DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
2300 E STREET NW
WASHINGTON DC 20372-5300

IN REPLY REFER TO

BUMEDINST 6470.10B
BUMED-M3M7
26 Sep 2003

BUMED INSTRUCTION 6470.10B

From: Chief, Bureau of Medicine and Surgery
To: Ships and Stations Having Medical Department Personnel

Subj: INITIAL MANAGEMENT OF IRRADIATED OR RADIOACTIVELY CONTAMINATED PERSONNEL

Ref: (a) NAVMED P-117, Manual of the Medical Department
(b) NAVMED P-5055, Radiation Health Protection Manual
(c) Title 10, Code of Federal Regulations
(d) BUMEDINST 6710.62A

Encl: (1) External Irradiation
(2) External Contamination
(3) Wound Contamination
(4) Internal Contamination
(5) Neutron Exposure
(6) Chromium
(7) Cobalt
(8) Depleted Uranium (DU)
(9) Iodine
(10) Plutonium
(11) Radium
(12) Tritium
(13) Shipboard Items for Personnel Decontamination
(14) Bibliography

1. Purpose. To provide direction to the Medical Department, civilian medical personnel of the naval services, and Navy and Marine Corps commands for the initial exposure assessment, management, and treatment of individuals who are irradiated or externally or internally radioactively contaminated. References (a) through (d) provide additional guidance.

2. Cancellation. BUMEDINST 6470.10A.

3. Scope

a. This instruction applies to all naval facilities or commands and Navy-sponsored operations in which there exists a known potential for radioactive contamination or excessive ionizing radiation exposure and to all medical treatment facilities (MTFs), fixed and nonfixed.

b. This instruction applies to the period from actual exposure, contamination, or injury to the time when the individual is either returned to full duty or, if a seriously injured individual is on a

course of recovery at an MTF with definitive care capability. Definitive care is defined as the complete medical, surgical, and health physics support necessary to provide extended evaluation and treatment to seriously irradiated, contaminated, or injured personnel.

c. Although applicable to personnel irradiation or contamination following a nuclear weapon detonation in a time of war, the procedures outlined in this instruction are intended for use in occupational or accidental exposure environments.

d. The procedures outlined in this instruction do not preclude additional actions that may be taken by medical and health physics staffs in consultation with the Bureau of Medicine and Surgery (BUMED).

4. Background

a. The use of radiation sources, usually radioactive material, continues to expand within the Navy. With this increased use, there is a potential for accidental exposure or contamination of the people who are working with or around the sources. Exposure to radiation or radioactive contamination, either external or internal, rarely constitutes a medical emergency. However, whenever possible, external and internal contamination should be removed to prevent unnecessary exposure to the individual and reduce the likelihood of spreading contamination where other people could become contaminated.

b. Treatment of life-threatening injuries, e.g., severe trauma, shock, hemorrhage, and respiratory distress, always takes precedence over decontamination procedures, treatment of possible symptoms from irradiation, and dose estimation procedures. Medical emergency response personnel teams must not be impeded when proceeding to render emergent care for reasons such as issuing dosimeters or controlling access to restricted areas. To stop emergency response personnel in such situations clearly displays a lack of understanding and good judgment. It is instructive to note no health care worker in the United States has ever suffered radiation injury secondary to rendering emergency care to a contaminated patient. These points must be stressed because of a number of events that have occurred.

c. The procedures, guidelines, material, and physical data in enclosures (1) through (13) were compiled from the publications listed in enclosure (14). There is no requirement to maintain copies of these publications locally. Dose effects from given exposures and dose rates from surface and internal contamination were compiled from various values and models in the literature. While other values may be found depending on the assumptions made and sophistication of the model, these values are sufficiently accurate to predict the dose and clinical response.

d. Enclosures (1) through (13) provide procedures and information for use by personnel for evaluating, treating, or decontaminating personnel. Enclosures (1) through (5) provide general guidance. Enclosures (6) through (12) provide specific information and guidance for the isotopes most likely to be involved in a contaminating or exposure event in the Navy and Marine Corps. Enclosure (13) provides a list of items to be carried aboard ship for decontamination of personnel.

Facilities, such as research laboratories, etc., using other isotopes in sufficient quantities to cause the internal contamination limits of reference (b) to be exceeded, should refer to the publications listed in enclosure (14) for treatment and management guidance specific to those isotopes.

e. The definitions of radiation dose units and units of ionizing radiation in this instruction have not changed from those of traditional usage in the Navy, as used in most instructions and manuals. These definitions have been replaced in the scientific literature, reference (c), and in Europe with the System Internationale (SI) Units. Thus, a table of equivalents is provided below:

Traditional Units as Used in Navy Programs

One rad	= One centigray	= 1×10^{-2} Gray
One rem	= One centisievert	= 1×10^{-2} Sievert
One Curie	= 3.7×10^{10} Becquerel	= 3.7×10^{10} disintegrations/second.

SI Units

One Gray (Gy)	= 100 rad
One Sievert (Sv)	= 100 rem
One Becquerel (Bq)	= 2.7×10^{-11}
Curie	= 1 disintegration/second.

5. Action

a. Planning. Local procedures or guidelines must be developed by MTFs and commands having potential for exposure or contamination of personnel to include:

(1) Availability and location of local resources such as medical treatment and transportation facilities.

(2) Availability of personnel and instrumentation necessary to provide initial management and care of irradiated or contaminated individuals.

(3) Training requirements for personnel responsible for initial management of irradiated or contaminated individuals.

(4) Plans for minimizing the contamination and radiation exposure to medical personnel.

b. Medical Care

(1) The procedures, guidelines, and physical data in enclosures (1) through (12) are provided to assist in assessing the seriousness of an exposure and in managing the radiological aspects of an irradiated or contaminated person. Memorization of the specifics, i.e., instrument reading to dose conversion factors, etc., is neither necessary nor intended.

(2) Under no circumstances will any individual be denied access to necessary treatment or MTFs because of radioactive contamination. Medical treatment of emergency medical conditions (conditions which can become medically critical or life threatening) and medical conditions with the risk of morbidity (conditions which will result in permanent injury or deficits) must always take precedence over decontamination or containment procedures. Concerns about the spread of radioactivity, i.e., radioactive contamination, or the possible contamination of medical personnel are, nonetheless, appropriate, and should be attended to after the patient has been stabilized.

(3) An individual's survival should not be in question unless:

(a) Exposure to the entire body exceeds 200 rad.

(b) Exposure to a major segment of the body, e.g., head or thoracic region, is on the order of several hundred to thousands of rad.

(c) There is a combination of serious physical injury and exposure. (This latter circumstance is termed a "combination injury" in military medicine.)

(4) If an individual receives an exposure which is not expected to produce clinical symptoms, care should be taken not to frighten the individual or to give the perception a significant exposure has occurred, for example by implementation, administrative, or therapeutic procedures designed for a significant exposure. Alleviation of fears will reduce psychosomatic symptoms which can be misconstrued as symptoms of high radiation exposure.

(5) In all instances, treat the exposed individuals symptomatically until medical and health physics evaluations have been performed.

c. Specialist Assistance

(1) If an individual requires medical care, or if a facility requires assistance in planning for management of a patient or evaluating an exposure, consultation with one or more radiation medical specialists, e.g., physician specialists recognized as experts in assessing and treating cases of exposure or contamination, may be necessary. The services of appropriate radiation medical specialists will be obtained by contacting BUMED.

(2) Funding for the services of radiological evaluation specialists or radiation medical specialists will be arranged by the activity or type commander (TYCOM) requesting the assistance and will be provided following procedures in the Navy Comptroller Manual. Additional specific information concerning funding can be obtained from BUMED.

(3) Guidance from BUMED is available concerning medical treatment for irradiated or contaminated individuals, the services of radiological evaluation specialists, and the services of appropriate radiation medical specialists. Telephone communication is authorized and encouraged at the following numbers:

During weekday East Coast working hours:
DSN 762-3444
Commercial (202) 762-3444
FAX (202) 762-0931 or DSN 762-0931

At other times contact the BUMED Duty Officer:
(who will contact BUMED-M3F7)
DSN 762-3211
Commercial (202) 762-3211
FAX (202) 762-3217 or DSN 762-3217

If telephone communication is not available, contact BUMED via IMMEDIATE message. Message address is BUMED WASHINGTON DC with PASS TO BUMED-M3F7.

6. Forms

a. NAVMED 6470/1 (Rev. 4-1999), Exposure to Ionizing Radiation, is available at http://navymedicine/instructions/default.asp?type=F.

b. SF 600 (Rev. 6-97), Chronological Record of Medical Care, is available at http://contacts.gsa.gov/webforms.nsf/0/4951AF308C046D9785256A3F0005BE96/$file/sf600.pdf.

7. Reporting and Record Procedures. Medical reporting and documentation requirements for radiation exposure, external contamination, or internal contamination are provided in chapter 5 of reference (b).

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Available at: http://navymedicine.med.navy.mil/instructions/directives/default.asp

EXTERNAL IRRADIATION

1. Definition. External irradiation is exposure to radiation that originates external to and usually not in direct contact with the body. The radiation can be x-rays, gamma rays, neutrons, or charged particles. Penetrating radiation has sufficient energy to contribute dose to deep tissues and organs in addition to the skin. No penetrating radiation contributes dose primarily to the skin.

