# RI-45 RADIATION EMERGENCY NOTIFICATION AND RESPONSE

## PURPOSE

General instructions for responding to radiation emergencies are provided in the University's Radiation Control Manual. This procedure includes instructions for other types of emergencies.

## POLICY

The **CSU Police** are responsible for initial emergency response communication and coordination. The notification of appropriate response personnel and establishment of necessary communication links during emergencies are services provided by the organization in charge. This may be the CSU Police, the Poudre Fire Authority or personnel from Environmental Health Services. The RSO or designee will cooperate with the representatives to provide advice and technical support.

Depending upon the nature of the emergency, a command post will be established by the University Police or by the Poudre Valley Fire Department. Radiation Control Office and facility personnel shall check in with the command post, identify themselves, and provide technical advice to the emergency response personnel.

The **Radiation Safety Officer** (RSO) or an individual assigned by the RSO is responsible for providing technical guidance and assistance on all emergencies involving or potentially involving radition or radiation exposures. **The Radiation Control Office** must be notified promptly of all accidents or incidents involving radiation sources at CSU. Members of the technical staff of the Radiation Control Office (health physicists and radiation technicians) are required to know how to respond to emergencies and are authorized to act on behalf of the RSO during emergencies and provide the staff and facilities to deal with these emergencies.

Facilities or groups with unique radiation emergency response requirements shall maintain and use the detailed procedures applicable to their needs; some of these special procedures are attached to this procedure.

## REPORTING A RADIATION EMERGENCY

Rapid, concise communications are essential for an effective emergency response. Keep an emergency call list near the phone, with current numbers of individuals and organizations necessary to respond to any situation. For many emergencies, several organizations and individuals must be contacted rapidly. A reliable network is required to contact the necessary individuals and organizations and to relay information accurately.

**Radiation emergencies involving fire, explosion, building collapse, etc.** call the CSU Police, then notify the Radiation Control Office. **If a patient is contaminated with radioactive material, provide specific information on the extent of the contamination and the relative hazard, if known.** This information may be obtained from the Principal User or other knowledgeable persons. Ambulance personnel may require this information before transporting the patient.

**All radiation emergencies**

During normal office hours, **PROMPTLY NOTIFY the Radiation Control Office at 491-4835 or Environmental Health Services at 491-6745**. Unanswered calls, e.g. those received when RCO personnel are not in the office, are instructed to press 0 to be forwarded to the Environmental Health Services main telephone, who then notifies the appropriate individuals for specific facilities as contained in the attached Notification List.

At all other times, **notify the CSU Police Dispatcher, 911** (491-6425), who will then use a call list to contact Environmental Health Services emergency response personnel. For emergencies involving specific facilities, Environmental Health Services and/or the University Police dispatcher will notify appropriate resource persons.

**How and what to report**

When reporting a radiation emergency, **stay on the line** until you are sure that you provided all of the necessary information. Let the person you called end the conversation. Be sure to provide the following information:

1. Your name and phone number.
2. Location of emergency, i.e. building, specific rooms, etc.
3. Exact nature of the emergency; e.g. injuries, fire, spill, **radioactive materials involved.** etc.
4. Names of others already notified or tried but not reached.

## RADIATION EMERGENCY RESPONSE BY THE RADIATION CONTROL OFFICE PERSONNEL

Responsible users of radiation sources are responsible for clean up of spilled materials and for assuring that all individuals within their jurisdiction comply with monitoring and reporting requirements established by the RCO. RCO personnel will respond to any perceived emergency reported and requested by campus personnel. Authorized radiation users are trained to respond to minor spills and problems. Contact the RCO if exposure rates exceed 50 mR/hr and evacuate the area immediately.

## PREPAREDNESS

The most important factor that determines the adequacy and success of the response to an emergency is the preparedness of the responding individuals or organization. Although detailed procedures and specialized equipment are sometimes important, predetermined priorities and systematic thought processes are essential in all cases. Careful planning is often of greater importance than how specific jobs should be done, at least for individuals who are already technically competent. Clearly defined lines of responsibility and communications are key elements in any emergency response preparedness.

The first individual thus notified should ascertain the nature and extent of the emergency, the names of any other radiation safety personnel already notified and the need for additional assistance.

## COMMUNICATIONS

When a member of the Radiation Control Office receives an emergency call, whether in the office or elsewhere, the following actions are important:

1 Ask the caller to stay on the line until you are sure that you have all of the necessary information;

2 Write down all of the information you receive. It is better to take a little extra time to assure complete and accurate information than to overlook something through haste;

3 Information to request and record:

- Caller's phone number
- Name of caller
- Date and time of call
- Location of emergency, i.e. building, specific rooms, etc.
- Exact nature of the emergency; e.g. injuries, fire, spill, quantities of materials, etc.

- Names of others already notified or tried but not reached;

4. Determine how much additional help may be needed and before disconnecting, determine whether or not the caller will or should call additional individuals. Continue the calling effort until at least one health physicist or the RSO has been notified and instructions are given to cease. For each person contacted, record their name and the time contacted;

5. Make certain that other emergency response personnel are notified as indicated for each of the following major types of emergency situations:

**Fire, explosion, structure collapse:**
Dial 911 to notify the Fire Department and the CSU Police Department;

**Illness or injury:**
Dial 911 to call an ambulance; if the patient could be contaminated, notify the person on the other end of the phone of the contamination;

**Utility or equipment failure:**
Facilities Management, Ext. 1-6116;

**Chemical (other than radioactive) spills or releases:**
Environmental Health Services. Ext. 1-6745.

## RADIOLOGICAL CLASSIFICATION OF EMERGENCIES

Determining the proper response to an emergency requires that the type and magnitude of the emergency be determined as rapidly as possible. If in doubt, it is better to over-classify and over-respond than to under-classify and under-respond. Regardless of the nature of the emergency, radiation protection personnel must concentrate on the radiation aspects of the response and leave other concerns to the appropriate professionals, if possible.

A facility emergency is any event that involves the uncontrolled release or potential release of radioactive material into the air, water or ground to the extent that protective measures off-site might be required.

The **nature of radiation hazards** in an emergency may be any or all of the following:

External exposure to penetrating radiation;

External personal contamination, e.g. on skin, hair or clothing;

Internal personal contamination, e.g. injected through wounds, absorbed through the skin, inhaled or ingested;

Equipment or facility contamination;

Environmental release and contamination.

