Title 40 CFR Part 191
Subparts B and C
Compliance Recertification Application 2014
for the
Waste Isolation Pilot Plant

Application of Release Limits
(40 CFR § 194.31)

United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Field Office
Carlsbad, New Mexico

Compliance Recertification Application 2014
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Acronyms and Abbreviations

ATWIR	Annual Transuranic Waste Inventory Report
CARD	Compliance Application Review Document
CCA	Compliance Certification Application
CH-TRU	contact-handled transuranic
Ci	curies
CRA	Compliance Recertification Application
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
m^3	cubic meters
MCi	million-curie
PA	performance assessment
PABC	Performance Assessment Baseline Calculation
PAIR	Performance Assessment Inventory Report
PAVT	Performance Assessment Verification Test
RH-TRU	remote-handled transuranic
WIPP	Waste Isolation Pilot Plant
WUF	waste unit factor

Elements and Chemical Compounds

Am	americium
Cs	cesium
Pu	plutonium
Sr	strontium
Y	yttrium
^{137m}Ba	metastable barium-137

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31.0 Application of Release Limits (40 CFR § 194.31)

31.1 Requirements

> § 194.31 Application of Release Limits
>
> The release limits shall be calculated according to part 191, appendix A of this chapter, using the total activity, in curies, that will exist in the disposal system at the time of disposal.

31.2 Background

The radioactive waste disposal regulations at 40 CFR Part 191 (U.S. EPA 1993) include requirements for the containment of radionuclides. The containment requirements specify that releases from a disposal system to the accessible environment must not exceed the release limits set forth in Part 191, Appendix A, Table 1. To calculate the applicable release limits for the Waste Isolation Pilot Plant (WIPP), information is needed on the expected total curie content in the repository. However, because the inventory estimates are updated as part of the recertification effort, and because the curie content of the waste inventory in the repository will change over time as a result of natural decay and in-growth of radionuclides, the U.S. Department of Energy (DOE) must establish an inventory for use in performance assessment (PA) and must determine a date for decay purposes to be used as a reference point for calculating the curie content of waste. 40 CFR § 194.31 (U.S. EPA 1996) specifies that release limits should be calculated based on the curie content at the time of disposal (that is, after the end of the operational period, when the shafts of the repository have been backfilled and sealed).

31.3 1998 Certification Decision

The U.S. Environmental Protection Agency (EPA) stated in Compliance Application Review Document (CARD) 31 (U.S. EPA 1998) that they expected the Compliance Certification Application (CCA) (U.S. DOE 1996) to estimate curies of each radionuclide in the disposal system at the time of disposal, and provide sample calculations of release limits, including the relative contribution of each radionuclide to the normalized releases. The EPA later determined as part of its compliance determination that the CCA PA and the EPA-mandated Performance Assessment Verification Test (PAVT) (U.S. DOE 1997) were calculated using release limits developed in accordance with 40 CFR Part 191, Appendix A.

A complete description of the EPA's 1998 Certification Decision for compliance with section 194.31 can be obtained from CARD 31 (U.S. EPA 1998).

31.4 Changes in the CRA-2004

In the 2004 Compliance Recertification Application (CRA-2004) (U.S. DOE 2004), the DOE used updated versions of the same computer codes as those used in the CCA and CCA PAVT to decay the radionuclide inventory and calculate EPA units per cubic meter of waste (Fox 2003). The only change of note was the CRA-2004 inventory, which is discussed in Appendix DATA-

2004, Attachment F, Appendix TRU WASTE-2004, and CARD 24 (U.S. EPA 2006a), and the CRA-2004 PABC inventory, as documented in U.S. DOE (2006).

Since the radioactivity in each waste stream is not measured at the same time, the waste stream activities were decay-corrected to December 31, 2001, using the computer code ORIGEN2 Version 2.2 (Oak Ridge National Laboratory 2002). The total radioactivity in the repository is based on contact-handled transuranic (CH-TRU) and remote-handled transuranic (RH-TRU) waste volumes of each radionuclide and then scaled to the WIPP's maximum allowable CH-TRU and RH-TRU volumes (168,485 cubic meters (m^3) and 7,079 m^3, respectively). The scaling factor for each type of waste is calculated by subtracting the stored and emplaced waste volumes from the disposal limit value (for disposal volumes of CH-TRU waste [168,485 m^3] and RH-TRU waste [7,079 m^3]) and dividing this value by the projected waste volume.

The total radioactivity associated with CH-TRU and RH-TRU wastes from the CCA PAVT, CRA-2004, and CRA-2004 Performance Assessment Baseline Calculation (PABC) are shown in Table 31-1. These RH-TRU waste values are substantially lower than the RH-TRU waste limit of 5.1 million curies (MCi) specified in the WIPP Land Withdrawal Act (U.S. Congress 1992).