2. Dose Evaluation. Appropriate management depends upon proper assessment of the clinical seriousness of the exposure. The biological response is dependent upon the dose received, the time over which the dose was received, the area and volume irradiated, the energy of the radiation, and the type of radiation. General information to help evaluate the potential seriousness of a human exposure is given below for acute whole body exposures. For small area penetrating radiation exposures, i.e., hand, arm, finger, etc., the response of deep tissues may be predicted by observing the skin response and applying the same dose effect as predicted by the guidelines for nonpenetrating irradiation.

PENETRATING IRRADIATION

Dose Range*	Signs and Symptoms	Action
0-5 rad	None expected.	Administrative and documentation action. See chapters 2 and 5, reference (b).
5-25 rad	None expected. Only special laboratory procedures can verify the exposure.	Notify BUMED within 24 hours. Administrative and documentation action. See chapters 2 and 5, reference (b).
25-100 rad	Transient diagnostic symptoms, e.g., decreased lymphocyte count may occur within 1-4 days.	Notify BUMED immediately. Performance decrement not expected. Document exposure, symptoms, signs, and recovery. See chapters 2 and 5, reference (b).
100-200 rad	Obvious diagnostic symptoms, e.g., nausea, vomiting, hematopoietic syndrome appears in hours or days.	Notify BUMED immediately. Performance decrement expected. Treat symptomatically. See chapters 2 and 5, reference (b).
Several 100's of rad	Persistent, severe diagnostic symptoms, e.g., nausea or vomiting, hematopoietic or gastrointestinal syndrome, erythema, etc.	Notify BUMED immediately. Fatality possible. Treat symptomatically. See chapters 2 and 5, reference (b).

NONPENETRATING IRRADIATION

Dose Range*	Signs and Symptoms	Action
0-50 rad	None.	Administrative documentation action. See chapters 2 and 5, reference (b).
50-250 rad	None expected.	Notify BUMED immediately. See chapters 2 and 5, reference (b).
250-400 rad	None expected.	Notify BUMED immediately. See chapters 2 and 5, reference (b).
400-800 rad	Transient erythema (sunburn appearance) expected in 1-3 days after exposure.	Notify BUMED immediately. See chapters 2 and 5, reference (b).
800-1500 rad	Prompt (8 hours-1 day) erythema, may be followed by blistering, similar to severe sunburn.	Notify BUMED immediately. Treat symptomatically. See chapters 2 and 5, reference (b).
1500 rad and Greater	Severe blistering, tissue sloughs, long-term course to heal.	Notify BUMED immediately. Difficult management problem, may have long-term complications. See chapters 2 and 5, reference (b).

* Acute (seconds to hours) exposure.

3. Procedures. Depending upon the exposed individual's physical condition and the extent of exposure, the following actions should be taken. The actions may be performed concurrently.

a. Attend to acute medical problems first.

b. Determine or estimate the dose received, e.g., evaluate personnel dosimetry, simulate the exposure, reconstruct the exposure event, multiply exposure rate times time, etc. The primary purpose of this dose estimate is to determine whether or not clinical symptoms are expected.

c. Obtain and document a history of the exposure. Pay special attention to identify the time and duration of exposure.

d. For a whole body dose exceeding 5 rad, eye dose exceeding 15 rad, or a shallow dose of 50 rad in a single incident notify BUMED immediately of the estimated dose by telephone or by "IMMEDIATE" message, following chapter 5 of reference (b), with follow-up report within 24 hours. Perform a situational radiation medical examination following chapter 2 of reference (b). In addition to the complete blood count (CBC) with white blood cell (WBC) differential, obtain a platelet count. Repeat the CBC and WBC with differential including platelet counts at 24-hour intervals for at least 2 days. Notify BUMED immediately of the estimated dose following chapter 5 of reference (b), with follow-up report within 24 hours. Additional blood work may be required if directed by BUMED. Where capabilities do not exist for performing CBC and WBC with differential and platelet counting, draw and retain (refrigerate at 2 to 6^{o} C) samples for later counting, and make a peripheral smear, permanently mounted with cover slip.

e. For a whole body dose exceeding 25 rad, or an eye dose of more than 75 rad, or a shallow dose of 250 rad in a single event, complete actions in 3d above and report the exposure to BUMED following chapter 5 of reference (b).

f. If the acute external whole body dose was greater than 25 rad, but less than 100 rad, perform additional CBCs and WBCs with differential and platelet counts at least twice weekly for a period to be determined in consultation with BUMED. Where capabilities do not exist, draw the samples for later counting.

g. If the acute whole body dose exceeds 100 rad, the following additional procedures must be followed. It should be emphasized high exposure cases are treated based on medical signs and symptoms rather than estimated doses because dose estimates following an accident may be imprecise.

(1) Transfer the individual to an MTF capable of providing definitive patient care. Ensure the MTF is notified before the individual's transfer. The urgency for transfer will depend on the need to treat acute medical problems. The patient's transfer should not be delayed to collect information.

(2) Provide BUMED with the names and telephone numbers of the medical officer and an alternate in charge of the individual's care at the receiving MTF. BUMED will provide consultation to the medical officers or contact appropriate radiation medical specialists to provide consultation as necessary. Direct telephone communication with BUMED is authorized, call collect if necessary.

(3) Provide technical personnel and equipment for evaluating the patient's exposure and maintaining radiological controls if such assistance is needed by the MTF.

(4) Establish liaison between the referring activity and the MTF to which the individual is being transferred. The following information, as appropriate and as it becomes available, should be obtained to assist in evaluating and treating the individual:

(a) Identifying information, i.e., name, grade or rate, social security or identification number, age, and parent command.

(b) Physical injuries noted and treatment provided by the referring activity.

(c) Results of dosimetry evaluation or exposure estimate performed by the referring activity. The dosimetry evaluation should include the approximate dose, radioactive material involved, area exposed, and total time of exposure, i.e., acute (seconds to minutes) or chronic (hours to days) exposure.

(d) The presence of any external or internal contamination, if known. If external or internal contamination is present, indicate the location, amount, and chemical form, if known.

(e) Name and telephone number of the authorized contact point at the referring facility for providing or obtaining additional information.

EXTERNAL CONTAMINATION

1. Definition. An area of the body is considered to be externally contaminated if it contains in excess of 450 picocuries (micromicrocuries) of beta-gamma emitters by direct frisk or 50 picocuries (micromicrocuries) of alpha emitting contamination by direct frisk, i.e., 100 counts/minute of beta-gamma emitting contamination as measured under the area of a DT-304 probe or 50 counts/ minute of alpha emitting contamination as measured on an AN/PDR-56. Different limits may be approved by the Naval Radiation Safety Committee for radioactive material used under a Naval Radioactive Material Permit or by BUMED for radioactive material not under a Naval Radioactive Material Permit.

2. Dose Evaluation. Appropriate management depends upon proper assessment of the clinical seriousness of the contamination. The expected biological response is dependent upon the dose received, the time over which the dose is received, the area contaminated, and the energy and type of irradiation. This problem is compounded if the contamination is loose or mobile so it can enter the body through absorption, inhalation, or ingestion. Skin response from contamination may be estimated from the Nonpenetrating Irradiation Table in enclosure (1).

3. Procedures. Depending on the patient's physical condition and the extent of external contamination, the following actions should be taken. The actions may be performed concurrently.

a. Attend to acute medical problems. Treatment of life threatening injuries, e.g., severe trauma, shock, hemorrhage, and respiration distress always takes precedence over decontamination procedures, treatment of possible symptoms from irradiation, and dose estimation procedures.

b. Evaluate the extent of skin contamination. Evaluate the possibility of the presence of internal contamination, i.e., was the activity airborne so it could be inhaled? It may be necessary to interview the individual and witnesses to document a description of the events leading to the contamination. This is a qualitative evaluation to assist in planning the management of the individual. It should answer such questions as: What is the extent of the skin contamination; is it likely internal contamination is involved; are clinical symptoms or signs expected; and is this an acute health problem or primarily a documentation and administrative problem?

c. Decontaminate the area. The decontamination method or methods chosen will depend upon the circumstances and material available. Experience has shown small amounts of reactor corrosion products, chemically stable medical isotopes, and other isotopes used for industrial applications are easily removed with soap and water or waterless hand cleaner. The extent of decontamination effort should be a balance between the risk of injuring the skin in the process of decontamination and the possibility of injury to the skin from the contamination or the need to have the contamination controlled or removed for resumption of normal duties. It should be recognized signs of excessive decontamination efforts will be more evident 24 hours later than at the time the decontamination is ongoing. Do not injure the skin! Decontamination of eyes, ears, nose, or any injury must be supervised or performed by medical personnel. Decontamination e.g., wiping hands or face with a damp cloth, or cleaning hands with waterless hand cleaner, may be performed at the scene or control point if conditions permit. Or, the individual may be moved to an area appropriate for performing

decontamination while maintaining radiological controls. Radiological controls which are consistent with the urgency for transferring the individual should be maintained during transfer, i.e., do not delay transferring an individual needing life or limb saving medical care to complete contamination evaluation, documentation, or implementation of radiological controls. The following procedures are effective in removing external contamination. They do not need to be applied in specific order to be effective. The procedures chosen should depend upon the location of the contamination, type of contaminate, convenience of decontaminating material, etc. (Removing radioactive contamination is very similar to removing grease or dirt.) Multiple procedures should be done with caution because skin irritation, abrasion, and possibly chemical burns occur more easily as additional and more aggressive procedures are employed. The amount of dedicated decontamination material to be maintained depends upon the type of work being performed and the probability for a contaminating event. Normally, aboard ships, enough dedicated material to decontaminate approximately one tenth of the occupationally exposed personnel is more than adequate. At shore facilities, the amount of dedicated material will be dependent on the type and extent of work. Enclosure (13) provides a list of items necessary for decontamination by forces afloat. Quantities should be determined by local guidelines.

