Appendix E. Example Potential Intake Responses

This appendix describes some example responses to potential intakes. It focuses on bioassay measurements, their capability and application to the dose assessment process, and action levels for consideration of dose reduction therapy. It is not intended that these examples be considered comprehensive or absolute. They are provided as examples of the kind and quality of dose estimates that can be made based on data available at various times following an intake. The exposure evaluator is responsible for interpreting the data available and estimating dose for actual cases, based on the unique aspects and data obtained for that case. Likewise, the discussion of dose reduction therapy is provided for general information. The HEHF Occupational Medicine staff are the Hanford Site authorities responsible for dose reduction therapeutic measures.

E.1. Example Incident Bioassay Responses

E.2. Guides for Immediate Care

E.1 Example Incident Bioassay Responses

The IDP has a wide range of bioassay measurements and processing categories available. Following an incident of potential intake, the exposure evaluator recommends an investigation bioassay protocol to the contractor dosimetry representative. Factors considered in this recommendation include the type of intake, radionuclides involved, probable severity of intake, information needs of the physician and the worker's management, and the relative cost-effectiveness of reasonable alternatives. There is a trade-off between the promptness by which estimates of intake or dose can be made and the accuracy of those estimates. Some example responses for the most probable radionuclides and scenarios at Hanford follow. The discussion also provides estimates of minimum detectable dose (in terms of the resulting CEDE) that can be determined at various stages of response.

E.1.1 Tritium Intake Assessment

Single-void or overnight urine sampling is the recommended bioassay method for an unplanned intake of tritium. A single-void sample obtained 2 or more hours after the intake can be adequate for dosimetry. Generally, an overnight sample or next-morning single-void sample provides adequate response for dosimetry. Dose assessment can be made based on either of these two samples, with a minimum detectable dose of about 1 mrem. However, if the dose estimated at that time is greater than 100-mrem CEDE, then additional samples collected over the next 2 weeks should be obtained to improve the precision of the dose assessment.

It is unlikely that an intake of tritium could occur at Hanford that would require emergency processing of urine samples for purposes of treatment, but emergency processing might be important for reporting purposes. Priority processing (3-day analysis time) is usually adequate. This decision can best be made at the time the sample is collected.

E.1.2 Mixed Fission and Activation Product Intake Assessment

Mixed fission and activation products emitting gamma-rays with energies >300 keV are easily measured by whole body counting. A whole body, wound, or thyroid count (if radioiodine is suspected) within the first week after intake is sufficiently sensitive to confirm an intake resulting in a few mrem CEDE. Counts taken on the same day as the intake should generally not be used for dose assessment because of the possible interference from external contamination and because of the rapidly changing biokinetics of the material. If a same-day count results in an estimated dose >10-mrem CEDE, then an additional count should be obtained during the next 7 days. If the estimated dose is >100 mrem, several more counts should be obtained over a period approximately the same as the effective retention half-time in the body (or 6 months, whichever is shorter) to quantify the dose.

Excluding special research projects, the only high-energy gamma emitting nuclides likely to be of concern now at the Hanford site are ^{137}Cs, ^{60}Co, and $^{154/155}$Eu. Other mixed fission or activation products have either decayed away or are mixed with and produce much less dose than the four principal radionuclides. If ^{137}Cs is detected, consideration should be given to other nuclides potentially involved and the appropriateness of excreta bioassay.

E.1.3 Strontium-90 Intake Assessment

There are some places onsite where workers may be exposed to ^{90}Sr without accompanying ^{137}Cs or other gamma-emitting radionuclides. Generally, a 12-hour urine sample analyzed by expedite processing is sufficient to give a prompt indication of the severity of the intake down to a few mrem. Actual dose assessment should be based on at least one 24-hour (or approximate 24-hour) urine sample taken a few days after the intake and analyzed by priority processing. If the preliminary dose estimate is >100 mrem, then several urine samples should be obtained during the next couple of months.

