Department of Energy
Washington, DC 20585

June 17, 2010

Mr. Thomas E. Mason
Director
UT-Battelle
P.O. Box 2008
Oak Ridge, Tennessee 37831-6107

Dear Mr. Mason:

This is in response to your February 17, 2010, request for an exemption from provisions contained in title 10, Code of Federal Regulations, part 835 (10 C.F.R. 835), *Occupational Radiation Protection.* The purpose of the exemption request is to permit UT-Battelle to use derived air concentration (DAC) values for specified airborne radionuclides that are calculated in accordance with UT-Battelle's Calculation Package: *Derivation of Facility-Specific Derived Air Concentration (DAC) Values in Support of Spallation Neutron Source Operations, ORNL/TM-2009/288, December 2009.* A copy of the calculation package was provided with the exemption request. Use of these values would be limited to 175 radionuclides produced at the Oak Ridge National Laboratory Spallation Neutron Source, but not specifically listed in appendices A or C. The DAC values calculated in accordance UT-Battelle's Calculation Package would be used rather than the default values listed in 10 C.F.R. 835, app. A (1–1–09 edition) and 10 C.F.R. 835, app. C (1–1–09 edition).

The Department of Energy's (DOE) Oak Ridge National Laboratory Site Office and the DOE Office of Science concur with the request.

The Office of Worker Safety and Health Policy, within the Office of Health, Safety and Security, conducted a technical review (enclosure 1) of the exemption request. Based on review of the information provided, we are granting UT-Battelle an exemption, with conditions, from the applicable provisions of 10 C.F.R. 835.

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The technical review provides additional information concerning the Exemption Decision (enclosure 2).

If you have any questions regarding this exemption, please contact me, or you may contact Dr. Patricia Worthington, of my staff, at (301) 903-5926.

Sincerely,

Glenn S. Podonsky
Chief Health, Safety and Security Officer
Office of Health, Safety and Security

Enclosures

cc w/enclosures:
William F. Brinkman, SC-1
Scott Blake Harris, GC-1
Docketing Clerk, HS-40
Radiological Control
Coordinating Committee
Price Anderson Amendments
Act Coordinator – ORO

Enclosure 2

EXEMPTION DECISION

Pursuant to title 10, Code of Federal Regulations, Sec. 820.61 (10 C.F.R. 820.61), the Chief Health, Safety and Security Officer is authorized to exercise authority on behalf of the Department of Energy (DOE) with respect to requests for exemptions from nuclear safety rules relating to radiological protection of workers, the public, and the environment.

On February 17, 2010, UT-Battelle submitted a request for relief from certain requirements contained in 10 C.F.R. 835, *Occupational Radiation Protection,* as they pertain to use of derived air concentration (DAC) values for airborne radionuclides.

In particular, UT-Battelle requested an exemption to allow use of DAC values that are calculated in accordance with UT-Battelle's Calculation Package: *Derivation of Facility-Specific Derived Air Concentration (DAC) Values in Support of Spallation Neutron Source Operations, ORNL/TM-2009/288, December 2009.* Use of these values would be limited to 175 radionuclides produced at Oak Ridge National Laboratory Spallation Neutron Source.

Under the terms set forth in 10 C.F.R. 820.61, I am granting the review and approval authority for exemption requests made with respect to 10 C.F.R. 835 provisions relating to radiological protection of workers, the public, and the environment. Based on a review of the supporting documentation, I find that the request set forth above has been justified for relief. Specifically, I find that the exemption criteria of 10 C.F.R. 820.62 have been met. The requested exemption is not prohibited by law; will not present an undue risk to the public health and safety, the environment, or facility workers; and is consistent with the safe operation of a DOE nuclear facility. In addition, I have determined that the exemption meets the special circumstances described in the technical review prepared by the Office of Worker Safety and Health Policy, which constitute a sufficient basis upon which to grant this exemption with three conditions.

On the basis of the foregoing, I hereby approve UT-Battelle's request for exemption from use of the default values in 10 C.F.R. 835, appendices A and C with three conditions:

<u>Conditions</u>:

1. UT-Battelle uses the DAC values shown in the attached table in place of using the default values listed in 10 C.F.R. 835, appendices A and C.

2. UT-Battelle notifies the DOE Oak Ridge National Laboratory Site Office prior to using any additional site-developed DACs determined using the methodology presented in the Calculation Package (i.e., a DAC for a radionuclide not listed in 10 C.F.R. 835 appendix A or C and not included in the attached table).

3. UT-Battelle updates its radiation protection program to reflect the revised DAC values for the isotopes as shown in the attached table and, in the future, makes additional updates to reflect any other additional DACs.