The **magnitude of radiation hazards** may be categorized as:

**Extremely serious**. Radiation doses of biological significance, large releases of radioactivity to the environment or accidents that cause major facility damage. Such events require immediate notification of the regulatory agency by telephone and fax.

**Serious.** Any radiation dose that exceeds the annual occupational dose limit, any significant releases of radioactivity to the environment or moderate facility damage. Such events require four-hour notification by telephone and fax (See Notifications to Regulatory Agencies").

## EMERGENCY EQUIPMENT

Emergency kits containing basic survey instruments, protective clothing, and supplies needed in emergencies are maintained at the Radiation Control Office (see attached emergency equipment list). The instruments include survey instruments for measuring exposure rates and for evaluating contamination. Other instruments may be required, depending on the type and intensity of radiation, and should be obtained from the Radiation Control Office. For evaluating contamination on personnel, these emergency instruments should be supplemented as soon as possible with a whole body count in the CSU whole body counter and/or an appropriate bioassay.

## RESPONSE GUIDELINES

The RSO (or Alternate RSO), if available, will normally be responsible for the radiological aspects. The individuals responsible for specific facilities are responsible for the overall response to, and recovery from, the emergency with oversight by the RSO or ARSO. The responsible individuals are listed in the attached List for Radiation Emergency Assistance and Notification.

During emergency situations, higher doses are allowed but limited. The attached Emergency Doses Allowed provides the limits for situations that may be encountered during an emergency response.

The priorities for response by the RSO and personnel of the Radiation Control Office are:

1. The person in charge of the radiation response to an emergency should avoid, if possible, becoming directly involved in performing rescues, giving first aid or containing radiation sources. Instead, his or her full attention should be devoted to assuring that all necessary actions are being carried out as efficiently as possible. Form RF-45A should be completed as soon as possible to assist the medical personnel at the hospital;
2. Personnel control and dosimetry should be assigned to one or more specific individuals. For this task, the response involves identifying and recording all individuals involved in the emergency, rendering first aid, surveying for personal contamination, decontaminating or containing clothing or personal articles, determining possible external exposures, collecting badges for special reading, releasing individuals that leave the area, etc. If injured persons are sent to the Emergency Room, be sure to attach a tag or note describing any contamination that may be present on skin or clothing. The most important equipment for this task will usually be a GM pancake survey instrument and a personnel decontamination kit containing detergent, waterless hand cleaner, plastic bags, coveralls, towels, tape, etc. Form RF-45B should be completed to assist the physician. Quick reference information is attached for questions about patient assessment and treatment;
3. Control of radiation sources and facility contamination is the second major response category. If enough help is available, this task should normally be assigned jointly to a radiation specialist and someone thoroughly familiar with the facility. The response includes controlling the event (fire, spill, etc.), determining the extent of any unconfined radioactive materials, determining any areas of high radiation exposure, controlling access to the area, etc. Since this task requires approaching or entering the emergency site, a personal dosimeter, appropriate protective clothing and, in some cases, respiratory protection should be worn. Be sure of adequate protection before proceeding. An appropriate survey instrument is the primary equipment for any type of radiation emergency. The facility and source conditions must be reported to the person in charge as quickly as possible.
4. Area and environmental sampling is the third major task to be assigned. The most urgent aspect of this task is to ascertain the likelihood of an airborne release and areas of high exposure, whether indoors, outdoors or both. This involves a determination of airflow and exhaust patterns from the location of potential release and the wind direction. If a significant release is possible, initiate an air sample at the most likely location of exposure or highest concentration. Be sure to record start time, airflow rate, location and relevant environmental conditions. This task also involves checking for possible surface contamination in likely locations outside the immediate emergency zone, e.g. walkways, vehicles, etc;
5. Documentation and reporting of all data collected and actions taken in an emergency are very important. Each individual involved in the response should

prepare and submit a written report covering his or her own activities. The report need not be lengthy or polished but it must be complete and factual. The RSO will determine to whom any comprehensive reports should be submitted and will prepare such reports.

**Personnel Emergencies**

Personnel emergencies include accidents or occurrences that involve actual or potential exposures to personnel reportable under the State Rules and Regulations Pertaining to Radiation Control. Such emergencies include radiation exposure and contamination of facility personnel although the operational status of the facility is not affected and no immediate safety action is required.

If an accident or incident involves injured or potentially contaminated individuals, the RSO shall evaluate such persons for contamination. Remove contaminated clothing, if possible, before sending an injured person for medical treatment. If the injury requires medical treatment, but involves no radioactive contamination, the injured person may be sent (or taken by ambulance) directly to the Emergency Room at the Hospital.

If an ambulance is required, telephoning 911 can obtain it most rapidly. Follow the steps outlined for RADIATION EMERGENCY RESPONSE FOR AMBULANCE PERSONNEL.

If radioactive contamination is present, confine the source of contamination to keep it from spreading and contaminating additional people. Remove contaminated clothing; remove contamination on skin and hair by normal washing, taking care not to spread the contamination. All facility personnel present during the emergency, and any other emergency personnel who responded, should not leave until they have been surveyed and found to be free of contamination.

Account for all personnel known or suspected to be in the area. The possibility for abnormal radiation exposures must be evaluated, and the appropriate emergency classification determined.

Define area boundaries for contamination control. Instruct University Police to set up control boundaries as required. If there is any potential impact on the general public due to security measures such as traffic control, non-University civil authorities are to be notified by University Police.

If radioactive material may have been released to the environment, or carried away as contamination on personnel or vehicles, make arrangements to collect and analyze samples as appropriate. Monitor all persons directly involved in the

emergency and the response personnel for contamination prior to their departure from the area.

The potential reasons that could require the evacuation of the building would be a bomb threat to the facility, a major fire or explosion, or the loss of a large quantity of radioactive material from an irradiator.

The RSO is responsible for determining whether or not a report is required. The RSO is also responsible for maintaining any records of radiation exposure to personnel and of release of radioactive materials to the environment. Facility personnel are responsible for maintaining all other records related to the emergency event.

