior to notifying the NRC. Ensure IOC will notify the U.S. Army Materiel Command (AMC). Some incidents are also reportable to HQDA (see paragraph 11.d.) When this occurs, ensure IOC will send the message through channels to HQDA. The phone numbers and office symbols are:

(1) IOC Safety Office, AMSIO, DSN 793-2989/3461, Commercial (309) 782-2989/3461; IOC Duty Officer, DSN 793-5621/6612;

(2) AMC Safety Office, AMCSF-P, DSN 284-9491, Commercial (617) 274-9491; AMC Duty Officer, DSN 284-9223;

(3) HQDA Safety Office, DACS-SF, DSN 255-7291, Commercial (202) 695-7291.

(4) Nuclear Regulatory Commission, NRC, Region III, 801 Warrenville Road, Lisle, IL, Commercial (800) 522-3025.

c. The following events are reportable to the NRC within the time period specified:

(1) As soon as possible, but not later than 4 hours after the discovery of any event where personnel normally are able to take any immediate protective action necessary to avoid either exposures to or releases of radioactive materials that could exceed regulatory limits but are prevented from doing so;

(2) Within 24 hours of the discovery of any unplanned radioactive contamination event that: (1) requires access to a contaminated area, by workers or members of the public, to be restricted for more than 24 hours; (2) involves a quantity of radioactive material greater than 5 times the lowest annual limit on intake specified in Appendix B to 10 CFR Part 20; or (3) access to an area is restricted for a reason other than to allow isotopes less than 24 hours to decay prior to decontamination.

(3) Within 24 hours of the discovery of any event in which safety equipment is disabled or fails to function as designed -- if the equipment is required by NRC regulations or license condition to prevent releases of radiation exceeding regulatory limits or exposure to radioactive materials in excess of regulatory limits, or to mitigate the consequences of an accident, or the equipment is required to be available and operable to perform the required safety function when the failure occurs and no redundant equipment is available and operable to perform the required safety function;

(4) Within 24 hours of the discovery of any event that requires unplanned medical treatment at a medical facility of an individual with spreadable contamination on the clothes or body;

(5) Within 24 hours of the discovery of any unplanned fire or explosion resulting in damage to licensed radioactive material or any device, container or equipment containing licensed radioactive material in excess of specified limits, and when the damage affects the integrity of the licensed material or its container.

d. Any reportable NRC event requires a written follow-up report that must be submitted within 30 days to both IOC and the NRC.

e. The following situations require immediate notification of the IOC, who should notify AMC, who should, in turn, notify HQDA. These situations also require you notify the NRC within 4 hours.

(1) For excessive personnel exposure that may have caused or threatened to cause exposure of whole body to 25 or more rems; or 150 or more rems to skin of the whole body; or 375 rems or more to the feet, ankles, hands, or forearms.

(2) For excessive release of radioactive material into the air or water that may have caused or threatened to cause radiation concentration, averaged over a period of 24 hours, excessive by 5000 times the levels permitted by 10 CFR, Appendix B, Table II.

(3) For theft of loss of radioactive materials such that quantity or circumstances could result in a substantial hazard to persons in unrestricted areas.

APPENDIX A

TRAINING REQUIREMENTS FOR RADIOGRAPHERS AFTER 31 MAR 95

1. Fundamentals of Radiation Safety

    a. Characteristics of gamma radiation.

    b. Units or radiation dose and quantity of radioactivity

    c. Hazards of exposure to radiation

    d. Levels of radiation from licensed material

    e. Methods of controlling radiation dose - time, distance, shielding

2. Radiation Detection Instruments

    a. Use, operation, calibration, and limitations of radiation survey instruments

    b. Survey techniques

    c. Use of personnel monitoring equipment

3. Equipment to be Used.

    a. Operation and control of radiographic equipment and storage containers, including pictures or models or source assemblies

    b. Storage, control and disposal of licensed material

    c. Maintenance of equipment

4. The requirements of pertinent Federal and Army regulations.

5. Case Histories of Accidents in Radiography.

APPENDIX B

TRAINING REQUIREMENTS FOR
RADIOGRAPHER'S ASSISTANTS

1. Radiation Protection Program.

   a. Applicable sections of 10 CFR, including parts 19, 20, 21, and 34.

   b. Applicable Army regulations.

   c. Local NRC License

   d. Adherence to Regulations

2. Operating Instructions.

   a. Who is authorized to operate equipment

   b. Requirements for usage of instruments.

   c. Specific instructions at operating sites.
      - isotope radiography within permanent facility
      - x-ray operations within permanent facility
      - portable x-ray operations

3. Dosimetry.

   a. TLDs.

   b. Pocket Dosimeters.

   c. Requirements.
      - Use
      - Care
      - Operation
      - Calibration

4. Posting Requirements.

5. Radiation Surveys.

   a. Purpose.

   b. Requirements.

   c. Methods.

6. Maintenance and Inspection.

   a. Inspection requirements and frequencies.

   b. Maintenance requirements and frequencies.

   c. Daily requirements prior to startup.

7. Emergency procedures.

   a. Possible personnel exposures.

   b. Incident within vicinity of source.
      - Malfunction of source camera
      - fire, etc.

   c. Explosion or fire in the building.

   d. Emergency notification procedures

8. Isotope radiography versus x-ray

9. Practical

   a. Provide a tour of the facility

   b. Discuss specific radiation protection for the facility

   c. Interlock system

   d. Using and securing equipment

   e. Correct start-up and survey procedures.

10. On-the-job training.

CRANE ARMY AMMUNITION ACTIVITY
CRANE, INDIANA 47522-5099

ITEM 11

WASTE MANAGEMENT

1. Unwanted radioactive material will be disposed of in accordance with AMCCOM Pamphlet 385-1 (Handbook for Disposal of Unwanted Radioactive Material) and TM 3-261 (Handling and Disposal of Unwanted Radioactive Material. The U.S. Army Industrial Operations Command (IOC) has been designated as the responsible agency for the safe disposal of the unwanted low-level radioactive material for the U.S. Army. IOC is responsible to provide information and guidance to all generators of unwanted radioactive material to prevent violations of Federal and State regulations, thereby ensuring safe and legal transport and disposal of the material. Shipments are made only by authorization from IOC. Disposal costs will be paid by IOC. Packaging costs will be paid by Crane Army Ammunition Activity.

2. Any unwanted radioactive material generated is expected to be solid, generated solely during the demilitarization processes, and is not expected to involve the generation of liquid, dusts, mists, fires, organic vapors or gases. Items that may be generated include disposable protective clothing and equipment, contaminated swipes, and contaminated metal parts from the demilitarization processes.

3. Statement of Intent:

a. Crane Army Ammunition Activity is exempted from the conditions of Title 10, Code of Federal Regulations (CFR), Part 40.36(a), which requires a licensee to submit a decommissioning funding plan/statement of intent for source material operations, for the following reasons:

(1) While our total possession of depleted uranium (DU) will be greater than 100 millicuries, the form is not readily dispersible in nature. The DU is contained within penetrators as an alloy and is essentially a sealed source. No significant dispersal of the material is expected to occur during the conditions under which the DU will be licensed at CAAA. While the penetrator itself is not in dispersible form, corrosion products of the penetrator are. DU corrosion products may be on the projectile, the propellant, or the sabot segments. Demilitarization proceedures will include inspection for corrosion and removal of DU corrosion products under controlled ventilation conditions.

(2) The conditions under which the DU will be licensed at CAAA are those of static storage and demilitarization (disassembly). The DU munitions and penetrators are received and committed to storage magazines, which are periodically surveyed for radiological contamination.

(3) Region III, NRC, has acknowledged that DU, as an alloy form in four versions of the penetrator, is not readily dispersible, when Amendment No. 7 to NRC license SUC-1380 was granted. This license, issued to the U.S. Industrial Operations Command (IOC), covers the receipt, storage and transfer of DU in the M774, M833 (105MM), M827, and M829 (120MM) rounds. Our license covers those versions, also. We additionally cover the 20mm, 25mm, 30mm, 7.62mm and .50 Caliber rounds. These five other rounds are similar in construction to the four covered in the IOC license, therefore, the DU in them should also be classed as not readily dispersible in form.

b. If required to comply with 10 CFR 40.36(a), funding will be requested through Army budgetary procedures for decommissioning when and as needed.

U.S. Department
of Transportation

Research and
Special Programs
Administration

400 Seventh Street, S.W.
Washington, D.C. 20590

OCT - 5 1992

DOT-E 9649
(SECOND REVISION)

1. U.S. Department of Defense, Washington, D.C., is hereby granted an exemption from certain provisions of this Department's Hazardous Materials Regulations to offer or transport in commerce packages prescribed herein of munitions of any explosive hazard class containing components manufactured of depleted uranium metal subject to the limitations and special requirements specified herein. This exemption authorizes radiation levels slightly higher than normally allowed for limited quantity radioactive materials and relief from certain marking requirements for the depleted uranium component of the packages, and provides no relief from any regulation other than as specifically stated.

2. BASIS. This exemption is based on an application from the U.S. Department of Defense dated February 1, 1992, submitted in accordance with 49 CFR 107.105.

3. HAZARDOUS MATERIALS (Descriptor and class). Packages and overpacks containing munition products that have depleted uranium components; Classification determined by the explosive component of the munition product.

4. PROPER SHIPPING NAME (49 CFR 172.101). Specific or generic as appropriate for the explosive properties of the munition.

5. REGULATIONS AFFECTED. 49 CFR 173.424(c) and 173.421(b) and (d), as referred to from 173.424(b).

6. MODES OF TRANSPORTATION AUTHORIZED. Motor vehicle, rail freight, cargo vessel.

7. SAFETY CONTROL MEASURES.

a. Maximum radiation levels on any external surface of the package, overpack or unitized/palletized group of packages shall not exceed 2.5 millirem per hour (25 microsieverts per hour).

b. Packaging and safety controls during transportation shall be appropriate to the explosive hazard of the product.

c. Safety procedures for the less significant radiological hazards and for the more significant explosive hazards, shall be described in the operations and transportation instructions for the products. Both normal and accident conditions shall be addressed in these documents.

8. SPECIAL PROVISIONS.

a. Packages are not required to bear a marking with the word radioactive inside or on the package as specified in §173.421(d), and the shippers notice referred to by §173.424(c) is not required.

b. The product description on shipping documents for each consignment transported under this exemption shall include: a statement that the consignment contains depleted uranium metal; the exemption number DOT-E 9649; and the identity and phone number of a Department of Defense authority familiar with both the explosive and radiological hazards of the product.

c. Each package, overpack or unitized/palletized group of packages shall be conspicuously marked "DOT-E 9649" with figures at least one inch (2.5 cm) high.

d. Only those military services and contractors designated by the Department of Defense are authorized to operate under this exemption. Before a service within the Department of Defense offers or transports munition products under this exemption, that service shall have on file with the Military Traffic Management Command (MTMC) a complete set of instructions and procedures that have been approved by MTMC as satisfying the documentation requirements of paragraphs 7(b) and 7(c) of this exemption. The MTMC shall have on file the names of the contractors that the service has designated as authorized to make shipments under their instructions and procedures for the products under this exemption.

e. This exemption provides no relief from the applicable rules and regulations of any foreign country into or through which the consignments are to be transported.

f. A copy of this exemption must be carried aboard each cargo vessel used to transport packages covered by this exemption.

9. REPORTING REQUIREMENTS. Any incident involving loss of packaging contents or packaging failure must be reported to the Associate Administrator for Hazardous Materials Safety as soon as practicable. (49 CFR 171.15 and 171.16 apply to any activity undertaken under the authority of this exemption.)

10. EXPIRATION DATE. August 31, 1994.

Issued at Washington, D.C.:

J. Suzanne Hedgepeth OCT - 5 1992

Alan I. Roberts (DATE)
Associate Administrator
for Hazardous Materials Safety

Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Research and Special Programs Administration, Department of Transportation, Washington, D.C. 20590. Attention: Exemptions Program.

Dist: FHWA, FRA, USCG.

SYSTEM: 30MM Depleted Uranium Demilitarization DATE: 25 Mar. 1996 LOCATION: N/A
SUBSYSTEM: 30MM Ctg Breakdown

OPERATION: Receive Material at Bldg. PPE TO BE USED: N/A

SYSTEM EVENTS	HAZARD DESCRIPTION	EFFECT ON SYSTEM	HZD SVRTY	MISHAP PROB	UNCNTL'D RAC	RECOMMENDED CONTROL	CONTL'D RAC
Step 1, Forklift working in trailer	Truck rolls away from dock	Personnel injury, Damage to equipment or material	II	D	4	When forklift is working in trailer, wheels must be chocked.	III E 5

HZD SVRTY: CATASTROPHIC-I; CRITICAL II; MARGINAL-III; NEGLIGIBLE-IV
MISHAP PROBABILITY: FREQUENT-A; PROBABLE-B; OCCASIONAL-C; REMOTE-D; IMPROBABLE-E
RAC (RISK ASSESSMENT CODE): RAC1: IA, IB, IIA
RAC2: IC, IIB, IIIA
RAC3: ID, IIC, IIIB, IVA
RAC4: IID, IIIC, IVB
RAC5: IIE, IIID, IE, IIIE, IVC, IVD, IVE

ENCLOSURE 2

SYSTEM: 30MM Depleted Uranium Demilitarization DATE: 25 MAR, 1996 LOCATION: N/A
SUBSYSTEM: 30MM Ctg Breakdown

OPERATION: Unpalletize/ Unpack Cartridges PPE TO BE USED: Gloves, Faceshield, Safety Glasses, Leather Palmed Gloves

SYSTEM EVENTS	HAZARD DESCRIPTION	EFFECT ON SYSTEM	HZD SVRTY	MISHAP PROB	UNCNTL'D RAC	RECOMMENDED CONTROL	CONTL'D RAC
Remove banding from pallet	Operator is removing banding from pallet, banding recoils when cut, striking operator and inflicting cuts. Operator cuts hand on banding during removal.	Minor to severe personnel injury	III	C	4	Operators will wear personal protection equipment as required in SOP	III D 5
Place metal can or wood box on transfer cart or worktable	Possible smashed fingers or back injury. Energetic material dropped on floor or table	Personnel injury	II	C	3	Operators lifting material will assure safe handholds and assume proper lifting position. Avoid twisting when lifting or carrying	III D 5
Remove ctgs from container and place onto cart or worktable	Possible iniation of primer during handling	Personnel injury	I	D	5	Operator will protect primer with hand during handling operations Cartridges with electric primers will be handied by operators wearing conductive soled shoes, and standing on conductive rubber matting. Operators will inspect ctgs for cracked projectile bodies or damaged windshields. If DU penetrator is exposed, place cartridge into plastic bag and notify RPO.	III E 5

HZD SVRTY: CATASTROPHIC-I; CRITICAL II; MARGINAL-III; NEGLIGIBLE-IV
MISHAP PROBABILITY: FREQUENT-A; PROBABLE-B; OCCASIONAL-C; REMOTE-D; IMPROBABLE-E
RAC (RISK ASSESSMENT CODE): RAC1: IA, IB, IIA
RAC2: IC, IIB, IIIA
RAC3: ID, IIC, IIIB, IVA
RAC4: IID, IIIC, IVB
RAC5: IIE, IIID, IE, IIIE, IVC, IVD, IVE

PRELIMINARY HAZARD ANALYSIS

SYSTEM: 30MM Depleted Uranium Demilitarization
SUBSYSTEM: 30MM Ctg Breakdown

DATE: 25 MAR, 1996 LOCATION: N/A

OPERATION: Process Cartridges Through Breakdown Machine

PPE TO BE USED: Safety Glasses

SYSTEM EVENTS	HAZARD DESCRIPTION	EFFECT ON SYSTEM	HZD SVRTY	MISHAP PROB	UNCNTL'D RAC	RECOMMENDED CONTROL	CONTL'D RAC
Process ctgs through APE 2214 for breakdown	Primer initiated during handling	Personnel injury	II	D	V	Operator will protect primer with hand at all times during handling of cartridges. Operator will wear conductive soled shoes and stand on conductive rubber matting when handling cartridges with electric primers. NO PERSONNEL WILL BE ALLOWED IN BAY WITH BREAKDOWN MACHINE WHEN MACHINE IS PROCESSING LIVE AMMUNITION Door to breakdown cell shall be closed and interlocked with breakdown machine controls to prevent entry to cell when breakdown machine is in operation. Operators will inspect ctgs for cracked projectile bodies or damaged windshields. If DU penetrator is exposed, place cartridge into plastic bag and notify RPO.	II E V

HZD SVRTY: CATASTROPHIC-I; CRITICAL II; MARGINAL-III; NEGLIGIBLE-IV
MISHAP PROBABILITY: FREQUENT-A; PROBABLE-B; OCCASIONAL-C; REMOTE-D; IMPROBABLE-E
RAC (RISK ASSESSMENT CODE): RAC1: IA, IB, IIA
RAC2: IC, IIB, IIIA
RAC3: ID, IIC, IIIB, IVA
RAC4: IID, IIIC, IVB
RAC5: IIE, IIID, IE, IIIE, IVC, IVD, IVE

SYSTEM: 30MM Depleted Uranium Demilitarization
SUBSYSTEM: 30MM Ctg Breakdown

DATE: 25 MAR, 1996 LOCATION: N/A

OPERATION: Process Cartridges Through Breakdown Machine

PPE TO BE USED: Safety Glasses

SYSTEM EVENTS	HAZARD DESCRIPTION	EFFECT ON SYSTEM	HZD SVRTY	MISHAP PROB	UNCNTL'D RAC	RECOMMENDED CONTROL	CONTL'D RAC
						Operator will stand to side of cartridge delivery system. No one will be allowed to stand directly in front of delivery system. Operators handling DU projectiles will wear leather or vinyl gloves. Operators will wear radiation ring badges on the outside of their gloves and a TLD badge on their torso. Prior to going to break, lunch, the restroom, and at the end of the shift, operators will be monitored. Operators will wash hands after monitoring and prior to eating, drinking or smoking.	

HZD SVRTY: CATASTROPHIC-I; CRITICAL II; MARGINAL-III; NEGLIGIBLE-IV
MISHAP PROBABILITY: FREQUENT-A; PROBABLE-B; OCCASIONAL-C; REMOTE-D; IMPROBABLE-E
RAC (RISK ASSESSMENT CODE): RAC1: IA, IB, IIA
RAC2: IC, IIB, IIIA
RAC3: ID, IIC, IIIB, IVA
RAC4: IID, IIIC, IVB
RAC5: IIE, IIID, IE, IIIE, IVC, IVD, IVE

SYSTEM: 30MM Depleted Uranium Demilitarization
SUBSYSTEM: 30MM Ctg Breakdown

DATE: 25 MAR, 1996 LOCATION: N/A

OPERATION: Pack Depleted Uranium Projectiles.

PPE TO BE USED: Safety Glasses

SYSTEM EVENTS	HAZARD DESCRIPTION	EFFECT ON SYSTEM	HZD SVRTY	MISHAP PROB	UNCNTL'D RAC	RECOMMENDED CONTROL	CONTL'D RAC
Remove Projectiles from Conveyor and place into transfer/ storage containers	Broken windshield or projectile exposes DU penetrator	Personnel injury equipment contamination	I	E	V	Operators handling DU projectiles will wear leather or vinyl gloves. Operators will wear radiation ring badges on the outside of their gloves and a TLD badge on their torso. Prior to going to break, lunch, the restroom, and at the end of the shift, operators will be monitored. Operators will wash hands after monitoring and prior to eating, drinking or smoking.	II E 5

HZD SVRTY: CATASTROPHIC-I; CRITICAL II; MARGINAL-III; NEGLIGIBLE-IV
MISHAP PROBABILITY: FREQUENT-A; PROBABLE-B; OCCASIONAL-C; REMOTE-D; IMPROBABLE-E
RAC (RISK ASSESSMENT CODE): RAC1: IA, IB, IIA
RAC2: IC, IIB, IIIA
RAC3: ID, IIC, IIIB, IVA
RAC4: IID, IIIC, IVB
RAC5: IIE, IIID, IE, IIIE, IVC, IVD, IVE

ENCLOSURE

The enclosure contains a study, with calculations, concerning the effects of bulk storage accidents on the dispersal of depleted uranium munitions used in tanks.

Although the munitions involved in the study are large caliber, we believe that the study provides evidence to show that minimum dispersal can be expected under bulk storage conditions for other types of DU munitions as well. It should be noted that very conservative estimates were made in performing the calculations; the scenarios that would produce dispersals which exceed guidelines are very improbable.