(1) Decontamination Procedures for both Forces Afloat and Shore Facilities

(a) Apply self-adhering adhesive tape to lift removable material from the skin. This procedure works best for dry dust type contamination, however this should not preclude washing if washing is more convenient. Avoid using strongly adherent tape such as duct tape. Do not apply tape to areas with significant body hair. Do not apply tape on or near the eyelids or any other fragile tissue that may tear.

(b) Wash 1 to 3 minutes using soap and water or detergent and water. A washcloth or soft surgical scrub brush may be used to aid in removing contamination.

(c) Wash 1 to 3 minutes using waterless hand cleaner. Do not use waterless hand cleaner on the face or other areas where it can cause an irritation.

(d) Wash 1 to 3 minutes using a mild abrasive, e.g., "Lava" soap, or "Soft Scrub" or equivalent, and water.

(e) If the contamination cannot be removed by washing, wrap or cover, e.g., bandage, glove, etc., the contaminated area to allow removal through sweating or skin sloughing. After 6 to 9 hours remove the wrapping or cover to measure the amount of contamination remaining. Wash the area again if significant amounts remain. Replace the glove or bandage if necessary.

(2) Decontamination Procedures at Research Facilities, Naval Nuclear Repair Shipyards, and Major Treatment Facilities. At facilities where large quantities or exotic or chemically active isotopes are used or where more in-depth medical and radiation health support is present, more aggressive techniques such as the ones given below may be used in addition to those above provided there is supervision by medical or health physics personnel. Again, these do not have to be performed in any specific order. The procedures chosen should depend upon the location of the contamination, type of contaminate, convenience of decontaminating material, etc.

(a) Wash 1 to 3 minutes with 10 percent dilute bleach. Wash in the bleach solution and then rinse with water.

(b) Upon a physician's determination and supervision, a 20 percent dilution (5:1 dilution with water) of commercial bleaches (5 percent sodium hyperchlorite) may be used around the face, wounds, etc. Lesser dilution up to undiluted bleach may be used on other skin areas, such as, hands or extremities.

(c) Wash 1 to 3 minutes with a 1 percent citric acid solution.

(d) Wash 1 to 3 minutes with a 1 percent ethylene-diamine-tetra-acetic (EDTA) acid in detergents.

(e) If symptom-producing exposures are expected and other methods have not been effective, wash ½ to 1 ½ minutes with a saturated potassium permanganate (KMnO-4) in 0.2N solution of sulfuric acid. Rinse with water. Use fresh 5 percent solution of sodium acid sulfite to remove the potassium permanganate stain. Do not use this procedure on the face or other areas where it may produce an injury.

d. The primary objective of skin decontamination is to prevent internal contamination through ingestion or inhalation. To prevent ingestion or inhalation the area contaminated should not be released from some type of control, i.e., a covering, bandage, glove, etc., unless the levels by direct frisk are less than 450 picocuries (micromicrocuries) for beta-gamma emitters or less than 50 picocuries (micromicrocuries) for alpha emitters by direct frisk. A secondary objective is to minimize the dose to the skin. Skin decontamination should proceed with appropriate urgency to ensure skin dose limits are not exceeded. Refer to the specific isotope's physical data to estimate the skin exposure rate.

e. Document and report the occurrence of skin contamination following chapter 5 of reference (b).

f. If clinical symptoms or signs are expected, transfer the individual to an MTF for care and follow-up evaluation. Coordinate patient transfer with BUMED.

g. If assistance is needed in decontaminating an individual, or if clarification of the above guidance is needed, contact BUMED.

WOUND CONTAMINATION

1. Definition. Wound contamination is defined as radioactive material present inside or at the border of a break in the skin, thereby providing increased potential for access to or retention in internal tissues.

2. Procedures

a. Treat life threatening injuries, e.g., severe trauma, shock, hemorrhage, and respiratory distress, first.

b. Monitor the wound for the presence of contamination. Direct monitoring may be used for contamination emitting beta and/or gamma radiation. However, for alpha emitting contamination, dry swabs or surgical sponges should be used to probe the wound for contamination. The swabs must then be thoroughly dried before effective alpha counting can be accomplished.

c. If contamination is detected or alpha contamination is likely, the wound should be irrigated with sterile saline or water until contamination in the wound is removed or no change in contamination level is noted. If the wound and a small area around it are both contaminated, then both may be decontaminated by washing without concern for washing more activity into the wound. Experience with contamination of skin and even wounds frequently indicates only a small proportion of radioactive material is absorbed systemically into the body. Wound contamination with alpha emitters is a potential problem area, nevertheless, because of the small amount of this material allowed in the body. The possibility of a significant amount of activity being absorbed through a wound is remote. A contaminated abrasion or burn can be cleaned with a mild soap or detergent solution. If necessary, a topical anesthetic can be used to allow more vigorous cleaning. All contamination does not have to be removed since the residual remaining on the surface will normally be incorporated into and sloughed with the scab. If residual contamination remains in a puncture wound, simple wet debridement of the wound may be performed following standard surgical procedures. However the benefits, versus the risk to the patient, should be carefully evaluated. This evaluation should specifically consider the potential radiation exposure resulting from the residual contamination. If doubt exists about whether the wound is sufficiently decontaminated for closure following decontamination procedures, consult BUMED. Under no circumstances should radical or function impairing surgical procedures be undertaken because of radioactive contamination without first consulting BUMED.

d. Record the location, type of radionuclide in the contaminate, chemical form, if known, method or description of monitoring, the counts or levels of contamination, and the methods used to decontaminate the wound.

e. Coordinate documentation of treatment, decontamination, and the specification of the amount, contamination, or dose with BUMED.

INTERNAL CONTAMINATION

1. Definition. An individual is considered to have internal contamination when radioactive material has gained access into the body through inhalation, ingestion, absorption, or impingement.

2. Dose Evaluation. The seriousness of the radiation exposure may be judged by estimating the whole body dose and using the table for external irradiation to penetrating radiation. If only small volumes, e.g., wounds, are contaminated, the seriousness may be judged by estimating the small volume dose and using the table for external exposure to nonpenetrating radiation. Depending on the isotope, the expected dose may be estimated by partial or whole body counting, counting of excreta, counting of a blood sample, direct frisk, or by calculation using the derived air concentration (DAC) limits and the exposure time and concentration levels.

3. Procedures. Depending on the exposed individual's physical condition and the circumstances and extent of the exposure, the following actions should be taken.

a. Attend to acute medical problems first.

b. Establish control of external contamination, i.e., take action to prevent additional internal contamination through inhalation or ingestion. Depending on the circumstances, this may mean removing the external contamination or simply covering the external contamination.

c. Document a history of the exposure. Pay special attention to identify the time and duration of exposure, isotope involved, chemical form, and any indication of particle size.

d. Determine or estimate the amount of contamination and expected dose, i.e., evaluate the seriousness of the contamination. A number of different approaches may be used to evaluate the extent and magnitude of contamination. Among these are:

(1) If the suspected contaminant was an alpha emitter of particulate nature, e.g., dust, mist, smoke, etc., obtain nasal and oral swab samples with moistened nasal swabs for counting before showering or washing the face. For these to be useful they need to be collected in the first few (10 to 15) minutes after the potential exposure to particles via inhalation. Allow the swabs to dry before monitoring. Positive swabs are indicative of, but not conclusive for, internal contamination. If swabs are not taken, then the presence of internal contamination can be determined from fecal samples.

(2) If pulmonary or gastrointestinal tract contamination is suspected, perform partial or whole body counting, if appropriate, for the isotope involved, i.e., if the partial or whole body counting equipment can detect the isotope. The counting system must be calibrated for the isotope and geometry involved. External contamination must be removed before partial or whole body counting to prevent a false-positive indication. Counts to estimate the presence of contamination, or to verify there is no contamination, may be performed a short time after the exposure. However, counts used to quantify the amount of internal contamination in the lungs should be performed 24 hours or more after the exposure to minimize interference from very low levels (less than amounts

detectable by frisking) of external contamination remaining on the skin. For individuals who have internal contamination, a program of follow-up counts should be established to monitor deposition and to determine the resultant dose assignment.

(3) If partial or whole body counting equipment is not available, estimates of internal contamination may be made using field monitoring equipment and the guidelines in enclosures (6) through (12).

(4) Depending on the isotope and chemical form, estimates of internal contamination may be made by collecting and counting excreta (urine or fecal material). Consideration of the transit times should be taken to assure collection of a valid sample. For comparative purposes, normal background samples should also be taken from unexposed individuals.

(5) Estimates of potential contamination intake may be made by comparing the known airborne levels and duration of exposure with the DAC limits in reference (c).

e. Notify BUMED of the estimated dose immediately by telephone or "IMMEDIATE" message, for the sum of deep dose equivalent and committed dose equivalent (CDE) for any organ or tissue other than the lens of the eye (organ dose) exceeding 50 rem or a total effective dose equivalent (TEDE) exceeding 5 rem in a single incident. Perform a situational radiation medical examination following chapter 2 of reference (b). Forward a follow-up written report using NAVMED 6470/1 within 24 hours from the determination of such exposures following chapter 5 of reference (b).

f. Evaluate the "risk versus benefit" of initiating action to reduce the internal contamination. If possible, consult with BUMED before initiating therapeutic procedures. A situational medical examination is required following reference (b) for any individual who has exceeded 50 percent of the internal contamination limits of reference (b). The following procedures are effective in removing internal contamination. The procedures chosen will depend upon the circumstances of the situation, isotope, and chemical form.

