

**2009 Compliance Recertification Application (2009 CRA)
Compliance Application Review Document (CARD) No. 31
Application of Release Limits**

31.0 BACKGROUND

The radioactive waste disposal regulations at 40 CFR Part 191 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 Appendix A, Table 1, of Part 191. To calculate the applicable release limits for Waste Isolation Pilot Plant (WIPP), information is needed on the potential total curie content in the repository. However, 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. Environmental Protection Agency (EPA or Agency) must establish when the curie content of waste should be fixed for purposes of calculating the release limits. Section 194.31 specifies that release limits should be calculated based on the curie content at time of disposal (that is, after the end of operational period, when the shafts of the repository has been backfilled and sealed). This CARD describes EPA's evaluation of U.S. Department of Energy's (DOE or Department) calculation of release limits in the 2009 Compliance Recertification Application (2009 CRA or CRA09).

31.1 REQUIREMENTS

“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 1998 CERTIFICATION DECISION

EPA expected the Compliance Certification Application (CCA) 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. EPA determined that the CCA performance assessment and the EPA-mandated Performance Assessment Verification Test (PAVT) were calculated using release limits according to Appendix A of 40 CFR 191.

31.3 CHANGES IN THE 2004 COMPLIANCE RECERTIFICATION APPLICATION (2004 CRA OR CRA04)

DOE used the updated versions of the same computer codes to decay the radionuclide inventory and calculate EPA units per cubic meter. During the 2004 CRA review, EPA reviewed the codes and they adequately performed the decay calculations. Thus, the only change of note was the 2004 CRA inventory, which is discussed in 2004 CRA CARD 24.

A complete description of EPA's 1998 Certification Decision for Section 194.31 can be obtained from EPA Air Docket, A-93-02, Items V-A-1 and V-B-2.

31.3.1 EVALUATION OF COMPLIANCE FOR THE 2004 RECERTIFICATION

EPA reviewed the information collected by DOE related to the waste inventory for the 2004 CRA PA and the 2004 PABC; EPA conducted verification calculations on the data used by DOE in the 2004 CRA PA (see 2004 CRA CARD 24 and the 2004 CRA Technical Support Document (TSD) for Section 24: Review of the Baseline Inventory Used in the Compliance Recertification Application and the Performance Assessment Baseline Calculation, Docket A-98-49, Item II-B1-9). DOE discussed the waste unit factor calculations and the radionuclides that were important to the calculations and other items EPA expected in 2004 CRA Appendix TRU Waste and the PABC Inventory Report (TRU Waste Inventory for the 2004 Compliance Recertification Application Performance Assessment Baseline Calculation, (Docket A-98-49, Item II-B2-60)).

Since the radioactivity in each waste stream is not measured at the same time, the waste stream activities are decay-corrected to December 31, 2001, using the ORIGEN2 Version 2.2 computer code. The radioactivity based on scaled contact-handled, transuranic (CH-TRU) waste volumes of each radionuclide in each waste stream is summed over all the waste streams to give the total CH-TRU waste activity for each nuclide. This activity is divided by the allowable CH-TRU waste volume of 168,485 m³ to determine the activity concentration in Ci/m³. The process is duplicated for remote-handled, transuranic (RH-TRU) waste using a volume limit of 7,079 m³. The total radioactivity associated with CH-TRU waste in the 2004 CRA is 5.33 H 10⁶ Ci (decayed to December 31, 2001), as compared to 6.42 H 10⁶ Ci (decayed to December 31, 1995) in the CCA/PAVT (2004 CRA Appendix DATA, Attachment F, Annex B, Table DATA-F-B-27). As shown in Table 31-1, the five most significant radionuclides in the waste—Am-241, Pu-238, Pu-239, Pu-240, and Pu-241—contribute 97.2% of the total CH-TRU waste activity in the 2004 CRA and 99.0% in the CCA/PAVT.