CALCULATIONS OF THE EFFECTS OF SHIPPING AND BULK STORAGE ACCIDENTS INVOLVING DEPLETED URANIUM PENETRATORS

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EXECUTIVE SUMMARY

As part of its overall assessment of the potential hazards from the use of new depleted uranium (DU) munitions, the Large Caliber Weapon Systems Laboratory (Large Cal) of the U. S. Army Armament Research and Development Center (ARDC), with technical support from the ARDC Safety Office, sponsored a study by the Pacific Northwest Laboratory (PNL) to assess the potential radiological and toxicological hazards to the downwind population from postulated accidents during shipping and bulk storage of the M829 munitions.

Scenarios, representing severe but not impossible situations, were postulated and used to estimate an "umbrella" source term to represent maximum "realistic" accidents for these two use modes. The scenario for the shipping accident was based upon results from two external heat tests performed with the M829 and, therefore, represented relatively realistic parameters. The behavior of materials during the bulk storage enclosure fire was less certain and, therefore, the values chosen were much more conservative to assure encompassing all the uncertainties.

Source terms (fractional airborne release of particulate DU, the size distribution of the airborne material, and the accident conditions which affect downwind transport and deposition) were estimated using the best available data. A downwind transport and inhalation and body redistribution code (DUW) was used to determine the potential hazard to the downwind population as a function of downwind distance from the postulated accidents. DUW also considered the elevation of the released materials due to bouyancy and momentum effects, the deposition of materials as a function of downwind distance, the potential beta skin dose and whole body dose from the passing cloud of radioactive material, and the whole body dose due to radiation emitted by material deposited on the ground. The external components to the overall dose were found to be insignificant for the accidents considered.

The potential radiological and toxicological impact from the postulated accident during shipping was found to be insignificant. The calculated inhalation and external doses are comparable to those that would be received from natural background, and they are orders of magnitude lower than published limits.

Although the potential dose and toxicological hazard from the bulk storage accident approaches or slightly exceeds some of the limits and guideline values, the scenario contains many conservative assumptions which make the postulated scenario highly unlikely. Most of the dose from this scenario is due to the airborne release from the explosion that is assumed to occur after the fire has completely oxidized all of the DU. The application of these conservative assumptions has a significant influence on the calculated doses. Some of these assumptions and their potential effect on the estimated doses are:

- Assumption: A truck must breach the facility in the manner described to initiate the fire.

  Potential Effect: If there were no fire, there would be no oxidation of the DU and no driving force to inject the oxidized DU into the environment.

- **Assumption:** The fire, once ignited, must propagate through the densely packed wooden containers.

  Potential Effect: If the fire would not propagate throughout the entire storage magazine, the quantity of DU oxide produced would be significantly reduced.

- **Assumption:** The storage magazine must withstand the fire's heat load without failure.

  Potential Effect: If the magazine fails prior to the explosion, much of the oxide formed would be buried under the debris and would not be available for release to the atmosphere.

- **Assumption:** High explosives must be stored with the DU munitions and must not detonate until the end of the burning phase, when the DU is totally oxidized.

  Potential Effect: A detonation during the initial phases of the burning would disperse the material before it could oxidize, so very little DU would become airborne. An early detonation could also extinguish the fire, fail the facility and scatter the DU into areas where it would not oxidize.

- **Assumption:** The fraction of oxidized DU becoming airborne and the respirable fraction must be at their maximum credible values.

  Potential Effect: If lower airborne and respirable fractions were applied, the amount of respirable DU reaching an individual would also be lowered.

It is, therefore, anticipated that the hazard in a more likely scenario would be much lower than calculated in this study. While the potential effects of such an accident would still cause some concern, the radiological and toxicological effects would be well below the derived action levels.

INTRODUCTION

An accident involving depleted uranium (DU) munitions could pose a hazard to people in the vicinity of the accident due to a number of possible effects. Some of the hazards associated with such an accident may be the heat of the fire, missiles projected by an explosion, or hazardous substances released during the accident. This study focuses specifically on the hazards that could be posed to persons in the vicinity of the accident involving the M829 munitions due to hazardous material released to the atmosphere and carried downwind. This study ignores blast and heat effects of fire or explosion aside from their contribution to the transport of hazardous material through the air. It addresses the radiological and toxicological effects that would accompany the release of oxidized DU to the atmosphere by an accident.

A series of calculations were performed to determine these potential effects. Since there is a nearly infinite range of possible accident conditions, it is not reasonable to attempt to determine the effects of every accident scenario that may be postulated. The approach used in this study was to identify two likely classes of accidents, a shipping accident and a bulk storage accident. For each accident class, a scenario was designed with conditions that would produce the most severe results, yet not involve any totally unrealistic assumptions. The values determined by these analyses could then be considered to be upper bounds to the range of effects that may result from possible accidents. These values can then be compared with established protection guidelines, and can be used by planners in making decisions on deploying the munitions.

In this report, the accident scenarios will be described, the method of performing the calculations and any additional assumptions will be stated, and the results of the calculations will be presented. These results will then be compared to established protection guidelines and discussed in the study's conclusions.

METHODS USED IN THE ANALYSIS

Each accident analysis involved three major parts:

- determining the source term and release conditions,
- calculating the atmospheric transport to the dose points,
- evaluating the radiological and toxicological effects at the dose points.

The source term evaluation involved calculating the amount of hazardous material that could be released to the atmosphere, calculating the characteristics of the hazardous material, and finding the release conditions. The material released is described by a list of radioisotopes, with the quantity per hour that would become airborne during the course of the scenario. In addition to the amounts, characteristics such as the size and solubility of the particles were also determined. The release characteristics include the duration of the release, the elevation of the release, and any factors that may affect plume rise, such as temperature of the released plumes. The source term evaluation was performed using knowledge of the shipping and storage configurations of the M829 munitions, the results of experiments to determine characteristics such as particle size and solubility, knowledge of the behavior of combustible material, and computer evaluations of fire scenarios. These methods are detailed in the scenario descriptions.

The atmospheric transport was performed using a modified version of the computer code WRAITH (Scherpelz at el. 1980) (referred to as "DUW" in this report). DUW uses a bivariate Gaussian plume model to calculate the transport of airborne particles, and evaluates the resultant concentrations on the plume centerline at a number of downwind dose points. DUW incorporates plume depletion by dry deposition, and it can handle either ground-level or elevated releases. It can calculate building wake effects for ground-level releases, and it can calculate both momentum and buoyancy plume rise effects. The code can use dispersion parameters corresponding to either a continuous or an instantaneous release, and it can take into account the effects of an initiating explosion.

DUW also evaluates the radiological and toxicological effects of particles that are transported to each of the downwind dose points. For radiological effects, it calculates inhalation doses to each of four internal body compartments: lungs, total body, red marrow, and kidney. The inhalation doses calculated by DUW are all 50-year dose commitments, accounting for radionuclides that may reside in the body for as long as 50 years. (In this report the term "dose" is occasionally used in place of "dose commitments": whenever the radiological effects due to inhalation are described, the stated values always refer to 50-year dose commitments.) The code DUW also calculates external total body doses due to radiation by radionuclides in the passing plume and by those deposited on the ground, and it calculates the skin dose due to beta radiation from the passing plume. For evaluating toxicological effects it also calculates the quantity of uranium passing through the kidneys.

ASSUMPTIONS MADE IN THE CALCULATIONS

The methods and assumptions used in determining the source terms and release conditions are described under the accident scenario descriptions.

For the atmospheric dispersion calculation, it was assumed that a steady wind of 2 meters per second (4.5 miles per hour) was blowing for all phases of the accidents. The downwind concentrations are inversely proportional to the windspeed, and this low value, therefore, results in high doses. The dispersion of the airborne particles depends on the atmospheric condition, described by the stability class. These classes are designated by letters A through F, with classes A and B referring to unstable atmospheres, C and D to neutral, and E and F to stable conditions. Different stability classes can produce greatly different downwind concentration profiles, especially for elevated releases, since the unstable classes can produce rapid dilution of the released particles, but a very stable condition may keep an elevated plume from touching the ground until it is several kilometers downwind. To account for the range of possible profiles, the atmospheric transport was calculated for all six stability classes. For each of these classes, concentrations were calculated for twenty downwind distances ranging from 100 meters to 40 kilometers, with the dose points spaced approximately uniformly on a logarithmic scale.

For the inhalation dose pathways, a breathing rate of 300 cm^3/sec was used. This rate is typical of a moderately active adult. The internal dose commitments were calculated for a time period of fifty years, thus evaluating the residual effects of radionuclides that may linger in the body for a lifetime. The released radionuclides were assumed to consist of three uranium isotopes in the proportions listed in Table 1.

TABLE 1. URANIUM ISOTOPES INCLUDED IN THE RELEASES

Radionuclide	Weight Fraction
^{234}U	3.7×10^{-6}
^{235}U	0.0025
^{238}U	0.9975

Pa-234m was also assumed to be released in equilibrium with the U-238. Thus the activity of Pa-234m (in curies) was equal to the activity of its parent radionuclide, U-238.

Solubility studies that have been performed on DU-oxide particles produced in fires have shown that the material is insoluble. The particles were, therefore, assumed to be in the "Y" solubility class, resulting in the slowest clearance from the lungs. The particle size chosen for these calculations was 1 micron AMAD (Activity Median Aerodynamic Diameter). This is the value that would result from a log-normal distribution of particles in the respirable sizes ranging from 0.2 to 10 microns AMAD.

The selection of particle size is an important parameter in the determination of inhalation dose. A sensitivity study was performed to determine the effect of particle size on the doses to four organs due to inhalation. The results of this study are graphically presented as Figure 1. The doses on this graph were calculated by DUW, with all input parameters (except particle size) chosen to represent the values used in the accident calculations. The relationships on the graph, therefore, can be applied to any of the accident calculations.

This study shows that the inhalation doses to lungs are higher than the inhalation doses to other organs. The doses for all organs consistently increase with decreasing particle size, due to the increasing proportion of inhaled particles that are deposited in the deepest compartment of the lung and, therefore, remain in the body for the longest time. For lung and total body the doses due to 0.1-micron particles are about 30 times higher than the doses due to 20-micron particles. For red marrow and kidney the ratios of these doses are about 7.5. For 1-micron particles, the following relationship between the doses were found:

Lung Dose:	1.00000
Red Marrow Dose:	0.04728
Total Body Dose:	0.03094
Kidney Dose:	0.00399

Since the proportion of radionuclides is constant for all dose points in all of the postulated accident conditions, the relationship between inhalation doses found here will be true for all situations in this report.

Although the calculations in this study used particle sizes of 1 micron AMAD, a change in particle size could be evaluated by ratios derived from the data in Figure 1. Thus a lung dose could be nigher by a factor of 2.47 than the dose reported in this study if the inhaled particle sizes were assumed to be 0.1 microns AMAD, or a factor of 5.0 lower if the particles were assumed to be 10 microns AMAD. While these factors appear to be high, the particle distributions assumed by either 0.1 or 10 microns are at the extreme ranges of respirability, and, therefore, unlikely to be realistic.

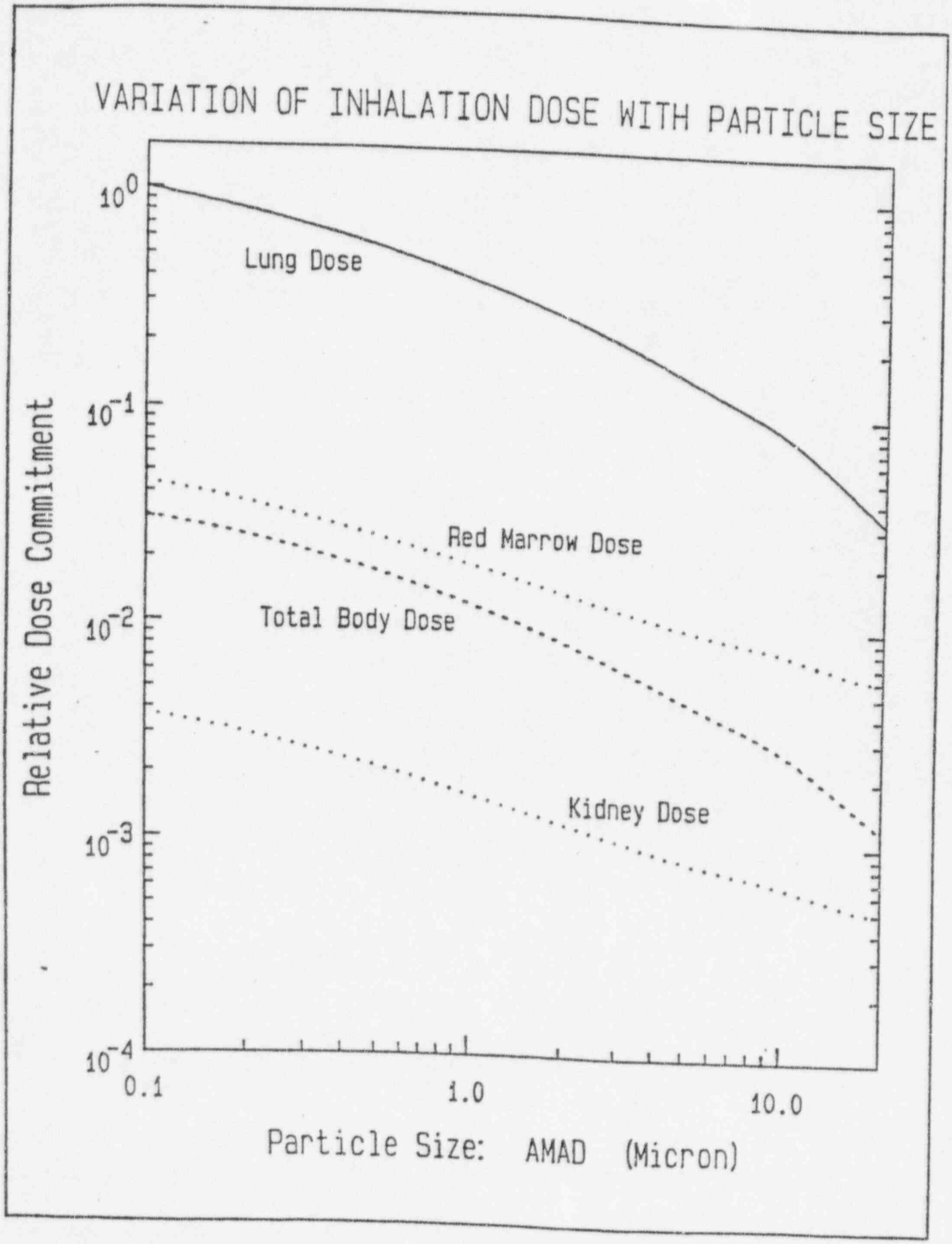

VARIATION OF INHALATION DOSE WITH PARTICLE SIZE
Lung Dose
Red Marrow Dose
Total Body Dose
Kidney Dose
Relative Dose Commitment
10^0
10^-1
10^-2
10^-3
10^-4
0.1
1.0
10.0
Particle Size: AMAD (Micron)

Figure 1

SHIPPING ACCIDENT SCENARIO

SCENARIO DESCRIPTION

It is postulated that a commercial semi truck containing a full, single-shipment load of M829 munitions and fuel collides with another vehicle or object. The fuel in the semi (130 gallons of diesel fuel) is released and ignites. The combustion of the fuel ignites the combustible materials present (primarily wood from the pallets and packages of the M829) and burns until self-extinguishment.

A fully loaded commercial semi truck carries 512 M829 rounds on 32 pallets, each pallet holding 16 individually packaged rounds (Honeywell 1983). Each round weighs 41.1 lb. of which 18 lb. is propellant, 1.5 lb. is the combustible case, and 8.8 lb. is DU. Each round is individually packaged; the packaging consists of wood, cardboard, sheet metal, etc. weighing 38.8 lb. For the purposes of this analysis, the entire weight of the package is considered to be wood. Based upon the observations during the two external heat tests performed on this round (Hooker et al. 1983), the diesel fuel combustible case, and propellant are consumed prior to the oxidation of the DU and, therefore, are not considered in this analysis of the heat generation during the airborne release of DU oxides. The fire duration is assumed to be the same as observed for the M829 external heat tests (48 hours) with the cook-off of the munitions occuring during the initial hour. Thus, it is postulated that the airborne release of DU oxide occurs over the remaining 47 hours. In order for the greater quantity of combustibles to be consumed over the same time frame as observed for the external heat test, the area of the fire must be proportional. The fire area for the external heat test which used 12 rounds was approximately 30 square ft. and, therefore, the fire area for the fully-loaded truck is assumed to be 512/12 x 30 square ft. = 1290 square ft. or a circle of diameter 40.5 ft.

HEAT GENERATION DURING THE AIRBORNE RELEASE

The total weight of wood involved is:

individual packages - 512 x 38.8 lb. = 19,866 lb.
pallets - 32 x 73 lb. = 2,336 lb.
total = 22,202 lb.

Harmathy (1972) modelled the burning of a wood crib and assumed that "typical" wood was composed of 0.872 volatiles and 0.128 char. He further assumed the two components burn linearly with the volatiles consumed in one half the time required for the burning of the char. This latter assumption is contrary to the observations made during the M829 external heat tests where the flaming combustion of the volatiles was observed for approximately 8 hours and the glowing oxidation of the char was observed for an additional 40 or more hours. For the purposes of this analysis, it is assumed that the fire follows the fires observed during the external heat tests. Thus; heat generation during the initial 7 hours of airborne release-

$$\text{heat/hr.} = H_c(\text{volatiles})(0.872)(22{,}202 \text{ lb.} \div 2.2 \text{ lb./kg})/8 \text{ hr.}^* + H_c(\text{char})\ (0.128)(22{,}202 \text{ lb.} \div 2.2 \text{ lb./kg})/48 \text{ hr.} = 5354 \text{ Watts}$$

*the actual burning time is 8 hours but the DU is not exposed during the initial hour.

where: H_c(volatiles) = 17.6×10^6 J/kg (Harmathy 1973)
H_c(char) = 33.4×10^6 J/kg (Harmathy 1973)

heat generation during the subsequent 40 hours of airborne release-

$$\text{heat/hr.} = H_c(\text{char})\ (0.128)(22{,}202\ \text{lb.} \div 2.2\ \text{lb./Kg})/48\ \text{hr.} = 250\ \text{W.}$$

AIRBORNE RELEASE OF DU OXIDES

It is assumed that the staballoy is 85% oxidized during the fire. The value is chosen as a conservative estimate of the oxidation observed during the two external heat tests during which no attempt was made to limit the oxidation of the DU (Hooker et al. 1983). No significant airborne release was detected during these or other fire situations involving DU munitions (Bloore and Wilsey 1979). Fractional airborne releases under experimental conditions as high as 4.5 wt. % have been measured (Mishima et al. 1984). Experimental values as high as 0.5 wt. % have been reported using bare staballoy penetrators under elevated temperatures (1100°C) and high air flows (223 cm/s) for periods during a 3 hour experiment in which 44 to 45% of the staballoy was oxidized (Elder and Tinkle 1980). None of the experimental configurations parallel the situation found during external heat test in which the oxidizing staballoy was buried under the charcoal and ash generated by the fire. Schmidt (1975) reported that a layer of carbon microspheres could substantially reduce the airborne release from ignited uranium chips. Based upon the apparent lack of airborne release during the various fire tests, the low airborne releases during experiments during which more rigorous conditions were imposed, and the anticipated presence of a large layer of carbon over most of the oxidizing staballoy, a 0.1 wt. % airborne release under the conditions of a fire during a shipping accident is assumed. The probability of a fire in the event of a truck accident is small, approximately 3×10^{-8} probability per mile (Clark et al. 1975).

The rate at which the DU oxide is released is not known. The mechanism by which the DU oxide particles are injected into the airstream has not been defined and could occur during the formation of the oxide, during breakaway of the non-adherent oxides, or after the material is deposited upon other materials; or all of the postulated mechanisms could contribute during some or all of the duration of the airborne release. For the purposes of this analysis, it is assumed that the airborne release is linear with time (47 hours) and is:

$$\text{airborne release/hr.} = 0.001\ (512 \times 4\ \text{kg})/47\ \text{hr.} = 0.0436\ \text{kg/hr.}$$

The size distribution of the particles airborne is important for assessing the potential downwind dose. Since no detectable airborne quantities of DU were found during the various fire tests, no data is available as to their size distributions. The size distribution of the DU oxides recovered indicated that less than 0.6% was "respirable" (less than 10 μm Aerodynamic Equivalent Diameter, AED) (Mishima et al. 1984). The Mass Median Diameter (MMD) of the recovered material corresponds to the MMD found by Elder and Tinkle (1980) at a temperature of 600°C to 700° C. The experiments described by Elder and Tinkle were conducted for a given period of time and did not allow complete oxidation of the staballoy penetrators. Elder and Tinkle did measure the mass airborne and the mass of the airborne respirable fraction (Figures 22 & 23, Elder and Tinkle 1980). The respirable fraction is approximately 7% of the airborne

mass at the highest airborne mass concentration. It could be assumed that the airborne material is the same distribution found for the oxides recovered from the fire or that observed by Elder and Tinkle. Since the latter yields higher doses (is conservative), it is applied in this analysis. Thus:

mass respirable particle/hr. = 0.070(0.0436 kg/hr.)
=3.05 g/hr.