(1) If gastrointestinal (GI) tract contamination is detected or suspected based on air concentration data obtained at the scene of the incident, and the expected dose to the GI tract exceeds 15 rad, the following actions may be performed to enhance contamination removal if no potentially adverse health effects are indicated by the patient's medical condition or medical history. Additional procedures may be performed in consultation with BUMED.

(a) Minimize absorption by administering antacids, e.g., aluminum hydroxide or similar material.

(b) Hasten elimination of waste by administering a cathartic, e.g., magnesium sulphate or castor oil. Collect urine and fecal samples for radioanalysis.

(2) If pulmonary contamination from a "bone seeker" (radium, strontium, actinium, thorium, plutonium, etc.) is detected or suspected based upon intake data at the scene and the internal

contamination appears to exceed 10 percent of the limits in reference (b), or if there is evidence of a very high specific activity particle (R/hr) lodged in the sinuses, the following actions in addition to the above should be performed to enhance removal of the contamination. (These actions are usually not necessary for reactor corrosion products, due to their insolubility and low specific activity. These procedures cause irritation to the sinuses which generally outweighs the benefits of reducing the exposure.)

(a) Irrigate nasal passages gently with saline solution or water through a catheter or syringe. Keep patient's head bent over a basin with mouth open.

(b) If contamination persists, repeat the irrigation procedure. If the contamination levels cannot be reduced to less than 10 percent of the limits in reference (b) after three irrigation attempts, contact BUMED for further guidance.

(c) Monitor any coughed up mucus for contamination.

g. Document the exposure and report the occurrence of internal contamination following chapter 5 of reference (b).

NEUTRON EXPOSURE

1. Background. Neutron exposure and its effect differ from gamma exposure because the neutrons have a higher relative biological effectiveness. They also activate small amounts of material within the body to the extent that certain elements become radioactive, thus helping to confirm an exposure occurred.

2. Procedures. If the history from the individual and witnesses indicates an accidental high neutron exposure may have occurred, the following procedures should be performed, in addition to the procedures for an external exposure.

a. Treat the patient symptomatically. Caution should be taken to avoid placing undue confidence on crude dose evaluations obtained immediately following the accident. These estimates are, at best, a relative measure of exposure and are only useful for screening purposes.

b. If the exposure was accompanied by the release of radioactive contamination, perform an evaluation of the extent of any skin contamination. If skin contamination is present, perform decontamination at the scene or establish control of the contamination and transfer the individual to an area appropriate for performing decontamination procedures and maintaining radiological controls. Evaluate the possibility of internal contamination.

c. If the exposure was accompanied by a fission release, producing an iodine exposure expected to exceed 10 rad, administer potassium iodide as a thyroid block for any inhaled radioactive iodine. (See enclosure (9).)

d. If the history from the individual and witnesses indicates the exposure was suspected to be greater than approximately 25 rad, evaluate the exposure using the following methods:

(1) Process Lithium Fluoride TLD. Immediately hand-carry or send the lithium fluoride TLD by airmail special delivery with control TLD's to the Naval Dosimetry Center for evaluation at the following address:

Officer in Charge
Naval Dosimetry Center
Navy Environmental Health Center Detachment
Bethesda, MD 20889-5614

(2) Process DT-518/PD or DT-526/PD Personnel Dosimetry. Perform the following procedure as soon after the exposure as possible:

(a) Select a radiac set, type AN/PDR-27 (J through S series), and switch the radiacmeter to the most sensitive (0.5 mR/hr) scale. Operate the radiacmeter following the applicable technical manual. Record the meter indication as the "background reading."

(b) Place the DT-518/PD capsule or DT-526/PD case, with cap in place, against and parallel to the larger (most sensitive) probe of the AN/PDR-27. Observe the meter reading as the DT-518/PD or DT-526/PD case is moved along the length of the probe. Record the highest reading observed as the "gross screening reading" of the accident dosimeter. Subtract the "background reading" from the "gross screening reading" to obtain the "net screening reading."

Hours After Exposure	Net Screening Action Level (mR/hr)
0	0.3
0.5	0.2
1	0.14
1.5	0.09
2	0.06
2.5	0.04
3	0.03
3.5	0.02

(c) If the "net screening reading" exceeds the "net screening action level," a dose in excess of 25 rad is assumed. The patient should receive a medical examination and appropriate treatment to medical signs or symptoms. The screening action levels were conservatively derived so actual doses may be much less.

(d) The DT-518/PD assembly or the DT-526/PD case, with cap in place, must be hand-carried or sent by airmail special delivery immediately to the following address:

Officer in Charge
Naval Dosimetry Center
Navy Environmental Health Center Detachment
Bethesda, MD 20889-5614

Note. If the DT-526/PD is being used for gamma or x-ray radiation monitoring, the detector element of the DT-526/PD must be removed from the case and evaluated by a CP-1112/PD before forwarding the DT-526/PD case with cap in place. Forward the reading obtained from the detector with the DT-526/PD.

(3) All DT-518/PD detector assemblies, DT-526/PD cases, DT-583/PDs, or DT-648/PDs forwarded for processing must have an identification number marked on the detector or detector assembly and must be placed in an envelope marked with the same identifying information number and the following information:

(a) The name of the person wearing the detector during the suspected accident (if not worn, the location where the dosimeter was stationed must be given).

(b) The date and time of the suspected exposure.

(c) The type of radiation source involved in the suspected accident, including a statement regarding its shielding (i.e., "shielded," "bare," or "not known").

(d) The approximate position of the dosimeter on the body of the wearer at the time of the suspected accident.

(e) The direction the wearer was facing relative to the source, if known.

(f) The time when the gross screening reading was made.

(g) If the DT-526/PD is being used for gamma or x-ray radiation monitoring, process and include the reading obtained from the detector element.

(4) If no dosimetry was worn, a crude estimate of the exposure may be made using the quick-sort technique based on measurement of the sodium-24 activation in the body. Quick-sort procedures are provided below:

(a) Remove outer clothing and external skin contamination.

(b) Hold the sidewall of the AN/PDR-27 dual probe against the abdomen with the individual seated and bent over as far as possible with forearms on thighs. A reading of about 0.2 mR/hr above background is assumed to represent an exposure above 25 rad. Use caution in interpreting the results of the quick-sort method, unless it is obvious an exposure has occurred.

(5) If it appears from the history and measurements an exposure exceeding 25 rad actually occurred, take the following actions as a further means of assessing the exposure:

(a) Collect approximately 10 cc of blood and 100 cc of urine for sodium-24 spectral analysis to confirm the findings of the quick-sort method.

(b) Collect approximately ½ gm of hair to analyze for phosphorus-32.

(c) Collect any metal objects worn by the individual and perform activation analysis. If metallic objects are removed for activation analysis, carefully document their location on the individual.

(d) Hand-carry or send the samples airmail special delivery immediately to the following address:

Officer in Charge
Naval Dosimetry Center
Navy Environmental Health Center Detachment
Bethesda, MD 20889-5614

e. Therapy. The patient should be treated symptomatically.

CHROMIUM

1. Background. Chromium-51 (Cr-51), element number 24, has a physical half-life of 27.8 days and decays by emitting a gamma ray [0.320 MeV (9%)]. If ingested, chromium is not readily absorbed through the wall of the intestine. Antacids are not recommended as a treatment for ingestion of chromium. Antacids increase slightly the absorption of chromium through the wall of the intestine.

a. As a skin contaminant, the dose rate to the germinal cell layer is approximately 1/60th of that for the same amount of cobalt-60. As a surface contaminant, the resuspension factor is approximately l/80th of that for cobalt-60. (A "resuspension factor" relates surface contamination to airborne concentration.) In addition, the dose rate from internally deposited Cr-51 is approximately l/70th of that for cobalt-60. Consequently, Cr-51 contamination is not as serious a concern as for cobalt-60. This is reflected in the higher water and airborne concentration limits.

b. Perhaps of more importance than the radiation insult of Cr-51 are its chemical effects on living systems. Potassium chromate is no doubt a chemical toxin. It has shown toxic effects in mice at doses of 1.6 gm/kg body weight. No toxic effects from oral intake have been observed in humans. An individual readily recognizes when he or she is approaching the toxic level because of irritation to the skin and the nasal passages. Potassium chromate as an aerosol is a severe irritant at concentrations below the Occupational Safety and Health Act (OSHA) and Navy Occupational Safety and Health (NAVOSH) levels of 100 and 50 micrograms/m^3. The NAVOSH aerosol toxin standards are more restrictive than the radiation protection standards at the chromium radioactivity levels commonly seen in the Navy. You will have problems with chromium as a toxin before it becomes a true radiological hazard.

2. Exposure Evaluation

a. Skin Contamination. The following table converts instrument readings from corrected counts per minute (ccpm), (ccpm minus background counts) to activity and dose rate. The numerical values are based on a dose rate of 0.075 rad/hr/uCi/cm^2 to the germinal layer of the skin (0.07 mm depth) from chromium uniformly distributed over the skin.