Table 31-1. Most Important Radionuclides in CRA04 CH-TRU Waste Inventory

Radionuclide	Radioactivity in CCA/PAVT ¹ (Ci)	Radioactivity in CRA04 ² (Ci)
Am-241	4.42 x 10 ⁵	4.01 x 10 ⁵
Pu-238	2.61 x 10 ⁶	1.61 x 10 ⁶
Pu-239	7.85 x 10 ⁵	6.60 x 10 ⁵
Pu-240	2.10 x 10 ⁵	³ 1.07 x 10 ⁶
Pu-241	2.31 x 10 ⁶	³ 2.40x 10 ⁶
Fraction of Total Inventory	99.0%	97.2%

¹ Decayed through 1995

² Decayed through 2001

³ Corrected-because of reading errors.

Similar information on the five most significant radionuclides in RH-TRU waste is presented in Table 31-2 (Appendix DATA, Attachment F, Annex B, Table DATA-F-B-28). The total RH-TRU waste inventory in the CCA/PAVT is 1.02 H 10⁶ Ci while that in the 2004 CRA is

1.33 H 10⁶ Ci. These values are substantially lower than the RH-TRU waste limit of 5.1 million curies specified in the WIPP LWA (PL102-579).

Table 31-2. Most Important Radionuclides in CRA04 RH TRU Waste Inventory

Radionuclide	Radioactivity in CCA/PAVT ¹ (Ci)	Radioactivity in CRA ² (Ci)
Ba-137m	2.04 x 10 ⁵	3.36 x 10 ⁵
Cs-137	2.16 x 10 ⁵	3.65 x 10 ⁵
Pu-241	1.42 x 10 ⁵	1.12 x 10 ⁵
Sr-90	2.09 x 10 ⁵	2.46 x 10 ⁵
Y-90	2.09 x 10 ⁵	2.43 x 10 ⁵
Fraction of Total Inventory	96.1%	97.6%

¹ Decayed through 1995

² Decayed through 2001

For use in PA, these inventories are decayed using the ORIGEN2 Version 2.2 computer code to 2033, the assumed closure date for the WIPP, and to various dates up to 10,000 years to assess the effects of various intrusion times on disturbed repository performance scenarios (e.g., see 2004 CRA Appendix PA, Attachment PAR, Table PAR-50).

Isotopic Decay Calculation Checks

To verify whether the ORIGEN2 Version 2.2 decay calculations were performed correctly, selected isotopes from the 2004 CRA PA were decayed independently using this code. Results of these decay calculations are presented in Attachment B to the 2004 CRA Inventory TSD (Docket A-98-49, Item II-B1-9). Decay calculations show that, on a spot-check basis, the ORIGEN2 values derived by DOE and used in EPAUNI¹ were done correctly.

In addition, spreadsheets were developed to assess the decay of Np-237 with respect to the potential need for inclusion in PA. Results of this analysis were also presented in Attachment B of the CRA04 Inventory TSD (Docket A-98-49, Item II-B1-9), based on the three spreadsheet comparisons. The first spreadsheet presented the calculation of activity for Pu-241, Am-241, and Np-237 using a three-isotope Bateman equation formulation. Values were calculated at 100-year intervals to 10,000 years, with initial values taken from Table 4-7 of the 2004 CRA, which provides the repository inventories at closure (defined as 2033). The second spreadsheet presented a set of validation calculations on the formulation to ensure the expected conservation of atoms. The third spreadsheet provided a summary of the results. As expected, based on a 14.4-year half-life, the Pu-241 were effectively gone within 100 years, and the Np-237 builds up to a relatively small, almost equilibrium value of about 100 curies. For perspective, the total radioactivity in the 2004 CH-TRU waste inventory after 10,000 years is about 5.3 H 10⁵ curies (2004 CRA Appendix PA, Attachment PAR, Table PAR-60).

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

According to Table 1 (Note 1e) in Appendix A of 40 CFR Part 191, release limits for the radionuclides specified in the rule are based on “an amount of transuranic (TRU) waste containing one million curies of alpha-emitting transuranic radionuclides with half-lives greater than 20 years.” To obtain release limits for use in PA, the release limits per 10^6 curies specified in Table 1 of Appendix A must be multiplied by a factor which defines the number of millions of TRU curies in the waste. For PA purposes, this factor, defined as the waste unit factor (WUF) or unit of waste, is expressed as:

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

where f_w is the waste unit factor and W_f is the inventory in curies of each alpha-emitting TRU radionuclide with a half-life of 20 years or more. DOE identified a total of 138 radionuclides expected to be present in the waste based on the PABC inventory. Of these, 17 met the definition of TRU waste in 40 CFR 191, Appendix A, Table 1 for calculating the waste unit factor. Table 2 of Leigh and Trone 2005 (Docket A-98-49 Item II-B2-60) identified these nuclides and determines that they contribute 2.32×10^6 Ci at closure resulting in a WUF of 2.32 in the PABC.