The fraction of airborne particles less than 100 um AED are assumed to be carried up to 1 km and could potentially contribute to other dose mechanisms (e.g. direct radiation, skin dose, ground deposition). The fraction of material in this size fraction measured in the oxide recovered from the external heat test was 30% (Mishima et al. 1984). Since the respirable fraction of the airborne material is considerably greater than that recovered in the test, this fraction in turn is increased to 60%, and is considered to be capable of transport for up to 1 km:

mass particles carried up to 1 km downwind = 0.60 (0.0436 kg/hr.) = 26.2 g/hr.

The remainder of the airborne particles are considered to be greater than 100 um AED and settle out within 100 m of the source:

mass particles carried only up to 100 m downwind = 0.4(0.0436 kg/hr.)
= 17.4 g/hr.

Based upon the solubility test performed on the oxide recovered from the external heat test (Mishima et al. 1984), all the airborne particles are considered to be class Y solubility. The solubility tests indicated that the solubility half time for the DU oxide likely to be released in a fire is approximately 1100 days, whereas the Y solubility class uses a half time of 500 days for dissolution in the pulmonary region of the lung. A more soluble form of uranium, either D or W class, would result in a greater hazard to the kidney due to higher doses caused by more uranium being transported through the body. There is some conservatism, however, in assigning the Y solubility class to this material since the calculations actually use shorter half times than experiments would indicate.

SCENARIO ANALYSIS

A series of DUW calculations was performed to analyze the potential effects of the DU shipping accident. Calculations were performed for all six atmospheric stability conditions, Pasquill Classes A through F. For all radiological pathways, the inhalation dose commitment to the lung was the highest dose calculated. Figure 2 graphically presents the results of these calculations for distances from 100 meters to 40 kilometers. The doses on this graph are 50-year dose commitments to the lung for a moderately active adult positioned at the dose location, assumed to be on the plume centerline, for the entire 47 hours of the accident scenario. The shapes of the curves on this graph illustrate a dramatic difference in dose-vs-distance profiles, depending on the assumed atmospheric conditions. The stable atmospheric conditions (classes E & F)

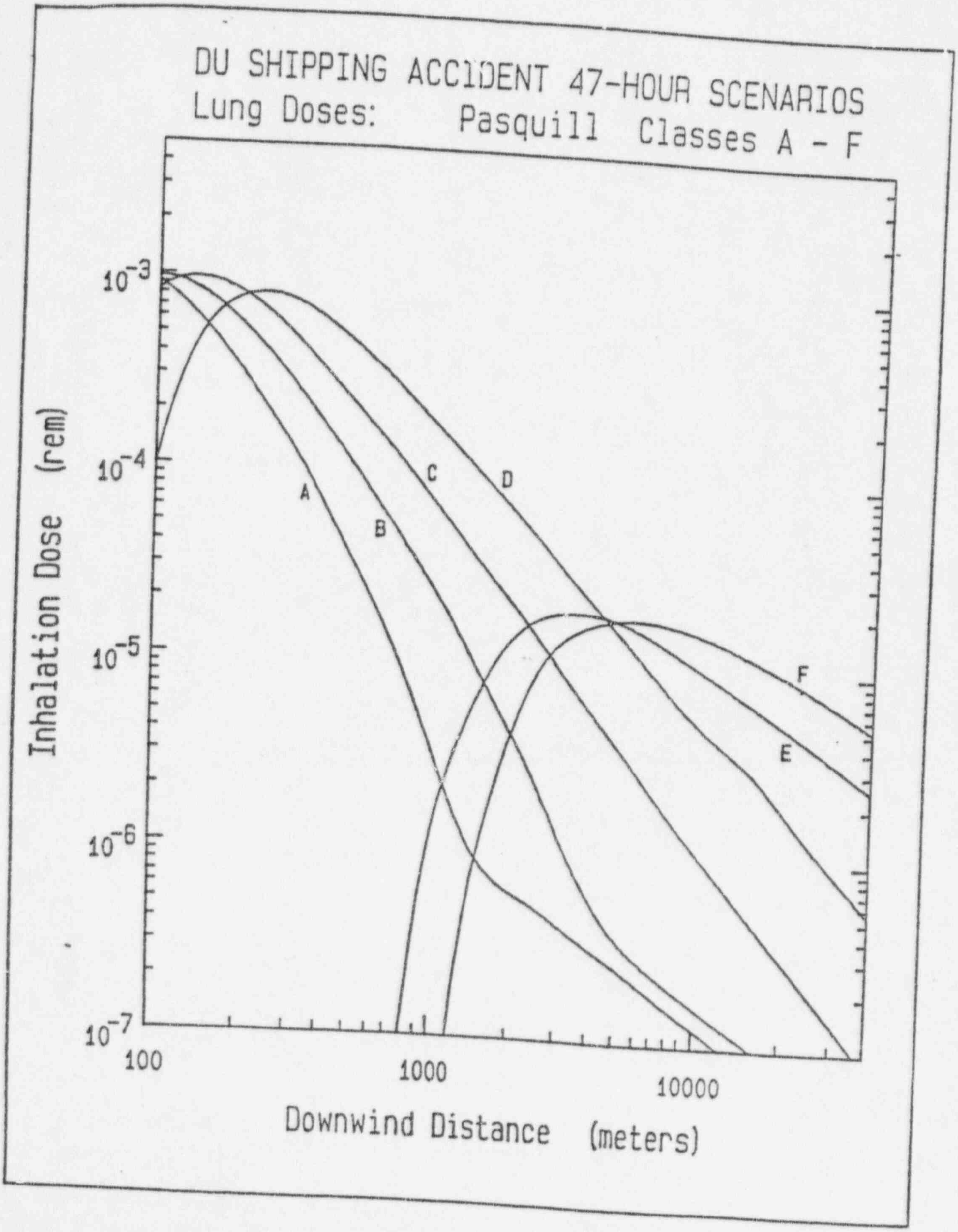
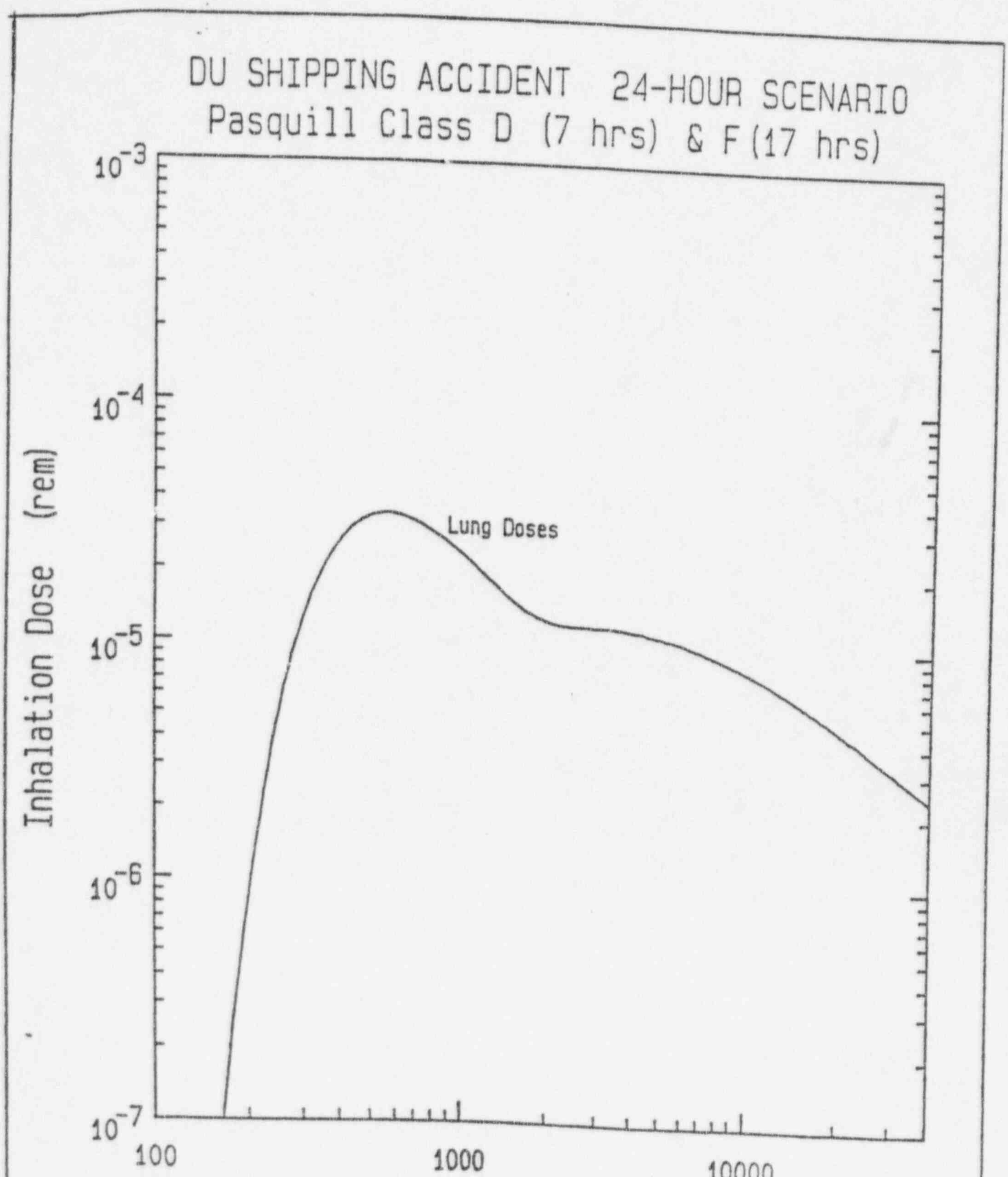

DU SHIPPING ACCIDENT 47-HOUR SCENARIOS
Lung Doses: Pasquill Classes A - F
Inhalation Dose (rem)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
100
1000
10000
Downwind Distance (meters)
A
B
C
D
E
F

Figure 2

show almost a zero dose at distances less than 1 km, since the elevated plume is prevented from touching the ground by the low dispersion. At distances greater than about 5 km, however, classes E & F result in higher doses than the neutral and unstable classes due to the greater dispersion of classes A through D. At distances very close to the release point, less than 200 meters, classes A, B or C produce the highest doses due to greater dispersion allowing the plume to quickly touch the ground. At intermediate distances, from about 200 meters to about 5 km, class D produces the highest doses. The selection of atmospheric conditions for a worst-case scenario, therefore, is dependent on the downwind distances being addressed.

It is usually unrealistic to assume that an atmospheric condition would remain constant for a period as long as 47 hours. There are usually time-of-day variations due to daytime heating and nighttime cooling, so that a realistic scenario would involve a mixture of stability classes. An example of a more realistic scenario is illustrated in Figure 3. In this scenario the atmospheric condition was assumed to be class D (neutral) for the first 7 hours of the release, corresponding to the first burning phase, then switching to class F (stable) for the second burning phase, up to a total of 24 hours. It is difficult to arrive at a realistic worst-case scenario in terms of atmospheric conditions, since there is an infinite number of combinations that could be assumed. Therefore, this report will concentrate on constant conditions for the duration of a release.

Table 2 compares the magnitudes of doses incurred by all the radiological pathways analyzed in this study. This compilation uses a different atmospheric stability class for each of the ten distances presented, thus producing the highest possible dose for each distance. The inhalation doses, external plume total body and beta skin doses were calculated assuming that a person remained on the plume centerline for the entire 47 hours of the accidental release. The ground dose rates were calculated based on the radionuclides that would be deposited over the entire 47 hours of the scenario; the tabulated values are the total body dose rates that a person would receive standing on the dose point at the end of the release, after all the material had been deposited.



DU SHIPPING ACCIDENT 24-HOUR SCENARIO
Pasquill Class D (7 hrs) & F (17 hrs)
Inhalation Dose (rem)
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
Lung Doses
100
1000
10000
Downwind Distance (meters)

Figure 3

TABLE 2. Radiological Effects of the DU Shipping Accident

		Inhalation Doses 50-year Dose Commitments			External Doses		
Distance (m)	Stability Class	Total Body (rem)	Lungs (rem)	Kidney (rem)	Plume Total Body (rem)	Betas Skin (rem)	Ground Total Body (rem/hr.)
100	A	2.78×10^{-5}	9.01×10^{-4}	3.58×10^{-6}	2.88×10^{-11}	1.36×10^{-8}	1.16×10^{-10}
200	B	1.71×10^{-5}	5.53×10^{-4}	2.21×10^{-6}	1.52×10^{-10}	5.18×10^{-9}	5.30×10^{-11}
360	C	1.20×10^{-5}	3.87×10^{-4}	1.55×10^{-6}	1.02×10^{-10}	1.70×10^{-9}	2.62×10^{-11}
500	D	1.46×10^{-5}	4.73×10^{-4}	1.89×10^{-6}	1.00×10^{-11}	1.11×10^{-9}	2.65×10^{-11}
900	D	6.37×10^{-6}	2.06×10^{-4}	8.24×10^{-7}	4.90×10^{-12}	1.19×10^{-10}	9.44×10^{-12}
1250	D	3.92×10^{-6}	1.27×10^{-4}	5.05×10^{-7}	3.95×10^{-13}	5.13×10^{-12}	6.57×10^{-13}
1700	D	2.47×10^{-6}	7.98×10^{-5}	3.19×10^{-7}	2.81×10^{-13}	2.82×10^{-12}	4.13×10^{-13}
4400	E	4.47×10^{-7}	1.80×10^{-5}	7.21×10^{-8}	1.19×10^{-13}	6.54×10^{-13}	9.35×10^{-14}
6000	E	4.70×10^{-7}	1.51×10^{-5}	6.07×10^{-8}	1.00×10^{-13}	5.51×10^{-13}	7.89×10^{-14}
15500	F	3.57×10^{-7}	1.16×10^{-5}	4.62×10^{-8}	7.74×10^{-14}	4.85×10^{-13}	6.07×10^{-14}

The values tabulated in Table 2 indicate that the radiological effects of the shipping accident would be negligible. The highest doses are the inhalation lung doses, less than 1 millirem to a person standing on the plume centerline 100 meters downwind of the accident site for 47 hours. The corresponding total body dose would be 0.03 millirem. The USEPA published a set of "Protective Action Guides" (PAGs) (USEPA, 1975) that are commonly used by FEMA (Federal Emergency Management Agency) the NRC (Nuclear Regulatory Commission) and other regulatory agencies for determining protective actions to be taken during an emergency response situation. The PAG for total body dose due to an accidental release of radionuclides is set at 1 rem (1000 mrem) for most conditions, but it could be extended up to 5 rem in special cases such as bad weather conditions. The PAG dose is the level at which emergency response authorities should order protective action as sheltering or evacuation to protect the public from radiological hazards. While no PAG has been set for lung doses, the Code of Federal Regulations, 10CFR20 (USNRC, 1983), in Sections 20.4 and 20.101, indicates that the dose to the lung should be treated in the same way as the dose to total body. Such a consideratin would suggest applying the total body PAGs to the projected lung doses. All projected doses for the shipping accident are several orders of magnitude lower than the PAG.

The total body dose due to exposure to contaminated ground contributes little to the dose that would be accrued during the course of an accident, but it gives an indication of the long-term effects resulting from the release. The worst dose rate is approximately 10^{-10} rem/hr. By comparison, the total body dose rate due to natural background is on the order of 10^{-5} rem/hr. The radiation due to DU deposited on the ground would be many orders of magnitude lower than natual background and no increase in radiation levels could be detected by even the most sensitive detector. If a person remained on the contaminated ground for 75 years, and the ground were undisturbed, the person's total body dose would be about 9×10^{-5} rem, a trivial dose.

In analyzing the toxicological effects of the shipping accident release, the air concentration of uranium is integrated over the duration of the release, to get an integrated concentration in units of mg-hr/m^3. This value is then compared to the upper bound guidelines as described in Mishima et al., 1984. This report references a guideline value of 25 mg-hr/m^3 that can be used in an emergency situation. This value is derived from continuous occupational exposure limits. Since no regulatory agency sets or recommends uranium-in-air limits applicable to an accidental exposure situation, this value of 25 mg-hr/m^3 should be viewed as an informally-derived guideline, rather than a regulatory limit.

The time-integrated air concentrations calculated for this scenario are listed in Table 3.

TABLE 3. Time-Integrated U-in-Air Concentrations (maximum exposure for each distance)

Distance (m)	Stability Class	Time-integrated Air Concentration (mg-hr./m^3)
100	A	0.00940
200	B	0.00584
360	C	0.00417
500	D	0.00516
900	D	0.00231
1250	D	0.00145
1700	D	0.00093
4400	E	0.00019
6000	E	0.00015
15500	F	0.00012

Table 3 shows that for all cases the time-integrated concentrations of uranium in air are far lower than the guideline. The shipping accident, therefore, poses a negligible toxicological hazard to persons situated downwind from the release.

STORAGE ACCIDENT SCENARIO

SCENARIO DESCRIPTION

It is postulated that a large vehicle impacts the entry of a Stradley magazine with sufficient force to puncture the structure and create an 8 ft. x 8 ft. opening. The collision ruptures the fuel tank, spilling its entire contents. Sparks from the collision ignite the diesel fuel which in turn ignites the wood packages of the munitions and the pallets.

The Stradley magazine is an oblong, slightly rounded structure made of reinforced concrete. Its dimensions are 25 ft. wide x 80 ft. long x 14 ft. high (Honeywell 1983). The walls, ceiling, and floor are greater than 1 ft. thick with two manually controlled ventilation stacks in the roof. Five of its six sides (excluding the entry wall) are covered by various thicknesses of earth: the ceiling is covered with 1 to 2 ft. of earth sloping to 5 to 6 ft. at the base depending upon the mounding characteristics of the earth used; the floor rests upon earth.

The quantity of M829 munitions which can be stored is 386 pallets, each containing 16 rounds, for a total of 6176 rounds. The total weight of DU is 6176 x 4 kg/round = 24,704 kg. The total weight of fuel is 268,806 lb. or 1.29×10^9 g of wood. The diesel fuel is assumed to be burned prior to the oxidation of the DU and the contribution of the propellant and combustible cases cannot be estimated at this time but only adds to the heat generation, and not including its contribution makes the evaluation more conservative (diminishes the release height).

It is assumed that the fuel ignites the entire front face of munition containers facing the entry - 12 pallets. The largest side of a pallet of 16 rounds is 45 inches x 36 inches. Thus, the surface area of the burning wood is 21,060 square inches or 13.59 square meters. The fuel would be rapidly consumed since there is little porous material with which to absorb it. The fire would soon become oxygen-limited due to the small size of the single opening available for air intake and combustion product exhaust. Under these conditions, the upper 2/3 of the opening are used to exhaust the combustion products and the lower 1/3 used to provide air for the fire (Harmathy 1973). As the fire progresses and the wood packages are consumed, the combustible cases and propellant in the exposed cartridges would burn rapidly (flare) and the projectiles drop onto the surface beneath. The sabot and other components would be affected by the heat of the fire and the staballoy cores exposed. The flaring of the propellant and cases, which does not require oxygen, would aid in propagating the fire to other containers. The fire is assumed to progress from the outer layers to the inner and lower layers. The volatiles from the wood may or may not burn within the enclosure due to the lack of oxygen but the char must oxidize or the fire would self-extinguish. The oxidation of the char can continue even at low oxygen concentrations (Harmathy 1973).

The temperature of the oxidizing char is high (up to 1000° C) and is sufficient to promote the accelerated oxidation of the staballoy which again does not require the normal oxygen concentrations found in air (approximately 22%). The staballoy penetrators are assumed to oxidize as they become exposed and may lose some of the oxide when dropped from level to level as the lower layers of containers are burned. Airborne release is assumed to occur during the burning and be released via the opening along with the combustion products.

At some point in time after all the cores are oxidized, an explosion is postulated to occur due to the deflagration of sensitized propellant or the presence of high explosive (HE) munitions. Since the explosive material is not intimately mixed with the DU oxide present, the entraining mechanism is assumed to act more like a depressurization than a detonation (shock front) and expels the oxide and debris by entrainment in the gases ejected.

The aforementioned scenario is conservative from several points of view. First, it has not been established that a tightly packaged mass of wooden containers such as found in magazines can burn to completion. Second, it has not been established that magazines can burn to completion. Third, it has not been established that magazines will withstand the postulated heat load without failing. If the magazines were to fail, the fire would probably be extinguished at that point with some airborne release of the DU oxide formed due to the air movement generated by the failure. Fourth, the rate of oxidation of staballoy under the conditions postulated (the temperatures and oxygen-availability are not known) has not been established. Bloore and Wilsey (1979) assumed that staballoy remaining in a tank during their fire test did not oxidize. Finally, an explosion may well fail the fire-weakened magazine and bury much of the material rather than release it.