Table 31-2 shows that the five radionuclides with the highest activity in the waste—americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239 (^{239}Pu), plutonium-240 (^{240}Pu), and plutonium-241 (^{241}Pu)—contribute 97% of the total CH-TRU waste activity in the CRA-2004 PABC, 97% in the CRA-2004, and 99% in the CCA PAVT.

Similar information on the five radionuclides with the highest activity in the RH-TRU waste—metastable barium-137 (^{137m}Ba), cesium-137 (^{137}Cs), ^{241}Pu, strontium-90 (^{90}Sr), and yttrium-90 (^{90}Y)—is presented in Table 31-3.

For use in the PA, these inventories are decayed using ORIGEN2 Version 2.2 to the year 2033, the assumed closure date for the WIPP, and to various dates up to 10,000 years after closure to obtain the radioactivity profiles as a function of time (e.g., see Appendix PA-2004, Attachment PAR, Table PAR-50).

Table 31-1. Total Radioactivity Associated with CH-TRU and RH-TRU Wastes

Analysis	CH-TRU Waste Total Activity (Ci)	RH-TRU Waste Total Activity (Ci)
CCA PAVT[a,c]	6.4×10^6	1.0×10^6
CRA-2004[b,c]	5.3×10^6	1.3×10^6
CRA-2004 PABC[b,d]	4.7×10^6	1.6×10^6

[a] Decayed through 1995
[b] Decayed through 2001
[c] Values from Appendix DATA-2004, Attachment F, Annex B, Table DATA-F-B-27
[d] Values from Transuranic Waste Baseline Inventory Report 2004, Table B.1-27 (U.S. DOE 2006)

Table 31-2. Radionuclides with Highest Activity in the CH-TRU Waste Inventory

Radionuclide	Radioactivity in CCA PAVT[a,c] (Ci)	Radioactivity in CRA-2004[b,c] (Ci)	Radioactivity in CRA-2004 PABC[b,d] (Ci)
^{241}Am	4.4×10^5	4.0×10^5	4.8×10^5
^{238}Pu	2.6×10^6	1.6×10^6	1.5×10^6
^{239}Pu	7.9×10^5	6.6×10^5	5.8×10^5
^{240}Pu	2.1×10^5	(1.1×10^5)[e]	9.4×10^4
^{241}Pu	2.3×10^6	(2.4×10^6)[f]	2.0×10^6
Fraction of Total Inventory	99%	97%	97%

[a] Decayed through 1995
[b] Decayed through 2001
[c] Values directly from Appendix DATA-2004, Attachment F, Annex B, Table DATA-F-B-27
[d] Values directly from Transuranic Waste Baseline Inventory Report 2004, Table B.1-27 (U.S. DOE 2006)
[e] Value incorrectly reported in CARD 31 as 2.40×10^6 (U.S. EPA 2006b)
[f] Value incorrectly reported in CARD 31 as 5.18×10^6 (U.S. EPA 2006b)

Table 31-3. Radionuclides with Highest Activity in the RH-TRU Waste Inventory

Radionuclide	Radioactivity in CCA PAVT[a,c] (Ci)	Radioactivity in CRA-2004[b,c] (Ci)	Radioactivity in CRA-2004 PABC[b,d] (Ci)
^{137m}Ba	2.0×10^5	3.4×10^5	3.9×10^5
^{137}Cs	2.2×10^5	3.7×10^5	4.3×10^5
^{241}Pu	1.4×10^5	1.1×10^5	1.3×10^5
^{90}Sr	2.1×10^5	2.5×10^5	3.2×10^5
^{90}Y	2.1×10^5	2.4×10^5	3.2×10^5
Fraction of Total Inventory	96%	98%	98%

[a] Decayed through 1995
[b] Decayed through 2001
[c] Values directly from Appendix DATA-2004, Attachment F, Annex B, Table DATA-F-B-28
[d] Values directly from Transuranic Waste Baseline Inventory Report 2004, Table B.1-28 (U.S. DOE 2006)

