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Environmental Programs Directorate

Standard Operating Procedure

for **AIRNET—SAMPLE ANALYSES FOR UNPLANNED RELEASES**

APPROVAL SIGNATURES:

Subject Matter Expert:	**Organization**	**Signature**	**Date**
Andrew Green	WES-EDA	Signature on File	4/6/2009
Responsible Line Manager:	**Organization**	**Signature**	**Date**
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1.0 PURPOSE AND SCOPE

This standard operating procedure (SOP) states the responsibilities and describes the response to a request for air monitoring network (AIRNET) data from the Emergency Management and Response (EM&R) office following an unplanned release of radioactive material for the Los Alamos National Laboratory (LANL) Waste and Environmental Services Division (WES).

All **WES participants** shall implement this procedure following an unplanned release of radioactive material.

2.0 BACKGROUND AND PRECAUTIONS

2.1 Background

Exercises are simulations or practice “games” that are performed periodically for training. In an exercise, you may use simulated AIRNET samples so as not to disturb the real AIRNET filters and cartridges.

2.2 Precautions

Even in a real emergency, don't rush and don't do anything you believe to be unsafe.

Understand what information is being requested.

- Is this an exercise or a real emergency? Will you use real or simulated samples?
- Is tritium data requested, or particulate data, or both? Do you need to change the filter, the silica-gel cartridge, or both?

Understand the hazards before you proceed. In an emergency, ask EM&R about the hazards. The EM&R phone number is 667-6211. Ask about the following.

- What personal protective equipment (PPE) will you need? At a minimum, wear a lab coat and nitrile gloves while handling filter heads.
- Will you need a respirator? If you are not trained to wear a respirator, do not enter areas where a respirator is needed.
- Which AIRNET stations will you visit and by what route? What locations should you avoid?
- Is RCT coverage needed or available? If not, what type of contamination is expected and how can you detect it?
- What type of communication is required (e.g., radio)?

Proceed carefully. Do not become another victim.

Note: Rules and regulations are intended for routine operations and for emergency planning; they should not prevent you from using your best judgment during an actual emergency.

3.0 EQUIPMENT AND TOOLS

In addition to the supplies needed for a normal changeout, take

- a box of nitrile gloves
- lab coats
- plastic bags (preferably Ziplock ®)
- tissues and Fantastik® liquid cleaner
- an E-600 detector kit and a radioactive source (lantern mantle)
- a copy of this procedure including the form in Attachment 2
- radio or other emergency communication as determined by EM&R
- fresh silica-gel cartridges and/or filter heads according to which type of samples were requested.

4.0 STEP-BY-STEP PROCESS DESCRIPTION

4.1 Response to an Unplanned Release of Radioactive Material

EM&R personnel	1.	The Emergency Management and Response (EM&R) personnel coordinate all emergencies at the Laboratory, including unplanned releases. They monitor 911 calls, and may be contacted directly by phone at 667-6211.
EM&R personnel	2.	In the event of an unplanned release of radioactive material, EM&R personnel might contact WES and request AIRNET data. This procedure describes the WES response. The goal of this procedure is to provide limited information within 24 hours of the request.
Meteorology team	1.	The WES meteorology team makes dispersion predictions based on real-time meteorology and estimates of source terms, e.g., from the LANL Hazards Assessment Document, available from EM&R. The meteorology team will assist EM&R in determining which AIRNET samples should be analyzed.
AIRNET project leader (or designee)	1.	The AIRNET project leader (or designee) decides whether to change the tritium samples, the particulate filters, or both, and whether to make measurements in addition to those described in this procedure. As one option, AIRNET samples might be analyzed by the Health Physics Analysis Laboratory (HPAL). HPAL may be contacted by phone, 665-8888 or the emergency digital pager: 505-996-1380. The main HPAL is at the south end of the HPAL group buildings, TA-3-2010. Tritium samples could be distilled using WES apparatus, as described in WES SOP-5144, and counted in an HPAL liquid scintillation counter. WES should keep some distillation equipment in Los Alamos or White Rock for this purpose. Alternatively, samples could be sent to the laboratories that analyze routine AIRNET samples.
TLD project leader (or designee)	1.	The DPRNET (Thermo-luminescent Dosimeter - TLD) project leader (or designee) decides whether to change the co-located TLDs at the same time as the AIRNET samples are retrieved. TLDs should be changed only if: (a) the release includes significant gamma emitters, and (b) replacement TLDs are available.

4.2 Steps to Obtain AIRNET Samples

To obtain AIRNET samples in response to a request from EM&R, perform the following steps. If any steps seem unsafe under the particular emergency conditions at the time, consult EM&R by phoning 505-667-6211.

AIRNET Field Team Members	1.	Inform the AIRNET and DPRNET program managers and the group office by phone, leaving messages as appropriate.
	2.	Make a plan, assemble a team, and gather the equipment, Identify which AIRNET samples to change.

AIRNET Field Team Members	3.	Before leaving, check the performance of the E-600 by doing a source check as described in Attachment 2.
	4.	Follow the standard procedures (WES SOP-5143 and ENV-MAQ-210) to change AIRNET samples and TLDs at those stations requested the AIRNET project leader or designee, except as follows. • Before touching the filter head, wear nitrile gloves and a lab coat. • Before removing the filter head, use the E-600 to measure and log the alpha and beta activity on the filter, following the instructions in Attachment 2. Typical activities are on page 1 of Attachment 3. • After changing the filter head, use the E-600 to measure and log the alpha and beta background from a fresh filter in the same location. • Change the silica-gel cartridges (only if this was requested). • Place the filter head in a ziplock bag. • Use the E-600 to monitor for contamination after you place the filter head in the vehicle, and use tissues and Fantastik® liquid cleaner to decontaminate as needed. Remove your nitrile gloves and put them with other potentially contaminated items in a ziplock bag to be dealt with by an RCT after the emergency. Label the bag with the location the waste was created and the date and time.
	5.	Report the data collected from the E-600 to the AIRNET project leader or designee. Take the filter heads and/or tritium cartridges to a WES lab and await further instructions. (Note: the activity on the filters will decrease as the radon daughters decay, as described in Attachment 3.)
	6.	If any TLDs were recovered from the field, place them in the safe in building 1001 at TA-54 and await instructions from the DPRNET project leader.
	7.	Contact an RCT (e.g., by phoning the RCT Group at 667-7171 during work hours) and check for contamination. Do not leave for home until you are free of contamination.
	8.	After the emergency is over, the AIRNET housings, their contents, the vehicle, and all equipment used during the emergency must be checked by an RCT.

4.3 Date of Latest Changout

AIRNET Field Team Member	1.	Write down the time and date of the previous AIRNET change-out for each station of interest and make a copy of this information available to EM&R.

4.4 Records Management

AIRNET Field Team Member	1.	Maintains and submits records and/or documents generated to the Records Processing Facility according to EP-DIR-SOP-4004, Records Transmittal and Retrieval Process and to AIRNET Project files.

5.0 DEFINITIONS

AIRNET–air-monitoring network

RCT–radiation control technician

EM&R–Emergency Management and Response

HPAL–Health Physics Analysis Laboratory

TLD–thermo-luminescent dosimeter

6.0 PROCESS FLOW CHART

None

7.0 ATTACHMENTS

Attachment 1 Hazard Control Plan (1 page)

Attachment 2 Measurement of AIRNET samples using an E-600 with SHP380AB (2 pages)

Attachment 3 Analysis of AIRNET data (3 pages)

Attachment 4 Appendix A to 10 CFR 835 (21 pages)

8.0 REVISION HISTORY

Revision No. *[Enter current revision number, beginning with Rev.0]*	**Effective Date** *[DCC inserts effective date for revision]*	**Description of Changes** *[List specific changes made since the previous revision]*
0	1/4/01	New document
1	4/15/02	Quick-change revision to add step in attachment for uploading data from E-600 to databases.
2	4/25/05	Quick-change revision to convert Hazard Control Plan to Hazard Review for annual review.
0	4/7/2009	New document number and reformatted for WES division. Formerly ENV-MAQ-230.

ATTACHMENT 1

SOP-5173-1

Hazard Review for AIRNET Sample Analyses for Unplanned Releases

Records Use only

Work Tasks/Steps	**Hazards, Concerns, and Potential Accidents; Likelihood/Severity**	**Controls, Preventive Measures** *(e.g., safety equipment, administrative controls, etc.)*	**Hazard Level** *from IMP 300.7, Integrated Work Management*, Attachment 1, *Hazard Grading Matrix*
Collect AIRNET samples according to steps in this procedure.	Thermal burns--skin burns from pumps Occasional/Negligible = Minimal	Use care to avoid these injuries.	Low
As part of sampling work, enter radiation areas and explosives testing areas.	Site-specific hazards such as high explosives testing (TA-15, TA-16, TA-49) or radiation Areas (TA-54 [Area G], TA-16) Remote/Negligible = Minimal	Comply with all site-specific access requirements. Existing facility access controls include site-specific training, sign-in/sign-out, and scheduling procedures. Area G and TA-15 require entry through manned access control gates.	Low
As part of sampling work at AIRNET stations, work around electrical equipment.	Electrical shock in wet conditions Remote/Catastrophic = Low Electrical shock from electrical conduit damaged by vehicle or large animal Improbable/Catastrophic = Medium	For wet conditions, all stations were retrofitted with GFICs (ground fault current interrupters). If damaged station is found with potential for electrical contact in damaged conduit, contact electrician to shut off power before any further work.	Low
Collect AIRNET filters that are potentially contaminated from a radiologic accident, according to steps in this procedure or instructions from EM&R.	Radioactive material, especially on filter head or in silica-gel cartridge.	Guidance on exceptionally high count rates on air filters is contained in the ESH-1 Air Monitoring Procedure, ESH-1-05-02.2, Section 4.6.2, which states "if the count rate is >20,000 dpm alpha or >100,000 dpm beta … notify … supervision and the Health Physics Analysis Laboratory (HPAL) before sending the filter to HPAL." Use personnel protective equipment as instructed in Radiological Worker Training.	Low
Wastes or residual materials resulting from process	Filters and silica gel will be processed according to steps in SOP 5143 and SOP-5144. Contaminated gloves– left in AIRNET housing to be disposed of by an RCT after the emergency.		
Emergency actions to take in event of control failure	For all injuries, provide first aid and see that injured person is taken to Occupational Medicine (only if immediate medical attention is not required) or the hospital. Notify supervisor and group office as soon as possible. For any exposed, energized electrical wires, contact an electrician or the appropriate authority to turn off the power. Follow all site-specific emergency plans for any radiation or explosives emergencies.		

ATTACHMENT 2

Records Use only

SOP-5173-2

Measurement of AIRNET Samples Using an E-600/ SHP380AB

Steps to measure AIRNET samples

To measure the alpha and beta activity on AIRNET filters, perform the following steps.

AIRNET Field Team Member

1. On the form (MEASUREMENT OF AIRNET SAMPLES USING AN E-600 WITH SHP380AB), record the station location, date, names of personnel, property numbers and calibration void dates, and note any physical damage to the equipment (if applicable).
2. Connect the SHP380AB probe to the E-600 with the cable. Turn the switch to "check" and record the battery condition (%).
3. Place the SHP380AB probe as follows:
   a) without the radioactive material, for background data (Step 7);
   b) 0.25 in. from a source such as a lantern mantle for a source check (with all protective covers, plastic bags, etc., removed);
   c) 0.25 in. from a used filter, e.g., against the brass filter holder (with all protective covers, plastic caps, etc., removed);
   d) 0.25 in. from a new filter in the same location (to measure the background with the setup identical to Step 3c except for the new filter).