Dose Table for Chromium-51 Contamination

Probe	Net Count Rate(ccpm)	Contamination (pCi(uuCi)/20cm^2)	Dose Rate mrad/hr	Number of days for 5.0 rad	Number of days for 50 rad
DT-304	100	30,000	0.1	---	---
	7,000	2,100,000	7.8	26.7	267*
	50,000	15,000,000	50.0	4.2	42*
PRM-5 w/	1,000,000 **	40,000,000	150.0	1.4	14*
SPA-3	1,000,000 ***	53,000,000	176.0	1.2	12*

* Worst case. It ignores the fact the skin normally sloughs in 2 to 20 days depending on the body location.

** PRM-5/SPA-3, HV2/Gross mode, calibrated in the standard calibration mode, HV1 Cobalt-60, HV2 Cadmium-109. This conversion factor should not be used in the presence of other isotopes due to the summing of counts over the entire spectrum.

*** PRM-5/SPA-3, HV2/PHA mode, calibrated in the special calibration mode, HV1Cobalt-60, HV2 Barium-133.

b. Internal Contamination

(1) The presence of internal contamination may be verified by performing partial or whole body counting.

(2) The presence of internal contamination may be verified by performing radioanalysis of urine or fecal material. Contact BUMED before collecting any samples for radioanalysis.

COBALT

1. Background. Cobalt (Co), element number 27, has 14 radioactive isotopes, cobalt-54 to cobalt-64. The radionuclides most likely to be encountered are cobalt-60, cobalt-58, and cobalt-57. Cobalt-60 is the activation product produced by the bombardment of stable cobalt-59 by neutrons. Its half-life is 5.3 years and it decays by emitting a beta particle [maximum energy = 0.31 MeV, average energy = 0.091 MeV(99+%)] and gamma rays of two energies: 1.17 MeV (100%) and 1.33 MeV (100%). The other isotopes have shorter physical half-lives, cobalt-57 being 271 days, and cobalt-58, 71 days. Both decay with the emission of penetrating gamma rays. Cobalt-60 is the principle cobalt radionuclide of concern because it is the predominant radionuclide present in nuclear reactor corrosion products, has a relatively long half-life, and emits high energy gammas.

a. Exposure Evaluation

(1) External Exposure. The seriousness of the radiation exposure may be estimated by evaluating the amount of exposure and using the table for external exposure to penetrating radiation for whole body exposures and using the table for external exposure to nonpenetrating radiation exposure for small area exposures. The amount of exposure may be determined by processing personnel dosimetry devices, or estimated, based on exposure rate and time in the area, or by reconstructing the exposure and taking physical measurements.

(2) External Contamination. External contamination is generally not a serious clinical problem because of the relatively low dose rate to the germinal layer of the skin. The primary concern is to control the contamination to prevent ingestion, absorption, or inhalation. Cobalt-60 uniformly distributed on a 20 square centimeter area of skin delivers approximately 4.3 rad/hr/uCi/cm^2 to the germinal layer of the skin, i.e., 0.09 mrad/hr/100 ccpm (ccpm, minus background counts) on a DT-304. (Dose rate values in the literature vary from approximately 1-7.5 rad/hr/uCi/cm^2 depending on the assumptions made in the calculation and the dose model used.) The following table converts instrument readings from ccpm to activity and dose equivalent rate. Use caution when interpreting the results of instrument readings for unknown geometry, detection efficiencies, and calibration conditions.

Dose Table for Cobalt-60 Contamination

Probe	Net Count Rate(ccpm)	Contamination (pCi(uuCi)/20cm^2)	Dose Rate mrad/hr*	Number of days for 5 rad**	Number of days for 50 rad**
DT-304	100	450	0.09	---	---
	8,700	39,000	7.8	26.7***	267***
	50,000	225,000	45.0	4.6	46

* Dose rates are calculated based on a dose rate of 4.3 rad/hr/uCi/cm^2 to basal cell layer from cobalt-60 uniformly distributed over the surface. The accuracy of the above conversions is believed to be within 25 to 50 percent which is sufficiently accurate to evaluate the seriousness of the exposure.

** Worst case value for uniform distribution over 1 square centimeter. Actual readings would be counting activity over the area of probe, i.e., 20 cm^2.

*** The horny layer of the skin (outer layer of dead skin) will naturally slough in 2 to 20 days removing any trapped surface contamination.

(3) Internal Contamination. The seriousness of internal contamination may be judged by estimating the amount of activity, estimating the whole body dose and using the table for external exposure to penetrating radiation to estimate the biological effect. Cobalt salts and particularly reactor corrosion products transit through the gastrointestinal (GI) tract in approximately 42 hours. Swallowing 1 microcurie of cobalt-60 results in a committed dose to the GI tract of approximately 80 millirem (mrem), and a committed effective dose of approximately 10 mrem, most accumulated in the first year. If inhaled, about 80 percent of the isotopes are eliminated with a biological half-life of 1 day or less. Approximately 1/4 of the activity is exhaled. Approximately 5/8 is trapped in the mucous of the pulmonary system, swallowed, and passes through the intestinal tract. The remaining 1/8th is eliminated much more slowly, varying considerably from case to case due presumably to chemical and particle size differences. As a thumb rule: one microcurie of cobalt-60 still remaining in the lungs 24 hours after inhalation will result in a committed dose to the lungs of approximately 6 rem, and a committed effective dose of approximately 700 mrem, of which about 1/3 is accumulated in the first year. Partial or whole body counts obtained within the first 24 hours are useful for ruling out an exposure; they are not reliable for quantifying the amount of activity in the lung and determining the resulting dose. Lung clearance rates for insoluble cobalt-60 vary significantly from individual to individual. Consequently, early measurement of internally deposited radioactivity in conjunction with use of the above thumb rules is valuable but provides only an initial rough exposure estimate. This initial estimate is useful for determining whether a clinically significant exposure has occurred. The initial estimates are also useful for the management of nonclinically significant exposures in making near term decisions for controlling further exposure within occupational limits as the individual returns to work. The above thumb rule is not appropriate for the final assignment of exposure for record purposes. Total dose assignment should be based upon measurements made over an extended time, i.e., weeks, months, years. Such assignments should be made upon consultation with BUMED. The following guidelines may be used to estimate the amount of internal contamination:

(a) Use of a partial or whole body counting facility or other gamma scintillation analysis techniques with a single or multi-channel analyzer is the preferred method of internal monitoring.

(b) To determine whether or not surface contamination exists on the chest or abdomen, AN/PDR-27 readings or the IM-265 Multifunction RADIAC (MFR) readings (at a distance of approximately 1 centimeter) may be made with the Beta window open and closed. If the two readings are the same, surface contamination is sufficiently low to permit monitoring for internal contamination. (Note: The Beta window on the large probe can only be used on the two lowest ranges, i.e., 0.5 and 5 mR/hr.) If a DT-304 frisker is used, a piece of 1 millimeter or thicker plastic may be added between the skin and the detector to distinguish between contamination on the surface and internal contamination.

(c) One microcurie of cobalt-60 in the lungs or digestive system will produce a gamma exposure rate of approximately 0.04 mR/hr above background when measured with an AN/PDR-27 or MFR on contact with the chest or abdomen, or about 100 counts per minute above background with a DT-304 frisker. Readings should be taken in an area with low background radiation, i.e., less than 0.02 mR/hr or less than 100 counts per minute.

(d) The headset should be used with the AN/PDR-27 to provide a better indication of low levels of internal contamination. On the 0.5 and 5 mR/hr ranges (large probe) 30 audible clicks per minute is approximately equivalent to 0.01 mR/hr.

(4) Wound Contamination. Wound contamination is generally not a serious clinical problem from the viewpoint of hindering the healing of the wound (requires 50 to 100 rad/day) or from causing acute necrosis (requires 200 or more rad/day). It is of concern because of the psychological effect on the individual, possible long-term effects from internal contamination, and the ability of the individual to clear a frisking station upon returning to work. The amount of activity in a wound is difficult to quantify because of the unusual geometry and because the tissue shields the betas. The following guidelines may be used to estimate the activity in a wound:

(a) DT-304 Probe. For 100 corrected counts on a DT-304 probe counting cobalt-60, 5 to 10 counts are from gamma interactions and 90 to 95 counts are from beta interactions. The amount of cobalt-60 in a wound may be estimated by: (1) Frisking the wound; (2) adding approximately 1 millimeter of plastic or equivalent (enough material to absorb the cobalt-60 betas) between the skin and the probe; and (3) frisking again, and comparing the results of the two frisks. If they are approximately (±10 percent) the same, then the activity is very likely in the wound, is localized to an area of 20 cm^2 or less, and may be estimated by using the above dose table for cobalt-60 giving activity as a function of instrument response. The activity must be divided by (0.05) to correct for the lower response of the probe to the cobalt-60 gamma photons, i.e., if the betas are shielded by tissue, 100 ccpm on the DT-304 corresponds to approximately 9,000 pCi(uuCi) of cobalt-60 under the area of the probe. If the two frisks are not the same, then some portion or all of the radioactivity is on the surface. However, this does not necessarily rule out activity being in the wound.

(b) PRM-5/SPA-3. A point source of 1,500 pCi(uuCi) produces 90 to 100 counts per minute above background at ½ inch from the face of the probe on a PRM-5/SPA-3 system on the HV1/PHA scale. The minimum detectable activity is approximately 1,500 pCi (uuCi).