HEAT GENERATION DURING AIRBORNE RELEASE

The heat generation parameters for this scenario were calculated using a locally available fire compartment code, FIRIN (a code developed at PNL, but not formally documented). The input data used were:

total amount of fuel - 1.29 x 10^9 g wood,
surface area - 13.59 square meters,
dimensions of building - 7.62 m wide x 4.27 m high x 24.39 m long,
thickness of floor - 0.30 m reinforced concrete + infinite earth,
thickness of ceiling - 0.3 m reinforced concrete + 0.45 m earth,
thickness of walls, - 0.30 m reinforced concrete + 1.0 m earth,
external pressure - 1 atm.,
initial temperature - 293 K,
inlet filter height - 0.91 m*,
outlet filter height - 1.83 m*,
fire elevation - grade, floor level
inlet flow rate - unspecified*.

The results of the analysis indicate:

outflow rate - 10 m^3/s
hot layer temperature - 450 F,
mass loss rate - 159 g/s (the fire burns for 213.3 hr. or 8.9 days),
total heat generation - 1968 kW,
heat to fire gases - 275 kW.

* FIRIN is structured for a ventilation system configuration and the values used represent the heights assumed to be the upper value for the inlet & outlet flow heights. No inlet flow could be specified and this value was iterated until a steady state flaming combustion resulted.

AIRBORNE RELEASE OF DU OXIDES

The fractional airborne release of DU oxide during the fire is assumed to be the same as postulated for the Shipping Accident scenario over the duration of the fire - 0.1% of the DU oxide over 8.9 days (the duration of the fire determined by FIRIN). Thus:

> mass DU oxide airborne = 0.001 x 24,704 kg = 24.7 kg DU, or,
> rate of DU release = 24.7 kg DU/213.3 hr. = 116 g/hr.

The mass release rate for the various particle sizes is:

> "respirable" fraction - (0.07) (116 g/hr.) = 8.11 g/hr.;
> particles carried up to 1 km downwind - (0.60) (116 g/hr.) = 69.5 g/hr. and
> particles carried less than 100 m downwind - (0.40) (116 g/hr.) = 46.5 g/hr.

Based upon the solubility measurements performed on the oxide recovered from the external heat test (Mishima et al. 1984), all the airborne paticles are considered class Y with a dissolution haftime of greater than 1000 days.

The fractional airborne release due to the unspecified explosion at the end of the fire is difficult to define due to the lack of information on the type and quantity of explosives involved. High explosives would detonate upon absorbing sufficient heat to initiate the reaction. The characteristics of an explosion of sensitized propellant are unknown but could range from burning to detonation. Since the explosion is not postulated until the complete combustion of almost all the material and the complete oxidation of all the DU, it is not anticipated that it would be a detonation and would resemble a rapid generation of gases. The aerodynamic entrainment of particles into the expelled gases was determined based on the steady-state entrainment models of Martin et al. (1983), Travis (1975) and Sehmel (1980). In the investigations by Sutter (1983) of aerosols generated by the release of pressurized powders, the average mass fraction of particles made airborne was 20% at a pressure of 500 psig; the maximum airborne fraction was 30%. The application of these aerosol generation and entrainment models is based on a very conservative assumption that all the material in the enclosure is pressurized. With this assumption, the mass fraction of airborne DU oxide particles is set at 25% for the explosion in the storage scenario.

The oxide recovered from the external heat test (Mishima et al. 1984) was found to have from 0.6 to 0.2 wt. % particles 10 micron AED or less. The largest fraction of these sized particles reported for the high temperature oxidation of uranium was that reported by Megaw et al. (1961) and indicated as much as 4 wt. % of the material could be less than 10 micron AED. Using such an assumption for this analysis would be conservative and is, therefore, used.

The airborne release of DU oxide from the explosion is estimated to be:

total mass airborne - (.25)(24,704 kg) = 6176 kg;
mass "respirable" particles (10 micron AED & less) - (0.04)(6176kg) = 247 kg
mass particles transported 1 km downwind (100 micron AED & less) - (0.30)(6176 kg) = 1853 kg
mass particles transported less than 100 meters (greater than 100 micron AED) = 4323 kg.

The initial volume of the gas cloud generated is assumed to be five (5) times the volume of the building, 3970 cubic meters.

SCENARIO ANALYSIS

For the storage accident scenario, much of the heat generated by the fire was absorbed by the structure of the magazine, so less was released to the fire gases than in the shipping accident. The cooler plume resulted in a lower plume rise, so the plume elevation had less of an effect on the atmospheric dispersion of radionuclides than in the shipping scenario. The distance profiles of the inhalation dose curves are, therefore, different than in the shipping accident scenario.

As in the shipping accident scenarios, the inhalation lung dose commitments represented the most severe radiological effects. Figure 4 is a graph of the lung doses for six atmospheric stability classes. The dose calculations assumed that a person remained on the plume centerline at the specified distance for the entire duration of the accident scenario, including 8.9 days of burning and the explosion at the end of the 8.9 days.

Figure 4 illustrates that fairly high lung doses (50-year dose commitments) could be incurred at distances less than about 4 kilometers. Some of the values are higher then the 1 rem total body PAG, but under the 5 rem value for mitigating circumstances. The total body doses, however, are far lower (under 100 mrem), and therefore well under the total body PAG. The total body PAG is, therefore, not explicity exceeded. If the lung dose values are compared to the total body PAG, however, doses in the 2 to 3 rem range would be a cause for concern and would cause emergency response officials to consider protective actions.

The doses resulting from all radiological pathways are presented in Table 4.

The values presented in Table 4 show that the doses from all external pathways are well below background levels and are several orders of magnitude lower than values that would cause concern.

The toxicological effects are presented graphically in Table 5 and they are summarized in Table 5.

Table 5 and Figure 5 show that for this accident scenario the toxicological guideline value of 25 mg-hr/m^3 is exceeded for classes E and F for distances ranging from 1 to 4 km, and it is approached for classes C and D in the range of 200 to 600 meters. For all other conditions the guideline values are not exceeded.

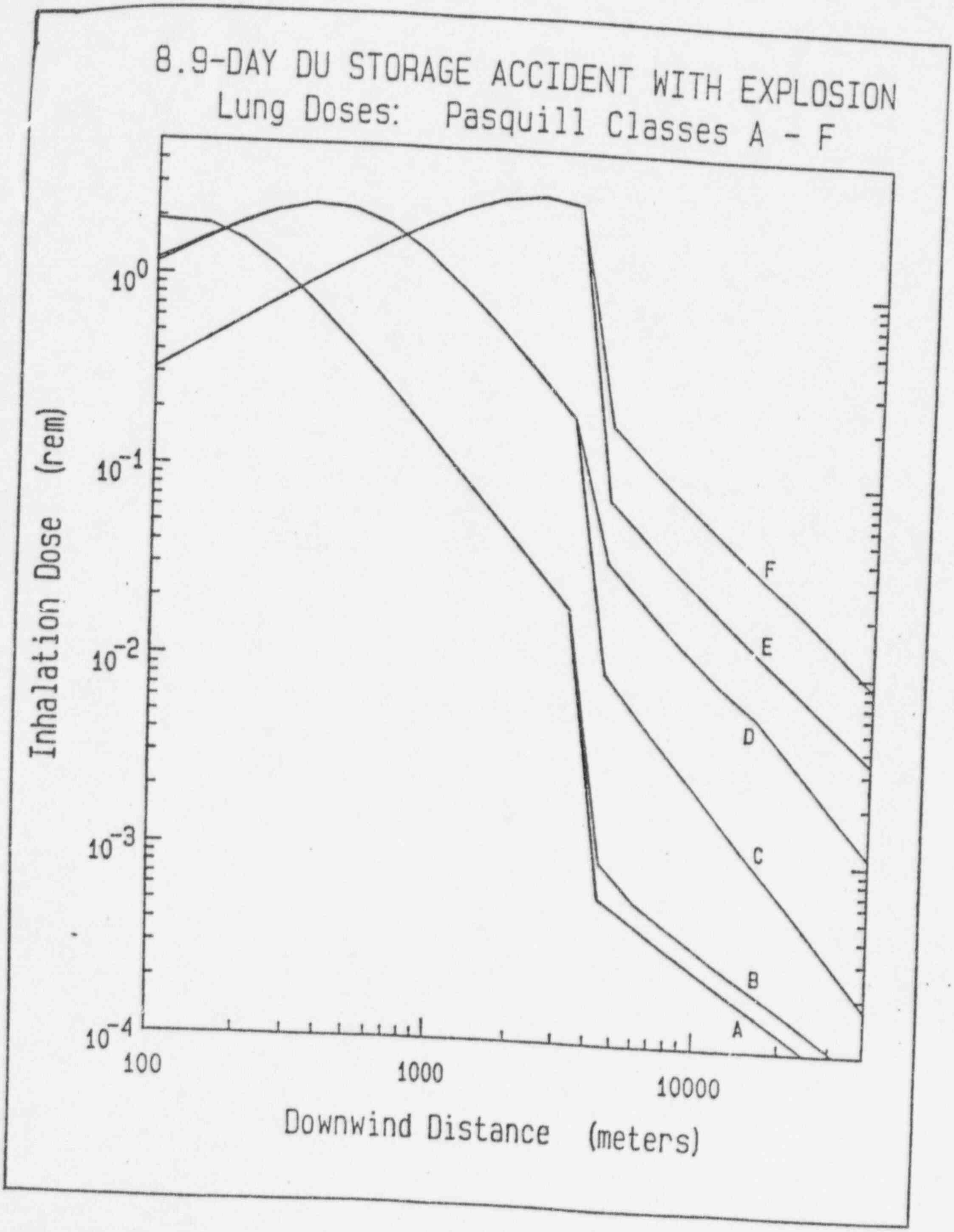

8.9-DAY DU STORAGE ACCIDENT WITH EXPLOSION
Lung Doses: Pasquill Classes A - F
Inhalation Dose (rem)
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
100
1000
10000
Downwind Distance (meters)
F
E
D
C
B
A

Figure 4

TABLE 4. Radiological Effects of the DU Storage Accident

Distance (m)	Stability Class	Inhalation Doses 50-year Dose Commitments Total Body (rem)	Lungs (rem)	Kidney (rem)	External Doses Plume Total Body (rem)	Betas Skin (rem)	Ground Total Body (rem/hr.)
100	D	.0366	1.18	.00473	3.71×10^{-8}	1.42×10^{-5}	1.35×10^{-7}
200	D	.0590	1.91	.00762	4.06×10^{-8}	1.56×10^{-5}	1.60×10^{-7}
360	D	.0751	2.44	.00972	3.59×10^{-8}	9.38×10^{-6}	1.44×10^{-7}
500	D	.0720	2.33	.00931	3.04×10^{-8}	4.80×10^{-6}	1.14×10^{-7}
900	D	.0442	1.43	.00571	1.92×10^{-8}	7.26×10^{-7}	7.27×10^{-8}
1250	F	.0744	1.96	0.00962	3.28×10^{-9}	9.73×10^{-8}	1.25×10^{-8}
1700	F	.0854	2.41	0.0110	3.50×10^{-9}	9.78×10^{-8}	1.43×10^{-8}
4400	F	.00586	2.76	7.57×10^{-4}	5.70×10^{-10}	6.85×10^{-9}	9.83×10^{-10}
6000	F	.00369	0.119	4.76×10^{-4}	9.68×10^{-10}	4.43×10^{-9}	6.21×10^{-10}
15500	F	9.82×10^{-4}	.0318	1.26×10^{-4}	1.33×10^{-10}	1.34×10^{-9}	1.67×10^{-10}

TABLE 5. Time-Integrated U-in-Air Concentrations (maximum exposure for each distance)

Distance (m)	Stability Class	Time-integrated Air Concentration (mg-hr./m^3)
100	D	12.1
150	D	16.1
200	D	19.6
260	D	22.6
360	D	24.9
500	D	23.9
675	D	19.8
900	D	14.7
1250	F	24.7
1700	F	28.3
2350	F	29.6
3200	F	27.1
4400	F	1.94
6000	F	1.22
15500	F	0.32

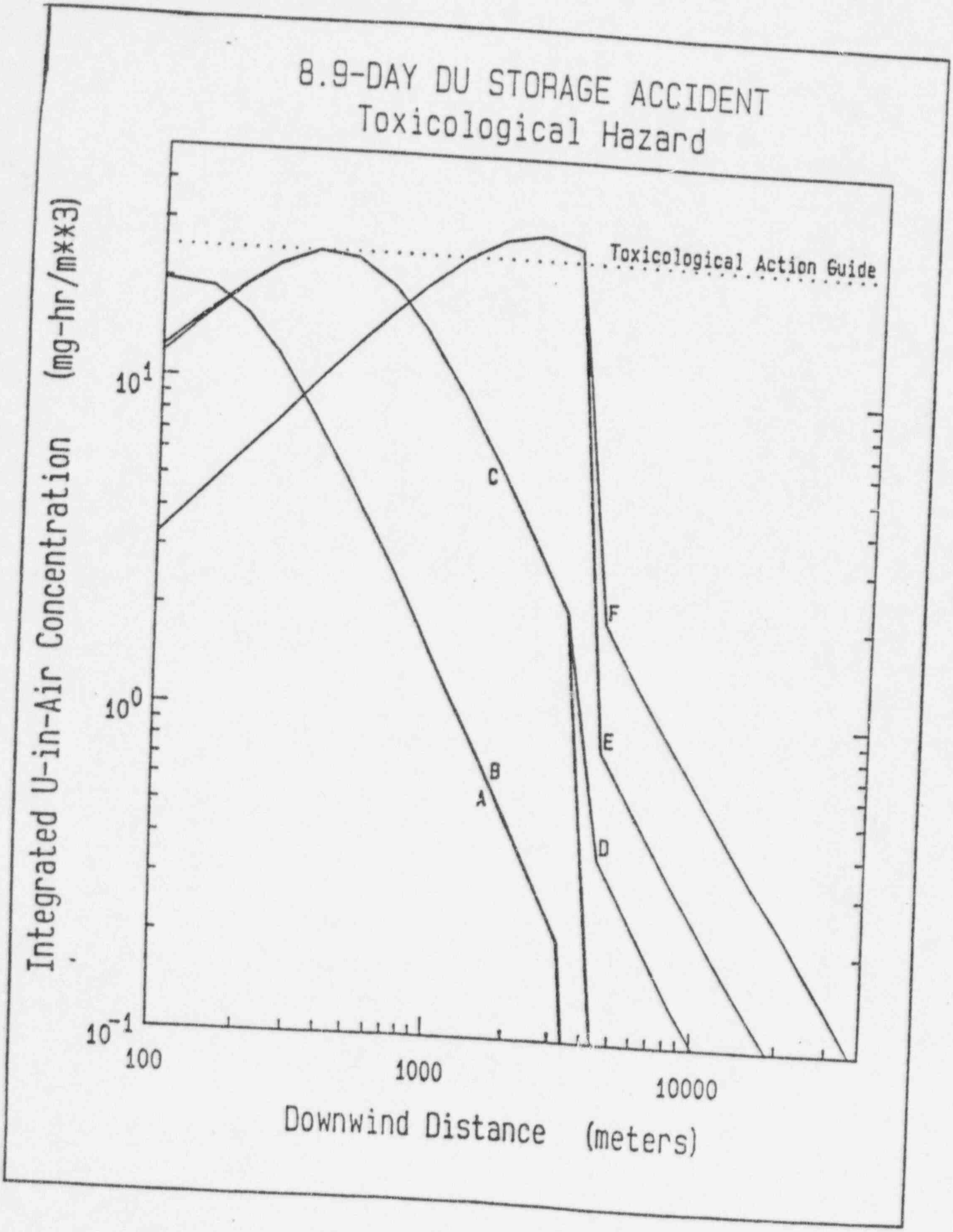

8.9-DAY DU STORAGE ACCIDENT
Toxicological Hazard
Toxicological Action Guide
Integrated U-in-Air Concentration (mg-hr/m**3)
10^1
10^0
10^-1
A
B
C
D
E
F
100
1000
10000
Downwind Distance (meters)

Figure 5

The majority of potential radiological and toxicological effects for the storage accident scenario are due to the explosive phase of the accident. Figure 6 shows the lung doses that would result from the burning phase alone. The doses due to the burning phase are far lower than those incurred during the explosion phase of the scenario: the worst lung dose incurred is approximately 100 mrem, approximately 8.5% of the lung dose for the entire scenario consisting of the burning and explosion phases. The total body inhalation doses would also be far lower than those presented in Table 4, and all potential doses would be well under the PAG value. The toxicological effects for the burning phase are similarly far lower than they would be for the explosive phase. They would also be on the order of 8.5% of those presented in Table 5 and Figure 5. Thus the toxicological effects of the burning phase alone would be well under guideline values.

CONCLUSIONS

The calculations performed in this study have demonstrated that the shipping accident scenarios involving depleted uranium would have insignificant radiological and toxicological impacts in the vicinity of the accident. The shipping accident scenarios result in doses and toxicological effects that are orders of magnitude below any action guidelines. At the low dose levels calculated by this study, no adverse health effects would be expected to occur.

The bulk storage accident scenario as presented produces doses and uranium-in-air concentrations that are high enough to cause consideration of a protective response. The PAG value for total body dose is not exceeded, but the lung dose is in the range of 2 to 3 rem for several accident conditions. The uranium-in-air concentrations for stability classes E & F are about 20% higher than the toxicological guidelines.

The storage accident scenario was chosen to be a worst case, however, so there are many conservative assumptions that could be decreased in a more likely scenario and would produce corresponding decreases in the projected radiological and toxicological effects. The scenario was assumed to begin with a truck crashing into the magazine, creating a large opening in the structure. If the truck were unable to breach the facility, there would probably be no fire in the magazine. If the scenario began with a smaller opening, less oxygen would be introduced and the fire would be less severe, possibly incapable of oxidizing all of the uranium. The burning phase must propogate through densely packed wooden containers and last for 8.9 days to completely oxidize the DU. The magazine structure must be able to withstand the heat load for this entire burning phase; if the magazine collapsed prior to the explosion, it could extinguish the fire and much of the oxidized DU would be buried rather than injected into the air. Any of these alternative possibilities would decrease the amount of oxidized uranium available for airborne transport downwind, and would lower the high doses projected for the explosion phase. If the explosion took place when the DU was less than 100% oxidized, the resulting doses would also be lowered accordingly. If the airborne fraction of the oxidized DU were less than 25%, or if the respirable fraction were less than 4%, the doses would also be lowered.

It is difficult to imagine that a fire would be allowed to burn for more than 8 days, or that explosives would be stored in the magazine that could survive more than eight days of burning before detonating. Thus a number of assumptions made in this worst case scenario are quite extreme, and it is noteworthy that the assumed conditions of the release must be this extreme in order to produce effects high enough for the consideration of protective responses. In more likely cases with less severe conditions the guidelines would not be exceeded and there would be no need for protective responses such as evacuation or declaring exclusion boundaries.

Additional studies would be useful to determine more realistic values that could be used in these calculations rather than the very conservative values that were used in this study. Additional tests should be aimed at determining the characteristics of oxides that are produced and made airborne during an explosion or various fires. Such characteristics as the fraction of oxidized DU made airborne, size distribution of the airborne particles, and the solubility of the airborne particles in lung fluid could all be defined by additional study.