If workplace monitoring indicates a potential for a very large intake, then same-day and next-day in vivo counts should be made and a second-void urine sample should be obtained and analyzed by emergency processing. In vivo bremsstrahlung counting should be able to detect an intake down to 1-rem CEDE within a few hours after intake, and the urine sample should be able to detect an intake around 10-mrem CEDE within 12 to 24 hours after intake. Therefore, a decision to begin or end treatment can easily be made within a few hours after intake.

E.1.4 Uranium Intake Assessment, Soluble Forms

Because most uranium at Hanford is natural, depleted, or just slightly enriched (up to 1.2% ^{235}U), soluble forms of uranium (e.g., UO_3 and uranyl nitrate) can pose a chemical as opposed to a radiological hazard. If a major intake is suspected, early response is focussed on the kidney burden relative to the threshold for transient toxicity. A same-day chest count should be made as quickly as possible, and a second-void urine sample should be obtained and analyzed by emergency processing. The second-void urine sample should be followed by an overnight or 12-hour sample. Twenty-four-hour samples would follow if the worker is being treated. The chest count

should be able to detect an intake of about 45 -90 mg (Class D and W) depending on how soon after intake the measurement is made, and the spot urine sample should be able to detect an intake of about 1 - 5 mg Class D and W. If anything is detected in a chest count, or if the spot urine and 12-hour urine samples exceed 0.1 mg or 0.3 mg, respectively, then HEHF should be notified. Monitoring of kidney function is recommended.

If workplace monitoring or prompt urine results indicate that the threshold for toxicity was not approached, then actual dose assessment should be based on at least one 24-hour (or approximate 24-hour) urine sample taken at least 3 days after the intake and analyzed by priority processing. The 3-day delay allows for elimination from the body of the unabsorbed fraction of the intake, which can introduce a large error in the dose calculation. Doses down to fractions of a mrem can be detected at that time.

E.1.5 Uranium Intake Assessment, Insoluble Forms

Uranium that is more slowly transferred from the lung or wound site can be encountered at the former fuel production or metallurgy facilities (e.g., 303-M, 333, and 306-W Buildings) and may possibly be contained in liquid effluent pipes or disposal sites associated with such facilities.

An inhalation of class Y uranium is considered the most difficult to detect. Details of the response capabilities are given in Table E.1. Early fecal samples are essential for good estimates of class Y intakes. The presence of a small class D component can improve the early urine sampling sensitivity but also if dose calculations are based on urine samples alone, a small uncertainty in the percentage of class D material present in an intake could lead to a large miscalculation of the dose.

If activity in urine remains above normal after the first couple of days, then additional urine samples should be obtained at about 5, 10 and 30 days after intake.

Table E.1. Inhalation of Recycled Class Y Uranium, No Treatment

Days Post-intake	Measurements	When Results Are Known	What Can Be Said At That Point	Problems or Comments
Same day	3000-s chest count	Same day	Can say if CEDE is < or > 5 rem	If ^{235}U or ^{234}Th detected, advise HEHF for treatment decision.
Same day	2nd voiding spot urine emergency processing	Same day or first thing next Monday	Can say if CEDE is < or> 1rem	If spot urine > 60 µg, advise HEHF for possible treatment
1	If chest count detects activity, then collect a 12-h urine, emergency processing, and a second chest count.	End of second day	No real change in detectable dose, but second chest count will help determine split between class D and class Y, and 12-h urine will improve accuracy of dose estimate and efficacy of treatment.	
1	If first chest count did not detect activity, then collect 24-h total urine and expedite processing.	Morning of the fifth day	If nothing in sample, then dose ismost likely <20 mrem.	If nothing in 24-h sample, collect at least one more and analyze priority processing.
1-3	Two fecal samples; priority processing.	12 to 14 days after intake	Capable of determining <5 mrem	Used to determine class Y component of intake

If there is only normal activity in urine but the activity is >100 times the minimum detectable amount (MDA) in feces, then as a minimum an additional fecal sample should be obtained at about 20 days after intake. Two samples, at 10 and at 20 to 30 days, are preferred.