Pursuant to 10 C.F.R. 820.66, UT-Battelle has 15 days from the date of the filing of this decision to file a Request to Review with this office. The Request to Review shall state, specifically, the respects in which the exemption determination is claimed to be erroneous, the grounds of the request, and the relief requested. If no Request to Review is submitted, the Exemption Decision becomes a Final Order 15 days after it is filed.

6/17/10
Date

Glenn S. Podonsky
Chief Health, Safety and Security Officer
Office of Health, Safety and Security

Attachment

Enclosure 1

Technical Review

UT-Battelle
Title 10, Code of Federal Regulations, Part 835
Exemption Request

On February 17, 2010, UT-Battelle submitted a request for relief from certain requirements contained in title 10, Code of Federal Regulations, part 835 (10 C.F.R. 835), *Occupational Radiation Protection*, as they pertain to use of derived air concentration (DAC) values for airborne radionuclides. UT-Battelle requested an exemption to allow use of DAC values that are calculated in accordance with UT-Battelle's Calculation Package: *Derivation of Facility-Specific Derived Air Concentration (DAC) Values in Support of Spallation Neutron Source Operations, ORNL/TM-2009/288, December 2009*. These calculated DAC values would only be for radionuclides not listed in 10 C.F.R. 835 appendix A or C. A copy of the calculation package was provided with the exemption request. Use of these values would be initially limited to 175 radionuclides produced at Oak Ridge National Laboratory (ORNL) Spallation Neutron Source. The DAC values calculated in accordance UT-Battelle's Calculation Package would be used rather than the default values listed in 10 C.F.R. 835, app. A (1–1–09 edition) and 10 C.F.R. 835, app. C (1–1–09 edition).

The Department of Energy's (DOE) Oak Ridge National Laboratory Site Office and the DOE Office of Science concur with the request. As discussed below, relief from the provision of 10 C.F.R. 835 is justified. The DOE Office of Worker Safety and Health Policy recommends granting the requested exemption to 10 C.F.R. 835 requirements, with conditions, as specifically discussed in this technical review.

Discussion of Exemption Request

General

In particular, UT-Battelle requested an exemption from the requirement contained in 10 C.F.R. 835, appendices A and C, for radionuclides not listed in the appendices, to use the default DAC values in the appendices for controlling individual internal doses, identifying the need for air monitoring, and identifying and posting airborne radioactivity areas.

Requirements from which Exemption is Sought

Appendix A to Part 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).

… For any single radionuclide not listed in appendix A with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours, the DAC value shall be 4 E−11 μCi/mL (1 Bq/m3). For any single radionuclide not listed in appendix A that decays by alpha emission or spontaneous fission, the DAC value shall be 2 E−13 μCi/mL (8 E−03 Bq/m3).

Appendix C to Part 835--DERIVED AIR CONCENTRATION (DAC) FOR WORKERS FROM EXTERNAL EXPOSURE DURING IMMERSION IN A CLOUD OF AIRBORNE RADIOACTIVE MATERIAL

a. The data presented in appendix C are to be used for controlling occupational exposures in accordance with § 835.209, identifying the need for air monitoring in accordance with § 835.403 and identifying the need for posting of airborne radioactivity areas in accordance with § 835.603(d).

… For any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours, the DAC value shall be 6 E−06 μCi/mL (2 E+04 Bq/m3).

Results of Analysis

Discussion

DAC values mandated for DOE facilities are codified in appendices A and C to 10 C.F.R. 835, appendix A DAC values are based on inhalation and skin absorption of radioactive material and the appendix lists DAC values for slightly over 700 radionuclides. Appendix C DAC values are based on external exposure during immersion in a cloud of airborne radioactive material (e.g., noble gasses) and the appendix lists DAC values for 26 radionuclides. The 10 C.F.R. 835 specifies use of a default for any single radionuclide not listed in either appendix A or C, which has a decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours. The default DAC values correspond to the most restrictive DAC listed in the appendices.

UT-Battelle manages the ORNL Spallation Neutron Source (SNS) which generates neutrons through the bombardment of a mercury target by high-energy protons. The mercury target becomes radioactive due to the production of spallation products and the capture of neutrons and other secondary particles. The radioactive inventory for the mercury target and supporting structures is estimated to contain over 1,500 radionuclides extending from tritium to radioactive lead. Many of these radionuclides are extremely short lived and do not constitute a significant airborne radiological hazard. UT-Battelle contends that, for many of the SNS produced radionuclides, the default DAC values in 10 C.F.R. 835 present an unreasonable burden on the activities identified in 10 C.F.R. 835 because the values are not representative of the actual radiological hazard associated with the nuclides. UT-Battelle demonstrated this by using the same methodology as was used in the derivation of radionuclides, which are listed in the 10 C.F.R. 835 appendices. The UT-Battelle developed DAC values for most of the radionuclides of concern to UT-Battelle, which are not specifically listed in 10 C.F.R. 835, are significantly less restrictive than the default DAC values specified in 10 C.F.R. 835. In support of this position, UT-Battelle developed: UT-Battelle's Calculation Package: *Derivation of Facility-Specific Derived Air Concentration (DAC) Values in Support of Spallation Neutron Source Operations, ORNL/TM-2009/288, December 2009* (Calculation Package).