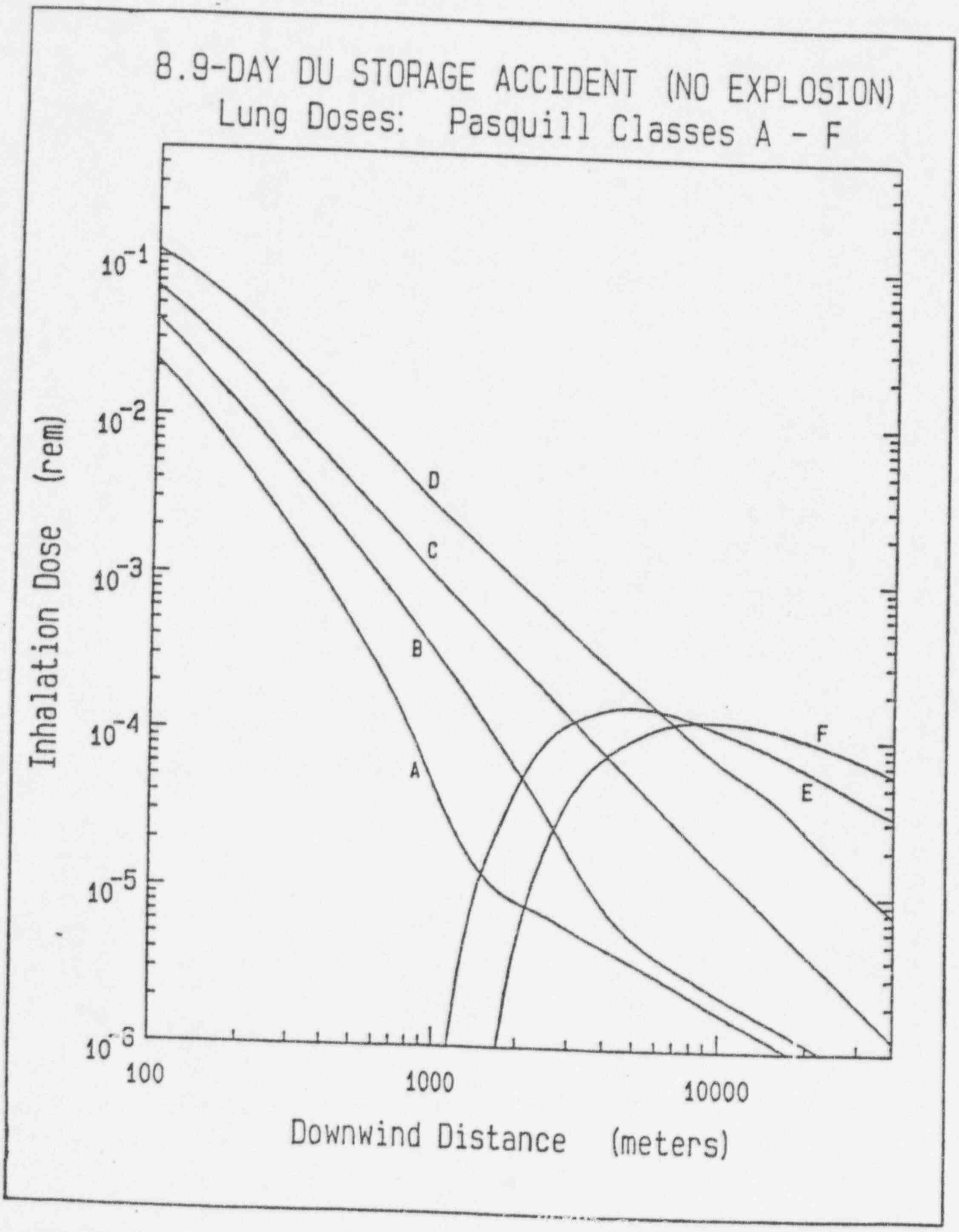

8.9-DAY DU STORAGE ACCIDENT (NO EXPLOSION)
Lung Doses: Pasquill Classes A - F
Inhalation Dose (rem)
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
A
B
C
D
E
F
100
1000
10000
Downwind Distance (meters)

Figure 6

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SAFETY AND HEALTH CONSIDERATIONS FOR HANDLNG STABALLOY MUNITIONS

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30 NOVEMBER 1979

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
DOVER, NEW JERSEY

Enclosure 4

FOREWARD

In June 1979, the Deputy Commander of ARRADCOM formed the ARRADCOM DU Task Force to address the testing requirements to define the radiological and toxicological hazards of fielding and deploying staballoy munitions. The Task Force consists of Dr. E. Bloore, chairman, Fire Control and Small Caliber Weapon Systems Laboratory; Mr. E. Wilsey, Ballistic Research Laboratory; Messrs R. Davitt and H. Anderson, Large Caliber Weapon Systems Laboratory; Messrs J. Elliott and S. Hoxha, Safety Office and MAJ M. Michlik, Tank Main Armament Systems Project Managers Office.

This report has been prepared by the Task Force to answer questions concerning the hazards of using DU ammunition. Questions or comments should be forwarded to the chairman of the Task Force.

ABSTRACT

The general types of question most often asked about depleted uranium and its use as a kinetic energy penetrators are reviewed.

Safety and health hazards that could result from the exposure of depleted uranium ammunition to a fire and/or detonation of other ammunition and explosives are addressed. Data from a series of laboratory and field tests exposing the XM774 DU penetrators to high temperatures and the results of burning a tank containing a full combat load of ammunition were used to assess damage to the penetrators. Based on information obtained from various organizations engaged in fire research and the test data it was concluded that ammunition containing depleted uranium penetrators would not present any hazard significantly greater than that presented by conventional ammunition.

TABLE OF CONTENTS

SAFETY AND HEALTH CONSIDERATIONS

FOR HANDLING STABALLOY MUNITIONS

I. INTRODUCTION

Safety and health considerations for handling staballoy munitions have been reviewed from manufacturing to demilitarization. The objective of this report is to review the general types of questions most often asked and then discuss those areas that have been of a major concern for deployment, i.e. transportation and storage.

Section II reviews the most commonly asked questions pertaining to depleted uranium (DU) and to handling and using DU (staballoy) munitions.

Section III includes a discussion of the characteristics of fires and defines credible potential accident scenarios in transportation and storage of 105mm APFSDS-T XM774 cartridges.

Section IV then discusses potential accidents in transportation and storage of the XM774 ammunition.

II. GENERAL QUESTIONS

The most commonly asked questions concerning the safety and health aspects of staballoy munitions are provided below with answers.

a. What is staballoy?

Staballoy is the name of a metal alloy made primarily of depleted uranium (DU) and alloyed with small amounts of other metals.

b. What is depleted uranium?

Natural uranium contains 0.005 percent U-234, 0.7 percent U-235, and 99.295 percent U-238. Depleted uranium (DU) is a byproduct of the gaseous diffusion process through which uranium containing a higher content of the U-235 isotope, referred to as enriched uranium, is produced from natural uranium. This material is used for reactor fuel and nuclear weapons. DU, the residue of the enrichment process, contains only a portion of the original U-235 and U-234 and is therefore "depleted" in these isotopes. The isotope distribution, and then the activity of DU will vary with different enrichment goals. Although the activity of DU varies with the enrichment goal, this activity is much less than that of natural or enriched uranium. During the refining and enrichment process, the radioactivity decay products (daughters) of the uranium isotopes are depleted in the uranium.

DU is a high density metal used as counterweights in some military and commerical aircraft and as a shielding materiel in containers in which radioactive materials such as cobalt-60 are stored and used. It protects people carrying such containers by screening them from the radiation that would emanate from the radioactive material within the container.

c. How much depleted uranium is in staballoy?

The particular staballoy alloy that the Army plans to use is composed of 99.25% DU and 0.75% titanium.

d. Do staballoy munitions contain radioactive substances?

Yes. Uranium in all forms is radioactive -- as an ore in its natural state, as a refined metal, as a machined armor penetrators, as fragments remaining after impact, as oxide produced on burning.

e. Are there sources of radioactivity that the general populace is exposed to?

It should be realized that everyone is radioactive. Everyone contains radioactive isotopes of carbon, potassium, rubidium, uranium radium, radon, polonium, lead, thorium and bismuth. The intake of uranium from various foodstuffs is about one microgram (1μg) daily in the United States.

It should also be realized that everyone is irradiated daily. Sources of natural background radiation include [1]:

1. Cosmic radiation consisting of energetic particles of extraterrestrial origin that strike the earth's atmosphere. Cosmic ray dose varies with altitude. At sea level the population receives half of what the population in Denver (1600 meters high) receives.

2. Cosmogenic radionuclides are produced by the interaction of cosmic rays and primarily the earth's atmosphere. Very little of the population dose is from this source.

3. External terrestrial radiation is from the radionuclides present in the earth such as uranium, thorium and potassium.

4. Inhaled radionuclides are essentially the same members as number three that became present in dust or soil particles. These nuclides contribute to doses in the lung due to the close proximity of the particles to the lung tissue. Natural gas and coal contain small amounts of radionuclides. A heavy smoker (2 packs per day) receives large doses to the bronchial epithelium from inhaling lead and polonium radionuclides.

f. How radioactive is DU?

The activity of a radioactive source is a measurable property proportional to the rate at which the source decays (number of disintegrations per unit time). The unit used to express activity is the curie (Ci). A curie is defined as the quantity of any radioactive nuclide in which the number of disintegrations per second is 37 billion (3.7×10^{10}). Approximately three metric tons of DU yield one curie. This activity is very low — one gram of radium yields approximately the same activity.

Another comparison can be made using a term called "specific activity." This is the number of curies in a gram of radioisotope. The specific activity of U-238, the major isotope of DU, is 3.36×10^{-7} Ci/g — This is not very active by comparison to other commonly used radioactive materials, such as radium which has a specific activity of 0.98 Ci/g.

g. Are there health hazards involved in handling or storing staballoy munitions?

Yes. Health hazards from handling staballoy munitions are very low, but they do exist. They are of two kinds — radiological and chemical toxicity. These hazards are easily reduced to a negligible consideration using simple, routine precautions.

With respect to the radiological hazards, staballoy munitions emit very low level radiation. The US Army has conducted radiation tests on the staballoy munitions as assembled cartridges, packed in wooden shipping boxes (2 cartridges per box), stacked in complete pallets (30 cartridges), and in a tank loaded with the cartridge.(2) In those cases, results reflected radiation readings well below those which require special handling or storage, such as personnel radiation badges, protective garments, etc. for routine exposures to the munitions.

The chemical toxicity hazard is pertinent only when particles of staballoy are small enough (less than 10 μcm AED*) to be inhaled into the body. The 3.4kg (7.5 lb) staballoy penetrator in the assembled XM774 tank round presents no chemical toxicity threat. However, when the round impacts a hard target or when it is subjected to an intense fire, particles small enough for ingestion are produced. This risk with respect to firing is minimized by restricting firing in peacetime to various testing activities only in specialized facilities.

h. What are the health hazards involved in manufacturing staballoy?

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*Aerodynamic Equivalent Diameter

Care must be taken during manufacturing that workers are not exposed to unacceptable levels of radiation, do not inhale heavy metal particles, and that there is not a buildup of small particles (submicron size) in the air during machining operations (they are susceptible to igniting spontaneously). Precautions include ventilation of machining areas, protective gloves and clothing and personnel dosimetry (film badge or TLD).

i. Does the storage of staballoy ammuntion require special precautions?

The storage of the staballoy ammunition will be identical to that of existing ammunition with the exception that portable radiation monitoring equipment should be available for routine and emergency procedures to be used with staballoy. Tests to determine if fire hazard considerations necessitate any unique storage requirements have been completed and data indicate that unique requirements should not be necessary.

j. What would happen in the event of a truck accident?

As with any ammunition, a truck or train accident could result in an explosion and/or fire. A Hazards-Burn test,[3,4] conducted with the 105mm XM774 staballoy ammunition resulted in an explosive safety radius of 800 feet. The staballoy penetrators did not burn and an airborne aerosol was not formed. Thus, there was no hazard due to the ammunition containing staballoy.

k. Would the accident site require extensive radioactive decontamination?

Probably not. Normal cleanup procedures could be utilized paying attention to the proper handling and recovering of the DU component. In a hazard classification burn test[3,4] a standard pallet of staballoy ammunition was set on fire with JP4 jet fuel. In addition, a series of tests exposing the penetrators to very high temperatures has been conducted[5,6] and a tank containing a normal combat load of 105mm ammunition (60 percent staballoy cartridges) has been burned.[7] The two latter tests results in some oxidation of the penetrators and in the tank test, a small number of the penetrators were broken. So little radioactive material was released downwind that radiation levels were well below Nuclear Regulatory Commission (NRC) standards. Therefore, the only requirement at the accident site should be to pick up the penetrators and

penetrator pieces. Normal post accident procedures should include radiation monitoring to assure that no penetrator pieces are overlooked and that some unexpected event has not produced more radioactive contamination than expected.

k. Will the staballoy ammunition require special packaging?

No. Conventional packaging can be used. Also, because of the very low radiation levels, no Department of Transportation (DOT) labelling is required. A "Use and Storage" Label, MIL-STD-1458,[8] is required. Bills of lading should be annotated "Radioactive Material."

m. Does the area used for testing staballoy ammunition become radioactively contaminated.

Yes, the target area will be contaminated with oxidized DU. However, test firing in a controlled area minimizes contamination outside that area. Strict controls are placed in the test area to prohibit the spread of contamination. Continuous monitoring is conducted to ensure that unacceptable levels of contamination and radiation are not approached.

n. What precautions are taken to safeguard the workers at the firing tests sites?

The test site is a controlled area with access limited to only necessary personnel. Workers wear protective clothing and are not allowed to enter the target area after a round is fired until an appropriate waiting period to allow settling of the particulate DU has elapsed. The operating procedures established for testing have resulted from studies and experiments[9,10,11] and have been reviewed by a host of experts to confirm their adequacy.

o. What are the radiological hazards a tank crew may experience?

An experiment was conducted to determine the maximum radiological exposure a tank crew could experience.[2] For instance, a tank crew would have to remain in a tank, combat loaded with staballoy munitions for periods exceeding 2,000 hours per year (40 hr/wk, 50 wk/yr) before exceeding the exposure limit for the general public. The probability of this situation occurring is extremely low. Thus, this risk is insignificant.

p. In the event of a tank accident resulting in a fire, would there be a radiological hazard?

No. Results of a test, in which a tank containing a combat load of staballoy and explosive rounds was burned,(7) indicates that downwind areas and the tank were not contaminated. Although some DU oxide was formed, the majority of it remained with the debris in the bottom of the tank. Normal demilitarization should be conducted.

q. What protective measures would be effective in removing respirable DU particles from air prior to human intake?

Use of NIOSH approved respirators for heavy metal use are considered to be satisfactory by the Nuclear Regulatory Commission for removing respirable DU. Testing to date indicates that the only condition that requires protective equipment would be in and about the impact area when staballoy rounds are being fired into hard targets.(9)

r. How should exposure to a DU fire be limited or controlled?

Current firefighting techniques for ammunition fires should be employed. If it is necessary to enter a smoke cloud suspected of containing high levels of DU, proper respirators should be worn.

s. Would special fire fighting apparatus be needed to combat fires involving staballoy munitions?

No, standard apparatus should be used. In the unlikely event that yellow smoke is present, indicting burning staballoy, extinguishing agents for metal fires should be employed.

t. What levels of respirable DU are considered hazardous?

Regulations have established levels for controlling exposures in an industrial and uncontrolled environment and are time weighted levels. These are 0.2 mg/m^3 (2×10^{-4} µg/ml) for toxicity(12) and 1×10^{-10} µCi/ml (2.78×10^{-10} µg/ml) for occupational exposure(13) or 5×10^{-12} µCi/ml (1.39×10^{-11} µg/ml) for uncontrolled areas.

III. CHARACTERISTICS OF FIRES AND ACCIDENTS SCENARIOS

A. Fire Characteristics

A number of questions concerning the temperatures and time history a staballoy penetrator will experience in an accident have been raised. Some of these are:

1. What are the temperatures staballoy cores would be exposed to in a transportation or storage fire and what would be the duration of the exposure?

2. What are realistic scenarios for transportation and storage accidents involving staballoy?

3. What would occur in accidents involving explosive loaded munitions during transportation or in storage?

To answer the above questions several organizations were contacted and asked about their research on fires involving palletized material. These organizations are performing studies of fire behavior using open cribs* of stacked wood in both open burning situations and burning within ventilated enclosures.

The organizations contacted include:

a. Center for Fire Research, US Fire Administration, Washington, DC

b. John Hopkins Applied Physics Lab, Scaggsville, MD

c. Factory Mutual Research Corp, Norwood, MA

d. US Naval Surface Weapons Station, Dahlgren, VA

These organizations were presented with igloo storage scenarios consisting of a standard 80 feet igloo(14) and a possible XM774 storage configuration and requested to postulate fire behavior.

Information and opinions provided by the organization are given below:

(1) Center for Fire Research. The temperature, duration of the fire, and time maximum temperature is sustained depends on the configuration of wood, surface-to-volume ratio, configuration of stack or crib, type of wood, and ventilation available. Under conditions that cause maximum temperatures, the temperature of the fire could

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*Cribs with cross-stacked lumber leaving air spaces between cross members.

reach 1300°C with surrounding gases at 750°C to 800°C. The fire could burn for several days but maximum temperatures would not be sustained at any single point for any length of time. At a fuel consumption rate of 15 to 20 pounds per hour, heat release would be approximately 200,000 BTU's per hour.(15,16,17)

(2) John Hopkins Applied Research Laboratory. In a standard crib fire, maximum temperatures obtained through the center of the fire would be approximately 900°C with a possible maximum temperature at the top of the fire of 1200°C. Burn-through* would occur in 15 to 20 minutes. Using the conditions for storage in an igloo, excluding input from the propellant, with heat being reflected back into the fire area, temperatures of 900 to 1000°C would readily be obtained.(18)

(3) Factory Mutual Research Corporation. Fire studies have been conducted with stacks of 0.057 m^3 (2 ft^3) particle board boxes of 1.59 cm (5/8 in) and 1.90 cm (3/4 in) thick material, burn-through occurred in 23 minutes at 816°C; a maximum temperature of 1077°C was reached 39.5 minutes after ignition. The rate of fuel consumption was 9.8 kg per minute (21.6 pounds per minute). Under the conditions described for igloo storage they would consider the fire in the initial stages to be a wood fire in an insulated enclosure followed by a wood-and-propellant fire in a partially ventilated enclosure with additional air becoming available when the propellant ignites. Under those conditions very high temperatures would be reached and exist for short periods of time in parts of the structure, i.e. 900-1000°C for approximately one to two hours maximum. In addition, the contribution of thermal energy by the propellant would have to be considered.(19,20)

(4) US Naval Surface Weapons Station. The USNSWS is currently conducting tests of packaged MK151, 2.75 inch and MK 63,5 inch rocket warheads stored in open space magazines. Tests are being conducted using sand filled warheads with thermocouples attached internally and externally to the warhead. They have found that the fire burns up through the center of the stack within 10 to 15 minutes and that maximum temperatures obtained at the outside surface of the warheads were 815 to 870°C.(21)

B. Accident Scenarios.

Various scenarios have been developed that define the most likely conditions for accidents involving staballoy ammunition during transportation, storage and use.

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*When flames exits the top of the stack with the complete stack afire.

1. Transportaton.

a. A vehicle (truck, box car, etc.) containing staballoy ammunition is involved in an accident that results in the cargo being ignited. Without ignition no radiation hazard exists. Once ignited, wooden shipping boxes feed the fire. Fire is not fought by fire vehicles but burns until all explosives are consumed.

b. A vehicle containing staballoy ammunition and high explosive (HE) ammunition is involved in an accident that results in the HE being detonated high order. Detonation of the HE results in scattering of the staballoy ammunition throughout the accident site. Some of the penetrators are separated from the cartridge and sabot and broken into various size pieces. Various small fires erupt within the accident site and burn until combustibles are consumed.

c. A vehicle containing staballoy ammunition and HE ammunition is involved in an accident that results in a low-order detonation of the HE. Staballoy ammunition are scattered around the accident site, however, a greater percentage stay within the immediate fire area than did in the case above. Fire burns until combustibles are consumed.

2. Storage.

a. Outside storage cases would become ignited, the rounds detonates high-order, or low-order. The results would be identical to the results of the transportation scenario.

b. An igloo containing staballoy ammunition becomes ignited. Wooden shipping boxes feed the fire. The igloo burns for a period of several days.

c. An igloo containing staballoy ammunition mixed with Class A explosives detonates high-order resulting in destruction of the magazine and a widespread distribution of debris.

3. Use.

A tank, combat loaded with the normal mix of 105mm ammunition (60% staballoy), is involved in an accident which results in ignition of flammables within the tank. Once ignited, the tank burns with intermittent cook-off of HE and propellant and possible high-order HE detonation.

C. Discussion.

All of the research organizations contacted indicated that temperature data should not be used alone in determining the effects of a fire on an object within the fire. Emissivity coefficient of the fire, thermal properties of the material (staballoy), heat flux into the object, and time the temperature exists around the item are critical to the effects of the fire. With respect to the latter point, zones where high temperatures exist would be constantly changing as the fire progressed through the burning material. Burning rates and temperatures of fires in an enclosure are limited by available ventilation and the size of the enclosure, but burning rates may approach open burning rates.

All of the presented scenarios result in the staballoy penetrator being involved in a wood or propellant-fueled fire for a duration of time. Based on the fire data, the result may be a long duration wood fire with occasional cook-offs of HE and/or propellant. Temperatures may be in the 400°C to 1000°C range with peaks of 1200°C occurring in very localized areas within the free fire zone and lasting for a very short periods of time (several minutes). Localized extremes would be present during propellant cook-off. Some of the scenarios also expose the staballoy to high and/or low-order detonations which are discussed in Sections IV.