Fecal samples are not required for intakes of insoluble uranium by wounds because there is no transfer of systemic uranium to the gastrointestinal tract. However, for a very significant intake of uranium via a wound, a fecal sample is suggested to verify this assumption.

Because of the lower specific activity of uranium relative to plutonium, workplace monitoring is a more reliable indicator of the severity of a uranium intake. For instance, the class Y intake resulting in a 500-mrem CEDE is about 10 mg, which should be readily detectable in the workplace. Consequently, the bioassay protocol is less automatic than for plutonium and can be tailored to reflect the seriousness of the intake as indicated by workplace monitoring. The decision to perform emergency processing of a spot urine sample on one extreme versus priority processing of a 24-hour sample on the other, or collection of a fecal sample for maximum sensitivity to inhalation intake detection is made based on the circumstances surrounding the intake.

E.1.6 Plutonium Intake Assessment

Plutonium at Hanford tends to be a mixture characterized by its weight percentage of ^{240}Pu and the time elapsed since its chemical separation and purification. The time since the plutonium was purified varies from a few years to many years, but generally there has been ample time for ^{241}Am to grow into the mixture from ^{241}Pu decay. For purposes of this discussion, a 20-year aged 6% ^{240}Pu mixture is assumed. The incident responses for various ages or types of Pu are not significantly different, however, the bioassay capabilities can vary substantially for the same response.

Details of the bioassay options and minimum detectable doses at various stages after an inhalation intake are provided in Tables E.2 and E.3. The response capabilities consider both inhalation classes W and Y. Evidence exists to suggest that class W plutonium becomes more and more like class Y as it ages, i.e., as it oxidizes at normal room temperature and humidity.

Generally, for low-level exposures (i.e., anticipated CEDE of less than 100 mrem), the bioassay protocol consists of fecal and urine sampling within the first 5 days following the intake. For super-class Y material or exposure levels greater than 100 mrem, the bioassay protocol may consist of a same-day chest count, a second-voiding urine sample, and one or more of the following:

- a 12-hour urine sample collected after the second voiding
- a 24-hour urine sample collected immediately after the 12-hour sample
- <u>all</u> of the fecal excretion for the first 3 to 5 days after the incident.

The fecal samples are essential if sensitivity at a 100-mrem CEDE is to be obtained for plutonium. If activity has been detected in urine during the early sampling listed in Tables E.2 and E.3, then additional urine samples should be obtained at about 5, 10, and 30 days after intake. If there has been no activity in urine but activity was >100 times the MDA in feces, then as a minimum an additional fecal sample should be obtained at about 20 days after intake. Two samples are preferred, at 10 days and at 20 to 30 days. Additional fecal samples at longer times post intake may be appropriate for verifying the excretion rate.

Details of the bioassay capability for a plutonium-contaminated wound are provided in Table E.4. Basically, the protocol consists of same-day wound counts and at least one urine sample. The decision on the type of urine sample (e.g., spot or 12-hour) and processing time will depend not only on what the wound count indicates but also on other contamination data (e.g., the results of the blood sample or the level of contamination on the wound source or on skin around the wound). A fecal sample is desirable for large intakes to verify the pathway, but is not essential.

Table E.2. Bioassay Capabilities for an Inhalation Intake of 20-year Aged 6% Pu Mixture, 5 µm AMAD Particle Size, No DTPA Given At Worksite

Days Post-Intake	Measurements	When Results Are Known	What Can Be Said At What Point	Problems Or Comments
Same day	3000-s chest count; second voiding spot urine; emergency processing	Same day or first thing next morning	Can say if CEDE is < or > 5 rem Urine can say if < or > 5 rem Class W	If anything detected, should consider DTPA.
1	12-h urine, emergency processing; second chest count if first result detected activity	End of second day	If nothing in urine or chest, then intake is class W <1 rem, class Y <5 rem	If nothing in urine, then DTPA is not needed. If Pu alpha in urine >2 dpm, then consider initiating DTPA.
2	24-h total urine, expedite processing	Morning of fifth day	If nothing in sample (and previous chest counts), then CEDE <500 mrem,	From bioassay data, still will not know inhalation class of material
1-3	Fecal excretion for first 3 days after intake Two processings by lab: 1) LEPD expedited processing, 2) IPA priority processing	LEPD results: 6-7 days after intake IPA priority: 16-17 days after intake	If nothing in LEPD analysis, then CEDE <500 mrem If nothing in IPA, then CEDE <100 mrem	