According to Part 191, Appendix A, Table 1 (Note 1e), release limits for the radionuclides specified in the rule are based on "an amount of TRU waste containing one million curies of alpha-emitting TRU radionuclides with half-lives greater than 20 years." To obtain release limits for use in the PA, the release limits per MCi specified in 40 CFR Part 191, Appendix A, Table 1 must be multiplied by a factor that defines the number of MCi of TRU radionuclides in the inventory. For PA purposes, this factor, defined as the waste unit factor (WUF), is expressed as

$$f_w = \frac{\sum W_f}{10^6 Ci} \tag{31.1}$$

where f_w is the WUF and W_f is the WIPP-scale inventory in curies of each alpha-emitting TRU radionuclide with a half-life of 20 years or more. The DOE identified a total of 138 radionuclides expected to be present in the waste based on the CRA-2004 PABC inventory. Of these, 17 meet the definition of TRU waste in Part 191, Appendix A, Table 1 for calculating the WUF. Table 2 of Leigh and Trone (Leigh and Trone 2005) identified these nuclides and

determined that they contribute 2.32×10^6 Ci at closure, resulting in a WUF of 2.32 in the CRA-2004 PABC. Appendix TRU WASTE-2004, and the CRA-2004 PABC Inventory Report (Leigh, Trone, and Fox 2005) discuss in detail the WUF calculations and the radionuclides important to the calculations.

31.5 EPA's Evaluation of Compliance for the 2004 Recertification

The CRA-2004 PABC Inventory Report (U.S. DOE 2006) was completed following the submittal of the CRA-2004 and was used in the CRA-2004 PABC calculations. Though this inventory was issued following the CRA-2004, it was included in the EPA's evaluation of the CRA-2004 (U.S. EPA 2004). The EPA reviewed the information collected by the DOE related to the waste inventory for the CRA-2004 PA and the CRA-2004 PABC, and conducted verification calculations on the data used by the DOE in the CRA-2004 PA (CARD 24, (U.S. EPA 2006a;U.S. EPA 2006c), Sections 3.4 and 4.4). The methodologies for calculating the WUF and release limits in the CRA-2004 PABC were unchanged from those used in the CCA and the CRA-2004, and the EPA determined that the approach used was appropriate and acceptable for the CRA-2004 PA (U.S. EPA 2006d).

To verify whether the ORIGEN2 Version 2.2 decay calculations were performed correctly, the EPA carried out independent calculations of the decay of the inventory. These calculations showed that, on a spot-check basis, the ORIGEN2 values derived by the DOE and used in EPAUNI[1] (Sandia National Laboratories 2003) were correct (CARD 31, U.S. EPA 2006b). During the CRA-2004 review, the EPA reviewed the codes and determined that they adequately performed the decay calculations. The EPA determined that the approach used by the DOE was appropriate and acceptable for the CRA-2004 PA (U.S. EPA 2006a).

31.6 Changes or New Information Between the CRA-2004 and the CRA-2009 (Previously: Changes or New Information Since the 2004 Recertification)

The CRA-2009 PA (Clayton et al. 2008) done in support of the CRA-2009 (U.S. DOE 2009) maintained the same inventory and WUF values that were used in the CRA-2004 PABC (Leigh, Trone, and Fox 2005) and previously accepted by the EPA. The CRA-2004 PABC inventory was the last published inventory (U.S. DOE 2006) at the time the PA calculation for the CRA-2009 commenced. After the CRA-2004 PABC was completed, the *Annual Transuranic Waste Inventory Report–2007* (U.S. DOE 2008a) was published and provided updated inventory information. The DOE anticipated this inventory update would only have a small impact on normalized releases for the CRA-2009, and would not be significant for compliance. The DOE's approach to demonstrating compliance with the application of release limits was not changed from that used in the CRA-2004 and CRA-2004 PABC, and therefore the DOE stated it continued to comply with section 194.31.

1 EPAUNI is a computer code that calculates the activity per m3 for each waste stream at a discrete set of times.

31.7 EPA's Evaluation of Compliance for the 2009 Recertification

Following receipt of results from the CRA-2009 PA, the EPA requested that an additional PA be performed that included updated inventory information (Cotsworth 2009). Consequently, the *Performance Assessment Inventory Report - 2008* (PAIR-2008) (Crawford et al. 2009) was generated using information contained in the *Annual Transuranic Waste Inventory Report-2008* (ATWIR-2008) (U.S. DOE 2008b). The ATWIR-2008 contained inventory information collected up to December 31, 2007. An additional PA calculation, referred to as the CRA-2009 PABC (Clayton et al. 2010), was executed to satisfy the EPA's request. The CRA-2009 PABC used inventory information contained in the PAIR-2008. The methodologies used for calculating the WUF and release limits in the CRA-2009 PABC were unchanged from those used in the CRA-2004 PABC, and were documented in Fox, Clayton, and Kirchner (Fox, Clayton, and Kirchner 2009). The value of the WUF used in the CRA-2009 PABC was 2.60 and was independently verified by the EPA (U.S. EPA 2010a).