**Fire Fighting**
Since fire fighters are likely to arrive at the facility before the RSO, they must be instructed on protective measures. Fire fighters entering the facility to respond to an actual or potential fire or explosion shall wear full protective gear and self-contained breathing apparatus until the absence of radioactive contamination is confirmed. In addition to any other reasons for protective clothing, this requirement is a precaution against contamination with radioactive material. Fire fighters shall also wear direct-reading radiation dosimeters provided by the RCO with their equipment.

**Emergency Condition Alerts**
Emergency condition alerts include situations recognized as potentially hazardous that could affect the operability of the irradiator or the safety of facility personnel. Civil disturbance, breach of security, or severe natural disasters are examples of conditions necessitating an emergency "Alert" classification.

If the emergency involves actual or potential
release of radioactive material and/or radiation exposure to non-facility personnel, the RSO in conjunction with facility personnel, shall determine the appropriate emergency classification. Notify other personnel as required by the emergency classification.

## RADIATION EMERGENCY NOTIFICATION LIST FOR UNIVERSITY POLICE DISPATCHER AND RADIATION CONTROL OFFICE PERSONNEL

This notification list is for the University Police Dispatcher and Radiation Control Office personnel in responding to radiation emergencies. Individuals with responsibilities for special facilities are also included in the notification list.

The RSO shall ensure that the notification list is kept up-to-date and provide the current version to affected individuals.

## PROCEDURE FOR NOTIFICATION

For any radiation emergency, the Dispatcher shall notify at least one RCO Designee from the Radiation Control Office list, starting at the top of the list. Pagers may be used at any time in summoning help.

For an emergency involving the Radiological Health Sciences Irradiators or the Biohazardous level 3 Laboratory at the foothills campus, at least one of the individuals listed for that facility should be contacted.

In the event of a release of radioactive material to the environment, Irradiator Facility and Radiation Safety personnel should request the University Police to contact off-campus agencies to help with security or radiation control measures.

The other individuals and organizations are listed for the convenience of Radiation Control Office personnel who may be required to report on the status of the emergency.

## NOTIFICATIONS TO REGULATORY AGENCIES

If there is any potential for radiation exposure, the RSO or representative shall notify city and state health departments, and the Nuclear Regulatory Commission, as required.

Notifications shall be made only by or with the concurrence of the RSO. The State of Colorado and CSU requirements for urgent notifications are in the attached Notification Criteria.

Short term effects of exposures of this matter may or may not be directly detectable. It is likely that exposures of this matter would be stochastic or long term.

# EMERGENCY EQUIPMENT LIST

**(Required)**

**Instruments –** Portable GM Pancake, Potable Thin Crystal NaI, Portable NaI for High Energy Gamma Photons, Portable Alpha Detector

**Absorbent** - Powder, Pads

**Barriers** - "CAUTION" Tape, Rope, Signs

**PPE –** Gloves (nitrile and latex large or extra large only), Lab Coat, Booties, Eye Wear, Respiratory Protection

**Markers –** Sharpies, Grease Pencils, Tape

**Clean-Up Supplies –** Brush (broom) and Dustpan, Detergent Solution, Scrub Pads, Towels

**Waste Containers** - Clear Plastic Bags of Assorted Sizes, Sealant for Bags

**Wipe Test Supplies** - Wipe Test Filters, Filter Envelopes, Wipe Test Forms, Markers for Containers and Forms

# LIST FOR RADIATION EMERGENCY ASSISTANCE & NOTIFICATION

**Ambulance, Fire Department, University Police 911**

**Radiation Control Office and Environmental Health Services 491-6745**

**EMERGENCIES AFTER HOURS, CSU Police 491-6425**

| | | | |
|---|---|---|---|
| **Radiation Control Office** | 491-4835 | **Vice Presidents in Charge of the RCO** | |
| Emergency Responder #1 | 229-8755 | Gerard Bomotti | 491-5257 |
| Emergency Responder #2 | 229-8758 | Tony Frank | 491-7194 |
| Radiation Safety Officer | 491-3736 | | |
| Alternate RSO | 491-3928 | | |
| RCO Technician | 491-4835 | | |
| **Radiological Health Sciences** | 491-5222 | **Regulatory Agencies** | |
| James Durham | 491-0563 | Colorado Department of Health | (303) 692-3030 |
| Chuck Sampier | 491-5359 | National Response Center | (800) 424-8802 |
| **Foothills Biohazardous Laboratory** | | | |
| Gerald Tews | 491-8625 | | |
| Bob Ellis | 491-6729 | | |

CSU EPA ID. No.: Main Campus COD069712792
CSU EPA ID. No.: Foothills Campus COT090011529

**NOTIFICATION CRITERIA FOR SINGLE EVENTS**

| Radiation Dose to Individual | Immediate Notice | 24 Hour Notice |
|---|---|---|
| Total Effective Dose Equivalent | ≥ 25 rem | ≥ 5 rem in a period of 24 hrs |
| Dose to the Eye | ≥ 75 rem | ≥ 15 rem in a period of 24 hrs |
| Shallow Dose to the Skin, Extremities or a Total Organ | ≥ 250 rad | ≥ 50 rem in a period of 24 hrs |
| | Any event that prevents immediate protective actions necessary to avoid exposures that could exceed regulatory limits or releases that could exceed regulatory limits (fires, explosions, gas release, etc.) | Any event where access is restricted for > 24 hrs |
| | | Any event that involves a quantity of material > 5 ALI |
| | | When access is restricted other than decay of material with a half-life < 24 hrs prior to decontamination. |
| | | Failure of equipment that is required to prevent a release or mitigate consequences of an accident where there is no redundant equipment. |
| | | Medical treatment at a medical facility for body or clothing contamination |
| | | Fire or explosion damaging licensed material, a device, container or equipment when > 5 ALI is involved and the integrity is compromised |

30 day notification is required for exceeding license and dose limits and for follow-ups on any 24 hour notification

| | Potential Intake from a Radioactivity Release | |
|---|---|---|
| If an Individual had been present for 24 hours | 5 ALI | ≥ 1 ALI in a period of 24 hrs |

**EMERGENCY DOSES ALLOWED**

| Emergency Situation | Allowable Dose Limit |
|---|---|
| For all activities | 5 rem |
| Protecting valuable property | 10 rem |
| Life saving activities | 25 rem |

# RF-45A RADIATION RESPONSE CHECK LIST

**At the Emergency Location:**

Who called for the ambulance? _____

Caller's phone #: _____

_____

Caller's Campus Location

Bldg:_____ Room: _____

_____

Name and Phone of Responsible User (posted on the laboratory door)

_____

Radioisotopes in use (posted on the laboratory door) ☐ Yes ☐ No ☐ Iodine

Physical form of spilled radioactive material ☐ Solid ☐ Liquid ☐ Gas

_____

Contact the person(s) listed on the laboratory door.