   Perform Steps 4 thru 6 to measure and record the data.
4. Turn the switch to "scaler" and press "Chnl" to select "α" or "β;" (collect data for both "α" and "β").
5. Press "*" to begin a 60-second count. At the end of the 60-second count, record the data on the form.
6. At the end of each 60-second count, press "Log" twice to log the data into the E-600 memory. Record the log number, which will be displayed momentarily, on the form.
7. Repeat Steps 3c, 3d, and 4 through 6 as needed.
8. At your convenience, obtain the help of an expert (e.g., from an RCT) to transfer the data from the E-600 to a PC computer and clear the E-600 memory. The "log" function of the E-600 will record 500 readings before the memory becomes full.
   Turn the E-600 switch to "off" before disconnecting the cable; squeeze the connector at the 6 small ridges to release it.
9. Transfer the E-600 data into an Excel spreadsheet and store it in the E-600 folder on the Users network drive. Name the file by the date it was acquired.
   Insert a column for “Station ID” and a column for “Sample or Background” and fill the cells accordingly. Note comments or whether a sample should be rejected in the first available column.

Notes on background. If the background and gross count rates are about equal, the background and gross count times should be about equal. Take a background reading at each AIRNET station. If a set of filters are to be counted at one location (e.g., at TA-54-1001) take background readings at the beginning and end of the set, and also every 15 minutes.

Waste and Environmental Services

MEASUREMENT OF AIRNET SAMPLES USING AN E-600 / SHP380AB

This form is from EP-WES-SOP-5173

See instructions on reverse of this form.

E-600 PN:			Calibration void date:			
SHP380AB PN:			Calibration void date:			
Note physical damage, if any:						
Battery Check (%)			Date:			
Time	**ID or Station**	**alpha** (dpm)	**log#**	**beta** (dpm)	**log#**	**Notes**
	Background					
	Source check					
	Background					

Measurements by:

______________________ ______________________ ____________

Signature Name (print) Date

ATTACHMENT 3	
SOP-5173-3 **Analysis of AIRNET data following an unplanned release of radioactive material**	Records Use only 

Purpose

This attachment is intended to aid technical staff members in interpreting the data. The general goal is to obtain limited information within 24 hours of a release.

Radon

AIRNET filters accumulate radon and thoron decay products. After subtracting background, the net count rate from these decay products will typically be within a factor of two of:

- 2k dpm α
- 4k dpm β

During an inversion, however, the count rates might be up to a factor of five higher. Guidance concerning very high count rates on air filters is contained in the ESH-1 Air Monitoring Procedure ESH-1-05-02.2 section 4.6.2, which states: "If the count rate is > 20,000 dpm alpha or > 100,000 dpm beta … notify supervision".

A count rate of 10k dpm α from Pu-239 corresponds to 1 rem, CEDE. Therefore, the following corrections for the count rate from radon and thoron decay products are significant.

Typically, about half the activity is from short-lived radon decay products with half lives of 26.8 -minutes or less, and about half is from longer-lived Pb-212 and its decay products, with a half life of 10.64 hours.

Five hours after the filter is removed from the pump, most of the residual activity decays with a half life of 10.64 hours. In this case, the long-lived activity, A, can be estimated from two measurements, A_0 and A_1, separated by time t, by using the equation:

$$A = [A_1 - A_0 \exp(-\lambda t)]/[1-\exp(-\lambda t)]$$

where λ is the decay constant ($\lambda = 0.693/10.64$ if t is in hours).

The long-lived activity, A, typically includes about 50 dpm of Bi-210 and about 5 dpm of Po-210. During the Cerro Grande fire, typical filter activities were about 100 dpm for each of Pb-210, Bi-210, and Po-210.

Uncertainty

Note: the detector records the number of disintegrations, whereas the uncertainty depends on the number of counts. The efficiency is about 20%, so the count rate (cpm) is about 20% of the disintegration rate (dpm).

Limitations of AIRNET Data

Subject to the limitations of radon and thoron background, AIRNET data can be used to estimate the committed effective dose equivalent, CEDE, that was accumulated from the time of the release to the time when the AIRNET filters and/or cartridges are collected from the field. AIRNET provides only retrospective data, because the radioactive material collected on the filters and cartridges consists of everything collected since the AIRNET station was last serviced.

It takes at least an hour to collect one sample, analyze it, and estimate the CEDE. Decisions such as whether to evacuate are based on the present release rate. Therefore, the retrospective information from AIRNET is of limited use during the early phase of a release.

AIRNET Locations

Approximately 50 AIRNET stations are located in Los Alamos County and approximately 5 are in nearby counties. Maps are available from http://www.esh.lanl.gov/~AirQuality/airnet.htm.

The locations are also marked on the FIMAD plot: ID: G105907 and listed in Attachment 1 of the procedure SOP 5143 and Appendix A of the AIRNET Sampling and Analysis Plan. An older (1980) report is entitled "Environmental and emergency response capabilities of LANL's radiological air sampling program," LA-8379-MS, by Tom Gunderson.

Particulate Filters

Each AIRNET station collects particulates on 47-mm-diameter polypropylene filter material. The filters are designed to be dissolved and are not ideal for alpha spectroscopy, but are satisfactory for a gross-alpha count-rate measurement from recently deposited material.

Tritium cartridges

Each station also has a silica-gel cartridge to collect water vapor, which is analyzed to measure the amount of tritiated water (HTO).

Note: Tritium gas (HT or T_2), is not collected in the silica gel.

Health Physics Analysis Laboratory (HPAL)

Filter and/or the distillate from tritium samples can be analyzed by the Health Physics Analysis Laboratory, HPAL. HPAL personnel may be contacted at 5-8888 or via the emergency digital pager: 505-996-1380.

Air flow Through the Filter

The nominal flow rate through the filter is 4 cfm (7 m^3/h) and is 6 times the standard breathing rate of 0.7 cfm (1.2 m^3/h). Therefore, if *C* is the number of curies on the filter, the human intake by inhalation is *C*/6.

If the actual flow rate was significantly less, the calculations of *H*, using the equations below, will be larger. Multiply *H* by the ratio of the actual flow rate to the nominal flow rate.

Calculating the Committed Effective Dose Equivalent (CEDE)

The committed effective dose equivalent, CEDE, corresponding to the intake may be calculated from the Derived Air Concentration, DAC, listed in Appendix A of the Code of Federal Regulations 10 CFR 835, (Attachment 4 of this procedure).

For example, for Y-class U-235 and U-238:

DAC = 2E-11 microCi/mL = 2E-11 Ci/m^3

Similarly, for W-class Pu-239:

DAC = 2E-12 microCi/mL = 2E-12 Ci/m^3

A person who breathes 2400m^3 of air with a concentration of 1 DAC will receive 5 rem. Therefore, if the activity on the filter is *C* curies, the CEDE is:

H = (5 rem)(*C*/6)/(DAC*2400) = 4E-4**C*/DAC rem

Similar results can be calculated by multiplying the dose response level, DRL, listed in Table 5-4 of EPA 400-R-92-001, by the AIRNET flow rate of 7m^3/h to give the equation:

H = *C*/(7*DRL) rem

Examples

Using the equation *H* = 4E-4**C*/DAC:

C = 5E-8 Ci of U-238 results in *H* = 4E-4 * 5E-8/2E-11 = 1 rem.

C = 5E-9 Ci of Pu-239 results in *H* = 4E-4 * 5E-9/2E-12 = 1 rem.

Using the equation *H* = *C*/(7*DRL):

C = 5E-8 Ci of U-238 results in *H* = 5E-8 / (7 * 7E-9) = 1 rem

C = 5E-9 Ci of Pu-239 results in *H* = 5E-9/(7 * 1.9E-9) = 0.4 rem

Note: 5E-9 Ci = 10,000 dpm.

Summary of particulate data

- 10,000 dpm α from Pu-239 on an AIRNET filter corresponds to 1 rem CEDE.
- 2000 dpm α from radon and thoron decay products is typically observed on AIRNET filters, but it might be a factor of ten higher after a rainstorm.

Tritium

Note: AIRNET collects tritiated water but not tritum gas.

Tritiated water is collected in the silica-gel cartridge with a nominal flow rate of 0.2 liters/minute (L/min.), which is 0.01 times the breathing rate of the standard reference man: 20 L/min. The flow rate is measured just before an old cartridge is removed, and after a new cartridge is installed. Use the flow rate that was measured just before the old cartridge was removed. If the measured flow rate is significantly different from 0.2 L/min., calculate the actual ratio of the measured flow rate to 20 L/min. and substitute the actual ratio for the number 0.01.

An intake of 0.08 Ci of tritiated water results in 5 rem CEDE, so if *C* is the number of curies in the cartridge, the CEDE is:

H = (5 rem)(*C*/0.01)/0.08 = 6250*C rem

Tritium example

Using EPA 400-R-92-001, the DRL = 1.3E-2 Ci-h/m^3. Multiplying the DRL by the nominal flow rate for the AIRNET cartridges, 1.2E-2 m^3/h, gives 1.6E-4 Ci. If C=1.6E-4 Ci, then:

H = 6250 * 1.6E-4 = 1 rem.

Element and Nuclide Identification

For beta-gamma emitters, HPAL can determine the radionuclides by using gamma spectroscopy.

For alpha emitters, HPAL can determine the elements by measuring the characteristic x rays.

For alpha emitters, nuclide identification is not essential because 2E-12 Ci is a reasonable estimate of the DAC for most transuranics. The specific nuclide is less important than the solubility class (D, W, or Y), which cannot be determined in a short time. When in doubt, assume the worst case, which is the smallest DAC.

ATTACHMENT 4

SOP-5173-4

Records Use only

Appendix A to 10 CFR 835–Derived Air Concentrations (DAC) for Controlling Radiation Exposure to Workers at DOE Facilities

The data presented in Appendix A are to be used for controlling individual internal doses in accordance with § 835.209, identifying the need for air monitoring in accordance with § 835.403, and identifying and posting airborne radioactivity areas in accordance with § 835.603(d).

The derived air concentration (DAC) values are given for individual radionuclides. For known mixtures of radionuclides, determine the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DAC for all radionuclides in the mixture. If this sum exceeds unity (1), then the DAC has been exceeded. For unknown radionuclides, the most restrictive DAC (lowest value) for those isotopes not known to be absent shall be used.

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m^3			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
H-3 (Water)[2]	2.E-05	2.E-05	2.E-05	8.E+05	8.E+05	8.E+05	St/St/St
H-3 (Elemental)[2]	5.E-01	5.E-01	5.E-01	2.E+10	2.E+10	2.E+10	St/St/St
Be-7	—[3]	9.E-06	8.E-06	—[3]	3.E+05	3.E+05	/St/St
Be-10	—	6.E-08	6.E-09	—	2.E+03	2.E+02	/St/St
C-11 (Org)[2]	2.E-04	2.E-04	2.E-04	6.E+06	6.E+06	6.E+06	/St/St
C-11 (CO)[2]	5.E-04	5.E-04	5.E-04	2.E+07	2.E+07	2.E+07	St/St/St
C-11 (CO_2)[2]	3.E-04	3.E-04	3.E-04	1.E+07	1.E+07	1.E+07	St/St/St
C-14 (Org)[2]	1.E-06	1.E-06	1.E-06	4.E+07	4.E+07	4.E+07	St/St/St
C-14 (CO)[2]	7.E-04	7.E-04	7.E-04	3.E+07	3.E+07	3.E+07	St/St/St
C-14 (CO_2)[2]	9.E-05	9.E-05	9.E-05	3.E+06	3.E+06	3.E+06	St/St/St
F-18	3.E-05	4.E-05	3.E-05	1.E+06	1.E+06	1.E+06	St/St/St
Na-22	3.E-07	—	—	1.E+04	—	—	St/ /
Na-24	2.E-06	—	—	8.E+04	—	—	St/ /
Mg-28	7.E-07	5.E-07	—	3.E+04	2.E+04	—	St/St/
Al-26	3.E-08	3.E-08	—	1.E+03	1.E+03	—	St/St/
Si-31	1.E-05	1.E-05	1.E-05	4.E+05	5.E+05	4.E+05	St/St/St
Si-32	1.E-07	5.E-08	2.E-09	4.E+03	2.E+03	8.E+01	St/St/St
P-32	4.E-07	2.E-07	—	1.E+04	6.E+03	—	St/St/
P-33	3.E-06	1.E-06	—	1.E+05	4.E+04	—	St/St/
S-35	7.E-06	9.E-07	—	3.E+05	3.E+04	—	St/St/
S-35 (Gas)	—	6.E-06	—	—	2.E+05	—	/St/
Cl-36	1.E-06	1.E-07	—	4.E+04	4.E+03	—	St/St/
Cl-38	2.E-05	2.E-05	—	6.E+05	7.E+05	—	St/St/