(c) Gamma Scintillation Counting. The amount of cobalt-60 in a wound can most accurately be determined by gamma scintillation counting due to the finer resolution of the count rate. If the efficiency (counts/pCi(uuCi)) for the detector is known and the detector is shielded to limit the field of view of the probe to the area under the face of the probe, then an estimate of the activity in or on the wound may be made. This would have to be used in conjunction with a frisker to determine if the activity is on the surface (betas not shielded) or in the wound.

b. Therapy

(1) External Exposure and External Contamination. Therapeutic procedures for external exposures are the same as for external irradiation. For skin contamination, follow the treatment procedures for external contamination.

(2) Wound Contamination. Washing, probing with a magnet, and simple debridement may be performed to remove contamination from within a wound. Any more extensive procedure must be coordinated with BUMED.

DEPLETED URANIUM (DU)

1. Background. Natural uranium (U) is a silver-colored metal that is radioactive and nearly twice as dense as lead. Small amounts of uranium naturally occurring in soil, water, air, plants, and animals contribute to our natural background radiation. Natural uranium is made up of three radioisotopes: U-238 (>99%), U-235 (0.72%), and U-234 (0.005%). Enriched U-235 is used in nuclear weapons and as fuel in nuclear reactors. The enrichment process increases the percentage of U-235. One byproduct of the enrichment process is DU that contains a larger percentage of U-238 than natural uranium. DU retains uranium's natural toxicological properties and approximately half of its radiological activity. Because of its high density and strength, DU is used by the U.S. military in ammunition for armored shore vehicles, aircraft, and ships; as armored shielding for tanks; as counterweights in aircraft; and as radiation shielding in hospital nuclear medicine and radiation therapy clinics.

a. Health Risks. The health risks associated with using DU in the peacetime military are minimal because the DU is shielded and/or intact. This includes risks associated with transporting, storing, and handling intact DU munitions and armor. The majority of peacetime Navy and Marine Corps DU applications are regulated by the Nuclear Regulatory Commission, via Naval Radioactive Material Permits (See OPNAVINST 6470.3 and Marine Corps Order 5104.3).

b. Toxicity. During combat operations, there is a possibility of personnel casualties being contaminated with DU, as occurred during Operation Desert Storm. Additionally, foreign militaries now have access to DU munitions. If the integrity of DU materials is compromised, such as when munitions are fired or armor is pierced, uranium can then react with other elements contiguous to it in the environment. This can create chemical reactions that may yield compounds with various chemical toxicities. Toxicologically, DU poses a health risk when internalized. Radiologically, the radiation emitted by DU results in health risks from both external and internal exposures, however, the external exposure risk is very low.

2. Medical Priorities. DU is but one of many harmful substances encountered on the battlefield, such as lead, petroleum, radium, and tritium. The health risks from known or possible DU exposure should be addressed only after management of a patient's immediate medical needs. A patient contaminated with DU poses no special hazard to others, including health care providers. Normal attention to antiseptic and infection control procedures is adequate to protect medical personnel from DU intake. Marines and sailors can internalize other toxic substances in a combat environment that present greater health risks than DU, and these must not be neglected or downplayed because of internalized DU. Higher level risks than those posed by DU, including exposure to other more toxic substances and serious injuries and wounds, must receive higher patient care priority.

3. External Personnel Contamination. Naturally occurring uranium decays by alpha emission. However, the primary external hazards from DU are beta and gamma radiation. These radiations are generated by radioactive decay of trace levels of uranium daughter products. All U.S. DU weapon systems are shielded to control beta radiation. During combat, this shielding may be compromised. Consequently, hand-held radiation detectors that measure beta and gamma

radiation are the instruments of choice for detecting DU. Specifically, the AN/VDR-2 (used by the Marine Corps and Army) and the DT-304 probe, AN/PDR-27, or MFR (used by the Navy) are widely available for detection of DU. Enclosure (2) provides appropriate guidance on exposure assessment and decontamination procedures.

Note. Surface Dose Rate. Unshielded DU material, e.g., a spent DU ammunition round, in contact with the skin delivers a skin dose (beta and gamma) of approximately 200 mrem/hr. The current skin occupational exposure limit for beta/gamma radiation is 50,000 mrem/yr. One plausible way an individual could exceed this skin dose would be if a piece of DU metal were carried as a souvenir. Consequently, DU metal fragments and spent ammunition should be treated as low level radioactive waste and properly disposed of by radiation safety personnel.

4. Internal Personnel Contamination. The magnitude of toxicological and radiological health risks of internalized DU is dependent on the amount internalized, the chemical form, and the route of entry into the body. DU can be internalized through inhalation, ingestion, wound contamination, as in the case of embedded fragments, and injection. DU is a heavy metal, similar to lead, cadmium, nickel, cobalt, and tungsten in its toxicological effects. The solubility of DU-containing material in bodily fluids is the primary determinate of the rate at which the uranium moves from site of internalization (lung for inhalation, gastrointestinal tract for ingestion, or the injury site for wound contamination and injection) into the blood stream and then to the body organs. In most instances, solubility also determines how quickly the body eliminates uranium in urine or feces.

Comparison of the Relative Radiation Dose
per Unit Mass Internalized, for DU and Other Substances*

Isotope	Relative Radiation Dose
Depleted Uranium	1.0
Naturally Occurring Uranium	1.7
Ra-226 **	200,000.0
Am-241 **	30,000,000.0

* Table 6-1 (from U.S. Army Environmental Policy Institute Technical Report of 1995).
** Ra-226 illuminated instrument dials of Soviet tanks used by Iraq during Operation Desert Storm. Am-241 is used in many home smoke detectors.

a. Bioassay. The most common form of DU found on the battlefield is triuranium octaoxide (U_3O_8). This is a relatively insoluble heavy metal molecule. The target organs are the kidney, bone, and liver. The kidney is the most sensitive organ to DU toxicity. There are no approved methods to reduce the chemical toxicity of DU in the body. Immediate and follow-up assessment of DU levels can help medical personnel assess the potential for chemical toxicity and radiation exposure by estimating the fractions of insoluble and soluble DU. Because the body eliminates much of the soluble internalized DU within a few days, delays in sampling reduce the accuracy of the estimates. Internalized DU is assessed by a standard urine sample. Contact BUMED for guidance on collection, shipping, and obtaining results for DU urine bioassays.

b. DU Contamination. Regular wound cleaning procedures should be effective in managing DU wound contamination. However, the radiation detectors described in enclosure (8), paragraph 3, "External Personnel Contamination," may be useful in determining wound cleaning efficacy. Similarly, DU embedded fragments are removed through standard surgical procedures. As previously noted DU fragments should be treated as low level radioactive waste. DU ingestion is minimized by not eating, drinking, or smoking in DU contaminated areas. Externally contaminated personnel should be decontaminated as soon as practical to minimize the potential ingestion pathway.

c. Respiratory Protection. Since there are no approved methods for therapeutically treating DU inhalation, prevention by respiratory protection is critical. Studies of the dispersal of aerosol particles of uranium, after a DU round hits a hard target, demonstrate 60-90 percent of particles are less than 10 microns in size. Further studies demonstrate 90 percent of the airborne DU remains within 50 meters of a burning tank struck by DU rounds. Personnel accessing potential airborne DU areas should minimize exposure to skin and wear protective gas masks capable of removing micron sized particles.

IODINE

1. Background. Of the more than 20 radioactive isotopes of iodine, about half occur as fission products, and among these iodine-131 contributes an increasingly important portion of the total activity starting at several hours after fission. The dominant internal exposure after a reactor accident or nuclear weapons detonation or any event involving fresh fission products is likely to be from iodine-131.

a. Iodine-131 has a physical half-life of about 8 days and an effective half-life in humans of about 7.6 days. It decays by emitting four beta particles (Emax of 0.25 to 0.81 MeV; the predominant beta has an Emax of 0.61 MeV (87.2%)) and gamma rays of five energies (0.08 to 0.82 MeV; the predominant gamma having an energy of 0.36 MeV (79%)). Most of the iodine in accidents will be soluble and capable of being quickly absorbed via inhalation, ingestion, absorption through the skin or any combination of these. Inhaled iodine reaches equilibrium with body fluids in about ½ hour. The thyroid gland, located just above the supra-sternal notch (just below the "Adam's Apple"), concentrates iodine. The iodine concentration is highest about 48 hours after exposure. The percentage of radioiodine uptake in the thyroid gland 1 day after ingestion is similar for children and adults; however, the dose to the child's thyroid is larger due to the smaller size of the thyroid gland.

b. For those in the immediate area of a radiation accident or otherwise directly exposed to the radioactive plume, inhalation of radioiodines may be a significant contributor to individual and population radiation exposures.

c. Experience from a number of epidemiological studies as well as more recent experience from the Chernobyl reactor accident indicates that the thyroid of the fetus and child is quite sensitive to the induction of thyroid cancer following radiation exposure. Hence, pregnant women and children are the most at risk group for radioactive iodine uptake. Fortunately, therapeutic administration of stable iodine (e.g. potassium iodide, (KI)) can reduce or block the uptake of radioactive iodine in the thyroid of exposed individuals.

d. The use of KI is intended to supplement, not to replace, other protective measures. Sheltering or evacuating personnel from the affected area are considered the best methods for reducing exposure to radioactive iodine.

2. Dose Evaluation

a. One microcurie at peak concentration in the thyroid from an acute exposure will produce a dose to the thyroid of approximately 6.5 rad.

b. When a person has been exposed to radioiodine, the radioactivity may be estimated by monitoring the thyroid gland. Approximately 50 percent uptake will occur 6 hours after the exposure; approximately 90 percent of the peak uptake will occur after 24 hours. The maximum uptake and consequently the maximum readings will be observed about 48 hours after exposure.