For wounds, the issue is not so much the sensitivity of early bioassay measurements, especially for shallow wounds, but the time involved to determine the biological behavior of the material. For instance, it may take months to determine the transfer rate of plutonium from the wound to blood and the quantity of plutonium transferred to the lymph system instead of to blood. Prolonged DTPA treatment will also prolong the time until the CEDE can be quantified.

Table E.3. Bioassay Capabilities for an Inhalation Intake of 20-year Aged 6% Pu Mixture, 5 µm AMAD Particle Size with DTPA Promptly Administered Based on Workplace Data

Days Post-Intake	Measurements	When Results Are Known	What Can Be Said At What Point	Problems Or Comments
Same day	3000-s chest count; second voiding spot urine, emergency processing.	Same day or first thing next morning	If CEDE is < or >5 rem. Much lower dose if sure material is class W.	Consider second DTPA shot if anything detected in spot urine.
1	12-h urine, emergency processing; second chest count if 1st detected activity.	End of second day	If nothing in urine or chest, then intake is class W<2 rem, class Y <10 rem.	If nothing in urine or chest, then DTPA can be discontinued. If Pu alpha in urine is >2 dpm, then consider continuing DTPA.
2	24-h total urine, expedite processing.	Morning of 5th day.	If nothing in sample (and previous chest counts), then CEDE class W <200 rem, class Y <4 rem.	From bioassay data, still will not know inhalation class of material.
1-3	Total fecal excretion for first 3 days post intake. Two lab processings: 1) LEPD expedited, 2) IPA priority processing (or routine processing if cost is a factor).	LEPD results: 6-7 days after intake; IPA priority: 17-18 days after intake; IPA routine: about 6 weeks after intake	If nothing in LEPD analysis, then CEDE <500 mrem. If nothing in IPA, then CEDE <100 mrem.	

The dose estimates in the tables assume that ^{241}Am has had about 20 years to build into the mixture. Longer ingrowth times will provide slight improvement for the chest count and low-energy photon (LEPD) fecal detection capabilities. However, shorter in-growth times can significantly reduce the sensitivity of chest and LEPD fecal counting. Intakes of freshly separated plutonium or pure isotopes of plutonium, are especially difficult to detect via bioassay.

Table E.4. Wound Contamination by 20-year Aged, 6% Pu Mixture, No DTPA Given at Worksite

Days Post-Intake	Measurements	When Results Are Known	What Can Be Said At What Point	Problems Or Comments
Same day	One or more wound counts; second voiding spot urine; emergency processing.	Same day or first thing next morning	Can say if CEDE is < or >3 rem.	If anything detected in wound or urine, should consider DTPA. If activity in wound is >0.5 nCi, excision should be considered.
1	12-h urine, emergency processing; second wound count if first detected activity	End of second day	Minimum detectable dose somewhat <3 rem, but cannot say exactly due to uncertainty in transfer rate from wound.	If nothing in urine or wound, then DTPA is not indicated. If Pu alpha in urine >2 dpm, then consider initiating DTPA.
2	If nothing was detected in previous samples, then one additional urine sample (24-h-simulated) is collected; priority processing.	11 days	If nothing in sample, then CEDE <100 mrem	
2	If activity was detected in previous samples, then additional wound, urine, and possibly fecal samples will be needed. Processing will depend on the activity in the samples.			

E.2 Guides for Immediate Care

E.2.1 Action Levels

Two kinds of action levels are described in this section. Notification levels are used to advise that an intake may have occurred. Intervention levels are used to assist with the decision to use medical therapy for dose reduction.