In support of the exemption request, the Calculation Package applies International Commission on Radiological Protection (ICRP) methodology combined with updated radiological decay data (i.e., ICRP Publication 107) to calculate DAC values for the unlisted radionuclides produced at the SNS. To ensure compliance with 10 C.F.R. 835, the DAC values calculated in the package apply a 5 micron activity median aerodynamic diameter particle size and address both deterministic and stochastic dose limits.

The Calculation Package applies dose coefficients generated by the Dose and Risk Calculation (DCAL) System. DCAL is a computer software code developed by the ORNL Life Sciences Division to calculate both deterministic (i.e., organ equivalent dose) and stochastic (i.e., effective dose) dose coefficients. DCAL is an extension of the computer code originally used to calculate the dose conversion factors published in ICRP 68, which DOE used in deriving the DACs listed in 10 C.F.R. 835. DCAL has also been adopted by the U.S. Environmental Protection Agency for risk analysis.

DAC values for 175 radionuclides produced at the Oak Ridge National Laboratory (ORNL) Spallation Neutron Source (SNS), but not listed in appendix A of 10 C.F.R. 835 (01/01/2009 version), are presented in the Calculation Package. UT-Battelle requests a permanent exemption to use DAC values for radionuclides not listed in appendices A and C that are calculated in accordance with the attached Calculation Package rather than the default values listed in 10 C.F.R. 835, app. A (1–1–09 edition) and 10 C.F.R. 835, app. C (1–1–09 edition).

UT-Battelle believes that its use of the methodology in the attached Calculation Package will have no adverse environment, health, or safety impacts to employees or to the public, and may in fact have a net positive safety benefit. UT-Battelle's exemption request states that the exemption request meets several of the special circumstances for granting exemptions to DOE's nuclear safety rules specified in 10 C.F.R. 820, *Procedural Rules for DOE Nuclear Activities.*

Specifically, UT-Battelle states that the application of the criteria would result in resource impacts, which are not justified by the safety improvements. In support of this statement, UT-Battelle noted that should the exemption request be denied, excessive controls would have to be put into place, resulting in unnecessary risk (such as heat stress from additional personal protective equipment requirements) and unnecessary use of resources (such as radiological job coverage and access controls). In its exemption request, UT-Battelle states that the exemption is required to avoid unnecessary posting of airborne radioactivity areas, overuse of personnel protective equipment and adverse impacts on laboratory operations.

The 10 C.F.R. 820.62(d)(2) provides for granting exemptions if application of the requirements in the particular circumstances would not serve, or is not necessary, to achieve its underlying purpose or would result in resource impacts, which are not justified by the safety improvements. The Office of Worker Safety and Health Policy agrees with UT-Battelle's assertion that it met the criterion in 10 C.F.R. 820.62(d)(2).

Concurrence

Relief from the requirement in 10 C.F.R. 835, appendices A and C, should be provided with three conditions. This decision recognizes the fact that the application of the requirements in the particular circumstances would not serve, or is not necessary, to achieve its underlying purpose or would result in resource impacts, which are not justified by the safety improvements.

Conclusion

The above exemption meets the criteria for granting an exemption under 10 C.F.R. 820.62, with conditions, for the following reasons:

1. Granting this exemption would be authorized by law.

2. This exemption would not present any undue risk to public health and safety, the environment, or facility workers.

3. The exemption would be consistent with the safe operation of a DOE nuclear facility.

4. In granting this exemption pursuant to §820.62(d)(2), DOE recognizes that special circumstances exist that justify exemption because application of the requirements in the particular circumstances would not serve, or is not necessary, to achieve its underlying purpose or would result in resource impacts that are not justified by the safety improvements.

Conditions

Based on the above, the Office of Worker Safety and Health Policy concurs with the request for exemption with the conditions that:

1. UT-Battelle may use the DACs shown in the table attached to the Exemption Decision in place of the default values listed in 10 C.F.R. 835, appendices A and C.

2. UT-Battelle notifies the DOE Oak Ridge National Laboratory Site Office prior to using any additional site-developed DACs determined using the methodology presented in the Calculation Package (i.e., a DAC for a radionuclide not listed in 10 C.F.R. 835 appendix A or C and not included in the table attached to the Exemption Decision).