The thyroid gland can be monitored for radioactivity by holding a beta-gamma or a sodium-iodide detector close to the suprasternal notch. Qualitative estimates of the thyroid dose may be performed with current field instruments.

(1) If a DT-304 probe is held between the "Adam's Apple" and suprasternal notch, then an estimate of radioactivity may be made using the following conversion:

500 counts per minute = 1 uCi ± 50 percent
Minimum detectable activity is approximately 0.2 uCi
(100 counts per minute is approximately = 1.3 rad)

(2) If an AN/PDR-27 or multifunction RADIAC probe is held between the "Adam's Apple" and suprasternal notch, then an estimate of radioactivity may be made using the following conversion:

0.8 mrem/hour = 1 uCi ± 50 percent
Minimum detectable activity is approximately 1 uCi
(1 mrem/hr is approximately = 8 rad)

(3) If a PRM-5/SPA-3, calibrated in the standard manner for cobalt-60, i.e., HV1 cobalt-60, HV2 cadmium-109, is held between the "Adam's Apple" and suprasternal notch then an estimate of radioactivity may be made using the following conversion:

190,000 counts HV2-Gross mode = 1 uCi ± 50 percent
Minimum detectable activity is approximately 0.07 uCi
(30,000 counts HV2-Gross mode is approximately = 1 rad)

(4) An estimate of the dose to the adult thyroid may be made based on the air concentration levels and time in the areas as follows:

Exposure time	Concentration uCi/cm^3 air	Dose
1 minute	1.5-7.5 x 10^{-4}	10 rad
10 minutes	1.5-7.5 x 10^{-5}	10 rad
100 minutes	1.5-7.5 x 10^{-6}	10 rad

For children, the dose would be approximately 20 rad. Predicted doses will vary from actual/ measured doses because thyroid uptake may vary from 5 to 20 percent from person to person. (Individuals with a high seafood, seaweed, or kelp diet may have a negligible uptake.)

(5) Quantitative measurements of the thyroid dose may be performed with a sodium-iodide crystal or germanium detector and pulse height analyzer calibrated with a phantom.

3. Potassium Iodide Use in Radiation Emergencies. In the event of an actual release of radioiodine to the environment, KI is provided for:

a. Emergency responders who may need to enter an area where there is a reasonable probability of inhalation of radioactive iodine, regardless of projected thyroid dose. Emergency responders should be administered one 130 mg dose of KI before entering the area.

b. All personnel on the installation who may exceed threshold thyroid dose levels listed in the table below.

c. Administration Protocol and Dosage. The Food and Drug Administration (FDA) has provided guidance on the use of KI as a thyroid blocking agent. The guidance includes information about dosage and projected radiation exposures at which such drugs should be used and is provided in the table below. This is available at: http://www.fda.gov/cder/guidance/4825fnl.htm.

Threshold Thyroid Radioactive Exposure and Recommended Daily Dose of KI for Different Risk Groups

	Predicted Thyroid Exposure (cGy)	KI dose (mg)	Number of 130 mg tablets	Number of 65 mg tablets
Adults over 40 yrs	≥500	130	1	2
Adults over 18 through 40 yrs	≥10	130	1	2
Pregnant or lactating women	≥5	130	1	2
Adolescents over 12 through 18 yrs	≥5	65	1/2	1
Children over 3 through 12 yrs	≥5	65	1/2	1
Over 1 month through 3 yrs	≥5	32	1/4	1/2
Birth through 1 month	≥5	16	1/8	1/4

Note: Adolescents approaching adult size (≥ 70 kg) should receive the full adult dose (130 mg). Absorbed Dose: 1 cGy = 1 rad.

(1) A daily oral dose of KI should be given until the risk of significant exposure to radioiodine no longer exists. For optimal protection against inhaled radioiodines, KI should be administered before or immediately coincident with passage of the suspected plume. Administration of KI will still have a substantial protective effect even if taken 3 or 4 hours after exposure. Administration of potassium iodide will be of some value even as long as 24 hours after intake of radioactive iodine. Prevention of thyroid uptake of ingested radioiodine, once the plume has passed and radiation protection measures (including KI) are in place, is best accomplished by food control measures and not by repeated administration of KI.

(2) The National Council on Radiation Protection and Measurements Report Number 55, Protection of the Thyroid Gland in the Event of Releases of Radioiodine [1977], recommends that the responsible physician for a nuclear facility be involved in the administration of KI for facility

emergency response personnel. In keeping with that recommendation, KI should be administered to emergency response personnel following the facility's local emergency response procedures. The facility's director of occupational medicine or other appropriate medical official must endorse the local procedures, and supervision by appropriate local medical authority should be exercised as necessary during the implementation of the procedure.

(3) Training and medical information on the use of KI should be provided to all personnel involved in the radiological emergency response plan.

(4) The person administering the KI must ask if the individual is allergic to iodine. Individuals intolerant of KI at protective doses, and neonates, pregnant and lactating women should be given priority with regard to other protective measures (i.e., sheltering, evacuation, and controls of the food supply). If not, KI may be issued. For emergency response personnel, the name, date of issue, and amount of KI issued to each individual must be recorded on an SF 600, Chronological Record of Medical Care. The SF 600 must be maintained in the individual's health care treatment record.

(5) Pregnant women should be given KI for their own protection and for that of the fetus. However, because of the risk of blocking fetal thyroid function with excess stable iodine, repeat dosing with KI of pregnant women should be avoided.

(6) When personnel are actually exposed to radioiodine, notify BUMED so a medical follow-up program can be recommended, based on the estimated dose to the thyroid.

4. Side Effects. Possible side effects include skin rashes, swelling of the salivary glands, and "iodism" (metallic taste, burning mouth and throat, sore teeth and gums, symptoms of a head cold, and sometimes stomach upset and diarrhea). A few people may have allergic reactions with more severe symptoms. These could be fever and joint pains, swelling of parts of the face and body, and at times severe shortness of breath requiring immediate medical attention. Manifestation of these side effects would be expected to be negligible under the dose regimen stated above. FDA maintains that KI is a safe and effective means by which to prevent radioiodine uptake by the thyroid gland, under certain specified conditions of use, and thereby obviate the risk of thyroid cancer in the event of a radiation emergency.

5. Inventory Management

a. Potassium iodide must be maintained under the control of the Medical Department. To enhance early access to KI, KI may be stored near likely issue points provided the locations are identified in the facility's local emergency response procedures. The KI can be obtained from the Defense Supply Center, Philadelphia (National Stock Number 6505-01-116-8198). This KI tablet has been approved by the FDA for use as a thyroid blocking agent and contains 130 mg of potassium iodide per tablet. Each bottle contains approximately 14 tablets, an amount sufficient for a 2-week period when administered at the rate of one tablet per day (cognizant medical authority will provide guidance on recommended dosage and duration of treatment as directed).

A package insert containing information for the patient comes with each bottle. Store the bottles at a controlled room temperature between 15° and 30° C (59° to 86° F), tightly closed, and protected from light.

b. For ships, the amount of KI tablets required to be maintained is defined in the Authorized Medical Material Allowance List (AMMAL) with additional guidance, where appropriate, from BUMED or Fleet Commanders. Shore-based commands should determine the amount of KI tablets to be maintained based upon the number of potential emergency response personnel and any additional guidelines outlined in this chapter or appropriate Naval Nuclear Propulsion Program (NAVSEA 08) directives.

c. Nominally, the expiration date for potassium iodide tablets is up to 5 years from date of manufacture. The actual expiration date will vary with differing manufacturer's lot numbers. Medical Department representatives should be aware of these dates and obtain replacement items prior to expiration of current inventory. If this cannot be accomplished, there is a procedure to obtain an extension of the expiration date of a given lot number through the Department of Defense/Food and Drug Administration Shelf Life Extension Program.

(1) Shelf Life Extension Program (SLEP). The SLEP is a key component of the Medical Readiness Strategic Plan (MRSP) developed by Department of Defense Health Affairs and the Military Medical Departments for conservation of military medical resources. SLEP defers replacement cost of military significant medical material by extending its useful life. Service specific guidance on Medical Chemical Defense Material (MCDM) is contained in reference (d).

(2) The FDA provides testing services to the SLEP for selected materials to determine whether the requirements have been met for extension of the expiration date. To be considered for testing in the SLEP, the quantity and dollar value of each product and lot number must meet certain minimum levels established by the board to justify the expense of the testing program.

(3) The SLEP internet site provides detailed information on the overall program as well as links to guidance documents, specific military service representatives, current status of items in the system, and a link to request addition of an item to the program. The Web site is http://www.usamma.army.mil/html/dodshelf.html.

(4) It is recommended that if a given lot number(s) of KI tablets is being submitted for consideration by the SLEP that this occur at least 12 months prior to the current expiration date of the item to allow sufficient time for a determination to be made by the board. BUMED should be consulted before submitting such a request to ensure that it is in compliance with current policy and directives.

(5) If the current expiration date will be, or has, been reached before a determination of shelf-life extension has been provided by the SLEP, do not issue this item. Procure sufficient quantities of non-expired tablets to cover the minimum number of emergency responders, as determined by appropriate program directives, until receipt of the SLEP approval (if granted). In the case of a true emergency, expired potassium iodide tablets may be issued to personnel

provided that they demonstrate no evidence of degradation (e.g., discoloration, fragmentation, irregular surfaces, adherence to vial or other tablets). BUMED should be notified, as soon as conditions allow, of this decision. If expired tablets are issued to personnel, this must be documented with all of the factors involved in making this decision adequately described.