# RF-45B CHECKLIST FOR RSO

Note: This information is used to assist historical management of early radioactivity contamination. The best information source is the RSO or someone acting in his place.

When did the incident occur? What were the circumstances and what were the most likely pathways of exposure?

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Are toxic corrosive chemicals involved in addition to the radiation?

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If known, what radionuclide(s) presently contaminate the patient?

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What information is available about the chemistry of the compounds containing the radionuclides? Soluble insoluble? Any information about the particle size?

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What radioactivity measurements have been made at the site of the incident?

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What decontamination measures have been taken? How well did they work?

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Was the victim also exposed to penetrating radiation? If so, what has been learned from processing personal dosimeters? If not yet known, when is the information expected?

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Has clothing removed at the site of accident been saved in case the contamination still present on it is needed for analysis?

# QUICK REFERENCE INFORMATION

Note: The sequence and priority of these actions will vary with different accident conditions.

- Provide emergency medical care immediately for serious injuries and preserve vital functions. Minor injuries can wait until after initial radiation survey has been completed.
- Remove individual from contaminated radiation area. Individual doses of up to 100 rem may be permitted for life saving purposes or up to 25 rem for less urgent rescue (NCRP 1971). Teams may be used in relays to remove injured persons from very high radiation areas.
- Survey individuals for surface contamination
- Get nasal smears. Do this before showering.
- Remove contaminated clothes and replace them with a clean dry sheet or blanket. Take individual to a place where skin decontamination or showering can be completed.
- Decontaminate skin. Remove all transferable contamination if possible by cleaning contaminated skin areas and showering.
- Cover contaminated wounds with sterile dressings before and after decontamination efforts.
- Alert hospital and call for ambulance service as soon as it is determined that it is needed. Let them know the extent of the situation if their services are required.
- Identify radionuclide(s) involved in the accident and, if possible ascertain its chemical form, solubility, and presumed particle size.
- Send personnel dosimeters for processing.
- Get complete history of accident, especially as it relates to the activities of the individual. Where were they? What were they doing? Exit path? Symptoms?
- Evaluate the possibility of penetrating radiation exposure.
- Advise individual of collection of all excreta. Provide containers. Save other contaminated materials.
- Be sure that someone has assumed responsibility for management of the accident area. Is radiological assistance needed? Who will request it? From who?
- Report all initial information gathered to the incident director.
- Get names of supervisory and health physics personnel who will remain on call in case additional information is needed.
- Take individual to the hospital if their injuries require surgical care or if further medical or dosimetric care is needed.
- Take precautions to prevent spread of contamination during transport and movement of patient. Have transport vehicles, attendants, and equipment checked for residual contamination before release to medical facility.
- If environmental contamination has occurred outside of the University, notify public health authorities (Larimer County Department of Health and the Environment).
- Advise family and next of kin on the extent of the injuries and exposure. University personnel and medical department personnel should agree on the proper procedure.
- Find out where to send bioassay specimens and length of time required for analysis. Specify who will receive these results.

# QUICK REFERENCE INFORMATION: PATIENT ASSESSMENT AND TREATMENT

***White blood cell count (total and differential):***

A rapid fall or low value in absolute lymphocyte count within 48 hours is highly indicative of radiation injury.

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***50 % Response (ED 50) acute whole body dose***

Anemia: 60-130 REM

Nausea: 120-170 REM

Vomiting: 170-270 REM

Diarrhea: 240-300 REM

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***(ED-50) skin reactions from acute dose***

Erythema (1ST degree burn) 600 rad

Transepidermal injury ( 2nd degree burn) 2000 rad

Dermal necrosis (3rd degree burn) 6000 rad

Threshold for erythema & dry desquamate~300-500 rad appear after ~3 weeks

Most desquamation ~2000rad, blistering ~4weeks

Cell death in epidermal & dermal layers 5000 rad ~3weeks.

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***Potassium Iodine Information***

For exposures involving radioactive iodine:

Give 300 mg KI or 1 NaI tablet immediately. 5 or 6 drops of SSKI, Saturated Solution of Potassium Iodide. 1g/ml in a glass of water can also be used (NCRP 1977 #55).

For internal exposures, repeat dose of 300 mg KI, 1 NaI tablet, or 5-6 drops of SSKI for 7-14 days following exposure.

Daily dose of 130 mg of KI (adult) for blockage from anticipated radiation dose, 65 mg/day for children under 1 year of age.

Early myxedema (hypothyroidism) is seen when in excess of 150 mCi/g of thyroid.

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***P32 exposure and control***

Immediately perform gastric lavage with potassium permaganate. (1:5000) or 3% hydrogen peroxide.

Copper Sulfate can be used at a dose of 0.25g in a glass.

Mineral oil (100ml) prevents absorption and hastens elimination. Can be repeated in 2 hours.

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***Technetium exposure and control***

30% excreted in the first 24 hrs.

Does not pose serious health problem.

Administering 5mg potassium perchlorate can block anticipated uptake.

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***Tritium exposure and control***

Collect urine sample immediately and analyze.

1mCi/l is approximately equal to 10 mrem.

Force fluids, 3-4 liters/day and measure tritium in urine.