The methodology for calculating the waste unit factor and release limits in the 2004 PABC were unchanged from that used in the CCA and the 2004 CRA and is appropriate and acceptable for PA.

EPA did not receive any public comments on DOE’s continued compliance with the application of release limits requirements of Section 194.31.

31.3.2 2004 RECERTIFICATION DECISION

Based on a review and evaluation of the 2004 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2004-0025, Air Docket A-98-49), During the CRA04 EPA determined that DOE continued to comply with the requirements for Section 194.31.

31.4 CHANGES IN THE 2009 COMPLIANCE RECERTIFICATION APPLICATION (2009 CRA OR CRA09)

DOE continued to use the updated versions of the same computer codes to decay the radionuclide inventory and calculate EPA units per cubic meter. During the CRA-2009 review, EPA reviewed the codes verification, documentation, and ensured that they adequately performed the decay calculations. Thus, the only change of note for the second recertification was the 2009 CRA inventory which is discussed in 2009 CRA CARD 24.

31.4.1 EVALUATION OF COMPLIANCE FOR THE 2009 RECERTIFICATION

EPA reviewed the information collected by DOE related to the waste inventory for the CRA-2009 PA and the 2009 PABC (see 2009 CRA DOE Section 31 and Section 24, Leigh, Trone, and Fox 2005, PAIR 2008, PABC 2009); EPA verified calculations on the data used by DOE in the 2009 CRA PA and 2009 PABC (see 2009 CRA CARD 24 and the CRA-2009 Technical Support Document (TSD) for Section 24: Review of the Baseline Inventory Used in the Compliance Recertification Application and the Performance Assessment Baseline Calculation, (EPA 2010f). DOE discusses the waste unit factor calculations and the radionuclides that are important to the calculations and other items EPA expected in 2009 CRA Section 24.4.2.9 and the 2008 Performance Assessment Inventory Report (PAIR 2008).

Since the radioactivity in each waste stream is not measured at the same time, the waste stream activities are decay-corrected to various dates used in the performance assessment calculations, such as the projected closure date of 2033, DOE continued to use the ORIGEN2 Version 2.2 computer code to calculate radioactive decay in all of the 2009 CRA inventory analysis. The radioactivities are scaled based on a full repository, and the contact-handled transuranic (CH-TRU) waste volumes of each radionuclide in each waste stream are summed over all the waste streams to give the total CH-TRU waste activity for each nuclide. This activity is divided by the allowable CH-TRU waste volume of 168,485 m³ to determine the activity concentration in Ci/m³. The process is duplicated for remote-handled, transuranic (RH-TRU) waste using a volume limit of 7,079 m³. The total radioactivity associated with CH-TRU waste in the 2009 CRA PABC is 3.54 x 10⁶ Ci (decayed to 2033), as compared to 3.53x10⁶ in the 2004 CRA PABC (decayed to 2033) and 4.22 x 10⁶ Ci (decayed to 2033) in the CCA/PAVT (PAIR 2008, Table 5.6). As shown in Table 31-3, the seven most significant radionuclides (yellow highlight) in all of the waste—Pu-238, Pu-239, Am-241, Pu-241, Pu-240, Cs-137 and Sr-90—contribute 92.7% of the total waste activity in the 2008 inventory used in the 2009 PABC calculation, 89.4% in the 2004 CRA PABC and 94.8% in the CCA/PAVT.

For use in PA, these inventories are decayed using the ORIGEN2 Version 2.2 computer code to 2033, the assumed closure date for the WIPP, and to various dates up to 10,000 years to assess the effects of various intrusion times on disturbed repository performance scenarios (e.g., see PAIR 2008, Appendix A).