PLUTONIUM

1. Chief Characteristics. Plutonium-239 (Pu-239) element number 94, has a physical half-life of 24,400 years, a biological half-life of 20 years for the liver, and 50 years for the bone. It emits two principal alpha rays [5.16 MeV (88 percent) and 5.11 MeV (11 percent)]. Pu-239 is the principal radioactive material of concern when considering radioactive contamination from nuclear weapon accidents. The lung, liver, and bone are the primary organs of concern for a plutonium exposure. The alpha radiation will not penetrate the dead outer layer of skin and therefore poses no external hazard. Removal of external alpha contamination is necessary to eliminate the potential for internal contamination via inhalation, ingestion, or breaks in the skin. Pu-239 contamination encountered in the Navy will most likely be in an insoluble form. Plutonium is not readily absorbed by ingestion. Exposures of most concern are by inhalation or contaminated wounds. The International Council on Radiation Protection states absorption of ingested plutonium is only 10-15 for oxides, 10-4 for nitrates, and 10-3 for other chemical forms.

2. Dose Evaluation

a. Internal Monitoring. Nasal and throat swabs should be monitored for alpha contamination after being dried. It is not necessary to collect nasal hair clippings. The presence of alpha contamination in any of these samples is an indication plutonium inhalation or ingestion may have occurred. The internal decontamination procedures in enclosure (4) should be initiated immediately if swab sample measurements exceed 50 cpm above background on an AN/PDR-56. If over 500 ccpm are detected on the nasal swab, the individual should be immediately transferred to a definitive care facility and consultation will be obtained to determine if Diethylenetriamine Pentaacetic acid therapy is appropriate. If internal alpha contamination is suspected, the patient may have to be transferred to a facility where residual internal alpha contamination levels can be measured. Consult with BUMED if uncertainty exists concerning the need to transfer a patient for internal monitoring. Insoluble plutonium contamination that has been swallowed can be monitored by bioassay of fecal samples. Lung contamination may be directly measured by the use of sophisticated gamma scintillation systems that can detect the low energy x-rays emitted. Plutonium levels in the body can be monitored over a long period by repeated urine, fecal, and whole body counting techniques.

b. Monitoring Guideline. The large probe of the AN/PDR-56 is calibrated so that 50 counts per minute above background measured l/16 to 1/8th inch above the surface is equivalent to 50 picocuries (micromicrocuries) or 0.01 ugm/m^2 of Pu-239 under the area of the probe, i.e., 17 cm^2. The small probe of the AN/PDR-56 is calibrated so that l count per minute above background measured l/16 to 1/8th inch above the surface is equivalent to 1 picocurie (micromicrocurie) under the area of the probe. The small probe is preferable for frisking the body because it is less bulky.

Note. If the photomultiplier tube is exposed to even a slight illumination while the small probe is being attached, approximately 2 hours should be allowed for the tube and phosphor to reach a stable quiescent state before normal operation can be expected.

c. Internal Contamination. An alpha particle of greater than 7.5 MeV is necessary to penetrate the outer layer of dead skin (horny layer). Since the energy of the plutonium alpha particle is only 5.15 MeV, the biological hazard from plutonium is strictly internal.

3. Decontamination. The portal of entry of plutonium into the body is the chief determinant of the course of the subsequent contamination and appropriate therapeutic efforts. Washing with waterless hand cleaner, water, detergents, and occasionally other agents easily manage plutonium contamination of intact skin. Wounds contaminated with plutonium should be decontaminated to the point where repeated swabs show no detectable alpha contamination when monitored with an AN/PDR-56. The swabs must be dried before counting. If after several decontamination attempts (up to three) swabs indicate contamination remains in the wound, simple wet debridement of the wound may be performed in an effort to remove the contamination. Consult with BUMED before additional surgical procedures are initiated.

RADIUM

1. Background. Radium, element 88, is a radioactive element occurring in each of the major series of natural radionuclides and transuranic elements. Radium-226, a member of the decay chain of uranium-238, has a physical half-life of 1,600 years. The most important daughter products of radium-226 are radon-222 (3.8 day physical half-life, alpha emitter, gaseous), bismuth-214 (20 minute physical half-life, alpha and gamma emitter), and lead-210 (22 year physical half-life, beta, and gamma emitter). After ingestion, about 30 percent of the radium-226 is absorbed. Most of that absorbed is excreted within a few days, 95 to 98 percent is eliminated in the feces and 2 to 5 percent in the urine. The remainder is deposited almost entirely in the skeleton. The effective half-life of radium is about 4.5 years for bone and 900 days for the whole body.

a. Dose Evaluation. Dose estimates may be made from radioanalysis of excreta (fecal or urine) or from radon breath samples. BUMED should be contacted for guidance and location where analysis may be performed. Based on ALI values for radium-226, classification W (clearance half times from 10 to 100 days), one microcurie of radium-226 results in a CDE to the bone surface of 25 rem committed effective dose equivalent (CEDE) = 0.75 rem, if ingested, or 8.3 rem if inhaled.

b. Therapy. Cumulative mean skeletal doses below 1,000 rad have not been associated with clinically significant radiobiological injury. Immediate stomach lavage with a 10 percent magnesium sulfate solution is recommended in patients who have just ingested significant quantities of radium, i.e., greater than 0.01 uCi. Daily saline purgatives with magnesium sulfate should follow this.

TRITIUM

1. Background. Tritium is the only radioactive isotope of hydrogen, (H). It decays to helium-3 by emitting a beta particle with a maximum energy of 0.018 MeV and an average energy of 0.0057 MeV. Its physical half-life is 12.3 years. Its biological and effective half-life is 12 days. Tritium exposures are comparable in their biological effect to whole body exposure to external x-ray or gamma radiation (see dose effect table on penetrating radiation). When it is incorporated in chemical compounds, the distribution and retention of the tritium in the body can be influenced markedly. As a gas, tritium is not significantly absorbed into the body and does not exchange significantly with the hydrogen in body compounds. In tritiated water (HTO) the tritium entering the lungs or gastrointestinal tract is completely absorbed, and is rapidly dispersed throughout the body.

a. Dose Evaluation. The seriousness of the radiation exposure may be judged by estimating the whole body dose and using the table for external exposure to penetrating radiation. Tritium is primarily of concern as an internal contaminant. Exposure is measured directly from tritium levels in urine or estimated based on air concentration and duration of exposure. If an exposure is suspected, the following actions should be taken:

(1) If exposure to tritium is suspected to have exceeded levels requiring internal monitoring by reference (b), then proceed to collect valid urine samples from the exposed individuals. If an individual has not emptied his or her urinary bladder completely since exposure, then he or she should void their urine completely and discard it.

(2) At least 4 hours after the suspected exposure collect urine samples for analysis from the exposed individuals. Prepare approximately a 100-milliliter aliquot from each urine sample collected. Preservatives are not required. Samples should also be collected from some known unexposed personnel to be used as normals or to establish background values.

(3) Liquid Scintillation Sample Analysis. Liquid scintillation counting for tritium may be performed at numerous hospitals, shipyards, weapons stations, or research facilities. If services cannot be acquired at those institutions, contact BUMED for assistance. If samples are to be shipped for analysis, the command address, designated point of contact for obtaining additional information and providing results, the time and duration of suspected exposure, and identifying information of most likely and least likely samples should be included with the samples. The following identifying information should be provided on each 100-milliliter aliquot to be shipped:

(a) Name.

(b) Social Security Number.

(c) Date and time after exposure urine was collected.

(4) For a single acute exposure, 1 microcurie/liter of tritium in urine at peak concentration is indicative of a TEDE of about 10 mrem in the average person, if no treatment is instituted. Doses from tritium exposures are comparable in their biological effect to whole body exposure to penetrating radiation.

b. Dose Estimate. The whole body CEDE can be estimated from tritium oxide air concentration levels and time in the area. Based upon the DAC and stochastic (5 rem) ALI limits for H-3 use: CEDE = (125 rem/DAC-hr) x air concentration (uCi/ml) x time (hr).

Note. Based on ALI values for tritium (H-3), one microcurie ingested or inhaled results in a CEDE of 6.25×10^{-5} rem.

c. Therapy. Increased fluid intake of 2 to 4 liters per day may be initiated under medical supervision. This will reduce the half time and the total dose to about 1/3 to 1/2 of the normal value. The half time may be determined by taking daily urine samples. Prolonged forced fluids may cause an electrolyte imbalance. Contact BUMED before initiating therapeutic procedures. Diuretics may be used when a physician supervises the therapy. One should bear in mind there could be harmful effects from therapy that is too aggressive for the clinical indications. Water imbalance can be dangerous and diuretics have other possible deleterious side effects. Thus diuretics should only be resorted to when the patient is expected to well exceed the yearly dose limit.

SHIPBOARD ITEMS FOR PERSONNEL DECONTAMINATION

A list of items to be carried aboard ship for personnel decontamination is provided below. Quantities are to be determined by the cognizant operational type commander.

- Porous tape
- Bar soap
- Waterless hand cleaner
- Soft scrub or "Lava" soap
- Specimen containers
- Aluminum hydroxide
- Magnesium sulfate or castor oil
- Potassium iodide tablets
- Cotton tip applicators
- Small magnetic probe
- Surgical brushes
- Laundry detergent
- Sterile water

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