Notification levels based on workplace indicators for reacting to a potential intake are provided in Section 7 (Table 7.1) of this manual. The intent of these notification levels is to provide guidance for field response to any potential intake of radioactive material with a potential for a dose commitment that is >100-mrem CEDE. Table 7.2 provides notification levels for possible early medical intervention for intakes. These tables are based on general considerations and significant experience with past intakes of radioactive material. They do not correspond with any specifically calculated value for intake or dose commitment to the worker.

Intervention levels are developed in this appendix to assist in the medical decision to treat an intake. These action levels, based on early bioassay results, have a strong correlation with the dose commitment received by the worker for different intake situations, although the degree of uncertainty is high - especially in early bioassay sample results.

The decision to administer dose reduction therapy and the treatment protocol used are the responsibility of the physician in charge. Guidelines for the medical intervention of a radionuclide intake can be found in several publications. NCRP Report No. 65 (NCRP 1980) and the joint publication of the Commission on European Communities (CEC) and the DOE *Guidebook for the Treatment of Accidental Internal Radionuclide Contamination of Workers* (Bhattachaaryya, et al 1992) both contain detailed guidance in intervention and medical procedures useful in mitigating radiation overexposures. The CEC/DOE Guidebook expressed its guidance in terms of the annual limit on intake (ALI) levels, rather than on dose. In doing so, it used the 2-rem (20-mSv) effective dose concept of ALI, found ICRP Publication 60 (1991a) and in ICRP Publication 61 (1991b). The basic guidance can be summarized as follows:

- When the estimated intake is below one ALI, treatment should not be considered.

- When the estimated intake is between 1 and 10 times the ALI, treatment should be considered. Under these situations, short-term administration will usually be appropriate, except for intake of materials poorly transported from the lung (class Y).

- When the estimated intake exceeds 10 times the ALI, then extended or protracted treatment should be implemented, except for materials poorly transported from the lung.

- For poorly transported material in the lung, lung lavage is the only recommended treatment, and should only be considered for intakes exceeding 100 times the ALI.

Because the dose associated with the ALI in the CEC/DOE Guidebook is 2 rem CEDE and because the upper administrative level used by DOEis also 2 rem CEDE, the Hanford Site uses 2 rem and 20 rem as intervention level guidance in the manner presented in the CEC/DOE Guidebook:

- When the estimated intake is below 2-rem CEDE, treatment is not generally recommended.
- When the estimated intake is between 2-rem and 20-rem CEDE, treatment should be considered. Under these situations, short-term administration will usually be appropriate.
- When the estimated intake exceeds 20-rem CEDE, then extended or protracted treatment is strongly recommended, except for poorly transported material in the lung.

General guidelines for when treatment may be considered reasonable, based on specific bioassay results, are presented below for radionuclides common at Hanford (see Table E.5). Except for plutonium and insoluble uranium, they have been derived from internal dosimetry models of intakes that result in a CEDE of 2 rem and 20 rem, corresponding to the intervention-level guidance discussed above.

E.2.2 Tritium Intervention Levels

Tritium cannot be measured by in vivo bioassay because it emits only a low-energy beta. The most sensitive method for bioassay measurement is the amount of tritium in urine, used to estimate the total tritium in body water.

Treatment (2 rem and 20 rem)

If the results of either a single-void urine sample taken 3 to 4 hours after exposure (to ensure equilibrium of tritium in body water) or a following overnight sample exceeds 10^6 dpm/mL, HEHF should be notified (implying an intake resulting in a CEDE of about 2 rem). If the urine content exceeds 10^7 dpm/mL, treatment is strongly indicated (implying an untreated CEDE of 10 to 20 rem).