3. UT-Battelle updates its radiation protection program to reflect the revised DAC values for the isotopes as shown in the attached table of the Exemption Decision and, in the future, makes additional updates to reflect any other additional DACs .

Table 1. DAC values for non-listed radionuclides

Radionuclide	Absorption type[b] (μCi/mL)			Absorption type[b] (Bq/m^3)			Stochastic or organ or tissue[a]
	F	M	S	F	M	S	(F/M/S)
Mg-27	1.E-05	1.E-05	-	6.E+05	4.E+05	-	ET / ET /
Al-28	3.E-05	3.E-05	-	1.E+06	1.E+06	-	ET / ET /
Al-29	1.E-05	1.E-05	-	6.E+05	5.E+05	-	ET / ET /
S-37 (vapor)	-	4.E-05	-	-	1.E+06	-	/ ET /
S-37	1.E-05	1.E-05	-	6.E+05	5.E+05	-	ET / ET /
S-38 (vapor)	-	2.E-06	-	-	1.E+05	-	/ St /
S-38	1.E-06	1.E-06	-	5.E+04	4.E+04	-	ET / E /
Ca-49	-	8.E-06	-	-	3.E+05	-	/ ET /
Ti-51	2.E-05	2.E-05	1.E-05	9.E+05	7.E+05	7.E+05	ET / ET / ET
V-52	2.E-05	2.E-05	-	9.E+05	8.E+05	-	ET / ET /
Cr-55	4.E-05	3.E-05	3.E-05	1.E+06	1.E+06	1.E+06	ET / ET / ET
Cr-56	1.E-05	1.E-05	1.E-05	7.E+05	5.E+05	5.E+05	ET / ET / ET
Cu-62	1.E-05	1.E-05	1.E-05	6.E+05	4.E+05	4.E+05	ET / ET / ET
Cu-66	3.E-05	2.E-05	2.E-05	1.E+06	8.E+05	8.E+05	ET / ET / ET
Ga-74	1.E-05	9.E-06	-	4.E+05	3.E+05	-	ET / ET /
As-79	-	1.E-05	-	-	4.E+05	-	/ ET /
Se-72	2.E-07	2.E-07	-	7.E+03	7.E+03	-	St / St /
Br-78	2.E-05	1.E-05	-	7.E+05	6.E+05	-	ET / ET /
Br-82m	1.E-04	9.E-05	-	3.E+06	3.E+06	-	ET / ET /
Rb-78	6.E-06	-	-	2.E+05	-	-	ET / /
Rb-82	6.E-05	-	-	2.E+06	-	-	ET / /
Rb-84m	2.E-05	-	-	8.E+05	-	-	ET / /
Sr-93	1.E-05	-	9.E-06	4.E+05	-	3.E+05	ET / / ET
Y-83	-	1.E-05	1.E-05	-	4.E+05	4.E+05	/ ET / ET
Y-85	-	2.E-06	2.E-06	-	9.E+04	9.E+04	/ ET / ET
Zr-85	1.E-05	1.E-05	1.E-05	5.E+05	4.E+05	4.E+05	ET / ET / ET
Zr-87	4.E-06	3.E-06	3.E-06	1.E+05	1.E+05	1.E+05	ET / ET / ET
Nb-91	-	3.E-06	5.E-07	-	1.E+05	1.E+04	/ St / St
Nb-91m	-	2.E-07	1.E-07	-	7.E+03	6.E+03	/ St / St
Nb-92m	-	6.E-07	6.E-07	-	2.E+04	2.E+04	/ ET / ET