The five radionuclides with the highest activity for the CH-TRU and the RH-TRU waste in the CRA-2009 PABC inventory, decayed through year 2033, are shown in Table 31-4. Values shown in the table are taken directly, or calculated from, Table 4-5 and Table A-1 of the PAIR-2008. As can be seen, five radionuclides—^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu—contributed 99.9% of the total CH-TRU waste activity in the CRA-2009 PABC. Radioisotopes ^{137}Cs, ^{137m}Ba, ^{90}Sr, ^{90}Y, and ^{238}Pu contributed 96.0% of the total RH-TRU waste activity in the CRA-2009 PABC.

Table 31-4. Radionuclides with Highest Activity in the CRA-2009 PABC Waste Inventory

Waste Type	Radionuclide	Radioactivity (Ci)	Fraction of Total Activity
Contact-handled TRU Total Activity 3.10×10^6 Ci	^{238}Pu	1.47×10^6	47.4%
	^{239}Pu	5.10×10^5	16.5%
	^{241}Pu	5.06×10^5	16.3%
	^{241}Am	4.68×10^5	15.1%
	^{240}Pu	1.44×10^5	4.6%
Remote-handled TRU Total Activity 3.50×10^5 Ci	^{137}Cs	8.89×10^4	25.4%
	^{137m}Ba	8.32×10^4	23.8%
	^{90}Sr	7.99×10^4	22.8%
	^{90}Y	7.89×10^4	22.5%
	^{238}Pu	5.11×10^3	1.5%

The EPA reviewed the information collected by the DOE related to the waste inventory for the CRA-2009 PA and the CRA-2009 PABC (CARD 31, (U.S. EPA 2010b)). The EPA also verified calculations on the data used by the DOE in the CRA-2009 PA and the CRA-2009 PABC (CARD 24, (U.S. EPA 2010;U.S. EPA 2010c)). In particular, the EPA verified that the ORIGEN2 Version 2.2 code was qualified appropriately and that decay calculations were

performed correctly. These decay calculations verified that the ORIGEN2 values derived by the DOE and used in EPAUNI were determined correctly.

The EPA's review of the CRA-2009 PA and the CRA-2009 PABC found that the DOE continued to comply with the application of release limits requirements of section 194.31.

31.8 Changes or New Information Since the CRA-2009

The inventory used in the CRA-2014 PA is updated from that used in the CRA-2009 PABC (Clayton et al. 2010). The *Annual Transuranic Waste Inventory Report-2012* (ATWIR-2012) (U.S. DOE 2012) contains an inventory of defense-related TRU waste information collected through December 31, 2011. The *Performance Assessment Inventory Report - 2012* (PAIR-2012) (Van Soest 2012) has been developed, and is based on the annual inventory collected from the TRU waste sites and documented in the ATWIR-2012. The CRA-2014 PA uses inventory information contained in the PAIR-2012. The methodologies used to calculate the WUF and release limits in the CRA-2014 PA are unchanged from those used in the CRA-2009 PABC, and are documented in Kicker and Zeitler (Kicker and Zeitler 2012). The value of the WUF used in the CRA-2014 PA is 2.06. The DOE anticipates this inventory update will have only a small impact on normalized releases relative to the CRA-2009 PABC, and will not be significant for compliance.

The five radionuclides with the highest activity for the CH-TRU and the RH-TRU waste in the CRA-2014 PA inventory, decayed through year 2033, are shown in Table 31-5. Values shown in that table are taken directly from, or calculated from, Table 5-3 and Table 5-4 of the PAIR-2012. As can be seen, five radionuclides—^{241}Am, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Pu—contribute 99% of the total CH-TRU waste activity in the CRA-2014 PA. Radioisotopes ^{137}Cs, ^{137m}Ba, ^{90}Sr, ^{90}Y, and ^{241}Pu contribute 94.2% of the total RH-TRU waste activity in the CRA-2014 PA.

Table 31-5. Radionuclides with Highest Activity in the CRA-2014 PA Waste Inventory

Waste Type	Radionuclide	Radioactivity (Ci)	Fraction of Total Activity
Contact-handled TRU Total Activity 2.70×10^6 Ci	^{241}Am	6.97×10^5	25.8%
	^{241}Pu	6.48×10^5	24.0%
	^{238}Pu	5.95×10^5	22.0%
	^{239}Pu	5.67×10^5	21.0%
	^{240}Pu	1.67×10^5	6.2%
Remote-handled TRU Total Activity 9.36×10^5 Ci	^{137}Cs	2.33×10^5	24.9%
	^{137m}Ba	2.20×10^5	23.5%
	^{90}Sr	2.07×10^5	22.1%
	^{90}Y	2.07×10^5	22.1%
	^{241}Pu	1.49×10^4	1.6%

The DOE's approach to demonstrating compliance with the application of release limits in the CRA-2014 PA has not changed from that used in the CRA-2009 PABC, and therefore continues to comply with section 194.31.

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