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Cl-39	2.E-05	2.E-05	—	8.E+05	9.E+05	—	St/St/
K-40	2.E-07	—	—	6.E+03	—	—	St/St/St
K-42	2.E-06	—	—	7.E+04	—	—	St/St/St
K-43	4.E-06	—	—	1.E+05	—	—	/St/St
K-44	3.E-05	—	—	1.E+06	—	—	/St/St
K-45	5.E-05	—	—	2.E+06	—	—	/St/St
Ca-41	—	2.E-06	—	—	6.E+04	—	/E/
Ca-45	—	3.E-07	—	—	1.E+04	—	/St/
Ca-47	—	4.E-07	—	—	1.E+04	—	/St/
Sc-43	—	—	1.E-05	—	—	4.E+05	St/St/St
Sc-44m	—	—	3.E-07	—	—	1.E+04	St/St/St
Sc-44	—	—	5.E-06	—	—	2.E+05	St/St/St
Sc-46	—	—	1.E-07	—	—	4.E+03	St/ /
Sc-47	—	—	1.E-06	—	—	5.E+04	St/ /
Sc-48	—	—	6.E-07	—	—	2.E+04	St/St/
Sc-49	—	—	2.E-05	—	—	8.E+05	St/St/
Ti-44	5.E-09	1.E-08	2.E-09	2.E+02	4.E+02	9.E+01	St/St/St
Ti-45	1.E-05	1.E-05	1.E-05	4.E+05	5.E+05	5.E+05	St/St/St
V-47	4.E-05	4.E-05	—	1.E+06	1.E+06	—	St/St/
V-48	4.E-07	3.E-07	—	2.E+04	1.E+04	—	St/St/
V-49	1.E-05	7.E-06	—	5.E+05	3.E+05	—	BS/St/
Cr-48	5.E-06	3.E-06	3.E-06	2.E+05	1.E+05	1.E+05	St/St/St
Cr-49	3.E-05	4.E-05	4.E-05	1.E+06	2.E+06	1.E+06	St/St/St
Cr-51	2.E-05	1.E-05	8.E-06	7.E+05	3.E+05	3.E+05	St/St/St
Mn-51	2.E-05	2.E-05	—	8.E+05	9.E+05	—	St/St/
Mn-52m	4.E-05	4.E-05	—	1.E+06	2.E+06	—	St/St/
Mn-52	5.E-07	4.E-07	—	2.E+04	1.E+04	—	St/St/
Mn-53	5.E-06	5.E-06	—	2.E+05	2.E+05	—	BS/St/
Mn-54	4.E-07	3.E-07	—	1.E+04	1.E+04	—	St/St/
Mn-56	6.E-06	9.E-06	—	3.E+05	2.E+05	—	St/St/
Fe-52	1.E-06	1.E-06	—	5.E+04	4.E+04	—	St/St/
Fe-55	8.E-07	2.E-06	—	3.E+04	6.E+04	—	St/St/
Fe-59	1.E-07	2.E-07	—	5.E+03	8.E+03	—	St/St/
Fe-60	3.E-09	8.E-09	—	1.E+02	3.E+02	—	St/St/
Co-55	—	1.E-06	1.E-06	—	4.E+04	4.E+04	/St/St
Co-56	—	1.E-07	8.E-08	—	5.E+03	3.E+03	/St/St
Co-57	—	1.E-06	3.E-07	—	4.E+04	1.E+04	/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Co-58m	—	4.E-05	3.E-05	—	1.E+06	1.E+06	/St/St
Co-58	—	5.E-07	3.E-07	—	2.E+04	1.E+06	/St/St
Co-60m	—	2.E-03	1.E-03	—	6.E+07	4.E+07	/St/St
Co-60	—	7.E-08	1.E-08	—	3.E+03	5.E+02	/St/St
Co-61	—	3.E-05	2.E-05	—	1.E+06	9.E+05	/St/St
Co-62	—	7.E-05	7.E-05	—	3.E+06	2.E+06	/St/St
Ni-56 (Inorg)	8.E-07	5.E-07	—	3.E+04	2.E+04	—	St/St/
Ni-56 (Vapor)	—	5.E-07	—	—	2.E+04	—	/St/
Ni-57 (Inorg)	2.E-06	1.E-06	—	7.E+04	5.E+04	—	St/St/
Ni-57 (Vapor)	—	3.E-06	—	—	1.E+05	—	/St/
Ni-59 (Inorg)	2.E-06	3.E-06	—	6.E+04	1.E+05	—	St/St/
Ni-59 (Vapor)	—	8.E-07	—	—	3.E+04	—	/St/
Ni-63 (Inorg)	7.E-07	1.E-06	—	3.E+04	4.E+04	—	St/St/
Ni-63 (Vapor)	—	3.E-07	—	—	1.E+04	—	/St/
Ni-65 (Inorg)	1.E-05	1.E-05	—	4.E+05	5.E+05	—	St/St/
Ni-65 (Vapor)	—	7.E-06	—	—	3.E+05	—	/St/
Ni-66 (Inorg)	7.E-07	3.E-07	—	3.E+04	1.E+04	—	St/St/
Ni-66 (Vapor)	—	1.E-06	—	—	5.E+04	—	/St/
Cu-60	4.E-05	5.E-05	4.E-05	1.E+06	2.E+06	2.E+06	St/St/St
Cu-61	1.E-05	2.E-05	1.E-05	5.E+05	6.E+05	5.E+05	St/St/St
Cu-64	1.E-05	1.E-05	9.E-06	5.E+05	4.E+05	3.E+05	St/St/St
Cu-67	3.E-06	2.E-06	2.E-06	1.E+05	8.E+04	7.E+04	St/St/St
Zn-62	—	—	3.E-05	—	—	4.E+04	/ /St
Zn-65	—	—	1.E-07	—	—	1.E+06	/ /St
Zn-69m	—	—	3.E-06	—	—	4.E+03	/ /St
Zn-69	—	—	6.E-05	—	—	1.E+05	/ /St
Zn-71m	—	—	7.E-06	—	—	2.E+06	/ /St
Zn-72	—	—	5.E-07	—	—	3.E+05	/ /St
Ga-65	7.E-05	8.E-05	—	3.E+06	3.E+06	—	St/ St/
Ga-66	1.E-06	1.E-06	—	5.E+04	5.E+04	—	St/ St/
Ga-67	6.E-06	4.E-06	—	2.E+05	2.E+05	—	St/ St/
Ga-68	2.E-05	2.E-05	—	6.E+05	8.E+05	—	St/ St/
Ga-70	7.E-05	8.E-05	—	3.E+06	3.E+06	—	St/ St/
Ga-72	2.E-06	1.E-06	—	6.E+04	5.E+04	—	St/ St/
Ga-73	6.E-06	6.E-06	—	2.E+05	2.E+05	—	St/ St/
Ge-66	1.E-05	8.E-06	—	4.E+05	3.E+05	—	St/ St/
Ge-67	4.E-05	4.E-05	—	1.E+06	2.E+06	—	St/ St/

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Ge-68	2.E-06	4.E-08	—	6.E+04	2.E+03	—	St/ St/
Ge-69	6.E-06	3.E-06	—	2.E+05	1.E+05	—	St/ St/
Ge-71	2.E-04	2.E-05	—	7.E+06	6.E+05	—	St/ St/
Ge-75	3.E-05	3.E-05	—	1.E+06	1.E+06	—	St/ St/
Ge-77	4.E-06	2.E-06	—	2.E+05	9.E+04	—	St/ St/
Ge-78	9.E-06	9.E-06	—	4.E+05	3.E+05	—	St/ St/
As-69	—	5.E-05	—	—	2.E+06	—	/St/
As-70	—	2.E-05	—	—	8.E+05	—	/St/
As-71	—	2.E-06	—	—	7.E+04	—	/St/
As-72	—	6.E-07	—	—	2.E+04	—	/St/
As-73	—	7.E-07	—	—	3.E+04	—	/St/
As-74	—	3.E-07	—	—	1.E+04	—	/St/
As-76	—	6.E-07	—	—	2.E+04	—	/St/
As-77	—	2.E-06	—	—	8.E+04	—	/St/
As-78	—	9.E-06	—	—	3.E+05	—	/St/
Se-70	1.E-05	2.E-05	—	6.E+05	7.E+05	—	St/St/
Se-73m	6.E-05	6.E-05	—	2.E+06	2.E+06	—	St/St/
Se-73	6.E-06	7.E-06	—	2.E+05	2.E+05	—	St/St/
Se-75	3.E-07	3.E-07	—	1.E+04	9.E+03	—	St/St/
Se-79	3.E-07	2.E-07	—	1.E+04	9.E+03	—	St/St/
Se-81m	3.E-05	3.E-05	—	1.E+06	1.E+06	—	St/St/
Se-81	9.E-05	1.E-04	—	3.E+06	4.E+06	—	St/St/
Se-83	5.E-05	5.E-05	—	2.E+06	2.E+06	—	St/St/
Br-74m	1.E-05	2.E-05	—	6.E+05	6.E+05	—	St/St/
Br-74	3.E-05	3.E-05	—	1.E+06	1.E+06	—	St/St/
Br-75	2.E-05	2.E-05	—	7.E+05	8.E+05	—	St/St/
Br-76	2.E-06	2.E-06	—	7.E+04	7.E+04	—	St/St/
Br-77	1.E-05	8.E-06	—	4.E+05	3.E+05	—	St/St/
Br-80m	7.E-06	6.E-06	—	3.E+05	2.E+05	—	St/St/
Br-80	8.E-05	9.E-05	—	3.E+06	3.E+06	—	St/St/
Br-82	2.E-06	2.E-06	—	6.E+04	6.E+04	—	St/St/
Br-83	3.E-05	3.E-05	—	1.E+06	1.E+06	—	St/St/
Br-84	2.E-05	3.E-05	—	9.E+05	1.E+06	—	St/St/
Rb-79	5.E-05	—	—	2.E+06	—	—	St/ /
Rb-81m	1.E-04	—	—	5.E+06	—	—	St/ /
Rb-81	2.E-05	—	—	8.E+05	—	—	St/ /
Rb-82m	7.E-06	—	—	3.E+05	—	—	St/ /