Table E.5. General Guidelines for When Treatment May be Considered Reasonable for Radionuclides Common at Hanford

Isotope	Measurement	Result	Action	Possible Treatment
Tritium				
2 rem	Single-void urine 3-4 h after exposure	10^6 dpm/mL	Notify HEHF	Fluids, diuretics
20 rem	Same	10^7 dpm/mL	Strongly recommend treatment	Fluids, diuretics
Mixed Fission Products				
2 rem (assumes 2:1 Sr/Cs ratio)	Whole body count, or urine/fecal for severe intakes	>2000 nCi uptake, or >40,000 nCi if no Sr present	Notify HEHF	Prussian blue Ca,(Sr), ammonium phosphate, others
20 rem (assumes 2:1 Sr/Cs ratio	Same	>20,000 nCi uptake, or >400,000 nCi if no Sr present	Treatment strongly recommended	Same
^{90}Sr				
2 rem	Second-void spot urine or in vivo detection	>70,000 dpm in spot urine, or >MDA in vivo	Notify HEHF	Alginate, Ca gluconate, Sr lactate, others
20 rem	Same	>700,000 dpm in spot urine, or >50 µCi in vivo	Treatment strongly recommended	Same
Uranium, Soluble				
Potential kidney toxicity	Chest count Second-void urine sample 12-hour urine sample	>MDA for ^{234}Th >0.1 mg >0.3 mg	Notify HEHF	Na or Ca bicarbonate; intestinal adsorbents
Uranium Insoluble[(a)]				
2 rem	Chest count	>MDA for ^{235}U or ^{234}Th	Notify HEHF	None recommended
200 rem	Same	100 x ALI	Treatment strongly recommended	Lung lavage
Plutonium				
For plutonium intakes, refer to Tables E.2, E.3, and E.4.				

(a) If soluble component is present, then urine sampling is appropriate. Use same action levels as above for soluble uranium.

E.2.3 Mixed Fission Products Intervention Levels

Mixed fission products can be detected easily by whole body counting. Minimum detectable doses for the major radionuclides encountered at Hanford are on the order of a few mrem CEDE. In severe intakes, other bioassays such as urine or fecal sampling can be implemented to provide a complete picture of the modes of clearance and retention of fission products. Cesium-137 and ^{90}Sr are the most prevalent fission products left at the Hanford Site.

Treatment (2 rem and 20 rem)

Assuming a 2:1 ratio for ^{90}Sr to ^{137}Cs, if the whole body content exceeds 2,000 nCi of ^{137}Cs at 1-day post-intake, HEHF should be notified and a spot urine sample should be analyzed for radiostrontium by emergency processing. If the whole body content exceeds 20,000 nCi, treatment is strongly indicated and a spot urine sample should be analyzed for radio-strontium by emergency processing. If it is likely that only ^{137}Cs is present, then the whole body contents suggesting or indicating treatment become 40,000 nCi and 400,000 nCi, respectively.

For ^{60}Co at 1-day post-intake (assuming class Y), if the whole body content exceeds 20,000 nCi, HEHF should be notified. If the whole body content exceeds 200,000 nCi, treatment is strongly indicated.

E.2.4 Strontium-90 Intervention Levels

Strontium is normally associated with mixed fission products at Hanford although there are some locations where it can be found without this association. Although urine sampling is most sensitive, for larger intakes measurements of the skull or whole body can be undertaken to detect the bremsstrahlung radiations from the beta emissions.

Treatment (2 rem and 20 rem)

If a second-void spot urine sample exceeds 70,000 dpm or if anything is detected in vivo, HEHF should be notified. If the second-void spot urine sample exceeds 700,000 dpm, treatment is strongly indicated.

E.2.5 Uranium Intervention Levels, Soluble Forms

Soluble uranium materials at Hanford pose a problem from chemical toxicity rather than from radiological toxicity due to the low enrichment found on the site (<1.2% ^{235}U.) A major intake of uranium should focus on kidney content and potential nephrotoxicity.

Treatment (nephrotoxicity)

An inhalation intake of about 7 mg class D or 30 mg class W uranium, should be considered potentially large enough to produce a kidney burden at or near the threshold for transient toxicity, and treatment (or at least monitoring of kidney function) should be considered. A same-day chest count should be made, and a second-void urine sample should be obtained and analyzed by emergency processing. If anything is detected in a chest count, or if the spot urine and 12-hour urine samples exceed 0.1 mg or 0.3 mg, respectively, then HEHF should be notified. Usually, the treatment for intervention is sodium or calcium bicarbonate. Monitoring of kidney function is recommended.