Radionuclide	Absorption type[b] (μCi/mL)			Absorption type[b] (Bq/m^3)			Stochastic or organ or tissue[a]
	F	M	S	F	M	S	(F/M/S)
Mo-91	1.E-05	-	9.E-06	5.E+05	-	3.E+05	ET / / ET
Mo-102	1.E-05	-	7.E-06	4.E+05	-	2.E+05	ET / / ET
Tc-105	1.E-05	1.E-05	-	5.E+05	4.E+05	-	ET / ET /
Ru-95	4.E-06	3.E-06	3.E-06	1.E+05	1.E+05	1.E+05	ET / ET / ET
Ru-107	2.E-05	2.E-05	1.E-05	9.E+05	7.E+05	7.E+05	ET / ET / ET
Ru-108	1.E-05	1.E-05	1.E-05	5.E+05	4.E+05	4.E+05	ET / ET / ET
Rh-96	9.E-06	7.E-06	7.E-06	3.E+05	2.E+05	2.E+05	ET / ET / ET
Rh-97	8.E-06	7.E-06	7.E-06	3.E+05	2.E+05	2.E+05	ET / ET / ET
Rh-98	1.E-05	1.E-05	1.E-05	5.E+05	4.E+05	4.E+05	ET / ET / ET
Rh-106	1.E-04	1.E-04	1.E-04	6.E+06	6.E+06	6.E+06	ET / ET / ET
Pd-98	1.E-05	7.E-06	7.E-06	3.E+05	2.E+05	2.E+05	ET / ET / ET
Pd-111	1.E-05	1.E-05	1.E-05	5.E+05	3.E+05	3.E+05	ET / ET / ET
Pd-112	7.E-07	4.E-07	4.E-07	2.E+04	1.E+04	1.E+04	St / St / St
Ag-101	1.E-05	1.E-05	1.E-05	5.E+05	4.E+05	3.E+05	ET / ET / ET
Ag-109m	3.E-04	3.E-04	3.E-04	1.E+07	1.E+07	1.E+07	ET / ET / ET
Ag-111m	2.E-03	1.E-03	1.E-03	1.E+08	6.E+07	6.E+07	St / St / St
Ag-113	4.E-06	2.E-06	2.E-06	1.E+05	8.E+04	8.E+04	St / St / St
Cd-105	7.E-06	6.E-06	6.E-06	2.E+05	2.E+05	2.E+05	ET / ET / ET
Cd-111m	1.E-05	6.E-06	6.E-06	3.E+05	2.E+05	2.E+05	ET / ET / ET
Cd-118	7.E-06	4.E-06	4.E-06	2.E+05	1.E+05	1.E+05	ET / E / ET
In-106	1.E-05	1.E-05	-	4.E+05	4.E+05	-	ET / ET /
In-107	8.E-06	7.E-06	-	3.E+05	2.E+05	-	ET / ET /
In-108	2.E-06	2.E-06	-	1.E+05	9.E+04	-	ET / ET /
In-112m	1.E-05	6.E-06	-	3.E+05	2.E+05	-	ET / ET /
In-114	8.E-05	7.E-05	-	3.E+06	2.E+06	-	ET / ET /
In-119	4.E-05	3.E-05	-	1.E+06	1.E+06	-	ET / ET /
Sn-108	1.E-05	1.E-05	-	6.E+05	5.E+05	-	ET / ET /
Sn-109	1.E-05	9.E-06	-	4.E+05	3.E+05	-	ET / ET /
Sn-113m	9.E-05	7.E-05	-	3.E+06	2.E+06	-	ET / ET /
Sn-125m	2.E-05	1.E-05	-	7.E+05	5.E+05	-	ET / ET /
Sb-113	2.E-05	1.E-05	-	8.E+05	6.E+05	-	ET / ET /
Sb-114	2.E-05	2.E-05	-	9.E+05	7.E+05	-	ET / ET /
Sb-118	3.E-05	3.E-05	-	1.E+06	1.E+06	-	ET / ET /
Te-114 (vapor)	-	1.E-05	-	-	6.E+05	-	/ St /
Te-114	7.E-06	5.E-06	-	2.E+05	2.E+05	-	ET / ET /
Te-117 (vapor)	-	1.E-05	-	-	6.E+05	-	/ ET /
Te-117	5.E-06	5.E-06	-	2.E+05	1.E+05	-	ET / ET /
Te-118 (vapor)	-	2.E-07	-	-	1.E+04	-	/ St /
Te-118	4.E-07	2.E-07	-	1.E+04	9.E+03	-	St / St /
Te-119 (vapor)	-	5.E-06	-	-	1.E+05	-	/ ET /
Te-119	1.E-06	1.E-06	-	5.E+04	5.E+04	-	ET / ET /