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Rb-83	4.E-07	—	—	2.E+04	—	—	St/ /
Rb-84	3.E-07	—	—	1.E+04	—	—	St/ /
Rb-86	3.E-07	—	—	1.E+04	—	—	St/ /
Rb-87	6.E-07	—	—	2.E+04	—	—	St/ /
Rb-88	3.E-05	—	—	1.E+06	—	—	St/ /
Rb-89	6.E-05	—	—	2.E+06	—	—	St/ /
Sr-81	5.E-06	—	5.E-06	2.E+05	—	2.E+05	St/ /St
Sr-83	3.E-05	—	3.E-05	1.E+06	—	1.E+06	St/ /St
Sr-85m	3.E-06	—	2.E-06	1.E+05	—	5.E+04	St/ /St
Sr-80	3.E-04	—	3.E-04	9.E+06	—	1.E+07	St/ /St
Sr-85	1.E-06	—	7.E-07	4.E+04	—	2.E+04	St/ /St
Sr-87m	5.E-05	—	6.E-05	2.E+06	—	2.E+06	St/ /St
Sr-89	3.E-07	—	6.E-08	1.E+04	—	2.E+03	St/ /St
Sr-90	8.E-09	—	2.E-09	3.E+02	—	6.E+01	St/ /St
Sr-91	2.E-06	—	1.E-06	9.E+04	—	5.E+04	St/ /St
Sr-92	4.E-06	—	3.E-06	1.E+05	—	1.E+05	St/ /St
Y-86m	—	2.E-05	2.E-05	—	9.E+05	9.E+05	/St/St
Y-86	—	1.E-06	1.E-06	—	5.E+04	5.E+04	/St/St
Y-87	—	1.E-06	1.E-06	—	5.E+04	5.E+04	/St/St
Y-88	—	1.E-07	1.E-07	—	4.E+03	4.E+03	/St/St
Y-90m	—	5.E-06	5.E-06	—	2.E+05	2.E+05	/St/St
Y-90	—	3.E-07	2.E-07	—	1.E+04	9.E+03	/St/St
Y-91m	—	1.E-04	7.E-05	—	4.E+06	3.E+06	/St/St
Y-91	—	7.E-08	5.E-08	—	3.E+03	2.E+03	/St/St
Y-92	—	3.E-06	3.E-06	—	1.E+05	1.E+05	/St/St
Y-93	—	1.E-06	1.E-06	—	4.E+04	4.E+04	/St/St
Y-94	—	3.E-05	3.E-05	—	1.E+06	1.E+06	/St/St
Y-95	—	6.E-05	6.E-05	—	2.E+06	2.E+06	/St/St
Zr-86	2.E-06	1.E-06	1.E-06	6.E+04	4.E+04	4.E+04	St/St/St
Zr-88	9.E-08	2.E-07	1.E-07	3.E+03	7.E+03	5.E+03	St/St/St
Zr-89	2.E-06	1.E-06	1.E-06	5.E+04	4.E+04	4.E+04	St/St/St
Zr-93	3.E-09	1.E-08	2.E-08	1.E+02	4.E+02	9.E+02	BS/BS/BS
Zr-95	6.E-08	2.E-07	1.E-07	2.E+03	6.E+03	4.E+03	BS/St/St
Zr-97	8.E-07	6.E-07	5.E-07	3.E+04	2.E+04	2.E+04	St/St/St
Nb-88	—	1.E-04	9.E-05	—	4.E+06	3.E+06	/St/St
Nb-89 (66 min)	—	2.E-05	2.E-05	—	6.E+05	6.E+05	/St/St
Nb-89 (122 min)	—	8.E-06	7.E-06	—	3.E+05	2.E+05	/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Nb-90	—	1.E-06	1.E-06	—	4.E+04	4.E+04	/St/St
Nb-93m	—	5.E-07	7.E-08	—	2.E+04	3.E+03	/St/St
Nb-94	—	8.E-08	6.E-09	—	3.E+03	2.E+02	/St/St
Nb-95m	—	1.E-06	9.E-07	—	4.E+04	4.E+04	/St/St
Nb-95	—	5.E-07	5.E-07	—	2.E+04	2.E+04	/St/St
Nb-96	—	1.E-06	1.E-06	—	4.E+04	4.E+04	/St/St
Nb-97	—	3.E-05	3.E-05	—	1.E+06	1.E+06	/St/St
Nb-98	—	2.E-05	2.E-05	—	8.E+05	8.E+05	/St/St
Mo-90	3.E-06	—	2.E-06	1.E+05	—	7.E+04	St/ /St
Mo-93m	7.E-06	—	6.E-06	3.E+05	—	2.E+05	St/ /St
Mo-93	2.E-06	—	7.E-08	8.E+04	—	3.E+03	St/ /St
Mo-99	1.E-06	—	6.E-07	4.E+04	—	2.E+04	St/ /St
Mo-101	6.E-05	—	6.E-05	2.E+06	—	2.E+06	St/ /St
Tc-93m	7.E-05	1.E-04	—	2.E+06	5.E+06	—	St/St/
Tc-93	3.E-05	4.E-05	—	1.E+06	2.E+06	—	St/St/
Tc-94m	2.E-05	2.E-05	—	7.E+05	9.E+05	—	St/St/
Tc-94	8.E-06	1.E-05	—	3.E+05	4.E+05	—	St/St/
Tc-96m	1.E-04	1.E-04	—	4.E+06	4.E+06	—	St/St/
Tc-96	1.E-06	9.E-07	—	5.E+04	3.E+04	—	St/St/
Tc-97m	3.E-06	5.E-07	—	1.E+05	2.E+04	—	SW/St/
Tc-97	2.E-05	2.E-06	—	8.E+05	9.E+04	—	St/St/
Tc-98	7.E-07	1.E-07	—	3.E+04	5.E+03	—	St/St/
Tc-99m	6.E-05	1.E-04	—	2.E+06	4.E+06	—	St/St/
Tc-99	2.E-06	3.E-07	—	8.E+04	1.E+04	—	SW/St/
Tc-101	1.E-04	2.E-04	—	5.E+06	6.E+06	—	St/St/
Tc-104	3.E-05	4.E-05	—	1.E+06	1.E+06	—	St/St/
Ru-94	2.E-05	3.E-05	2.E-05	7.E+05	1.E+06	9.E+05	St/St/St
Ru-97	8.E-06	5.E-06	5.E-06	3.E+05	2.E+05	2.E+05	St/St/St
Ru-103	7.E-07	4.E-07	3.E-07	3.E+04	2.E+04	1.E+04	St/St/St
Ru-105	6.E-06	6.E-06	5.E-06	2.E+05	2.E+05	2.E+05	St/St/St
Ru-106	4.E-08	2.E-08	5.E-09	1.E+03	8.E+02	2.E+02	St/St/St
Rh-99m	2.E-05	3.E-05	3.E-05	9.E+05	1.E+06	1.E+06	St/St/St
Rh-99	1.E+06	9.E-07	8.E-07	5.E+04	3.E+04	3.E+04	St/St/St
Rh-100	2.E-06	2.E-06	2.E-06	8.E+04	6.E+04	6.E+04	St/St/St
Rh-101m	5.E-06	3.E-06	3.E-06	2.E+05	1.E+05	1.E+05	St/St/St
Rh-101	2.E-07	3.E-07	7.E-08	8.E+03	1.E+04	2.E+03	St/St/St
Rh-102m	2.E-07	2.E-07	5.E-08	8.E+03	6.E+03	2.E+03	St/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Rh-102	4.E-08	7.E-08	2.E-08	1.E+03	3.E+03	9.E+02	St/St/St
Rh-103m	4.E-04	5.E-04	5.E-04	2.E+07	2.E+07	2.E+07	St/St/St
Rh-105	5.E-06	3.E-06	2.E-06	2.E+05	1.E+05	9.E+04	St/St/St
Rh-106m	1.E-05	1.E-05	1.E-05	4.E+05	6.E+05	5.E+05	St/St/St
Rh-107	1.E-04	1.E-04	1.E-04	4.E+06	4.E+06	4.E+06	St/St/St
Pd-100	6.E-07	5.E-07	6.E-07	2.E+04	2.E+04		St/St/St
Pd-101	1.E-05	1.E-05	1.E-05	5.E+05	5.E+05	5.E+05	St/St/St
Pd-103	3.E-06	2.E-06	1.E-06	1.E+05	7.E+04	5.E+04	St/St/St
Pd-107	9.E-06	3.E-06	2.E-07	3.E+05	1.E+05	6.E+03	St/St/St
Pd-109	3.E-06	2.E-06	2.E-06	1.E+05	8.E+04	7.E+04	St/St/St
Ag-102	8.E-05	9.E-05	8.E-05	3.E+06	3.E+06	3.E+06	St/St/St
Ag-103	4.E-05	6.E-05	5.E-05	2.E+06	2.E+06	2.E+06	St/St/St
Ag-104m	4.E-05	5.E-05	5.E-05	2.E+06	2.E+06	2.E+06	St/St/St
Ag-104	3.E-05	6.E-05	6.E-05	1.E+06	2.E+06	2.E+06	St/St/St
Ag-105	4.E-07	7.E-07	7.E-07	2.E+04	3.E+04	3.E+04	St/St/St
Ag-106m	3.E-07	4.E-07	4.E-07	1.E+04	1.E+04	1.E+04	St/St/St
Ag-106	7.E-05	8.E-05	8.E-05	3.E+06	3.E+06	3.E+06	St/St/St
Ag-108m	8.E-08	8.E-08	1.E-08	3.E+03	4.E+03	4.E+02	St/St/St
Ag-110m	6.E-08	8.E-08	4.E-08	2.E+03	3.E+03	1.E+03	St/St/St
Ag-111	7.E-07	4.E-07	4.E-07	2.E+04	1.E+04	1.E+04	L /St/St
Ag-112	3.E-06	4.E-06	4.E-06	1.E+05	2.E+05	1.E+05	St/St/St
Ag-115	4.E-05	4.E-05	3.E-05	1.E+06	1.E+06	1.E+06	St/St/St
Cd-104	3.E-05	5.E-05	5.E-05	1.E+06	2.E+06	2.E+06	St/St/St
Cd-107	2.E-05	2.E-05	2.E-05	8.E+05	9.E+05	8.E+05	St/St/St
Cd-109	1.E-08	5.E-08	5.E-08	5.E+02	2.E+03	2.E+03	St/St/St
Cd-113m	1.E-09	4.E-09	5.E-09	4.E+01	1.E+02	2.E+02	K /K /St
Cd-113	9.E-10	3.E-09	6.E-09	4.E+01	1.E+02	2.E+02	K /K /St
Cd-115m	2.E-08	5.E-08	6.E-08	8.E+02	2.E+03	2.E+03	K /K /St
Cd-115	6.E-07	5.E-07	6.E-07	2.E+04	2.E+04	2.E+04	St/St/St
Cd-117m	5.E-06	7.E-06	6.E-06	2.E+05	3.E+05	2.E+05	St/St/St
Cd-117	5.E-06	7.E-06	6.E-06	2.E+05	3.E+05	2.E+05	St/St/St
In-109	2.E-05	3.E-05	—	7.E+05	1.E+06	—	St/St/
In-110 (69 min)	2.E-05	2.E-05	—	7.E+05	9.E+05	—	St/St/
In-110 (5 h)	7.E-06	8.E-06	—	3.E+05	3.E+05	—	St/St/
In-111	3.E-06	3.E-06	—	1.E+05	1.E+05	—	St/St/
In-112	3.E-04	3.E-04	—	1.E+07	1.E+07	—	St/St/
In-113m	6.E-05	8.E-05	—	2.E+06	3.E+06	—	St/St/