# EMERGENCY TREATMENT FOR SELECTED ELEMENTS

The benefits of drug therapy recommendations will be influenced by the route of exposure, inhalation, ingestion, injection, or skin absorption. The chemical form and solubility of the radionuclide will also change notably the applicability of the suggested treatment. This table lists therapeutic treatment or drug therapy that may be helpful for the listed element in favorable circumstances.

| Element | Immediate Actions | Drugs to Consider | Information and Comment |
|---|---|---|---|
| Americium (Am) | DTPA | DTPA | Chelation should be started as soon as treatment decision can be made. CaEDTA can be used if CaDTPA is not immediately available. |
| Arsenic (As) | Consider lavage | Dimercaprol | Short lived isotopes. Use of dimercaprol is not indicated except in massive exposures. |
| Barium (Ba) | Consider lavage and purgatives | See Comment | Use of sodium or magnesium sulfate with and after stomach lavage will precipitate insoluble barium sulfate. |
| Calcium (Ca) | Consider lavage Purgatives and Calcium | Calcium and Furosemide | Massive exposure may warrant the use of the sodium salt of EDTA, but with caution over a 3-4 hour period to avoid tetany. Furosemide enhances urinary excretion. |
| Californium (Cf) | DTPA, Consider lavage and Purgatives | DTPA | Chelation should start as soon as treatment decision is made. CaEDTA may be used if CaDTPA is not immediately available. |
| Carbon (C) | | No Treatment available | Soft beta rays of $^{14}C$ not detected by survey instruments; collect samples and smears for special low-energy beta counting in laboratory. |
| Cerium (Ce) | DTPA, Consider lavage and Purgatives | DTPA | Chelation should start as soon as treatment decision is made. CaEDTA may be used if CaDTPA is not immediately available. |
| Cesium (Cs) | Prussian Blue, consider lavage and purgatives | Prussian Blue | Ion exchange resins should be as effective as Prussian Blue, but have not been used in humans. |
| Chromium (Cr) | Consider lavage and purgatives | No treatment For anionic Forms. DTPA Or DFOA for Cations. | Antacids are contraindicated. Absorbents (such as charcoal or $MgO_2$) may reduce intestinal tract absorption. |

| Element | Immediate Actions | Drugs to Consider | Information and Comment |
|---|---|---|---|
| Cobalt (Co) | Consider lavage and purgatives | See comment | Penicillamine may be considered for therapeutic trial in large exposures. |
| Curium (Cm) | DTPA consider lavage and purgatives | DTPA | Chelation should start as soon as treatment decision is made. Ca EDTA may be used if CaDTPA is not immediately available. |
| Europium (Eu) | Consider lavage and purgatives | DTPA | |
| Fission Products (Mixed) | Consider lavage and purgatives | Depends on major isotope(s) in mixture, which varies with age of the isotope mixture. | Gamma ray spectroscopy of plant air or swipe samples may identify prominent radionuclide(s) in mixture to determine definitive therapy. Check also for possible alpha emmiters. Most important nuclides may be iodine, cesium , cerium, and strontium. |
| Flourine (F) | Aluminum hydroxide gel | See comment | Very short half -life. Oral aluminum hydroxide gel will reduce adsorption from gastrointestinal tract. |
| Gallium (Ga) | See comment | See comment | Short half life. Penicillamine can be considered for therapeutic trial. |
| Gold (Au) | | Dimmercaprol and Penicillamine are possible therapeutic agents. | No known therapy for gold in colloidal form. |
| Hydrogen (H) | | | See Tritium |
| Indium (In) | | DTPA | Pharmaceutical from of indium is chelated already. |
| Iodine (I) | KI, consider lavage | KI | Success of stable iodine depends on early administration. |
| Iron (Fe) | Consider lavage and phytates | DFOA | GI absorption reducers include phytates, egg yolk, or adsorbents. Oral penicillamine also chelates iron. |
| Lanthanum (La) | Consider lavage and purgatives | DTPA | CaEDT may be used if CaDTPA is not immediately available. |
| Lead (Pb) | Consider lavage | EDTA | Dimercaprol and penicillamine are less satisfactory alternative drugs. |
| Mercury (Hg) | Consider lavage | Penicillamine | Dimercaprol may be considered for alternative therapy. Gastric lavage with egg white solution or 5 percent sodium formaldehye sulfoxide; if unavailable, ,use a 2-5% solution of sodium bicarbonate. |
| Neptunium (Np) | | See comment | DTPA may not be effective, but no other drugs are available. |

| Element | Immediate Actions | Drugs to Consider | Information and Comment |
|---|---|---|---|
| Phosphorous (P) | Consider lavage and aluminum hydroxide | Phosphates | Severe overdose may be treated with parathyroid extract IM in addition to oral phosphates. |
| Plutonium (Pu) | DTPA | DTPA | CaEDTA may be used if CaDTPA is not immediately available, but is less effective. Chelation should be started as soon as treatment decision can be made. Desferrioxamine may be used initially if DTPA is not available. |
| Polonium (Po) | Consider lavage and purgatives | Dimercaprol | Consider toxicity of dimercaprol before using in cases of low-level exposure. Penicilamine is an alternative treatment. |
| Potassium (K) | Consider purgatives, diuretics, aluminum hydroxide | Diuretics | Use aluminum hydroxide antacids first to reduce GI tract adsorption. Use oral liquid potassium supplements for dilution. |
| Promethium (Pm) | DTPA consider Lavage and purgatives | DTPA | Chelation should be started as soon as treatment decision is made. |
| Radium (Ra) | Magnesium sulfate, consider lavage and purgatives | See comment | Use 10% magnesium sulfate solution for gastric lavage and saline as a cathartic. Oral sulfates reduce intestinal absorption. No effective therapy after absorption. Ammonium chloride and calcium may increase urinary excretion slightly. Other agents that have shown little success include thyroid extract, parathyroid extract, and IV ACTH. Aliginates are useful to reduce gastrointestinal absorption. |
| Rubidium (Ru) | Prussian blue | Prussian blue | Chemical properties are similar to potassium, but efficacy of similar treatments is unknown. |
| Rutherium Ru) | Consider lavage and purgatives | See comment | Chlorthalidone causes enhanced urinary excretion. DTPA has variable effectiveness. |
| Scandium (Sc) | Consider lavage and purgatives | DTPA | EDTA may be used in place of DTPA. |
| Silver (Ag) | | | Short effective half life. NO therapy. |
| Sodium (Na) | Consider lavage | Diuretic | Isotopic dilution ( 1 liter I.V. – 0.9% NaCl) by I.V. route followed by furosemide or other diuretic agents. |