The Nuclear Regulatory Commission recognizes the possibility that licensed material may become exposed to fires during transportation or storage. A hypothetical accident condition is defined to establish the thermal exposure the material is most likely to see.(22) The condition is defined as "Exposure to a thermal test in which the heat input to the package is not less than that which would result from exposure of the whole package to a radiation environment of 1,475°F (802°C) for 30 minutes with an emissivity coefficient of 0.9, assuming the surfaces of the package have an absorption coefficient of 0.8. The package shall not be cooled artificially until three hours after the test period unless it can be shown that the temperature on the inside of the package has begun to fall in less than three hours."

The Army scenarios developed above are considerably more severe than that acceptable to the NRC.

IV. TRANSPORTATION AND STORAGE FIRES

A. Background

To evaluate the potential hazard that could be generated by the XM774 penetrator as a result of a transportation or storage fire, the following studies were conducted:

1. Hazard Classification Tests[3,4] - A hazard classification test was performed with six boxes (twelve cartridges) of XM774 ammunition on 17 and 18 Oct 77 and on 17 Nov 77. All the penetrators from this test were recovered intact and without any indication of oxidation. Conclusions reached from the test were:

(a) There was no airborne radiological or toxicological hazard caused by burning twelve rounds of XM774 ammunition in this test.

(b) Fragmentation distance of 400 feet is adequate.

(c) Recommend Hazard Classification (04) 1.2C.

In this test 92 percent of the penetrators were thrown out of the fire by the "cooked off" explosives of the rounds. It was believed that the test was not indicative of events that could occur in a fire in which the penetrators were not thrown out of the fire or were exposed to high temperatures for extended times. Thus, the following studies were conducted.

2. Los Alamos Tests

(a) Field Ignition Studies[5] - These tests included the attempted ignition of XM774 penetrators by packing them in uranium metal machine turnings and igniting the turnings. A hood was placed over the fire to provide accurate control of air velocity through the fire and to permit collection of the particulate effluent. Particle size of the effluent was determined using Andersen Impactors and the concentration of airborne uranium using high-efficiency filters. These tests were conducted at a gas-flow velocity of 223cm/s (5 mph). Under extremely severe test conditions, where temperatures in excess of 1200°C were maintained for 15 minutes, the penetrators oxidized but did not ignite. An average of 0.7 percent of the penetrators were oxidized in the worst case and 0.28 percent of the oxide was readily removed, i.e., aerosolized. To be conservative, it was concluded that 0.3 percent of the DU would be aerosolized and in the respirable size range. Additional tests, in which the penetrators were immersed in propellant which was ignited and in which the penetrators were immersed in burning uranium machine-turnings with air flowing around the burning turnings, failed to oxidize the penetrators.

(b) High Temperature Laboratory Studies[6]-XM774 penetrators were placed in a tube furnace and air was drawn over them at five miles per hour (mph) as the penetrator reached the desired temperature. Studies were conducted from 500 to 1000°C. A high volume (hi-vol) sampler was placed downwind to collect all the aerosolized depleted uranium. Fifteen experiments were conducted. Seven experiments were conducted in air for two hours at an air flow of five mph and one experiment was conducted in air for two hours with no air flow. Four experiments were conducted in 50 percent CO_2-air for four hours in a gas flow of five mph, two experiments were conducted for one hour. Maximum oxidation occurred at 700°C in air and 800°C in 50 percent CO_2-air. The pertinent conclusions were:

(1) The maximum amount of DU aerosolized in a five mph gas velocity for four hours was 0.01 percent of a penetrator.

(2) The maximum amount of DU that was respirable under conditions in (1) was 0.0008 percent of a penetrator, or approximately ten percent of the aerosolized material.

(3) The maximum amount of DU that was oxidized in four hours was at 800°C and was 30 percent of a penetrator. Subsequent sieve analyses of the collected oxides from the experiments, to determine the maximum amount of oxide that was less than 10 μm and therefore could possibly become airborne as a result of an explosion, led to the conclusion that a maximum of 0.07 percent of a penetrator was in the less-than-10 μm particle-size-range.

3. Tank Burn Test [7] - The primary objective of the Tank Burn Test was to evaluate the potential hazard from depleted uranium (DU) released downwind as a result of a US Army tank fire containing a combat load of XM774 rounds. A modified M103 tank with two fuel cells containing a total of 300 gallons of diesel fuel and a combat ammunition mix consisting of 63 rounds (37 XM774 rounds, 20 M456 HEAT rounds and 6 M393A2 HEP rounds) was used for the test. Air samplers and fallout trays were positioned in a 45 degree sector downwind from the tank from 100 meters to 1000 meters. In addition, the US Environmental Protection Agency (EPA) positioned eight samplers along the eastern border of the Nevada test Site (NTS), downwind from the tank.

Ignition of the fire was by incendiary devices placed along side the fuel cells and by a simultaneous high-order non-electrical detonation of a HEP round in the crew compartment. The duration of the fire was in excess of three hours. All of the 63 rounds detonated or were "cooked-off" and the tank was completely "gutted". The peak temperature recorded was 2300°F (1250°C) which was the upper limit of the measuring system. Thirty-one, 84 percent, of the staballoy penetrators survived without breaking up. Broken pieces of penetrators,

equivalent to 4.5 penetrators, also were recovered. Therefore, 35.5, or 96 percent, were recovered by visual inspection. The remaining 1.5 penetrators, four percent, were not recovered but were assumed to be broken into pieces too small to be distinguishable and remained mixed with other debris in the bottom of the tank. It was estimated that less than 0.01 percent of the DU became an aerosol. The following are some of the key conclusions:

(a) The test was of sufficient severity to be considered a maximum potential hazard since all rounds detonated or were cooked-off and all flammable material on and in the tank was destroyed by fire.

(b) All air concentrations for an eight hour exposure were well below the established limits of 0.2 mg/m^3 for toxicity and 1×10^{-10} μCi/ml for occupational exposure, or 5×10^{-12} μCi/ml for uncontrolled areas.

(c) A tank battle in which the tanks, carrying DU, catch fire will not generate a radiological hazard to a civilian population downwind from the battle.

4. Discussion - Although the amount of aerosolization varied for the different tests, the Tank Burn Test is believed to be representative of the most realistic condition that could occur to XM774 penetrators in a confined area. Thus, it is assumed that the results observed during this test can be used to approximate conditions to be encountered in a transportation or storage fire involving the XM774 rounds shipped with DOT Class A and B explosives, or stored with DOD Class 1.1 and 1.2 explosives. Based on the above conclusions, typical questions regarding potential hazards during transportation and storage of staballoy ammunition can be adequately answered.

B. Transportation

The type of questions concerning potential hazards during the transportation of staballoy ammunition are:

1. With staballoy ammunition assigned to DOT Class Explosives B[23] what would occur in an accident if the ammunition is shipped with Explosives A material?

2. What would happen during an accident in storage in Less-than-Carload-Lot (LCL) buildings* where both Explosives A and Explosives B material are stored?

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*LCL buildings are temporary storage facilities for receiving ammunition transported onto a site.

3. Should tests be conducted which expose staballoy ammunition to the detonation of Explosives A material?

If XM774 rounds are shipped with non-mass detonating Explosive A material, DOD Class 1.2 [24] and an accident occurs which results in a fire, the results would be similar to those observed during the tank burn test. Therefore, the total DU which would aerosolize is estimated to be 0.01 percent. The above value is conservative when considering that in a transportation fire, the confinement of the rounds is much less severe than in a tank fire. As such, more of the projectiles would be thrown away from the fire area and would not be exposed to severe blasts and high temperatures.

If the XM774 is shipped with mass detonating explosives A material, a detonation would scatter many of the XM774 rounds into an area around the accident site with some of the penetrators being separated from the sabots and cartridge cases. Debris in the area would consist of complete cartridges, projectiles, broken shipping containers, exposed penetrators and a limited quantity of small staballoy fragments. The aerosols produced would probably be less than in the situation involving Class A non-mass detonating or Class B material since nearly all of the rounds would be thrown clear of the accident site. Actual distribution and type of the debris would depend on the ratio of explosives to staballoy rounds and the physical location of the items within the vehicle.

If the XM774 is shipped alone or with Class B material and an accident occurs which results in a fire, the penetrators may be exposed to conditions that could result in a maximum of 0.01 percent of the DU being respirable. The above value is ultra-conservative when considering that only ten percent of the projectiles remained in the immediate fire zone during the hazard classification tests[3,4]; the above values would both be decreased by a factor of ten under these circumstances.

Storage in LCL buildings would present hazards similar to those discussed above except that the quantities of material involved may be larger. However, the percent of aerosolization is not expected to change.

In all of the above situations, the fact that some penetrators will have surface oxidation which will be partially removed and aerosolized by turbulence due to propellant cook-off, has been considered. It is evident from the Tank Burn Test[7] that this mode of aerosolization does not significantly contribute to an airborne hazard.

Considering the fire data presented in Section III and the above discussion, no further testing is necessary at this time as the burn

tests have established the potential results of a transportation accident involving staballoy penetrators.

C. Storage

Questions concerning the storage of staballoy ammunition with other ammunition items are:

1. What is the downwind hazard from a magazine fire containing staballoy cartridges and other items assigned to DOD Storage Compatibility Group (SCG) C?

2. Will radioactive contamination present a greater hazard than the fragmentation and/or blast hazard normally associated with items assigned to DOD Storage Class (08) 1.2?

3. Will storage of the XM774 with Class 1.1 bulk propellants present a significantly greater hazard?

If staballoy ammunition is stored with Class 1.2 material and a magazine fire ignited the staballoy material, the result would be the eventual rupture of the magazine with a number of the rounds broken up as described in the transportation section regarding detonation of explosive A material. A similar break-up occurred in the tank burn test. Estimated total DU which would become an aerosol would be on the order 0.01 percent.

If staballoy ammunition is stored with Class 1.1 propellant and the propellant ignited, results would be similar to that described in the transportation section regarding explosive B material. Destruction of the magazine and scattering of the contents around the accident site would occur. Damage to the penetrators would probably be less severe than from high explosive detonations since the detonations of bulk propellant produces less blast (impulse and overpressure) than high explosives. Therefore, less than 0.01 percent of the DU should become an aerosol.

When assigned to SCG C, the staballoy round will be stored with SCG D, E, and G only when warranted by operational considerations or by magazine non-availability[24]. Generally, rounds would not be mixed on a regular basis, but if mixing did occur, the hazard would be the same as that presented in Section B for transportation with mass detonating and non-mass detonating explosive A material.

To define the downwind safe distance from a storage facility fire containing XM774 rounds, an analysis was performed using the Gaussian Diffusion Model described in the Regulatory Guide 1.111[25]. The results obtained are based on the following assumptions:

1. The storage facility contains 10,000 XM774 rounds (34,000 kg of DU).

2. 0.01 percent of the DU is released to the atmosphere as an aerosol.(7)

3. 100 percent of the released DU is respirable.

4. 100 percent of the released DU is soluble.

5. The Constant Centerline Plume Model is used to analyzed downwind concentrations of DU.

6. Wind Stability Class D.

7. A wind velocity of 4 meters per second.

8. A fire duration of 48 hours.

9. A DU effective release height of 7 meters.

10. A deposition velocity of 0.01 meters per second.

11. The safe exposure level is based on the chemical toxicity limit for chronic exposure of the general populace to DU of 0.07 mg/m^3(13).

The above assumptions result in a conservative estimate of the downwind hazard distance because of the following:

1. Burn tests described in section IV of this report indicate much less than 100 percent of aerosolized Depleted Uranium is respirable.

2. Generally, less than 100 percent of the DU is soluble.

3. The Constant Centerline Plume Model is designed to provide conservative results.

4. The chemical toxicity value is the most limiting criterion of the exposure measures.

5. The safe exposure level is based on the chemical toxicity limit for chronic exposure of the general populace to DU. It would be more realistic to use the toxicity limits for acute exposure since the situation being evaluated involves an accidental fire with a very low probability of occurrence. The toxicity limits for acute exposure would be much greater than that for chronic exposure and the wind safe distance would be closer to the storage facility.

It should also be noted that the assumptions for wind velocity, wind stability class, fire duration and DU release height are approximations of conditions to be encountered in the field. The 48 hour fire duration is considered realistic based on the fire characteristics data presented in Section III and the fact that storage fires involving ammunition are allowed to burn rather than be fought by fire fighting personnel.

Based on the Gaussin Diffusion Model with the above assumptions the downwind safe distance from a storage facility fire containing a maximum of 10,000 rounds of XM774 ammunition (3400 kg of DU), is 780 feet.

V. CONCLUSIONS

The safety and health considerations for handling staballoy munitions have been adequately defined. Tests have established that the risk presented by the staballoy ammunition is no greater than that presented by currently fielded ammunition except during armor testing where definitive precautions must be taken.

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AUG 2 8 1996

Department of the Army
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Dear Col. King:

Enclosed is your NRC Material License Number SUB-1578 in accordance with your request.

Please review the enclosed document carefully and be sure that you understand all conditions. If there are any errors or questions, please notify the U.S. Nuclear Regulatory Commission, Region III office at (630) 829-9887 so that we can provide appropriate corrections and answers.

Please be advised that your license expires at the end of the day, in the month, and year stated in the license. Unless your license has been terminated, you must conduct your program involving byproduct materials in accordance with the conditions of your NRC license, representations made in your license application, and NRC regulations. In particular, note that you must:

1. Operate in accordance with NRC regulations 10 CFR Part 19, "Notices, Instructions and Reports to Workers; Inspections," 10 CFR Part 20, "Standards for Protection Against Radiation," and other applicable regulations.

2. Not possess and use materials authorized in Items 6, 7, and 8, on the license until:

   a. You have constructed the facilities and obtained the equipment described in the license application and supporting documentation; and

   b. You have notified the U. S. Nuclear Regulatory Commission, Region III, ATTN: Chief, Nuclear Materials Licensing Branch, in writing, that activities authorized by the license will be initiated.

3. Notify NRC, in writing, within 30 days:

   a. When the Radiation Safety Officer permanently discontinues performance of duties under the license or has a name change; or

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b. When the licensee's mailing address changes (no fee is required if the location of byproduct material remains the same).

4. In accordance with 10 CFR 30.36(b) and/or license condition, notify NRC, promptly, in writing, and request termination of the license:

   a. When you decide to terminate all activities involving materials authorized under the license; or

   b. If you decide not to complete the facility, acquire equipment, or possess and use authorized material.

5. Request and obtain a license amendment before you:

   a. Change Radiation Safety Officers;

   b. Order byproduct material in excess of the amount, or radionuclide, or form different than authorized on the license;

   c. Add or change the areas of use or address or addresses of use identified in the license application or on the license; or

   d. Change ownership of your organization.

6. Submit a complete renewal application with proper fee or termination request at least 30 days before the expiration date of your license. You will receive a reminder notice approximately 90 days before the expiration date. Possession of byproduct material after your license expires is a violation of NRC regulations. A license will not normally be renewed, except on a case-by-case basis, in instances where licensed material has never been possessed or used.

In addition, please note that NRC Form 313 requires the applicant, by his/her signature, to verify that the applicant understands that all statements contained in the application are true and correct to the best of the applicant's knowledge. The signatory for the application should be the licensee or certifying official rather than a consultant.

You will be periodically inspected by NRC. Failure to conduct your program in accordance with NRC regulations, license conditions, and representations made in your license application and supplemental correspondence with NRC will result in enforcement action against you. This could include issuance of a notice of violation, or imposition of a civil penalty, or an order suspending, modifying or revoking your license as specified in the General Policy and Procedures for NRC Enforcement Actions. Since serious consequences

to employees and the public can result from failure to comply with NRC requirements, prompt and vigorous enforcement action will be taken when dealing with licensees who do not achieve the necessary meticulous attention to detail and the high standard of compliance which NRC expects of its licensees.

Sincerely,

Original Signed By
Loren J. Hueter
Nuclear Materials Licensing Branch

License No.: SUB-1578
Docket No.: 040-09045

Enclosures:
1. License No. SUB-1578
2. 10 CFR Part 19
3. 10 CFR Part 20
4. 10 CFR Part 40
5. Form NRC-3
6. NRC Form 313

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OFFICE	DNMS/RIII N				
NAME	LJHUETER:jaw LJH				
DATE	08/27/96				

OFFICIAL RECORD COPY

CONVERSATION RECORD

TIME:

DATE: 8-12-96

O VISIT   O CONFERENCE   ☒ TELEPHONE

O INCOMING
☒ OUTGOING

NAME OF PERSON(S) CONTACTED OR IN CONTACT: Walter Shearin contact

ORGANIZATION (OFFICE, DEPT. ETC.): Dept. of Army Crane Army ammunition activity

TELEPHONE NO.: 812-854-1246

SUBJECT

CN 301358

SUMMARY

1. Walter concurred that name on license be headed by Dept. of the army
2. He confirmed that proposed activities will only be at Crane facility, 300 Highway 361 Crane, IN and that this material will be kept totally segregated from material under other military licenses at the 53,000 acre facility.
3. Walter also explained that under "Maintenance" on page 2-1, the statement "The exposure of depleted uranium is not incidental to these operations"; means there is no significant exposure to radiation in performing maintenance activities. He also explained that corrosion removal involved aluminum and not DU which is totally encased. He also stated that "demilitarization" involves separation of the aluminum encapsulated projectile (in which the DU is encased) from the rest of the munition and again should involve no potential for contamination other than very low levels that may be present from the time the munition was manufactured. Further demilitarization is done remotely by machine. Past experience under other licenses has shown no problem with contamination from these activities but applicant has committed to monthly wipe surveys when "demil" activity is going on.

(over)

NAME OF PERSON DOCUMENTING CONVERSATION:

SIGNATURE: Loren J. Hueter

DATE: 8-12-96

ACTION TAKEN

SIGNATURE

TITLE

DATE

DEPARTMENT OF THE ARMY
CRANE ARMY AMMUNITION ACTIVITY
300 HIGHWAY 361
CRANE INDIANA 47522-5099

August 15, 1996

REPLY TO
ATTENTION OF

Safety Office

Materials Licensing Section
U.S. Nuclear Regulatory Commission, Region III
ATTN: Loren Hueter
801 Warrenville Road
Lisle, Illinois 60532-4351

Dear Sir,

Enclosed are comments to questions addressed during a telephone conversation between Mr. Loren Hueter, NRC Region III and Mr. Walt Shearin, Crane Army Ammunition Activity, on 12 August 1994. Responses to questions are provided for License control number 301358.

If additional information is required, please contact the undersigned at (812) 854-1246.

Sincerely,

Walter F. Shearin

Walter F. Shearin
Chief, Safety Office

Enclosure

RECEIVED
AUG 19 1996
REGION III

AUG 19 1996

Response to Questions Concerning
Depleted Uranium Storage and Demilitarization
License - Control # 301358

Question #1. Clarify that all disassembly work is done remotely.

Answer #1. All hazardous operations such as disassembly of the projectile body from the cartridge case and dumping of the propellant is done remotely. Remote operations are done for the purpose of explosive safety. From a radiation safety aspect, in no instance will depleted uranium (DU) be subjected to grinding, sanding, milling, or any other physical or chemical alteration.

Question #2. Clarify that any contamination is residual contamination and not contamination from the DU penetrator.

Answer #2. As stated above, no physical or chemical alteration of the DU will be allowed under any circumstance. When the DU is enclosed in the aluminum shield it is a shielded source without any possibility of removable contamination. The depleted uranium core is not normally removed from the projectile assembly (encased in aluminum). Special instructions are included in the license submittal for removal of the depleted uranium core. The removal of the depleted uranium core does not require any physical or chemical alteration of the DU.

Question #3. Clarify that your operations will not include removal of aluminum shield from DU penetrator.

Answer #3. The DU penetrator is not normally removed from it's aluminum shield. Under a special test scenario (already covered in license renewal) this may occur. Savanna Army Depot has done this under their NRC License (see attached memorandum) with minimal contamination found, even when taking swipes of the DU penetrator. We want to continue this type testing, if required, as part of this license.

Question #4. Clarify Contamination Issue.

Answer #4. Enclosed is the history of storage and demilitarization of 30 mm DU munitions at Savanna Army Depot Activity. To summarize, all of their surveys of DU storage magazines have been negative. They demilitarized well over a million 30mm DU rounds without removing the DU penetrator. Over 2000 swipes were taken during the process and all came back negative for DU. A total of eight DU projectiles were broken down with the DU penetrators removed from the aluminum projectile body.

EUCL

Swipes were taken of all eight penetrators and windshields. All swipes measured less than 2 nanocuries. Test results are included with attached memorandum. Crane Army Ammunition Activity (CAAA) will be using the equipment and procedures developed at Savannah Army Depot for our operations. In addition, if CAAA performs the operation of removing the DU penetrator from it's aluminum projectile body, ventilation protection will be provided for operator safety.