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
In-114m	3.E-08	4.E-08	—	1.E+03	2.E+03	—	St/St/
In-115m	2.E-05	2.E-05	—	7.E+05	7.E+05	—	St/St/
In-115	6.E-10	2.E-09	—	2.E+01	8.E+01	—	St/St/
In-116m	3.E-05	5.E-05	—	1.E+06	2.E+06	—	St/St/
In-117m	1.E-05	2.E-05	—	5.E+05	7.E+05	—	St/St/
In-117	7.E-05	9.E-05	—	3.E+06	3.E+06	—	St/St/
In-119m	5.E-05	6.E-05	—	2.E+06	2.E+06	—	St/St/
Sn-110	5.E-06	5.E-06	—	2.E+05	2.E+05	—	St/St/
Sn-111	9.E-05	1.E-04	—	4.E+06	4.E+06	—	St/St/
Sn-113	5.E-07	2.E-07	—	2.E+04	9.E+03	—	St/St/
Sn-117m	5.E-07	6.E-07	—	2.E+04	2.E+04	—	BS/St/
Sn-119m	1.E-06	4.E-07	—	4.E+04	1.E+04	—	St/St/
Sn-121m	4.E-07	2.E-07	—	1.E+04	9.E+03	—	St/St/
Sn-121	6.E-06	5.E-06	—	2.E+05	2.E+05	—	St/St/
Sn-123m	5.E-05	6.E-05	—	2.E+06	2.E+06	—	St/St/
Sn-123	3.E-07	7.E-08	—	1.E+04	3.E+03	—	St/St/
Sn-125	4.E-07	2.E-07	—	1.E+04	5.E+03	—	St/St/
Sn-126	2.E-08	3.E-08	—	9.E+02	1.E+03	—	St/St/
Sn-127	8.E-06	8.E-06	—	3.E+05	3.E+05	—	St/St/
Sn-128	1.E-05	1.E-05	—	4.E+05	6.E+05	—	St/St/
Sb-115	1.E-04	1.E-04	—	4.E+06	5.E+06	—	St/St/
Sb-116m	3.E-05	6.E-05	—	1.E+06	2.E+06	—	St/St/
Sb-116	1.E-04	1.E-04	—	4.E+06	5.E+06	—	St/St/
Sb-117	9.E-05	1.E-04	—	3.E+06	4.E+06	—	St/St/
Sb-118m	8.E-06	9.E-06	—	3.E+05	3.E+05	—	St/St/
Sb-119	2.E-05	1.E-05	—	7.E+05	4.E+05	—	St/St/
Sb-120 (16 min)	2.E-04	2.E-04	—	7.E+06	8.E+06	—	St/St/
Sb-120 (6 d)	9.E-07	6.E-07	—	3.E+04	2.E+04	—	St/St/
Sb-122	1.E-06	4.E-07	—	4.E+04	2.E+04	—	St/St/
Sb-124m	3.E-04	3.E-04	—	1.E+07	9.E+06	—	St/St/
Sb-124	4.E-07	1.E-07	—	1.E+04	4.E+03	—	St/St/
Sb-125	1.E-06	2.E-07	—	4.E+04	8.E+03	—	St/St/
Sb-126m	8.E-05	8.E-05	—	3.E+06	3.E+06	—	St/St/
Sb-126	4.E-07	2.E-07	—	2.E+04	8.E+03	—	St/St/
Sb-127	9.E-07	4.E-07	—	3.E+04	1.E+04	—	St/St/
Sb-128 (9 h)	2.E-06	1.E-06	—	6.E+04	5.E+04	—	St/St/
Sb-128 (10 min)	2.E-04	2.E-04	—	6.E+06	7.E+06	—	St/St/

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Sb-129	4.E-06	4.E-06	—	1.E+05	1.E+05	—	St/St/
Sb-130	3.E-05	3.E-05	—	1.E+06	1.E+06	—	St/St/
Sb-131	1.E+05	1.E+05	—	4.E+05	4.E+05	—	St/St/
Te-116	9.E-06	1.E-05	—	3.E+05	5.E+05	—	St/St/
Te-121m	8.E-08	2.E-07	—	3.E+03	6.E+03	—	St/St/
Te-121	2.E-06	1.E-06	—	7.E+04	5.E+04	—	St/St/
Te-123m	9.E-08	2.E-07	—	3.E+03	8.E+03	—	BS/St/
Te-123	8.E-08	2.E-07	—	3.E+03	7.E+03	—	BS/BS/
Te-125m	2.E-07	3.E-07	—	7.E+03	1.E+04	—	BS/St/
Te-127m	1.E-07	1.E-07	—	4.E+03	4.E+03	—	BS/St/
Te-127	9.E-06	7.E-06	—	4.E+05	3.E+05	—	St/St/
Te-129m	3.E-07	1.E-07	—	1.E+04	4.E+03	—	St/St/
Te-129	3.E-05	3.E-05	—	1.E+06	1.E+06	—	St/St/
Te-131m	2.E-07	2.E-07	—	6.E+03	6.E+03	—	St/St/
Te-131	2.E-06	2.E-06	—	8.E+04	8.E+04	—	St/St/
Te-132	9.E-08	9.E-08	—	4.E+03	3.E+03	—	T /T /
Te-133m	2.E-06	2.E-06	—	8.E+04	8.E+04	—	T /T /
Te-133	9.E-06	9.E-06	—	4.E+05	4.E+05	—	T /T /
Te-134	1.E-05	1.E-05	—	4.E+05	4.E+05	—	T /T /
I-120m	9.E-06	—	—	3.E+05	—	—	St/ /
I-120	4.E-06	—	—	1.E+05	—	—	T / /
I-121	7.E-06	—	—	3.E+05	—	—	T / /
I-123	3.E-06	—	—	1.E+05	—	—	T / /
I-124	3.E-08	—	—	1.E+03	—	—	T / /
I-125	3.E-08	—	—	1.E+03	—	—	T / /
I-126	1.E-08	—	—	5.E+02	—	—	T / /
I-128	5.E-05	—	—	2.E+06	—	—	St/ /
I-129	4.E-09	—	—	1.E+02	—	—	T / /
I-130	3.E-07	—	—	1.E+04	—	—	T / /
I-131	2.E-08	—	—	7.E+02	—	—	T / /
I-132m	4.E-06	—	—	1.E+05	—	—	T / /
I-132	3.E-06	—	—	1.E+05	—	—	T / /
I-133	1.E-07	—	—	4.E+03	—	—	T / /
I-134	2.E-05	—	—	7.E+05	—	—	E / /
I-135	7.E-07	—	—	2.E+04	—	—	T / /
Cs-125	6.E-05	—	—	2.E+06	—	—	St/ /
Cs-127	4.E-05	—	—	2.E+06	—	—	St/ /

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Cs-129	1.E-05	—	—	5.E+05	—	—	St/ /
Cs-130	8.E-05	—	—	3.E+06	—	—	St/ /
Cs-131	1.E-05	—	—	5.E+05	—	—	St/ /
Cs-132	2.E-06	—	—	6.E+04	—	—	St/ /
Cs-134m	6.E-05	—	—	2.E+06	—	—	St/ /
Cs-134	4.E-08	—	—	2.E+03	—	—	St/ /
Cs-135m	8.E-05	—	—	3.E+06	—	—	St/ /
Cs-135	5.E-07	—	—	2.E+04	—	—	St/ /
Cs-136	3.E-07	—	—	1.E+04	—	—	St/ /
Cs-137	7.E-08	—	—	2.E+03	—	—	St/ /
Cs-138	2.E-05	—	—	9.E+05	—	—	St/ /
Ba-126	6.E-06	—	—	2.E+05	—	—	St/ /
Ba-128	7.E-07	—	—	3.E+04	—	—	St/ /
Ba-131m	6.E-04	—	—	2.E+07	—	—	St/ /
Ba-131	3.E-06	—	—	1.E+05	—	—	St/ /
Ba-133m	4.E-06	—	—	1.E+05	—	—	St/ /
Ba-133	3.E-07	—	—	1.E+04	—	—	St/ /
Ba-135m	5.E-06	—	—	2.E+05	—	—	St/ /
Ba-139	1.E-05	—	—	5.E+05	—	—	St/ /
Ba-140	6.E-07	—	—	2.E+04	—	—	St/ /
Ba-141	3.E-05	—	—	1.E+06	—	—	St/ /
Ba-142	6.E-05	—	—	2.E+06	—	—	St/ /
La-131	5.E-05	7.E-05	—	2.E+06	3.E+06	—	St/St/
La-132	4.E-06	5.E-06	—	2.E+05	2.E+05	—	St/St/
La-135	4.E-05	4.E-05	—	2.E+06	2.E+06	—	St/St/
La-137	3.E-08	1.E-07	—	1.E+03	4.E+03	—	L /E /
La-138	2.E-09	6.E-09	—	5.E+01	2.E+02	—	St/St/
La-140	6.E-07	5.E-07	—	2.E+04	2.E+04	—	St/St/
La-141	4.E-06	5.E-06	—	1.E+05	2.E+05	—	St/St/
La-142	9.E-06	1.E-05	—	4.E+05	5.E+05	—	St/St/
La-143	4.E-05	4.E-05	—	2.E+06	1.E+06	—	St/St/
Ce-134	—	3.E-07	3.E-07	—	1.E+04	1.E+04	/St/St
Ce-135	—	2.E-06	2.E-06	—	6.E+04	5.E+04	/St/St
Ce-137m	—	2.E-06	2.E-06	—	7.E+04	6.E+04	/St/St
Ce-137	—	6.E-05	5.E-05	—	2.E+06	2.E+06	/St/St
Ce-139	—	3.E-07	3.E-07	—	1.E+04	1.E+04	/St/St
Ce-141	—	3.E-07	2.E-07	—	1.E+04	9.E+03	/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Ce-143	—	8.E-07	7.E-07	—	3.E+04	2.E+04	/St/St
Ce-144	—	1.E-08	6.E-09	—	4.E+02	2.E+02	/St/St
Pr-136	—	1.E-04	9.E-05	—	4.E+06	4.E+06	/St/St
Pr-137	—	6.E-05	6.E-05	—	2.E+06	2.E+06	/St/St
Pr-138m	—	2.E-05	2.E-05	—	8.E+05	7.E+05	/St/St
Pr-139	—	5.E-05	5.E-05	—	2.E+06	2.E+06	/St/St
Pr-142m	—	7.E-05	6.E-05	—	3.E+06	2.E+06	/St/St
Pr-142	—	8.E-07	8.E-07	—	3.E+04	3.E+04	/St/St
Pr-143	—	3.E-07	3.E-07	—	1.E+04	1.E+04	/St/St
Pr-144	—	5.E-05	5.E-05	—	2.E+06	2.E+06	/St/St
Pr-145	—	4.E-06	3.E-06	—	1.E+05	1.E+05	/St/St
Pr-147	—	8.E-05	8.E-05	—	3.E+06	3.E+06	/St/St
Nd-136	—	2.E-05	2.E-05	—	9.E+05	8.E+05	/St/St
Nd-138	—	3.E-06	2.E-06	—	1.E+05	8.E+04	/St/St
Nd-139m	—	7.E-06	6.E-06	—	3.E+05	2.E+05	/St/St
Nd-139	—	1.E-04	1.E-04	—	5.E+06	4.E+06	/St/St
Nd-141	—	3.E-04	3.E-04	—	1.E+07	9.E+06	/St/St
Nd-147	—	4.E-07	3.E-07	—	2.E+04	1.E+04	/St/St
Nd-149	—	1.E-05	1.E-05	—	4.E+05	4.E+05	/St/St
Nd-151	—	8.E-05	8.E-05	—	3.E+06	3.E+06	/St/St
Pm-141	—	8.E-05	7.E-05	—	3.E+06	3.E+06	/St/St
Pm-143	—	3.E-07	3.E-07	—	9.E+03	1.E+04	/St/St
Pm-144	—	5.E-08	5.E-08	—	2.E+03	2.E+03	/St/St
Pm-145	—	7.E-08	8.E-08	—	3.E+03	3.E+03	/BS/St
Pm-146	—	2.E-08	2.E-08	—	8.E+02	7.E+02	/St/St
Pm-147	—	6.E-08	6.E-08	—	2.E+03	2.E+03	/BS/St
Pm-148m	—	1.E-07	1.E-07	—	5.E+03	5.E+03	/St/St
Pm-148	—	2.E-07	2.E-07	—	8.E+03	8.E+03	/St/St
Pm-149	—	8.E-07	8.E-07	—	3.E+04	3.E+04	/St/St
Pm-150	—	8.E-06	7.E-06	—	3.E+05	3.E+05	/St/St
Pm-151	—	2.E-06	1.E-06	—	6.E+04	5.E+04	/St/St
Sm-141m	—	4.E-05	—	—	2.E+06	—	/St/
Sm-141	—	7.E-05	—	—	3.E+06	—	/St/
Sm-142	—	1.E-05	—	—	4.E+05	—	/St/
Sm-145	—	2.E-07	—	—	8.E+03	—	/St/
Sm-146	—	1.E-11	—	—	6.E-01	—	/BS/
Sm-147	—	2.E-11	—	—	6.E-01	—	/BS/