| Element | Immediate Actions | Drugs to Consider | Information and Comment |
|---|---|---|---|
| Strontium (Sr) | Aluminum phosphate magnesium sulfate or alginates are alternatives. Consider lavage. | Strontium or Calcium I.V. and Ammonium chloride | Corticosteroid may be considered, but adverse reactions should be balanced against probable limited effectiveness. |
| Sulfur (S) | Consider lavage and purgatives | No therapy known | Soft beta energy of $^{35}S$ not detectable with conventional survey instrument. A thin window survey instrument may be used or obtain smears or samples for special low-energy beta counting in laboratory. |
| Technetium (Tc) | | | Potassium perchlorate has been used effectively to reduce thyroid dose. |
| Thorium (Th) | | DTPA or DFOA useful for soluble compounds | Treatment not effecative for thorotrast (ThO2). |
| Tritium ($^{3}H$) | Forced water | Forced water | Soft beta energy of $^{3}H$ not detectable with conventional survey instrument, require samples for special low-energy beta counts in laboratory. |
| Uranium (U) | DTPA | | DTPA must be given within 4 hours to be effective. Sodium bicarbonate protects kidney from damage. |
| Yttrium (Y) | | DTPA | CaEDTA may be used if CaDTPA is not immediately available. |
| Zinc (Zn) | Consider lavage Phytates may reduce intestinal uptake. | DTPA | Zinc sulfate may be used as a diluting agent if CaDTPA is not immediately available. CaEDTA may be used if CaDTPA is not immediately available. Penicillamine is a second alternative for DTPA. |
| Zirconium (Zr) -Niobium (Nb) | Consider lavage | DTPA | CaEDTA may be used if CaDTPA is not immediately available. |

# QUICK REFERENCE INFORMATION

| (1) Nuclide | (2) Radiation | (3) Rhm per curie | (4) Measurement Methods | | (5) Half-life | | (6) MPBB µCi | (7) Critical Organ[a] | (8) Dose (rem/µCi in organ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Critical Organ | | Lung (Inhalation) | |
| | | | External | Internal | Physical | Effective | | | 13 week | 50 yr | 13 week | 50 yr |
| Americium-241 | Alpha, gamma | 0.01 | A, BG, (SP), S | IVC, F, NS, U | 458 yr | 139 yr | 0.05 | Bone | 190 | 30,000 | 250 | 2,100 |
| Americium-243 | Alpha, gamma, D | 0.02 | A, BG, (SP), S | IVC, F, NS, U | 7,950yr | 195yr | 0.05 | Bone | 180 | 30,000 | 240 | 2,000 |
| Arsenic-74 | Beta, gamma | 0.42 | BG, S | BC, NS | 18d | 17d | | Total body | 0.009 | 0.01 | 0.36 | 0.36 |
| Arsenic-77 | Beta, gamma, D | 0.006 | BG, S | BC, NS | 39h | 24h | | Total body | 0.0004 | 0.0004 | 0.028 | 0.028 |
| Barium-140 | Beta, gamma, D | 0.14 | BG, S | BC, NS, U | 13d | 11d | | Bone | 0.049 | 0.49 | 1.3 | 1.3 |
| Cadmium-109 | Gamma, D | 0 | BG (S), S | F, U | 453d | 140d | 20 | Liver | 0.19 | 0.53 | 0.36 | 1.5 |
| Calcium-45 | Beta | | BG, S | U | 165d | 162d | 30 | Bone | 0.24 | 0.74 | 0.20 | 0.24 |
| Calcium-47 | Beta, gamma, D | 0.54 | BG, S | BC, NS, U | 4.5d | 4.5d | | Bone | 0.12 | 0.12 | 0.25 | 0.25 |
| Californium-252 | Gamma, alpha, neutron, D | | A, BG, S | BC, NS,U | 2.6yr | 2.2yr | 0.01 | Bone | 710 | 11,000 | 890 | 5,100 |
| Carbon-14 | Beta | | S (LS), BG (SP) | U, F, $B(CO_2)$ | 5,730yr | 12d | | Total body | 0.0006 | 0.0006 | 0.14 | 0.20 |
| Cerium-141 | Beta, gamma, D | 0.033 | BG, S | BC, F, NS, U | 32d | 30d | | Liver | 0.29 | 0.23 | 0.36 | 0.41 |
| Cerium-144 | Beta, gamma, D | 0.008 | BG, S | BC, F, NS, U | 284d | 280d | 5 | Bone | 3.7 | 16 | 5.1 | 17 |
| Cesium-137 | Beta, gamma, D | 0.32 | BG, S | BC, F, NS, U | 30yr | 70d | | Total body | 0.03 | 0.04 | 1.1 | 1.5 |
| Chromium-51 | Gamma | 0.018 | BG, S | BC, F, U | 28d | 27d | | Total body | 0.0006 | 0.0007 | 0.025 | 0.027 |
| Cobalt-57 | Gamma | 0.093 | BG, S | BC, F, U | 270d | 9d | | Total body | 0.0009 | 0.0009 | 0.13 | 0.16 |

| (1) Nuclide | (2) Radiation | (3) Rhm per curie | (4) Measurement Methods | | (5) Half-life | | (6) MPBB µCi | (7) Critical Organ[a] | (8) Dose (rem/µCi in organ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Critical Organ | | Lung (Inhalation) | |
| | | | External | Internal | Physical | Effective | | | 13 week | 50 yr | 13 week | 50 yr |
| Cobalt-58 | Beta, gamma | 0.54 | BG, S | BC, F, U | 71d | 8d | | Total body | 0.005 | 0.005 | 0.55 | 0.62 |
| Cobalt-60 | Beta, gamma | 1.3 | BG, S | BC, F, U | 5.3yr | 10d | | Total body | 0.015 | 0.015 | 1.9 | 2.6 |
| Curium-242 | Alpha, neutron, gamma | | A, BG, S | BC, F, U | 163d | 155d | 0.05 | Liver | 180 | 540 | 230 | 580 |
| Curium-243 | Alpha, gamma | 0.041 | A, BG, S | BC, F, U | 32yr | 27.5d | 0.09 | Liver | 160 | 15,000 | 260 | 2,100 |
| Curium-244 | Alpha, neutron, gamma | | A, BG, S | BC, F, U | 17.6yr | 16.7yr | 0.1 | Liver | 160 | 11,000 | 260 | 2,100 |
| Europium-152 | Beta, gamma, D | 0.53 | BG, S | BC, F, U | 13yr | 3yr | 20 | Kidney | 3.8 | 69 | 1.4 | 11 |
| Europium-154 | Beta, gamma | 0.63 | BG, S | BC, F, U | 16yr | 3yr | 5 | Bone | 1.8 | 34 | 3.7 | 29 |
| Europium-155 | Beta, gamma | 0.021 | BG, S | BC, F, U | 2yr | 1.3yr | 70 | Kidney | 1.2 | 9.3 | 0.4 | 1.9 |
| Fission products | Beta, gamma | | BG, S | BC, F, NS, U | | | | | | | | |
| Fluorine-18 | Beta, gamma | 0.56 | BG, S | BC | 2hr | 2hr | | Total body | 0.00007 | 0.00007 | 0.003 | 0.003 |
| Gallium-72 | Beta, gamma | 1.16 | BG, S | BC | 14hr | 12hr | | Liver | 0.024 | 0.024 | 0.047 | 0.047 |
| Gold-198 | Beta, gamma | 0.23 | BG, S | BC, F, U | 2.7d | 2.6d | | Total body | 0.001 | 0.001 | 0.087 | 0.087 |
| Hydrogen-3 (Tritium) | Beta | | BG, (SP), S (LS) | U | 12yr | 12d | | Total body | 0.0002 | 0.002 | | |
| Indium-114m | Beta, gamma, D | 0.042 | BG, S | BC | 49d | 27d | | Kidney, Spleen | 5.6 | 6.2 | 1.6 | 1.7 |
| Iodine-125 | Beta, gamma | 0.07 | BG, S | BC, IVC, U | 60d | 42d | | Thyroid | 4.2 | 5.4 | | |
| Iodine-131 | Beta, gamma, D | 0.21 | BG, S | BC, IVC, U | 8d | 8d | | Thyroid | 6.5 | 6.5 | | |
| Iron-55 | Gamma | | BG, S | F | 2.6yr | 1yr | 1000 | Spleen | 0.19 | 1.2 | 0.016 | 0.023 |
| Iron-59 | Beta, gamma | 0.063 | BG, S | BC, F | 46d | 42d | | Spleen | 5.5 | 7.0 | 0.69 | 0.74 |