Radionuclide	Absorption type[b] (μCi/mL)			Absorption type[b] (Bq/m^3)			Stochastic or organ or tissue[a]
	F	M	S	F	M	S	(F/M/S)
Te-119m (vapor)	-	8.E-07	-	-	3.E+04	-	/ St /
Te-119m	5.E-07	5.E-07	-	1.E+04	1.E+04	-	ET / ET /
I-118 (methyl)	3.E-06	-	-	1.E+05	-	-	T / /
I-118 (vapor)	-	2.E-06	-	-	9.E+04	-	/ T /
I-118	4.E-06	-	-	1.E+05	-	-	T / /
I-119 (methyl)	2.E-05	-	-	8.E+05	-	-	T / /
I-119 (vapor)	-	1.E-05	-	-	4.E+05	-	/ St /
I-119	1.E-05	-	-	4.E+05	-	-	ET / /
I-122 (methyl)	5.E-04	-	-	1.E+07	-	-	St / /
I-122 (vapor)	-	2.E-05	-	-	1.E+06	-	/ St /
I-122	3.E-05	-	-	1.E+06	-	-	ET / /
Cs-126	5.E-05	-	-	2.E+06	-	-	ET / /
Cs-128	3.E-05	-	-	1.E+06	-	-	ET / /
Cs-139	1.E-05	-	-	7.E+05	-	-	ET / /
Ba-124	1.E-05	-	-	4.E+05	-	-	ET / /
Ba-127	1.E-05	-	-	6.E+05	-	-	ET / /
Ba-129	8.E-06	-	-	3.E+05	-	-	ET / /
Ba-129m	3.E-06	-	-	1.E+05	-	-	ET / /
Ba-137m	1.E-04	-	-	6.E+06	-	-	ET / /
La-129	1.E-05	1.E-05	-	6.E+05	4.E+05	-	ET / ET /
La-130	1.E-05	1.E-05	-	5.E+05	4.E+05	-	ET / ET /
La-133	1.E-05	1.E-05	-	4.E+05	4.E+05	-	ET / ET /
La-134	3.E-05	2.E-05	-	1.E+06	9.E+05	-	ET / ET /
La-136	4.E-05	3.E-05	-	1.E+06	1.E+06	-	ET / ET /
Ce-130	-	5.E-06	5.E-06	-	2.E+05	2.E+05	/ ET / ET
Ce-131	-	1.E-05	1.E-05	-	4.E+05	3.E+05	/ ET / ET
Ce-132	-	2.E-06	2.E-06	-	7.E+04	7.E+04	/ ET / ET
Ce-133m	-	1.E-06	1.E-06	-	5.E+04	5.E+04	/ ET / ET
Ce-146	-	7.E-06	7.E-06	-	2.E+05	2.E+05	/ ET / ET
Pr-134m	-	7.E-06	6.E-06	-	2.E+05	2.E+05	/ ET / ET
Pr-135	-	9.E-06	9.E-06	-	3.E+05	3.E+05	/ ET / ET
Pr-138	-	6.E-05	6.E-05	-	2.E+06	2.E+06	/ ET / ET
Pr-140	-	4.E-05	4.E-05	-	1.E+06	1.E+06	/ ET / ET
Pr-146	-	7.E-06	7.E-06	-	2.E+05	2.E+05	/ ET / ET
Nd-134	-	1.E-05	1.E-05	-	4.E+05	4.E+05	/ ET / ET
Nd-135	-	7.E-06	6.E-06	-	2.E+05	2.E+05	/ ET / ET
Nd-137	-	6.E-06	6.E-06	-	2.E+05	2.E+05	/ ET / ET
Nd-140	-	4.E-07	4.E-07	-	1.E+04	1.E+04	/ St / St
Nd-152	-	7.E-06	7.E-06	-	2.E+05	2.E+05	/ ET / ET
Pm-139	-	2.E-05	2.E-05	-	9.E+05	8.E+05	/ ET / ET
Pm-152	-	2.E-05	2.E-05	-	8.E+05	8.E+05	/ ET / ET