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Sm-151	—	4.E-08	—	—	2.E+03	—	/BS/
Sm-153	—	1.E-06	—	—	4.E+04	—	/St/
Sm-155	—	9.E-05	—	—	3.E+06	—	/St/
Sm-156	—	4.E-06	—	—	1.E+05	—	/St/
Eu-145	—	8.E-07	—	—	3.E+04	—	/St/
Eu-146	—	5.E-07	—	—	2.E+04	—	/St/
Eu-147	—	7.E-07	—	—	3.E+04	—	/St/
Eu-148	—	2.E-07	—	—	6.E+03	—	/St/
Eu-149	—	1.E-06	—	—	5.E+04	—	/St/
Eu-150 (12 h)	—	3.E-06	—	—	1.E+05	—	/St/
Eu-150 (34 yr)	—	8.E-09	—	—	3.E+02	—	/St/
Eu-152m	—	3.E-06	—	—	1.E+05	—	/St/
Eu-152	—	1.E-08	—	—	4.E+02	—	/St/
Eu-154	—	8.E-09	—	—	3.E+02	—	/St/
Eu-155	—	4.E-08	—	—	1.E+03	—	/BS/
Eu-156	—	2.E-07	—	—	7.E+03	—	/St/
Eu-157	—	2.E-06	—	—	7.E+04	—	/St/
Eu-158	—	2.E-05	—	—	9.E+05	—	/St/
Gd-145	7.E-05	7.E-05	—	2.E+06	3.E+06	—	St/St/
Gd-146	5.E-08	1.E-07	—	2.E+03	4.E+03	—	St/St/
Gd-147	2.E-06	2.E-06	—	6.E+04	5.E+04	—	St/St/
Gd-148	3.E-12	1.E-11	—	1.E-01	5.E-01	—	BS/BS/
Gd-149	9.E-07	1.E-06	—	3.E+04	4.E+04	—	St/St/
Gd-151	2.E-07	5.E-07	—	6.E+03	2.E+04	—	BS/St/
Gd-152	4.E-12	2.E-11	—	2.E-01	6.E-01	—	BS/BS/
Gd-153	6.E-08	3.E-07	—	2.E+03	9.E+03	—	BS/St/
Gd-159	3.E-06	2.E-06	—	1.E+05	9.E+04	—	St/St/
Tb-147	—	1.E-05	—	—	5.E+05	—	/St/
Tb-149	—	3.E-07	—	—	1.E+04	—	/St/
Tb-150	—	9.E-06	—	—	3.E+05	—	/St/
Tb-151	—	4.E-06	—	—	1.E+05	—	/St/
Tb-153	—	3.E-06	—	—	1.E+05	—	/St/
Tb-154	—	2.E-06	—	—	7.E+04	—	/St/
Tb-155	—	3.E-06	—	—	1.E+05	—	/St/
Tb-156m (24 h)	—	3.E-06	—	—	1.E+05	—	/St/
Tb-156m (5 h)	—	1.E-05	—	—	4.E+05	—	/St/
Tb-156	—	6.E-07	—	—	2.E+04	—	/St/

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Tb-157	—	1.E-07	—	—	5.E+03	—	/BS/
Tb-158	—	8.E-09	—	—	3.E+02	—	/St/
Tb-160	—	1.E-07	—	—	4.E+03	—	/St/
Tb-161	—	7.E-07	—	—	2.E+04	—	/St/
Dy-155	—	1.E-05	—	—	4.E+05	—	/St/
Dy-157	—	3.E-05	—	—	1.E+06	—	/St/
Dy-159	—	1.E-06	—	—	4.E+04	—	/St/
Dy-165	—	2.E-05	—	—	7.E+05	—	/St/
Dy-166	—	3.E-07	—	—	1.E+04	—	/St/
Ho-155	—	7.E-05	—	—	2.E+06	—	/St/
Ho-157	—	6.E-04	—	—	2.E+07	—	/St/
Ho-159	—	4.E-04	—	—	2.E+07	—	/St/
Ho-161	—	2.E-04	—	—	7.E+06	—	/St/
Ho-162m	—	1.E-04	—	—	4.E+06	—	/St/
Ho-162	—	1.E-03	—	—	4.E+07	—	/St/
Ho-164m	—	1.E-04	—	—	5.E+06	—	/St/
Ho-164	—	3.E-04	—	—	1.E+07	—	/St/
Ho-166m	—	3.E-09	—	—	1.E+02	—	/St/
Ho-166	—	7.E-07	—	—	3.E+04	—	/St/
Ho-167	—	2.E-05	—	—	9.E+05	—	/St/
Er-161	—	3.E-05	—	—	1.E+06	—	/St/
Er-165	—	8.E-05	—	—	3.E+06	—	/St/
Er-169	—	1.E-06	—	—	4.E+04	—	/St/
Er-171	—	4.E-06	—	—	2.E+05	—	/St/
Er-172	—	6.E-07	—	—	2.E+04	—	/St/
Tm-162	—	1.E-04	—	—	4.E+06	—	/St/
Tm-166	—	6.E-06	—	—	2.E+05	—	/St/
Tm-167	—	8.E-07	—	—	3.E+04	—	/St/
Tm-170	—	9.E-08	—	—	3.E+03	—	/St/
Tm-171	—	1.E-07	—	—	5.E+03	—	/BS/
Tm-172	—	5.E-07	—	—	2.E+04	—	/St/
Tm-173	—	5.E-06	—	—	2.E+05	—	/St/
Tm-175	—	1.E-04	—	—	4.E+06	—	/St/
Yb-162	—	1.E-04	1.E-04	—	5.E+06	4.E+06	/St/St
Yb-166	—	8.E-07	8.E-07	—	3.E+04	3.E+04	/St/St
Yb-167	—	3.E-04	3.E-04	—	1.E+07	1.E+07	/St/St
Yb-169	—	3.E-07	3.E-07	—	1.E+04	1.E+04	/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Yb-175	—	1.E-06	1.E-06	—	5.E+04	5.E+04	/St/St
Yb-177	—	2.E-05	2.E-05	—	8.E+05	7.E+05	/St/St
Yb-178	—	2.E-05	1.E-05	—	6.E+05	6.E+05	/St/St
Lu-169	—	2.E-06	2.E-06	—	7.E+04	7.E+04	/St/St
Lu-170	—	9.E-07	8.E-07	—	3.E+04	3.E+04	/St/St
Lu-171	—	8.E-07	8.E-07	—	3.E+04	3.E+04	/St/St
Lu-172	—	5.E-07	5.E-07	—	2.E+04	2.E+04	/St/St
Lu-173	—	1.E-07	1.E-07	—	4.E+03	4.E+03	/BS/St
Lu-174m	—	1.E-07	9.E-08	—	4.E+03	3.E+03	/BS/St
Lu-174	—	5.E-08	7.E-08	—	2.E+03	2.E+03	/BS/St
Lu-176m	—	1.E-05	1.E-05	—	4.E+05	4.E+05	/St/St
Lu-176	—	2.E-09	3.E-09	—	7.E+01	1.E+02	/BS/St
Lu-177m	—	5.E-08	3.E-08	—	2.E+03	1.E+03	/BS/St
Lu-177	—	9.E-07	9.E-07	—	3.E+04	3.E+04	/St/St
Lu-178m	—	8.E-05	7.E-05	—	3.E+06	3.E+06	/St/St
Lu-178	—	5.E-05	5.E-05	—	2.E+06	2.E+06	/St/St
Lu-179	—	8.E-06	6.E-06	—	3.E+05	2.E+05	/St/St
Hf-170	2.E-06	2.E-06	—	9.E+04	7.E+04	—	St/St/
Hf-172	4.E-09	2.E-08	—	1.E+02	6.E+02	—	BS/BS/
Hf-173	5.E-06	5.E-06	—	2.E+05	2.E+05	—	St/St/
Hf-175	4.E-07	5.E-07	—	2.E+04	2.E+04	—	BS/St/
Hf-177m	2.E-05	4.E-05	—	9.E+05	1.E+06	—	St/St/
Hf-178m	6.E-10	2.E-09	—	2.E+01	8.E+01	—	BS/BS/
Hf-179m	1.E-07	3.E-07	—	5.E+03	9.E+03	—	BS/St/
Hf-180m	9.E-06	1.E-05	—	3.E+05	4.E+05	—	St/St/
Hf-181	7.E-08	2.E-07	—	3.E+03	7.E+03	—	BS/St/
Hf-182m	4.E-05	6.E-05	—	1.E+06	2.E+06	—	St/St/
Hf-182	3.E-10	1.E-09	—	1.E+01	5.E+01	—	BS/BS/
Hf-183	2.E-05	2.E-05	—	7.E+05	8.E+05	—	St/St/
Hf-184	3.E-06	3.E-06	—	1.E+05	1.E+05	—	St/St/
Ta-172	—	5.E-05	4.E-05	—	2.E+06	2.E+06	/St/St
Ta-173	—	8.E-06	7.E-06	—	3.E+05	3.E+05	/St/St
Ta-174	—	4.E-05	4.E-05	—	1.E+06	1.E+06	/St/St
Ta-175	—	7.E-06	6.E-06	—	3.E+05	2.E+05	/St/St
Ta-176	—	5.E-06	5.E-06	—	2.E+05	2.E+05	/St/St
Ta-177	—	8.E-06	7.E-06	—	3.E+05	3.E+05	/St/St
Ta-178	—	4.E-05	3.E-05	—	1.E+06	1.E+06	/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Ta-179	—	2.E-06	4.E-07	—	8.E+04	1.E+04	/St/St
Ta-180m	—	3.E-05	2.E-05	—	1.E+06	9.E+05	/St/St
Ta-180	—	2.E-07	1.E-08	—	7.E+03	4.E+02	/St/St
Ta-182m	—	2.E-04	2.E-04	—	8.E+06	6.E+06	/St/St
Ta-182	—	1.E-07	6.E-08	—	5.E+03	2.E+03	/St/St
Ta-183	—	5.E-07	4.E-07	—	2.E+04	2.E+04	/St/St
Ta-184	—	2.E-06	2.E-06	—	8.E+04	7.E+04	/St/St
Ta-185	—	3.E-05	3.E-05	—	1.E+06	1.E+06	/St/St
Ta-186	—	1.E-04	9.E-05	—	4.E+06	3.E+06	/St/St
W-176	2.E-05	—	—	8.E+05	—	—	St/ /
W-177	4.E-05	—	—	1.E+06	—	—	St/ /
W-178	8.E-06	—	—	3.E+05	—	—	St/ /
W-179	7.E-04	—	—	3.E+07	—	—	St/ /
W-181	1.E-05	—	—	5.E+05	—	—	St/ /
W-185	3.E-06	—	—	1.E+05	—	—	St/ /
W-187	4.E-06	—	—	2.E+05	—	—	St/ /
W-188	5.E-07	—	—	2.E+04	—	—	St/ /
Re-177	1.E-04	2.E-04	—	4.E+06	5.E+06	—	St/St/
Re-178	1.E-04	1.E-04	—	4.E+06	4.E+06	—	St/St/
Re-181	4.E-06	4.E-06	—	1.E+05	1.E+05	—	St/St/
Re-182 (64 h)	1.E-06	9.E-07	—	4.E+04	3.E+04	—	St/St/
Re-182 (12 h)	5.E-06	6.E-06	—	2.E+05	2.E+05	—	St/St/
Re-184m	1.E-06	2.E-07	—	5.E+04	7.E+03	—	St/St/
Re-184	2.E-06	6.E-07	—	6.E+04	2.E+04	—	St/St/
Re-186m	7.E-07	6.E-08	—	3.E+04	2.E+03	—	SW/St/
Re-186	1.E-06	7.E-07	—	5.E+04	3.E+04	—	St/St/
Re-187	3.E-04	4.E-05	—	1.E+07	2.E+06	—	SW/St/
Re-188m	6.E-05	6.E-05	—	2.E+06	2.E+06	—	St/St/
Re-188	1.E-06	1.E-06	—	4.E+04	4.E+04	—	St/St/
Re-189	2.E-06	2.E-06	—	8.E+04	7.E+04	—	St/St/
Os-180	2.E-04	2.E-04	2.E-04	6.E+06	8.E+06	7.E+06	St/St/St
Os-181	2.E-05	2.E-05	2.E-05	7.E+05	7.E+05	7.E+05	St/St/St
Os-182	2.E-06	2.E-06	2.E-06	9.E+04	7.E+04	6.E+04	St/St/St
Os-185	2.E-07	3.E-07	3.E-07	8.E+03	1.E+04	1.E+04	St/St/St
Os-189m	1.E-04	9.E-05	7.E-05	4.E+06	3.E+06	3.E+06	St/St/St
Os-191m	1.E-05	9.E-06	7.E-06	4.E+05	3.E+05	3.E+05	St/St/St
Os-191	9.E-07	7.E-07	6.E-07	3.E+04	3.E+04	2.E+04	St/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Os-193	2.E-06	1.E-06	1.E-06	7.E+04	5.E+04	4.E+04	St/St/St
Os-194	2.E-08	2.E-08	3.E-09	7.E+02	9.E+02	1.E+02	St/St/St
Ir-182	6.E-05	6.E-05	5.E-05	2.E+06	2.E+06	2.E+06	St/St/St
Ir-184	1.E-05	1.E-05	1.E-05	4.E+05	5.E+05	4.E+05	St/St/St
Ir-185	5.E-06	5.E-06	4.E-06	2.E+05	2.E+05	2.E+05	St/St/St
Ir-186	3.E-06	3.E-06	2.E-06	1.E+05	1.E+05	9.E+04	St/St/St
Ir-187	1.E-05	1.E-05	1.E-05	5.E+05	5.E+05	4.E+05	St/St/St
Ir-188	2.E-06	2.E-06	1.E-06	7.E+04	6.E+04	5.E+04	St/St/St
Ir-189	2.E-06	2.E-06	2.E-06	7.E+04	6.E+04	6.E+04	St/St/St
Ir-190m	8.E-05	9.E-05	8.E-05	3.E+06	3.E+06	3.E+06	St/St/St
Ir-190	4.E-07	4.E-07	4.E-07	1.E+04	2.E+04	1.E+04	St/St/St
Ir-192m	4.E-08	9.E-08	6.E-09	1.E+03	3.E+03	2.E+02	St/St/St
Ir-192	1.E-07	2.E-07	9.E-08	4.E+03	6.E+03	3.E+03	St/St/St
Ir-194m	4.E-08	7.E-08	4.E-08	2.E+03	3.E+03	2.E+03	St/St/St
Ir-194	1.E-06	8.E-07	8.E-07	5.E+04	3.E+04	3.E+04	St/St/St
Ir-195m	1.E-05	1.E-05	9.E-06	4.E+05	4.E+05	3.E+05	St/St/St
Ir-195	2.E-05	2.E-05	2.E-05	6.E+05	8.E+05	7.E+05	St/St/St
Pt-186	2.E-05	—	—	6.E+05	—	—	St/ /
Pt-188	7.E-07	—	—	3.E+04	—	—	St/ /
Pt-189	1.E-05	—	—	4.E+05	—	—	St/ /
Pt-191	3.E-06	—	—	1.E+05	—	—	St/ /
Pt-193m	2.E-06	—	—	9.E+04	—	—	St/ /
Pt-193	1.E-05	—	—	4.E+05	—	—	St/ /
Pt-195m	2.E-06	—	—	7.E+04	—	—	St/ /
Pt-197m	2.E-05	—	—	7.E+05	—	—	St/ /
Pt-197	4.E-06	—	—	2.E+05	—	—	St/ /
Pt-199	6.E-05	—	—	2.E+06	—	—	St/ /
Pt-200	1.E-06	—	—	5.E+04	—	—	St/ /
Au-193	1.E-05	8.E-06	8.E-06	4.E+05	3.E+05	3.E+05	St/St/St
Au-194	3.E-06	2.E-06	2.E-06	1.E+05	9.E+04	8.E+04	St/St/St
Au-195	5.E-06	6.E-07	2.E-07	2.E+05	2.E+04	6.E+03	St/St/St
Au-198m	1.E-06	5.E-07	5.E-07	4.E+04	2.E+04	2.E+04	St/St/St
Au-198	2.E-06	7.E-07	7.E-07	6.E+04	3.E+04	3.E+04	St/St/St
Au-199	4.E-06	2.E-06	2.E-06	1.E+05	6.E+04	6.E+04	St/St/St
Au-200m	1.E-06	1.E-06	1.E-06	5.E+04	4.E+04	4.E+04	St/St/St
Au-200	3.E-05	3.E-05	3.E-05	1.E+06	1.E+06	1.E+06	St/St/St
Au-201	9.E-05	1.E-04	9.E-05	3.E+06	4.E+06	4.E+06	St/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Hg-193m (Org)	6.E-06	—	—	2.E+05	—	—	St/ /
Hg-193m (Inorg)	4.E-06	3.E-06	—	1.E+05	1.E+05	—	St/St/
Hg-193m (Vapor)	—	4.E-06	—	—	1.E+05	—	/St/
Hg-193 (Org)	3.E-05	—	—	1.E+06	—	—	St/ /
Hg-193 (Inorg)	2.E-05	2.E-05	—	7.E+05	6.E+05	—	St/St/
Hg-193 (Vapor)	—	1.E-05	—	—	5.E+05	—	/St/
Hg-194 (Org)	1.E-08	—	—	4.E+02	—	—	St/ /
Hg-194 (Inorg)	2.E-08	5.E-08	—	7.E+02	2.E+03	—	St/St/
Hg-194 (Vapor)	—	1.E-08	—	—	5.E+02	—	/St/
Hg-195m (Org)	3.E-06	—	—	9.E+04	—	—	St/ /
Hg-195m (Inorg)	2.E-06	2.E-06	—	8.E+04	6.E+04	—	St/St/
Hg-195m (Vapor)	—	2.E-06	—	—	6.E+04	—	/St/
Hg-195 (Org)	2.E-05	—	—	7.E+05	—	—	St/ /
Hg-195 (Inorg)	1.E-05	1.E-05	—	5.E+05	5.E+05	—	St/St/
Hg-195 (Vapor)	—	1.E-05	—	—	5.E+05	—	/St/
Hg-197m (Org)	4.E-06	—	—	1.E+05	—	—	St/ /
Hg-197m (Inorg)	3.E-06	2.E-06	—	1.E+05	8.E+04	—	St/St/
Hg-197m (Vapor)	—	2.E-06	—	—	8.E+04	—	/St/
Hg-197 (Org)	6.E-06	—	—	2.E+05	—	—	St/ /
Hg-197 (Inorg)	5.E-06	4.E-06	—	2.E+05	1.E+05	—	St/St/
Hg-197 (Vapor)	—	3.E-05	—	—	1.E+05	—	/St/
Hg-199m (Org)	7.E-05	—	—	3.E+06	—	—	St/ /
Hg-199m (Inorg)	6.E-05	7.E-05	—	2.E+06	3.E+06	—	St/St/
Hg-199m (Vapor)	—	3.E-05	—	—	1.E+06	—	/St/
Hg-203 (Org)	3.E-07	—	—	1.E+04	—	—	St/ /
Hg-203 (Inorg)	5.E-07	5.E-07	—	2.E+04	2.E+04	—	St/St/
Hg-203 (Vapor)	—	3.E-07	—	—	1.E+04	—	/St/
Tl-194m	6.E-05	—	—	2.E+06	—	—	St/ /
Tl-194	3.E-04	—	—	9.E+06	—	—	St/ /
Tl-195	5.E-05	—	—	2.E+06	—	—	St/ /
Tl-197	5.E-05	—	—	2.E+06	—	—	St/ /
Tl-198m	2.E-05	—	—	9.E+05	—	—	St/ /
Tl-198	1.E-05	—	—	5.E+05	—	—	St/ /
Tl-199	3.E-05	—	—	1.E+06	—	—	St/ /
Tl-200	5.E-06	—	—	2.E+05	—	—	St/ /
Tl-201	9.E-06	—	—	3.E+05	—	—	St/ /
Tl-202	2.E-06	—	—	8.E+04	—	—	St/ /