| (1) Nuclide | (2) Radiation | (3) Rhm per curie | (4) Measurement Methods | | (5) Half-life | | (6) MPBB µCi | (7) Critical Organ[a] | (8) Dose (rem/µCi in organ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Critical Organ | | Lung (Inhalation) | |
| | | | External | Internal | Physical | Effective | | | 13 week | 50 yr | 13 week | 50 yr |
| Lead-210 | Beta, gamma, D | 0.002 | BG, S | F, U, IVC | 20yr | 1.3yr | 0.4 | Kidney | 150 | 1,200 | 66 | 92 |
| Mercury-197 | Gamma | 0.037 | BG, S | BC, U | 2.7d | 2.3d | | Kidney | 0.022 | 0.022 | 0.009 | 0.009 |
| Mercury-203 | Gamma, beta | 0.013 | BG, S | BC, U | 46d | 11d | | Kidney | 0.30 | 0.30 | 0.30 | 0.31 |
| Molybdenum-99 | Beta, gamma, D | 0.076 | BG, S | BC, NS, F, U | 2.8d | 1.5d | | Kidney | 0.17 | 0.17 | 0.094 | 0.094 |
| Neptunium-237 | Alpha, gamma, D | 0.017 | A, BG, S | BC, U | 2 x $10^6$yr | 200yr | 0.06 | Bone | 170 | 28,000 | 220 | 1800 |
| Neptunium-239 | Gamma, beta | 0.05 | A, BG, S | BC, U | 2.3d | 2.3d | | GI (LLI) | 0.023 | 0.023 | 0.027 | 0.027 |
| Phosphorous-32 | Beta | | BG, S | BC, U | 14d | 14d | | Bone | 0.10 | 0.10 | 0.56 | 0.56 |
| Plutonium-238 | Alpha, gamma | 0.001 | A, BG (SP) | IVC, F, NS, U | 88yr | 63yr | 0.04 | Bone | 190 | 26,000 | 250 | 2,100 |
| Plutonium-239 | Alpha, gamma | <0.001 | A, BG (SP) | IVC, F, NS, U | 2.4 x $10^4$yr | 197yr | 0.04 | Bone | 180 | 30,000 | 230 | 2,000 |
| Polonium-210 | Alpha | <0.001 | A | F, U | 138d | 46d | | Spleen | 880 | 1,100 | 120 | 150 |
| Potassium-42 | Beta, gamma | 0.14 | BG, S | BC, U | 12h | 12h | | Total body | 0.00 | 0.00 | 0.056 | 0.056 |
| Promethium-147 | Beta | | BG, S | F, U, NS | 2.6yr | 1.6yr | 60 | Bone | 0.22 | 2.2 | 0.29 | 1.7 |
| Promethium-149 | Beta, gamma | 0.004 | BG, S | F, U, BC NS | 2.2yr | 2.2d | | Bone | 0.044 | 0.044 | 0.071 | 0.071 |
| Radium-224 | Alpha, gamma, D | | A, BG | BC | 3.6d | 3.6d | | Bone | 11 | 11 | 70 | 70 |
| Radium-226 | Alpha, gamma, D | 0.825 | A, BG, S | BC, B | 1,600yr | 44yr | 0.1 | Bone | 73 | 10,000 | 290 | 410 |
| Rubidium-86 | Beta, gamma | 0.05 | BG | BC, F, U | 19d | 13.2d | | Total body | 0.009 | 0.009 | 0.66 | 0.66 |
| Ruthenium-106 | Beta, D | 0.11 | BG | BC, F, U | 368d | 2.5d | | Kidney | 0.80 | 0.80 | 5.6 | 22 |
| Scandium-46 | Beta, gamma | 1.1 | BG | BC, F, U | 84d | 40d | | Liver | 0.64 | 0.70 | 1.3 | 1.5 |
| Silver-110m | Beta, gamma, D | 1.4 | BG | BC, U | 255d | 5d | | Total body | 0.008 | 0.008 | 3.3 | 0 |