Radionuclide	Absorption type[b] (μCi/mL)			Absorption type[b] (Bq/m^3)			Stochastic or organ or tissue[a]
	F	M	S	F	M	S	(F/M/S)
Sm-140	-	7.E-06	-	-	2.E+05	-	/ ET /
Sm-143	-	2.E-05	-	-	9.E+05	-	/ ET /
Eu-152n	-	5.E-05	-	-	1.E+06	-	/ St /
Eu-154m	-	1.E-04	-	-	3.E+06	-	/ E /
Eu-159	-	9.E-06	-	-	3.E+05	-	/ ET /
Gd-144	1.E-05	1.E-05	-	6.E+05	5.E+05	-	ET / ET /
Gd-162	1.E-05	8.E-06	-	4.E+05	3.E+05	-	ET / ET /
Tb-148	-	3.E-06	-	-	1.E+05	-	/ ET /
Tb-152	-	9.E-07	-	-	3.E+04	-	/ ET /
Tb-162	-	1.E-05	-	-	4.E+05	-	/ ET /
Dy-148	-	4.E-05	-	-	1.E+06	-	/ ET /
Dy-149	-	1.E-05	-	-	6.E+05	-	/ St /
Dy-150	-	2.E-06	-	-	8.E+04	-	/ St /
Dy-151	-	6.E-06	-	-	2.E+05	-	/ St /
Dy-152	-	5.E-06	-	-	1.E+05	-	/ ET /
Dy-153	-	2.E-06	-	-	8.E+04	-	/ ET /
Ho-154	-	1.E-05	-	-	3.E+05	-	/ ET /
Ho-156	-	3.E-06	-	-	1.E+05	-	/ ET /
Ho-160	-	9.E-06	-	-	3.E+05	-	/ ET /
Ho-163	-	2.E-06	-	-	1.E+05	-	/ BS /
Ho-168	-	2.E-05	-	-	9.E+05	-	/ ET /
Er-154	-	3.E-05	-	-	1.E+06	-	/ ET /
Er-156	-	1.E-05	-	-	4.E+05	-	/ ET /
Er-159	-	8.E-06	-	-	3.E+05	-	/ ET /
Er-163	-	1.E-04	-	-	4.E+06	-	/ ET /
Tm-161	-	6.E-06	-	-	2.E+05	-	/ ET /
Tm-163	-	4.E-06	-	-	1.E+05	-	/ ET /
Tm-164	-	6.E-05	-	-	2.E+06	-	/ ET /
Tm-165	-	1.E-06	-	-	5.E+04	-	/ ET /
Tm-168	-	1.E-07	-	-	6.E+03	-	/ St /
Yb-163	-	1.E-05	1.E-05	-	6.E+05	6.E+05	/ ET / ET
Yb-164	-	6.E-06	6.E-06	-	2.E+05	2.E+05	/ ET / ET
Yb-165	-	4.E-05	4.E-05	-	1.E+06	1.E+06	/ ET / ET
Lu-165	-	1.E-05	1.E-05	-	4.E+05	4.E+05	/ ET / ET
Lu-167	-	5.E-06	5.E-06	-	1.E+05	1.E+05	/ ET / ET
Hf-167	5.E-05	5.E-05	-	2.E+06	1.E+06	-	ET / ET /
Hf-169	8.E-05	7.E-05	-	3.E+06	2.E+06	-	ET / ET /
Ta-170	-	1.E-05	1.E-05	-	4.E+05	4.E+05	/ ET / ET
Ta-178m	-	2.E-06	2.E-06	-	1.E+05	1.E+05	/ ET / ET
W-179m	2.E-05	-	-	7.E+05	-	-	ET / /
W-183m	1.E-03	-	-	5.E+07	-	-	ET / /

Radionuclide	Absorption type[b] (μCi/mL)			Absorption type[b] (Bq/m^3)			Stochastic or organ or tissue[a]
	F	M	S	F	M	S	(F/M/S)
Re-179	1.E-05	1.E-05	-	6.E+05	4.E+05	-	ET / ET /
Re-180	5.E-05	4.E-05	-	1.E+06	1.E+06	-	ET / ET /
Re-182	4.E-07	3.E-07	-	1.E+04	1.E+04	-	ET / St /
Re-183	1.E-06	2.E-07	-	3.E+04	9.E+03	-	St / St /
Os-183	2.E-06	1.E-06	1.E-06	7.E+04	6.E+04	6.E+04	ET / ET / ET
Os-183m	1.E-06	1.E-06	1.E-06	6.E+04	5.E+04	5.E+04	ET / ET / ET
Os-190m	1.E-05	1.E-05	1.E-05	6.E+05	5.E+05	5.E+05	ET / ET / ET
Os-191	1.E-06	4.E-07	3.E-07	5.E+04	1.E+04	1.E+04	St / St / St
Os-196	7.E-06	4.E-06	4.E-06	2.E+05	1.E+05	1.E+05	ET / ET / ET
Ir-183	5.E-06	4.E-06	4.E-06	2.E+05	1.E+05	1.E+05	ET / ET / ET
Ir-186	7.E-07	7.E-07	7.E-07	2.E+04	2.E+04	2.E+04	ET / ET / ET
Ir-196	1.E-04	9.E-05	9.E-05	3.E+06	3.E+06	3.E+06	ET / ET / ET
Ir-196m	2.E-06	1.E-06	1.E-06	8.E+04	7.E+04	7.E+04	ET / ET / ET
Pt-184	8.E-06	-	-	3.E+05	-	-	ET / /
Pt-187	4.E-06	-	-	1.E+05	-	-	ET / /
Pt-202	4.E-07	-	-	1.E+04	-	-	St / /
Au-186	9.E-06	8.E-06	7.E-06	3.E+05	2.E+05	2.E+05	ET / ET / ET
Au-187	2.E-05	2.E-05	2.E-05	9.E+05	7.E+05	7.E+05	ET / ET / ET
Au-190	6.E-06	5.E-06	5.E-06	2.E+05	2.E+05	2.E+05	ET / ET / ET
Au-191	4.E-06	4.E-06	4.E-06	1.E+05	1.E+05	1.E+05	ET / ET / ET
Au-192	1.E-06	1.E-06	1.E-06	6.E+04	5.E+04	5.E+04	ET / ET / ET
Au-196	1.E-06	1.E-06	1.E-06	5.E+04	5.E+04	4.E+04	ET / ET / St
Au-196m	1.E-06	1.E-06	9.E-07	4.E+04	3.E+04	3.E+04	ET / St / St
Au-202	1.E-04	1.E-04	1.E-04	6.E+06	6.E+06	6.E+06	ET / ET / ET
Hg-190 (org)	1.E-05	-	-	4.E+05	-	-	ET / /
Hg-190	1.E-05	1.E-05	-	4.E+05	4.E+05	-	ET / ET /
Hg-190 (vapor)	-	7.E-06	-	-	2.E+05	-	/ St /
Hg-192 (org)	1.E-06	-	-	6.E+04	-	-	ET / /
Hg-192	1.E-06	1.E-06	-	6.E+04	6.E+04	-	ET / ET /
Hg-192 (vapor)	-	5.E-07	-	-	2.E+04	-	/ St /
Hg-205 (org)	2.E-05	-	-	1.E+06	-	-	ET / /
Hg-205	2.E-05	2.E-05	-	1.E+06	8.E+05	-	ET / ET /
Hg-205 (vapor)	-	4.E-05	-	-	1.E+06	-	/ St /
Tl-190	3.E-05	-	-	1.E+06	-	-	ET / /
Tl-196	3.E-06	-	-	1.E+05	-	-	ET / /
Pb-194	1.E-05	-	-	5.E+05	-	-	ET / /
Pb-195m	7.E-06	-	-	2.E+05	-	-	ET / /
Pb-196	6.E-06	-	-	2.E+05	-	-	ET / /
Pb-197	2.E-05	-	-	1.E+06	-	-	ET / /
Pb-204m	4.E-06	-	-	1.E+05	-	-	ET / /