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Tl-204	9.E-07	—	—	3.E+04	—	—	St/ /
Pb-195m	8.E-05	—	—	3.E+06	—	—	St/ /
Pb-198	3.E-05	—	—	1.E+06	—	—	St/ /
Pb-199	3.E-05	—	—	1.E+06	—	—	St/ /
Pb-200	3.E-06	—	—	1.E+05	—	—	St/ /
Pb-201	9.E-06	—	—	3.E+05	—	—	St/ /
Pb-202m	1.E-05	—	—	4.E+05	—	—	St/ /
Pb-202	2.E-08	—	—	8.E+02	—	—	St/ /
Pb-203	4.E-06	—	—	2.E+05	—	—	St/ /
Pb-205	6.E-07	—	—	2.E+04	—	—	St/ /
Pb-209	2.E-05	—	—	9.E+05	—	—	St/ /
Pb-210	1.E-10	—	—	4.E+00	—	—	BS/ /
Pb-211	3.E-07	—	—	1.E+04	—	—	St/ /
Pb-212	1.E-08	—	—	5.E+02	—	—	St/ /
Pb-214	3.E-07	—	—	1.E+04	—	—	St/ /
Bi-200	3.E-05	4.E-05	—	1.E+06	2.E+06	—	St/St/
Bi-201	1.E-05	2.E-05	—	4.E+05	6.E+05	—	St/St/
Bi-202	2.E-05	3.E-05	—	6.E+05	1.E+06	—	St/St/
Bi-203	3.E-06	2.E-06	—	1.E+05	9.E+04	—	St/St/
Bi-205	1.E-06	5.E-07	—	4.E+04	2.E+04	—	St/St/
Bi-206	6.E-07	4.E-07	—	2.E+04	1.E+04	—	St/St/
Bi-207	7.E-07	2.E-07	—	3.E+04	5.E+03	—	St/St/
Bi-210m	2.E-09	3.E-10	—	7.E+01	1.E+01	—	K /St/
Bi-210	1.E-07	1.E-08	—	4.E+03	4.E+02	—	K /St/
Bi-212	1.E-07	1.E-07	—	4.E+03	4.E+03	—	St/St/
Bi-213	1.E-07	2.E-07	—	5.E+03	5.E+03	—	St/St/
Bi-214	3.E-07	4.E-07	—	1.E+04	1.E+04	—	St/St/
Po-203	3.E-05	4.E-05	—	1.E+06	1.E+06	—	St/St/
Po-205	2.E-05	3.E-05	—	6.E+05	1.E+06	—	St/St/
Po-207	1.E-05	1.E-05	—	4.E+05	4.E+05	—	St/St/
Po-210	3.E-10	3.E-10	—	1.E+01	1.E+01	—	E /St/
At-207	1.E-06	9.E-07	—	4.E+04	3.E+04	—	St/St/
At-211	3.E-08	2.E-08	—	1.E+03	8.E+02	—	St/St/
Rn-220	8.E-09[4]	-[4]	-[4]	3.E+02[4]	-[4]	-[4]	-[4]
Rn-222	3.E-08[4]	-[4]	-[4]	1.E+03[4]	-[4]	-[4]	-[4]
Fr-222	2.E-07	—	—	7.E+03	—	—	St/ /
Fr-223	3.E-07	—	—	1.E+04	—	—	St/ /