| (1) Nuclide | (2) Radiation | (3) Rhm per curie | (4) Measurement Methods | | (5) Half-life | | (6) MPBB µCi | (7) Critical Organ[a] | (8) Dose (rem/µCi in organ) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Critical Organ | | Lung (Inhalation) | |
| | | | External | Internal | Physical | Effective | | | 13 week | 50 yr | 13 week | 50 yr |
| Sodium-22 | Beta, gamma | 1.2 | BG | BC, U | 950d | 11d | | Total body | 0.018 | 0.018 | 0.0012 | 0.0012 |
| Sodium-24 | Beta, gamma | 1.8 | BG, S | BC, U | 15h | 14h | | Total body | 0.0017 | 0.0017 | 0.0023 | 0.0023 |
| Strontium-85 | Gamma | 0.3 | BG, S | BC, U, F | 65d | 65d | | Total body | 0.014 | 0.022 | 0.30 | 0.33 |
| Strontium-90 | Beta, D | | BG, S | U, IVC, F | 28yr | 15yr | 2 | Bone | 3.6 | 320 | 2.9 | 4.1 |
| Sulfer-35 | Beta | | BG (SP), S (LS) | F, U | 88d | 44d | | Testis | 22 | 40 | 0.00008 | 0.00008 |
| Technetium-99m | Gamma | 0.059 | BG, S | BC, NS, U | 6h | 5h | | Total body | 0.00001 | 0.00001 | 0.00064 | 0.00064 |
| Technetium-99 | Beta | | BG, S | U | $2 \times 10^5$yr | 20d | | Kidney | 0.12 | 0.13 | 0.09 | 0.13 |
| Thorium-230 | Alpha, gamma | | A, BG, S | BC, IVC, F, U | $8 \times 10^4$yr | 200yr | 0.05 | Bone | 160 | 29,000 | 210 | 1,800 |
| Thorium-232 | Alpha, gamma, D | | A, BG, S | BC, IVC, F, U | $1.4 \times 10^{10}$yr | 200yr | 0.04 | Bone | 180 | 33,000 | 210 | 1,800 |
| Thorium natural | Alpha, beta, gamma | | A, BG, S | BC, IVC, F, U | | 200yr | 0.01 | Bone | 180 | 33,000 | 200 | 1,700 |
| Tritium (see Hydrogen-3) | | | | | | | | | | | | |
| Uranium-235 | Alpha, gamma, D | | A, BG | BC, IVC, U | $7.1 \times 10^8$yr | 15d | | Kidney | 170 | 170 | 200 | 1,700 |
| Uranium-238 | Alpha, gamma, D | | A, BG | BC, IVC, U | $4.5 \times 10^9$yr | 15d | | Kidney | 160 | 160 | 190 | 1,600 |
| Uranium-Natural | Alpha, gamma, beta | | A, BG | BC, IVC, U | $4.5 \times 10^9$yr | 15d | | Kidney | 170 | 170 | 200 | 1,700 |
| Yttrium-90 | Beta | | B, SG | U | 64h | 64h | | Bone | 0.12 | 0.12 | 0.17 | 0.17 |
| Zinc-65 | Beta (+), gamma | 0.3 | BG, S | BC, U | 245d | 194d | 60 | Total body | 0.018 | 0.066 | 0.36 | 0.46 |
| Zirconium-95 | Beta, gamma, D | 0.4 | BG, S | BC, U | 66d | 56d | | Total body | 0.003 | 0.003 | 0.97 | 1.09 |

# COLUMN EXPLANATIONS FOR PREVIOUS TABLE

Column (1) *Nuclide* - The name of the element and the atomic mass of the particular isotope are listed alphabetically by element.

Column (2) Radiations - The primary radiations are listed. For simplicity, some liberties have been taken in listing the radiations.

*Beta* refers to both positron and electron emissions.

*Gamma* includes conversion x-ray emissions as well as gamma rays. The letter D refers to the possible presence of daughters with a half-life of less than 25 years. The radiations of the daughters are not included in the listing.

Column (3) *Rhm per Ci* - Roentgens per hour at 1 meter from 1 curie. These values are only approximate. A dash in the column indicates that the number was not evaluated because daughter radiations contribute appreciably to the gamma dose rate; because of an uncertain or complex decay scheme; or because the isotope emits no appreciable gamma radiation, as in the case of pure beta emiters.

Column (4) *Measurement methods* - The following symbols are used to indicate principal techniques for measuring external contamination or indicating internal exposure. The order of the symbols has no significance in the listing.

*External:* A - Alpha counting techniques.

BG - Beta Gamma counting and detection techniques. Start all monitoring with detector unshielded.

BG (SP) - Special attention necessary to select appropriate low-energy monitoring techniques.

S - Smear or swipe sample counted in laboratory.

S (LS) - Liquid scintillation counting of samples.

*Internal:* BC - Whole body count (standard gamma detection methods), including nuclear medicine counters.

F - Feces sample analyses.

IVC - Special in vivo counting techniques useful for low-energy counting, e.g., wound–monitoring, thyroid counting, or special low energy detectors for chest counts, e.g., plutonium or americium counting.

NS - Nose swipe counted in laboratory if inhalation suspected.

U - Urine sample analyses.

B - Breath analyses for gases.

Column (5) *Half-Life* - The radioactive and the effective half-lives are taken from ICRP (1960), except for the transuranic elements which were taken from ICRP (1972).

Column (6) *MPBB* - The maximum permissible body burden (MPBB) is listed for those radioisotopes with effective half-lives in excess of 120 days. For isotopes with shorter effective half-lives, the estimated dose to the critical organ is more meaningful for emergency decisions (see column 8). The MPBB is based on a life-time continued exposure under conditions in which an equilibrium is established, or at least approached between intake and elimination. It should not be used in the sense implied in this table for a single exposure situation.

Column (7) *CriticalOrgan* - The organ that receives the highest dose or has the most significant biological effect. Only one organ has been listed for each radioactive isotope. This is an artificial representation since different chemical forms and modes of exposure will determine the critical organ; this table is intended to give only a limited presentation on one principal organ at risk until more complete information can be obtained.

Column (8) *Dose* - An approximate dose equivalent in rem is calculated for 1microcurie of the radionuclide in the *critical organ* (Column 7) or lung, in the case of inhalation, after 13 weeks and 50 years residence time in that organ. These are approximate values to assist in rapid dose estimates if body (or organ) burden can be estimated. They are not definitive dose determinations particularly since they do not take into account the radionuclide distribution in the total body to the listed critical organ. Thus the physiological chemistry and solubility of the material involved in an actual exposure is not taken into account in this table. The curie for isotopes with radioactive daughters is defined as $3.7 \times 10^{10}$ disintegrations per second of the parent

only. Thus a curie of natural uranium includes only the activity of the $^{238}U$ parent and not the activity of the daughters such as $^{234}U$.