For wounds, excision by surgery is not usually recommended, due to the high transportability of the material. A wound with about 5 nCi (4 to 8 mg) of uranium or urine samples containing uranium at 0.1 mg (for spot urine samples) or 0.3 mg (for 12-hour samples) should involve notification of HEHF and kidney function monitoring.

E.2.6 Uranium Intervention Levels, Insoluble Forms

Uranium found in buildings 303-M, 333, and 306-W exhibits much less transportable behavior, because it is predominantly class Y material. Both 3000-second same-day chest counts and second-void spot urine samples are used for rapid estimation of the intake.

Treatment

There is no simple treatment for class Y components of the intake retained in the lung. If anything is detected in a chest count (implying a potential CEDE of 2 rem), then HEHF should be notified, although it is doubtful that any treatment will be appropriate. Lung lavage should be considered only for extremely large intakes. If the chest burden exceeds 200 nCi (600 mg) ^{238}U or 10 nCi (5 mg) ^{235}U then treatment for removal of activity in the lung should be considered. These burdens imply a potential CEDE of 200 rem or approximately 1700-rem committed dose equivalent (CDE) to the lung.

Because there can be some soluble material associated with the intake, nephrotoxicity can still be of concern for large intakes. If the second-void urine sample or the 12-hour urine sample exceeds 0.1 mg or 0.3 mg, respectively, then HEHF should be notified. (This excretion would imply that the threshold for transient chemical toxicity might have been exceeded.) Monitoring of kidney function is recommended.

Wounds that contain uranium metal exhibit a serious surface dose consequence to surrounding tissue due to beta particles (>200 mrad/h). Excision should be considered in these cases if the wound contains >15 nCi. Based on the 2-rem CEDE criterion, treatment should be considered for wounds containing about 170 nCi of ^{238}U and/or about 8 nCi of ^{235}U (assuming recycled uranium oxide form). At the same time, the urinary excretion should be watched closely because, if the material leaves the wound quickly, nephrotoxicity may be of concern.

E.2.7 Plutonium Intervention Levels

Treatment

Plutonium is treated by removal from blood and systemic organs using DTPA chelation via injection (by HEHF). This means that treatment does not affect activity in the lung to any appreciable extent, so treatment based on dose per unit intake (which is influenced by lung dose, especially for class Y material) is not as reliable an indicator of benefit. On the other hand, there is a direct correlation between DTPA, urinary excretion, and dose averted because of plutonium excreted. The CEDE dose averted per dpm excreted in urine is about 2 mrem, and the excretion enhancement factor using DTPA can vary from about 10 to 100. So if DTPA is administered when untreated excretion is 2 dpm/day, excretion should increase to 20 to 100 dpm for a dose savings of 40 to 200-mrem/day CEDE. It is probable that the efficacy of treatment will decrease with continued administration as plutonium is

removed from the liver and the rate of transfer from lung to blood decreases. Ceasing DTPA treatment when excretion drops to below 2 dpm/day probably sacrifices less than 40 mrem/day.

For wounds, refer to the preceding Table E.4. Generally, any detectable plutonium in the wound or in spot urine samples should warrant considering administration of DTPA. If the activity in the wound is >5 nCi, excision of tissue should also be considered.

E.2.8 Intervention for Ingestion of Radioactive Materials

Similar considerations for treatment or intervention levels apply to ingestion of radioactive materials as to inhalation. Exposure of the lower large intestine for poorly transported chemical species can be considerable in large intakes, but rapid clearance through the gastrointestinal (GI) tract to feces occurs. If an intake could potentially result in dose to an organ in the GI tract exceeding 50 rem, treatment should be considered.

E.2.9 Work Restrictions

Under any of the foregoing intake circumstances, a work restriction should be considered to prevent the worker from receiving further occupational radiation dose until an estimate of his/her dose is completed.

E.2.10 References

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