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Ra-223	—	3.E-10	—	—	1.E+01	—	/St/
Ra-224	—	7.E-10	—	—	3.E+01	—	/St/
Ra-225	—	3.E-10	—	—	1.E+01	—	/St/
Ra-226	—	3.E-10	—	—	1.E+01	—	/St/
Ra-227	—	6.E-06	—	—	2.E+05	—	/BS/
Ra-228	—	5.E-10	—	—	2.E+01	—	/St/
Ac-224	1.E-08	2.E-08	2.E-08	4.E+02	8.E+02	7.E+02	BS/St/St
Ac-225	1.E-10	3.E-10	3.E-10	4.E+00	1.E+01	1.E+01	BS/St/St
Ac-226	1.E-09	2.E-09	2.E-09	5.E+01	8.E+01	7.E+01	BS/St/St
Ac-227	2.E-13	7.E-13	2.E-12	7.E-03	3.E-02	6.E-02	BS/BS/St
Ac-228	4.E-09	2.E-08	2.E-08	2.E+02	6.E+02	7.E+02	BS/BS/St
Th-226	—	7.E-08	6.E-08	—	2.E+03	2.E+03	/St/St
Th-227	—	1.E-10	1.E-10	—	5.E+00	5.E+00	/St/St
Th-228	—	4.E-12	7.E-12	—	2.E-01	3.E-01	/BS/St
Th-229	—	4.E-13	1.E-12	—	1.E-02	4.E-02	/BS/BS
Th-230	—	3.E-12	7.E-12	—	9.E-02	2.E-01	/BS/BS
Th-231	—	3.E-06	3.E-06	—	1.E+05	1.E+05	/St/St
Th-232	—	5.E-13	1.E-12	—	2.E-02	4.E-02	/BS/BS
Th-234	—	9.E-08	6.E-08	—	3.E+03	2.E+03	/St/St
Pa-227	—	5.E-08	4.E-08	—	2.E+03	2.E+03	/St/St
Pa-228	—	5.E-09	5.E-09	—	2.E+02	2.E+02	/BS/St
Pa-230	—	2.E-09	1.E-09	—	7.E+01	5.E+01	/St/St
Pa-231	—	7.E-13	2.E-12	—	2.E-02	6.E-02	/BS/BS
Pa-232	—	9.E-09	2.E-08	—	3.E+02	9.E+02	/BS/BS
Pa-233	—	3.E-07	2.E-07	—	1.E+04	9.E+03	/St/St
Pa-234	—	3.E-06	3.E-06	—	1.E+05	1.E+05	/St/St
U-230	2.E-10	1.E-10	1.E-10	6.E+00	5.E+00	4.E+00	BS/St/St
U-231	3.E-06	2.E-06	2.E-06	1.E+05	9.E+04	7.E+04	St/St/St
U-232	9.E-11	2.E-10	3.E-12	3.E+00	6.E+00	1.E-01	BS/St/St
U-233	5.E-10	3.E-10	2.E-11	2.E+01	1.E+01	6.E-01	BS/St/St
U-234	5.E-10	3.E-10	2.E-11	2.E+01	1.E+01	6.E-01	BS/St/St
U-235	6.E-10	3.E-10	2.E-11	2.E+01	1.E+01	6.E-01	BS/St/St
U-236	6.E-10	3.E-10	2.E-11	2.E+01	1.E+01	6.E-01	BS/St/St
U-237	1.E-06	7.E-07	6.E-07	4.E+04	3.E+04	2.E+04	St/St/St
U-238	6.E-10	3.E-10	2.E-11	2.E+01	1.E+01	6.E-01	BS/St/St
U-239	8.E-05	7.E-05	6.E-05	3.E+06	3.E+06	2.E+06	St/St/St
U-240	2.E-06	1.E-06	1.E-06	6.E+04	4.E+04	4.E+04	St/St/St

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Np-232	—	1.E-06[5]	—	—	4.E+04[5]	—	/BS/
Np-233	—	1.E-03[5]	—	—	5.E+07[5]	—	/St/
Np-234	—	1.E-06[5]	—	—	4.E+04[5]	—	/St/
Np-235	—	5.E-07[5]	—	—	2.E+04[5]	—	/BS/
Np-236(1.E+05 yr)	—	1.E-11[5]	—	—	4.E-01[5]	—	/BS/
Np-236 (22 h)	—	2.E-08[5]	—	—	6.E+02[5]	—	/BS/
Np-237	—	2.E-12[5]	—	—	9.E-02[5]	—	/BS/
Np-238	—	4.E-08[5]	—	—	1.E+03[5]	—	/BS/
Np-239	—	1.E-06[5]	—	—	4.E+04[5]	—	/St/
Np-240	—	3.E-05[5]	—	—	1.E+06[5]	—	/St/
Pu-234	—	9.E-08[5]	8.E-08[5]	—	3.E+03[5]	3.E+03[5]	/St/St
Pu-235	—	1.E-03[5]	1.E-03[5]	—	5.E+07[5]	4.E+07[5]	/St/St
Pu-236	—	7.E-12[5]	1.E-11[5]	—	3.E-01[5]	6.E-01[5]	/BS/St
Pu-237	—	1.E-06[5]	1.E-06[5]	—	5.E+04[5]	5.E+04[5]	/St/St
Pu-238	—	3.E-12[5]	7.E-12[5]	—	9.E-02[5]	3.E-01[5]	/BS/BS
Pu-239	—	2.E-12[5]	6.E-12[5]	—	8.E-02[5]	2.E-01[5]	/BS/BS
Pu-240	—	2.E-12[5]	6.E-12[5]	—	8.E-02[5]	2.E-01[5]	/BS/BS
Pu-241	—	1.E-10[5]	3.E-10[5]	—	4.E+00[5]	1.E+01[5]	/BS/BS
Pu-242	—	2.E-12[5]	6.E-12[5]	—	9.E-02[5]	2.E-01[5]	/BS/BS
Pu-243	—	1.E-05[5]	1.E-05[5]	—	5.E+05[5]	6.E+05[5]	/St/St
Pu-244	—	2.E-12[5]	6.E-12[5]	—	9.E-02[5]	2.E-01[5]	/BS/BS
Pu-245	—	2.E-06[5]	2.E-06[5]	—	7.E+04[5]	6.E+04[5]	/St/St
Am-237	—	1.E-04[5]	—	—	4.E+06[5]	—	/St/
Am-238	—	1.E-06[5]	—	—	4.E+04[5]	—	/BS/
Am-239	—	5.E-06[5]	—	—	2.E+05[5]	—	/St/
Am-240	—	1.E-06[5]	—	—	4.E+04[5]	—	/St/
Am-241	—	2.E-12[5]	—	—	8.E-02[5]	—	/BS/
Am-242m	—	2.E-12[5]	—	—	8.E-02[5]	—	/BS/
Am-242	—	3.E-08[5]	—	—	1.E+03[5]	—	/BS/
Am-243	—	2.E-12[5]	—	—	8.E-02[5]	—	/BS/
Am-244m	—	2.E-06[5]	—	—	6.E+04[5]	—	/BS/
Am-244	—	7.E-08[5]	—	—	3.E+03[5]	—	/BS/
Am-245	—	3.E-05[5]	—	—	1.E+06[5]	—	/St/
Am-246m	—	7.E-05[5]	—	—	3.E+06[5]	—	/St/
Am-246	—	4.E-05[5]	—	—	2.E+06[5]	—	/St/
Cm-238	—	4.E-07[5]	—	—	2.E+04[5]	—	/St/
Cm-240	—	2.E-10[5]	—	—	8.E+00[5]	—	/BS/

Radionuclide	Inhaled Air-Lung Retention Class µCi/ml			Inhaled Air-Lung Retention Class Bq/m³			Stochastic or Organ[1]
	Day	Week	Year	Day	Week	Year	(D/ W/ Y)
Cm-241	—	9.E-09[5]	—	—	4.E+02[5]	—	/BS/
Cm-242	—	1.E-10[5]	—	—	4.E+00[5]	—	/BS/
Cm-243	—	3.E-12[5]	—	—	1.E-01[5]	—	/BS/
Cm-244	—	4.E-12[5]	—	—	2.E-01[5]	—	/BS/
Cm-245	—	2.E-12[5]	—	—	8.E-02[5]	—	/BS/
Cm-246	—	2.E-12[5]	—	—	8.E-02[5]	—	/BS/
Cm-247	—	2.E-12[5]	—	—	9.E-02[5]	—	/BS/
Cm-248	—	6.E-13[5]	—	—	2.E-02[5]	—	/BS/
Cm-249	—	6.E-06[5]	—	—	2.E+05[5]	—	/BS/
Bk-245	—	5.E-07	—	—	2.E+04	—	/St/
Bk-246	—	1.E-06	—	—	5.E+04	—	/St/
Bk-247	—	2.E-12	—	—	8.E-02	—	/BS/
Bk-249	—	9.E-10	—	—	3.E+01	—	/BS/
Bk-250	—	2.E-07	—	—	7.E+03	—	/BS/
Cf-244	—	2.E-07[5]	2.E-07[5]	—	9.E+03[5]	9.E+03[5]	/St/St
Cf-246	—	4.E-09[5]	4.E-09[5]	—	2.E+02[5]	1.E+02[5]	/St/St
Cf-248	—	4.E-11[5]	5.E-11[5]	—	1.E+00[5]	2.E+00[5]	/BS/St
Cf-249	—	2.E-12[5]	6.E-12[5]	—	8.E-02[5]	2.E-01[5]	/BS/BS
Cf-250	—	5.E-12[5]	1.E-11[5]	—	2.E-01[5]	4.E-01[5]	/BS/St
Cf-251	—	2.E-12[5]	5.E-12[5]	—	8.E-02[5]	2.E-01[5]	/BS/BS
Cf-252	—	1.E-11[5]	2.E-11[5]	—	4.E-01[5]	6.E-01[5]	/BS/St
Cf-253	—	8.E-10[5]	7.E-10[5]	—	3.E+01[5]	3.E+01[5]	/St/St
Cf-254	—	9.E-12[5]	7.E-12[5]	—	3.E-01[5]	3.E-01[5]	/St/St
Es-250	—	3.E-07	—	—	1.E+04	—	/BS/
Es-251	—	4.E-07	—	—	2.E+04	—	/BS/
Es-253	—	6.E-10	—	—	2.E+01	—	/St/
Es-254m	—	4.E-09	—	—	2.E+02	—	/St/
Es-254	—	4.E-11	—	—	2.E+00	—	/BS/
Fm-252	—	6.E-09	—	—	2.E+02	—	/St/
Fm-253	—	4.E-09	—	—	2.E+02	—	/St/
Fm-254	—	4.E-08	—	—	2.E+03	—	/St/
Fm-255	—	9.E-09	—	—	3.E+02	—	/St/
Fm-257	—	1.E-10	—	—	4.E+00	—	/E /
Md-257	—	4.E-08	—	—	2.E+03	—	/St/
Md-258	—	1.E-10	—	—	4.E+00	—	/BS/

Attachment 4. Footnotes

[1] A determination of whether the DACs are controlled by stochastic (St) or nonstochastic (organ) dose, or if they both give the same result (E), for each lung retention class, is given in this column. The key to the organ notation for nonstochastic dose is: BS = bone surface, K = kidney, L = liver, SW = stomach wall, and T = thyroid. A blank indicates that no calculations were performed for the lung retention class shown.

[2] The ICRP identifies tritiated water and carbon as having immediate uptake and distribution; therefore no solubility classes are designated. For the purposes of this table, the DAC values are shown as being constant, independent of solubility class. For tritiated water, the inhalation DAC values allow for an additional 50% absorption through the skin, as described in ICRP Publication No. 30: *Limits for Intakes of Radionuclides by Workers*. For elemental tritium, the DAC values are based solely on consideration of the dose-equivalent rate to the tissues of the lung from inhaled tritium gas contained within the lung, without absorption in the tissues.

[3] A dash indicates no values given for this data category.

[4] These values are appropriate for protection from radon combined with its short-lived daughters and are based on information given in ICRP Publication 32: Limits for Inhalation of Radon Daughters by Workers and Federal Guidance Report No. 11: Limiting Values of Radionuclide Intake and Air Concentrations, and Dose Conversion Factors for Inhalation, Submersion, and Ingestion (EPA 520/1-88-020). The values given are for 100% equilibrium concentration conditions of the radon daughters with the parent. To allow for an actual measured equilibrium concentration or a demonstrated equilibrium concentration, the values given in this table should be multiplied by the ratio (100%/actual %) or (100%/demonstrated %), respectively. Alternatively, the DAC values for Rn-220 and Rn-222 may be replaced by 1 WL* and 1/3 WL*, respectively, for appropriate limiting of daughter concentrations. Because of the dosimetric considerations for radon, no f_1 or lung clearance values are listed.

* A Working Level (WL) is any combination of short-lived radon daughters, in one liter of air without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3 E+05 MeV of alpha energy.