a A determination of whether the DACs are controlled by stochastic (St) or deterministic (organ or tissue) dose for each absorption type is given in this column. The key to the organ notation for deterministic dose is: BS = bone surface, ET = extra thoracic, K = kidney, L = liver, and T = thyroid. The "St" notation is applied to stochastically controlled DACs. The notation "E" is applied in cases where the stochastic and deterministic DACs are equivalent. A blank indicates that no calculations were performed for the absorption type shown.

b A dash indicates no values given for this data category.

APPENDIX E. INERT GASES

The SNS accident inventory includes 25 inert gases. DAC values are not listed in 10 CFR 835, Appendix C, for four of these:

- N-13 (9.97 minutes)
- Ar-42 (32.9 years)
- Ar-43 (5.37 minutes)
- Ar-44 (11.87 minutes)

For omitted radioactive gases with a decay mode other than alpha emission or spontaneous fission and a half-life of less than 2 hours, 10 CFR 835 requires a DAC value of 6E-06 μCi/mL (2E+04 Bq/m^3) to be applied. As N-13, Ar-43, and Ar-44 have half-lives less than 2 hours, this provision applies to these radionuclides. Argon-42, however, is not addressed.

The majority of DAC values for noble gases are controlled by the effective whole body dose accumulated from the immersion within a semi-infinite cloud. Dose rate coefficients are published in Annex D of ICRP 68. However, ICRP 68 does not address Ar-42.

The DCAL system provides a utility to calculate effective whole body dose rate coefficients for inert gases. For Ar-42, the DCAL-generated effective whole body dose rate factor is 1.26E-16 Sv/s per Bq/m^3. Unit conversion gives a factor of 4.54E-13 Sv/hr per Bq/m^3. Given that an occupational worker is limited to a whole body dose of 0.05 Sv over an occupational year of 2000 hours, the DAC for Ar-42 is calculated as:

$$\mathrm{DAC} = \frac{\dfrac{0.05\ \mathrm{Sv}}{2000\ \mathrm{hr}}}{4.54\mathrm{E}-13\ \dfrac{\mathrm{Sv/hr}}{\mathrm{Bq/m^3}}} = 5.5\mathrm{E}+07\ \mathrm{Bq/m^3} \quad = \quad 1.5\mathrm{E}-03\ \mu\mathrm{Ci/mL}.$$

Truncation yields 5E+07 Bq/m^3 and 1E-03 μCi/mL.

For validation, the dose factors associated with Ar-41 are examined. For Ar-41, ICRP 68 gives a dose rate factor of 5.3E-09 Sv/day per Bq/m^3. The DCAL-generated whole body dose rate coefficient for Ar-41 is 6.15E-14 Sv/s per Bq/m^3. Unit conversion gives a DCAL value of 5.3E-09 Sv/day per Bq/m^{3}which exactly agrees with the ICRP 68 value.