Question #5. Clarify Corrosion Issue.

Answer #5. Removal of corrosion is from the cartridge case and projectile not the DU. In no instance will DU be subjected to grinding, sanding, milling, or any other physical or chemical alteration.

Question #6. Confirm the license will only cover material at this address, 300 HWY 361, Crane IN.

Answer #6. This license is for use by CAAA. Only material controlled by CAAA, i.e. within their storage and production facilities will be covered by this license. The address for CAAA is 300 HWY 361, Crane, Indiana. This address is not just one building, but; includes numerous buildings and magazines controlled by CAAA. The CAAA will only use one production facility for the DU breakdown. This facility will be dedicated to this operation. The facility will be a standard production facility designed for explosive operations. It will have standard reinforced concrete wall construction. We currently have DU munitions stored in ten explosive storage magazines.

Question #7. Confirm that no source material covered by another license will be stored with DU munitions covered by this license.

Answer #7. DU munitions are stored separately from any other source material covered by any other license.

Question #8. Correct on page 2-3 (10). Should be 10 CFR 20.1906 not 20.205.

Answer#8. Concur. Shipments of DU munitions do not contain quantities of radioactive material that exceed Type A quantity. Type A quantity for DU is unlimited.

Question #9. Clarify that the CAAAR 385-7 is the CAAA regulation that covers all ionizing radiation and not just the DU portion covered by this license.

Answer #9. The CAAAR 385-7 is CAAA's Ionizing Radiation Safety Regulation. That is why their is information covering radiography operations.

Question #10. State on page 5-2 what the ranges are for the AN/PDR 77 Radiac Set.

Answer #10. The AN/PDR-77 Radiac set consist of a Radiacmeter to which can be connected either of three probes (Alpha, Beta/Gamma, or X-ray) for measuring a particular type of radiation. The three probes are a part of the overall Radiac set. The ranges for the Alpha probe are 0-999K Counts Per Minute, 0-180 Micro Curies per square meter, and 0-199K Disintegration's Per Minute, per 100 square centimeters. The range for the Beta/Gamma probe is 0-999K Millirads per hour. The X-ray probe has a range of 0-999K Counts per minute. It is also equipped with adjustable audio and visual alarms with a range of 0-999K Counts per minute.

Question #11. Change on page 6-6 (f), 7 consecutive days to 1 year per 10 CFR 20.1301 (a)(1).

Answer #11. Concur. No radioactive material shall create, in any unrestricted area for individual members of the public, radiation levels which, if an individual were continually present in the area, could result in an exposure in excess of 2 mrem in 1 hour or 100 mrem in a year.

Question #12. State planned use of thermoluminescent dosimeters (TLD) to monitor exposures.

Answer #12. Operators involved with renovation, exterior maintenance or demilitarization of DU munitions will wear a TLD until enough data can be generated to determine if TLD's are required or not. The TLD's will be used until it is proven that they are not required by 10 CFR 20.1502 (a) or 10 CFR 20.1201 (a). TLD's are exchanged quarterly and sent to the U.S. Army TMDE Activity, U.S. Army Ionizing Radiation Dosimetry Center, ATTN: AMSMI-TMDE-SR-D, Building 5417, Redstone Arsenal, AL 35898-5400 for processing. Warehouse workers moving DU ammunition around in storage i.e., shipping and receiving are not required to wear a TLD.

Question #13. Confirm that survey records are maintained for a minimum of 3 years.

Answer #13. All survey records are maintained for a minimum of 3 years.

Question #14. Discussed that Savanna Army Depot already had a NRC License in which this license was modeled after. Can you obtain data from this activity regarding detectable levels of radiation during breakdown and after a magazine had been downloaded of DU munitions?

Answer #14. See attached memorandum.

Question #15. On page 6-15 paragraph (6), Should this be millirems instead of micro roentgens?

Answer #15. Concur. The last sentence of paragraph (6) on page 6-15 should read: The readings will be recorded in millirems per hour along with distance at which the measurement was taken.

Question # 16. On page 6-15 paragraph (8), should the first sentence have the word contamination changed to radiation levels?

Answer #16. Concur. The first sentence of paragraph (6) on page 6-15 should read: Outgoing shipments will be wipe tested (one smear per pallet) and checked for radiation levels with a radiac meter.

Question #17. Fax a copy of page 7-1, yours is different than mine.

Answer #17. Concur a copy is attached.

Question #18. Clarify amount of dispersible material in regard to 10 CFR 40.36.

Answer #18. Since the DU penetrator is not in itself dispersible and will not be subjected to grinding, sanding, milling, or any other physical or chemical alteration, no readily dispersible form of radioactive material is expected. DU is an alloy in a non-dispersible form. There is no possible way we would ever exceed the 10 millicurie requirement that requires a decommissioning funding plan as stated in 10 CFR 40.36. Ten millicuries of DU would equate to approximately 61 pounds.

Question #19. We discussed the Department of Transportation exemption for shipment of DU munitions. You asked me to fax a copy.

Answer #19. A copy is in the license request as enclosure 1.

Question #20. How do you plan to package the DU penetrators once they are removed from the projectile? What is the disposal plan?

Answer #20. The DU penetrators inside aluminum sabot or with the aluminum sabot removed will be placed in 30 or 55 gallon steel drums approved for Department of Transportation shipment. In addition to steel drums metal ammo cans may be used and palletized for storage. Each container will be stenciled "Low Specific Activity". The containers will be stored in our DU storage magazines. The plan is to sell the material to a licensed buyer to be used as shielding material. If no buyers are available the DU components will be stored pending authorization to ship to a licensed recycling agent or to an NRC or Agreement State licensed disposal site. If shipped for disposal it would be labeled as radioactive waste.

Question #21. What are the personal protective equipment requirements and survey requirements for personnel handling DU munitions?

Answer #21. Typically Explosive Operators will wear flame retardant coveralls, safety eyewear w/sideshields, conductive shoes and gloves. This equipment is primarily for the explosive safety hazards. Workers demilling DU munitions will wear leather palmed gloves. Gloves will not be allowed to leave the facility until tested for contamination. Operators will be required to wash their hands prior to leaving the facility after handling DU munitions. They will also wear a TLD until proven unnecessary by survey data. The Radiation Protection Officer will perform routine surveys of the demilitarization facility and components of the DU munitions broken down. Surveys will also be taken of personnel protective equipment such as gloves worn by the operators. Surveys will include meter surveys and wipe tests. Surveys will be done twice daily when the job first starts up, then weekly, followed by monthly if data generated warrants. Survey frequency will not exceed monthly. Since the DU controlled by this license will not be chemically, physically, or metallurgically altered, respiratory protective equipment will not be required. Any residual contamination is expected to be minimal. Ventilation will be provided during special test where the DU penetrator is removed from the aluminum shield (sabot). According to test data at Savanna Army Depot, ventilation is not needed, but; will be provided for added safety.

OPTIONAL FORM 99 (7-

FAX TRANSMITTAL	# of pages ► 9
To WALT SHEARIN	From Wm S Scott
Dept./Agency SMCCN-SF	Phone # DSN 585-8838
Fax # 482 [illegible] - 3407	Fax # 585-6025
NSN 7540-01-317-7368 5099-101	GENERAL SERVICES ADMINISTRATION

DEPARTMENT O
SAVANNA ARMY DE
SAVANNA, ILLINOI

REPLY TO ATTENTION OF:

SIOSV-SAF

14 Aug 96

MEMORANDUM FOR Commander, Crane Army Ammunition Activity, Attn: SMCCN-SF, Crane, IN 47522-5099

SUBJECT: History of Storage and Demilitarization of 30mm Depleted Uranium Munitions at Savanna Army Depot Activity.

1. References:

a. Phonecon, 13 Aug 96, between Mr. Walt Shearin, Crane Army Ammunition Activity (CAAA) RPO, and Mr. William S. Scott, Savanna Army Depot Activity (SVDA) RPO.

b. Nuclear Regulatory Commission License # SUC-1394 for SVDA.

2. Per your request in reference 1.a., the following information on the history of storage and demilitarization activities involving the U.S. Air Force model PGU-14 series cartridge (30mm Depleted Uranium) is provided.

3. SVDA received its NRC license (ref 1.a.) in 1981 and received PGU-14 series cartridges shortly thereafter. The cartridges are stored in their authorized packaging configurations inside of standard ammunition magazines. These storage magazines are periodically surveyed to detect the presence of any uranium contamination. As of this date, all survey results have been negative.

4. SVDA has also demilitarized a large number PGU-14 series cartridges during the period 1991 through 1993. Demilitarization involves the disassembly of the cartridge in order to remove and dispose of its energetic components (i.e. propellant, etc.). This process was performed with the aid of a specially engineered piece of robotics designated as the APE 2214. The use of the APE 2214 allowed the actual disassembly to be performed remotely, thereby reducing the exposure of Depot personnel to explosive hazards in the event of a propellant ignition. The APE 2214 separated the projectile assembly from the cartridge but did not remove the DU penetrator, which remained encapsulated in the aluminum body of the projectile assembly. Well over one million cartridges were demilitarized in this manner. An extensive monitoring program was established to determine if any uranium contamination was being generated by this process. Over two thousand swipes were taken during the course of the operation. Swipes were taken in all areas of the operating building but concentrated on the APE 2214 and the path taken by the DU, both before and after processing. The swipes were first checked on site by the SVDA RPO, then they were sent to the U.S. Army Ionizing Radiation Dosimetry Center for lab analysis. All of the swipes tested negative for depleted uranium. The results of this laboratory analysis are kept on file in the SVDA Safety Office.

5. SVDA also performed a special tear down test in 1990 to evaluate the potential feasibility of removing the DU penetrators from the projectiles and recycling the aluminum projectile bodies. A total of eight projectiles were disassembled during this test. Swipes were taken of all eight penetrators and windshields, as well as the machine parts and the inner surface of some of the aluminum bodies. As expected, the greatest activity was found on swipes of the bare DU penetrator itself. These, however, all measured less than 2 nanoCuries with the other swipes having significantly lower activities. See enclosure 1.

6. POC is the undersigned, DSN 585-8838, *wscott@letterkenn-emh1.army.mil*.

FOR THE COMMANDER:

William S. Scott

Encl

WILLIAM S. SCOTT
Radiological Protection Officer

US Army Ionizing Radiation Dosimetry Center
Leak Test Analysis Results

Nomenclature: GENERAL
Batch: AB-02256.--1

Date of Analysis 13 AUG 90
Checked By ________

SAMPLE ID	(---------- EQUIVALENT	ACTIVITY ----------)		
AIR MONITOR 1	0.0	ALPHA/min	0.000	uCi ALPHA
	7.42	BETA/min	.0000033	uCi BETA
AIR MONITOR 2	0.0	ALPHA/min	0.000	uCi ALPHA
	13.17	BETA/min	.0000059	uCi BETA
MACHINE PART 1	0.0	ALPHA/min	0.000	uCi ALPHA
	26.43	BETA/min	.0000119	uCi BETA
MACHINE PART 2	31.64	ALPHA/min	.0000143	uCi ALPHA
	234.16	BETA/min	.0001055	uCi BETA
30MM PEN #1	134.62	ALPHA/min	.0000606	uCi ALPHA
	789.29	BETA/min	.0003555	uCi BETA
30MM PEN #2	262.80	ALPHA/min	.0001184	uCi ALPHA
	1712.15	BETA/min	.0007712	uCi BETA
30MM PEN #3	401.58	ALPHA/min	.0001809	uCi ALPHA
	2268.16	BETA/min	.0010217	uCi BETA
30MM PEN #4	598.70	ALPHA/min	.0002697	uCi ALPHA
	4145.70	BETA/min	.0018674	uCi BETA *
30MM PEN #5	674.28	ALPHA/min	.0003037	uCi ALPHA *
	3968.91	BETA/min	.0017878	uCi BETA
30MM PEN #6	221.25	ALPHA/min	.0000997	uCi ALPHA
	1502.65	BETA/min	.0006769	uCi BETA
30MM PEN #7	387.44	ALPHA/min	.0001745	uCi ALPHA
	2180.65	BETA/min	.0009823	uCi BETA
30MM PEN #8	419.70	ALPHA/min	.0001891	uCi ALPHA
	2067.94	BETA/min	.0009315	uCi BETA
CUTTER-1	0.0	ALPHA/min	0.000	uCi ALPHA
	16.26	BETA/min	.0000073	uCi BETA
CUTTER-2	2.03	ALPHA/min	.0000009	uCi ALPHA ok
	15.38	BETA/min	.0000069	uCi BETA
INT.PROJ.CSE.1	40.92	ALPHA/min	.0000184	uCi ALPHA
	248.74	BETA/min	.0001120	uCi BETA
INT.PROJ.CSE.2	15.29	ALPHA/min	.0000069	uCi ALPHA OK
	159.90	BETA/min	.0000720	uCi BETA
INT.PROJ.CSE.3	33.41	ALPHA/min	.0000151	uCi ALPHA
	239.90	BETA/min	.0001081	uCi BETA
W SHIELD-1	0.0	ALPHA/min	0.000	uCi ALPHA
	7.86	BETA/min	.0000035	uCi BETA

Detection Limit (LD)

LD FOR ALPHA =	4	ALPHA/min	.000002	uCi ALPHA
LD FOR BETA =	14	BETA/min	.000006	uCi BETA

Encl 1

US Army Ionizing Radiation Dosimetry Center
Leak Test Analysis Results

Nomenclature: GENERAL
Batch: AB-0225G.--1

Date of Analysis 13 AUG 90
Checked By --[signature]--

SAMPLE ID	(--------- EQUIVALENT		ACTIVITY	---------)
W-SHIELD-2	0.0	ALPHA/min	0.000	uCi ALPHA
	0.0	BETA/min	0.000	uCi BETA
W-SHIELD-3	0.0	ALPHA/min	0.000	uCi ALPHA
	9.63	BETA/min	.0000043	uCi BETA
W-SHIELD-4	0.0	ALPHA/min	0.000	uCi ALPHA
	0.0	BETA/min	0.000	uCi BETA
W-SHIELD-5	0.0	ALPHA/min	0.000	uCi ALPHA
	0.0	BETA/min	0.000	uCi BETA
W-SHIELD-6	0.0	ALPHA/min	0.000	uCi ALPHA
	0.0	BETA/min	0.000	uCi BETA
W-SHIELD-7	0.0	ALPHA/min	0.000	uCi ALPHA
	0.0	BETA/min	0.000	uCi BETA
-SHIELD-8	0.0	ALPHA/min	0.000	uCi ALPHA
	0.0	BETA/min	0.000	uCi BETA

etection Limit (LD)

FOR ALPHA =	4	ALPHA/min	.000002	uCi ALPHA
FOR BETA =	14	BETA/min	.000006	uCi BETA

Encl 1

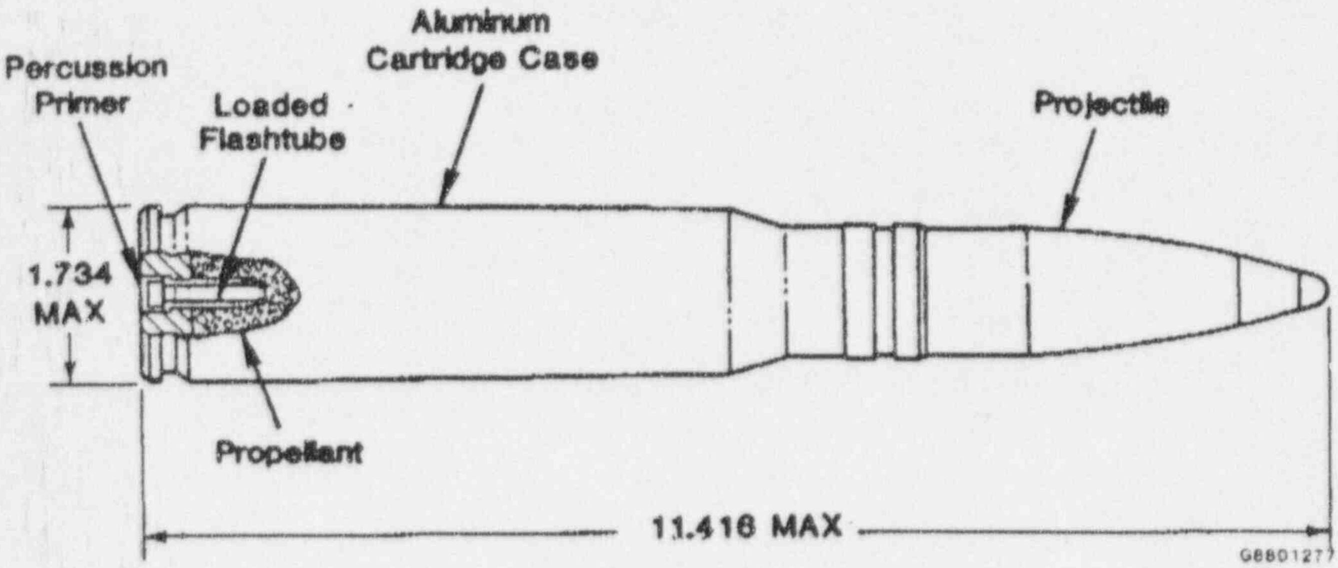

Figure 2-1. Typical 30MM Cartridge

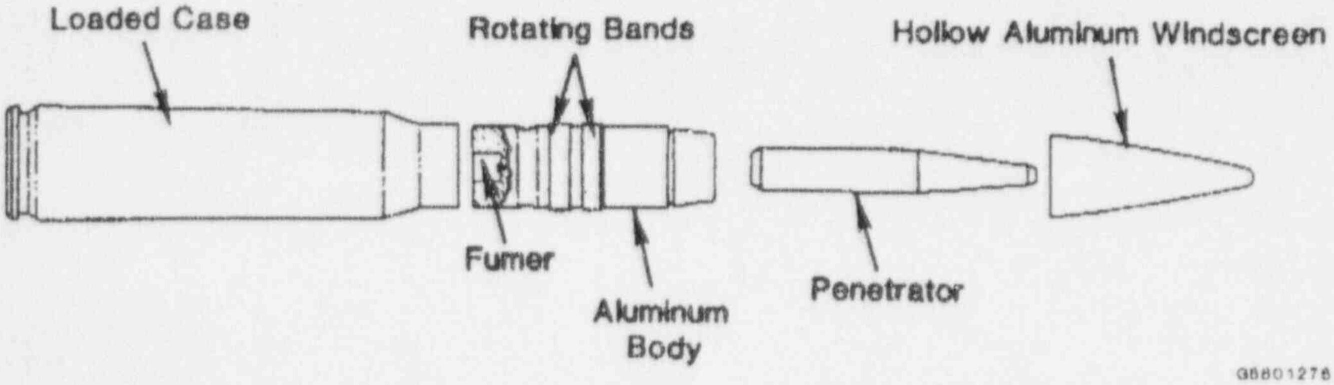

Figure 2-2 Cartridge, 30MM, PGU-14/B (APIT) Early Production Lots (Aerojet)

Encl 2

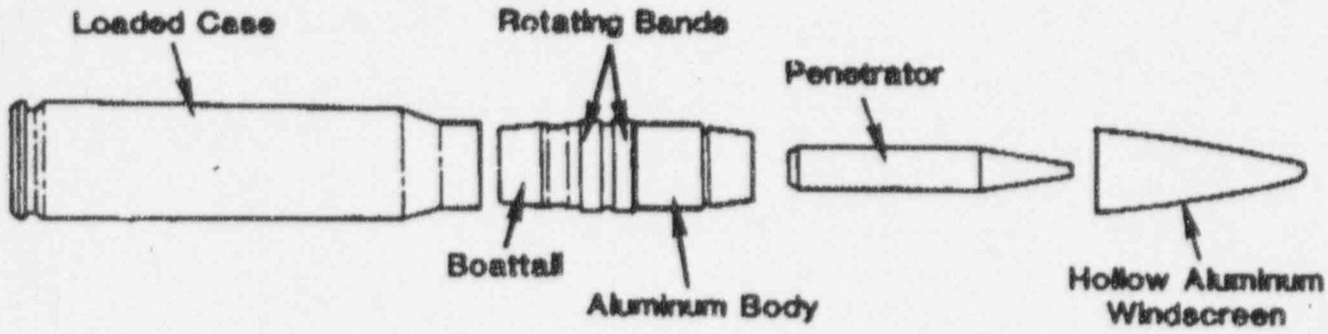

Figure 2-3. Cartridge, 30MM, PGU-14A/B (API) Early Production Lots (Aerojet)