Table 31-3 2009 CRA Most Important Radionuclides Comparison³

**Comparison of 29 Important
2009 CRA PABC Radionuclides (Ci)**

Nuclide⁶	CCA¹	CRA-2004 PABC²	CRA-2009 PABC³
Pu-244	1.51E-06	5.53E-05	3.51E-04
Cm-248	3.71E-02	7.43E-02	1.31E-01
Th-230	3.05E-01	1.80E-01	5.97E-01
Pa-231	4.68E-01	8.69E-01	5.65E-01
Ac-227	5.05E-01	6.86E-01	2.42E+00
U-236	6.72E-01	2.87E+00	1.60E+00
Th-232	1.01E+00	3.42E+00	3.44E-01
Pb-210	8.75E+00	3.59E+00	1.61E+01
Th-229	9.97E+00	5.21E+00	1.30E+01
Ra-226	1.14E+01	4.56E+00	2.06E+01
C-14	1.28E+01	2.41E+00	5.63E+00
U-235	1.74E+01	5.01E+00	4.49E+00
U-232	1.79E+01	1.02E+01	5.92E+01
Cm-243	2.08E+01	4.14E-01	3.43E+00
Am-243	3.25E+01	7.87E+01	7.95E+01
U-238	5.01E+01	2.17E+02	2.73E+01
Np-237	6.49E+01	1.22E+01	3.90E+01
Cm-245	1.15E+02	1.71E-02	6.69E-01
U-234	7.51E+02	3.44E+02	3.09E+02
Pu-242	1.17E+03	1.27E+01	7.59E+01
U-233	1.95E+03	1.23E+03	2.07E+02
Cm-244	7.43E+03	2.13E+03	3.05E+03
<i>Sr-90</i>	8.73E+04	1.76E+05	8.04E+04
<i>Cs-137</i>	9.32E+04	2.07E+05	8.95E+04
<i>Pu-240</i>	2.14E+05	9.54E+04	1.45E+05
<i>Pu-241</i>	3.94E+05	4.48E+05	5.10E+05
<i>Am-241</i>	4.87E+05	5.17E+05	4.72E+05
<i>Pu-239</i>	7.95E+05	5.82E+05	5.13E+05
<i>Pu-238</i>	1.93E+06	1.13E+06	1.47E+06
<i>7 Highest Total</i>	4.00E+06	3.16E+06	3.28E+06
<i>% of Total</i>	94.80%	89.39%	95.07%
Grand Total	⁴ 4.22E+06	⁵ 3.53E+06	³ 3.45E+06

¹DOE 1996a Table 4-6

²Leigh et al. 2005 Table 14

³2008 PAIR Table 5-6

⁴Sanchez et al 1997 ERMS 243843 Table 1-3b

⁵Leigh and Fox 2005, ERMS 539643 Table A-2

⁶All decayed to 2033
Isotopic Decay Calculation Checks

EPA verified that the ORIGEN2 Version 2.2 code was qualified appropriately and that decay calculations were performed correctly (EPA 2010g, EPA 2010e and EPA 2010f). These decay calculations verified that the ORIGEN2 values derived by DOE and used in EPAUNI² were done correctly.

As noted in Appendix A of 40 CFR Part 191, release limits for the radionuclides specified in the rule are based on “an amount of transuranic (TRU) waste containing one million curies of alpha-emitting transuranic radionuclides with half-lives greater than 20 years.” (See 31.3.1 in this CARD for details). DOE identified a total of 145 radionuclides expected to be present in the waste based on the 2009 PABC inventory. Of these, 17 meet the definition of TRU waste in 40 CFR 191, Appendix A, Table 1 for calculating the waste unit factor. Table B-2 of Fox, Clayton and Kirchner 2009 identifies these nuclides and determines that they contribute 2.60×10^6 Ci at closure resulting in a WUF of 2.60 in the 2009 CRA PABC.

The methodology for calculating the waste unit factor and release limits in the 2009 PABC is unchanged from that used in the CCA, the 2004 CRA and is appropriate and acceptable for PA.

EPA did not receive any public comments on DOE’s continued compliance with the application of release limits requirements of Section 194.31.

31.4.2 2009 RECERTIFICATION DECISION

Based on a review and evaluation of the 2009 CRA and supplemental information provided by DOE (FDMS Docket ID No. EPA-HQ-OAR-2009-0330, Air Docket A-98-49), EPA determines that DOE continues to comply with the requirements for Section 194.31.

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