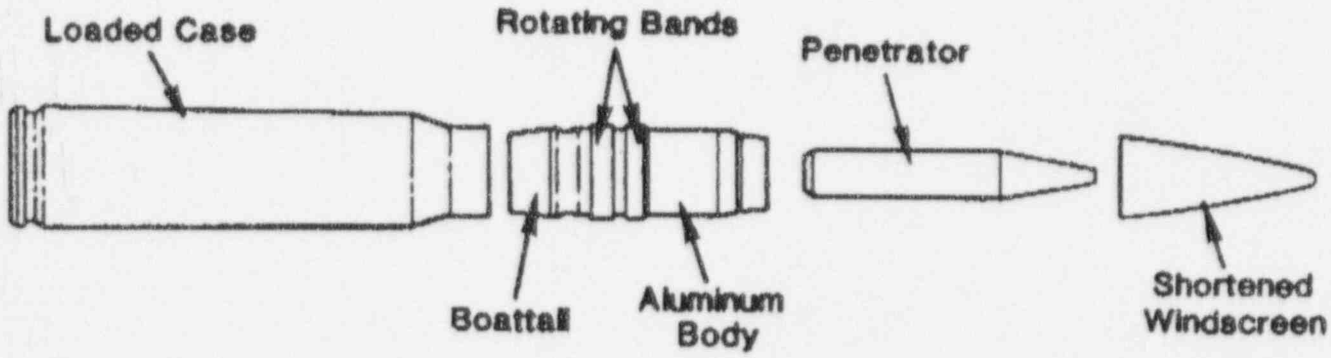

Figure 2-4. Cartridge, 30MM, PGU-14B/B (API) Current Production Lots (Aerojet)

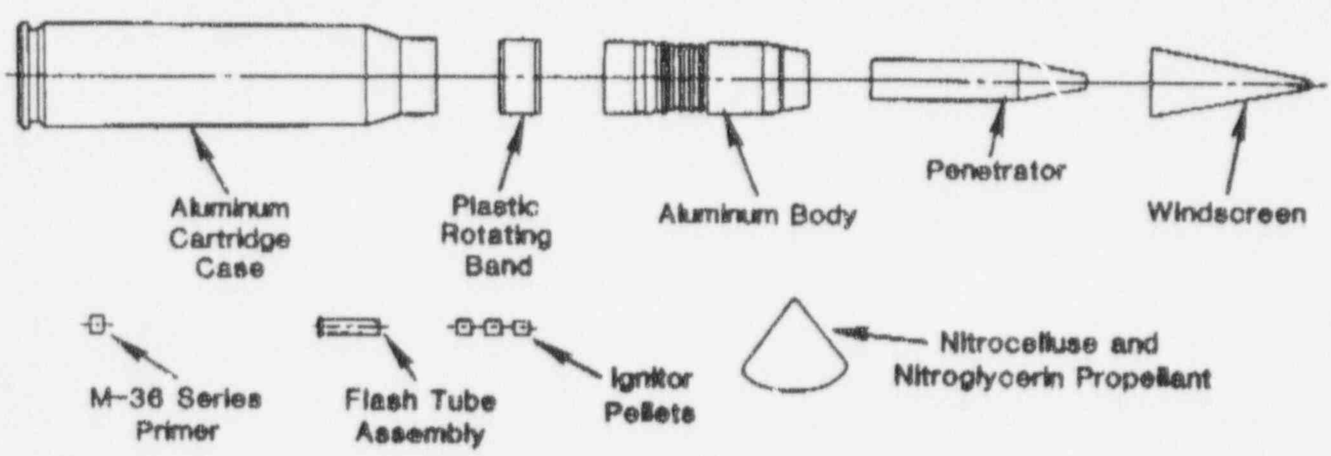

Figure 2-5. Components of 30MM Armor Piercing Incendiary Cartridge, PGU-14A/B (Honeywell)

Encl 2

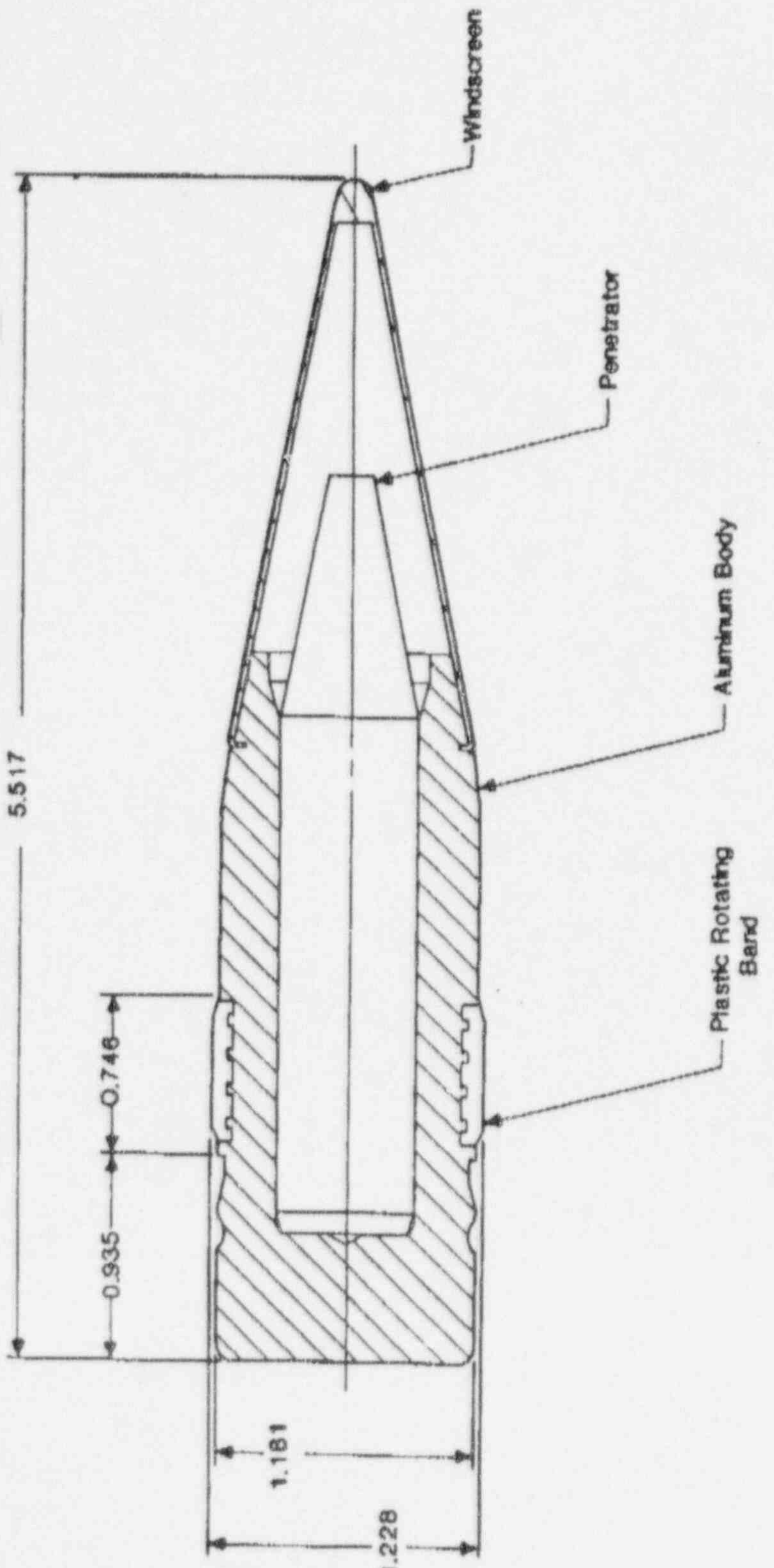

Figure 2-6. Projectile, 30MM PGU-14A/B (API) (Honeywell)

Encl 2

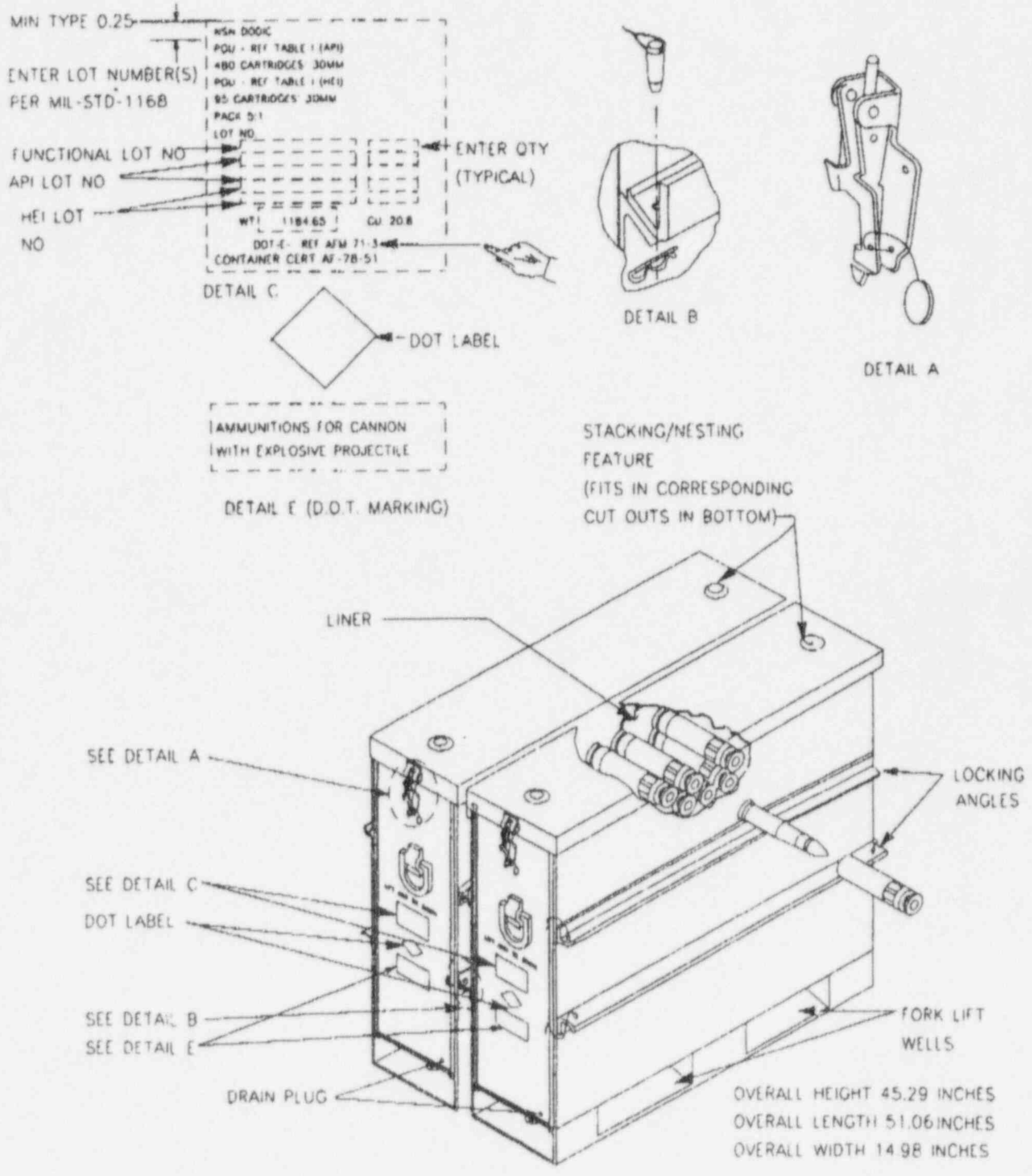

Figure 2-24. CNU-309/E Shipping and Storage Container (Typical)

Encl 2

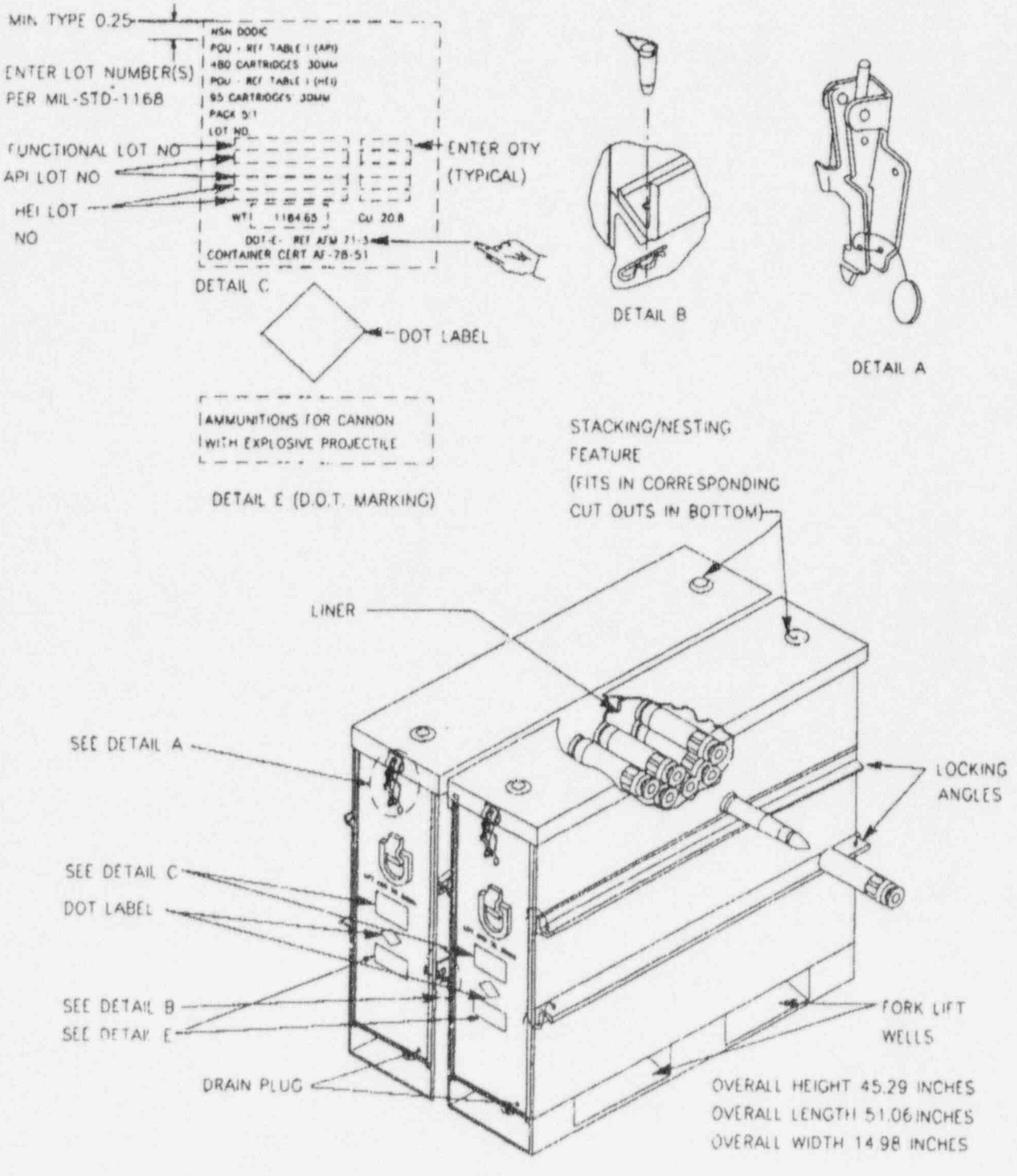

Figure 2-24. CNU-309/E Shipping and Storage Container (Typical)

Encl 2

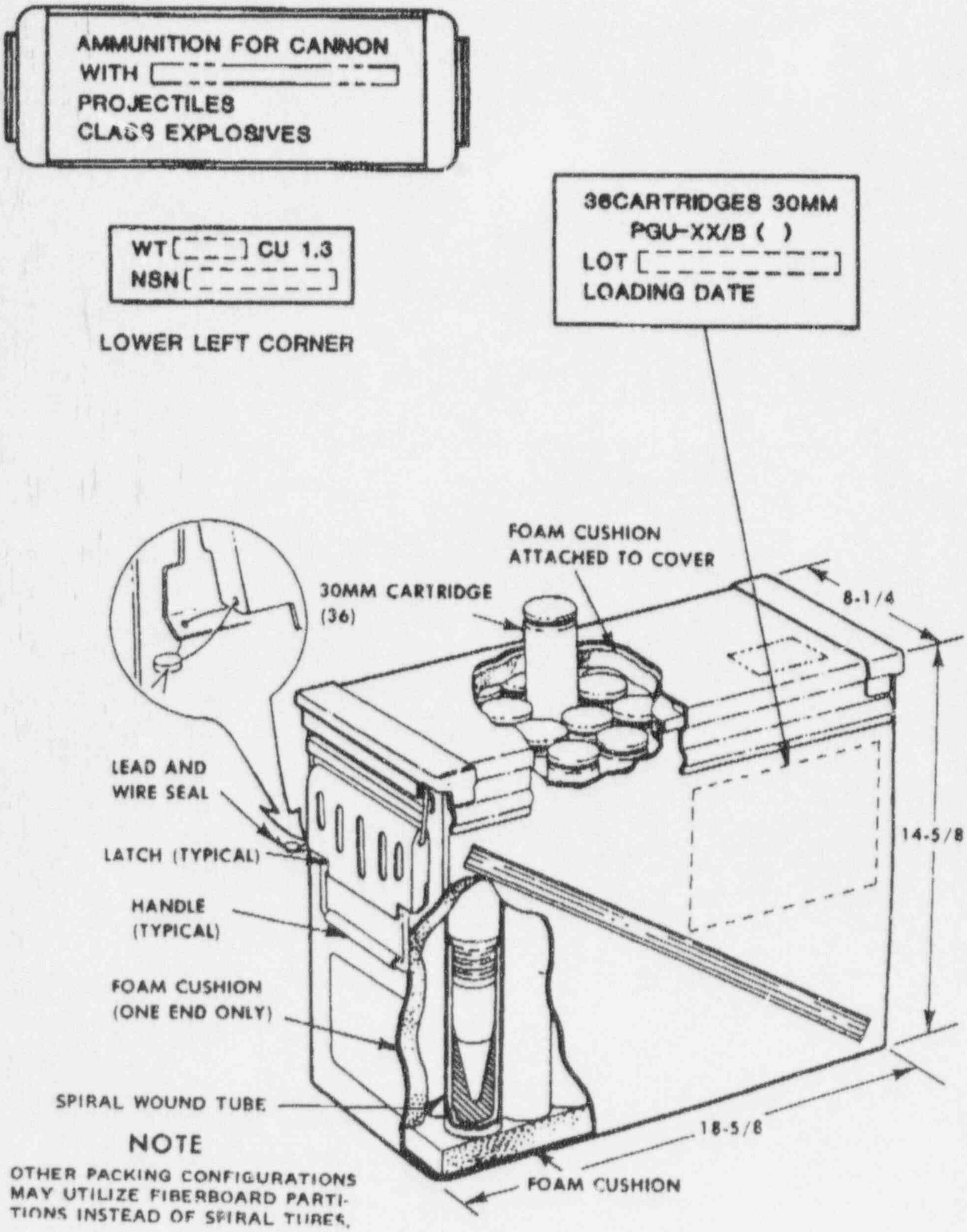

Figure 2-21. M548 Shipping Container Outer Package/Markings

Encl 2

CRANE ARMY AMMUNITION ACTIVITY
CRANE, INDIANA 47522-5099

ITEM 11

WASTE MANAGEMENT

1. Unwanted radioactive material will be disposed of in accordance with AMCCOM Pamphlet 385-1 (Handbook for Disposal of Unwanted Radioactive Material) and TM 3-261 (Handling and Disposal of Unwanted Radioactive Material. The U.S. Army Industrial Operations Command (IOC) has been designated as the responsible agency for the safe disposal of the unwanted low-level radioactive material for the U.S. Army. IOC is responsible to provide information and guidance to all generators of unwanted radioactive material to prevent violations of Federal and State regulations, thereby ensuring safe and legal transport and disposal of the material. Shipments are made only by authorization from AMCCOM. Disposal costs will be paid by IOC. Packaging costs will be paid by Crane Army Ammunition Activity.

2. Any unwanted radioactive material generated is expected to be solid, generated solely during the demilitarization processes, and is not expected to involve the generation of liquid, dusts, mists, fires, organic vapors or gases. Items that may be generated include disposable protective clothing and equipment, contaminated swipes, and contaminated metal parts from the demilitarization processes.

3. Statement of Intent:

a. Crane Army Ammunition Activity is exempted from the conditions of Title 10, Code of Federal Regulations (CFR), Part 40.36(a), which requires a licensee to submit a decommissioning funding plan/statement of intent for source material operations, for the following reasons:

(1) While our total possession of depleted uranium (DU) will be greater than 100 millicuries, the form is not readily dispersible in nature. The DU is contained within penetrators as an alloy and is essentially a sealed source. No significant dispersal of the material is expected to occur during the conditions under which the DU will be licensed at CAAA.