NWP
Nuclear Waste Partnership LLC
A URS-led partnership with B&W and AREVA

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March 27, 2013

ATTN: Document Control Desk
Director, Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: RESPONSE TO SECOND REQUEST FOR ADDITIONAL INFORMATION FOR REVISION 23 OF THE TRUPACT-II SHIPPING PACKAGE APPLICATION, DOCKET NO. 71-9218, TAC NO. L24643, AND REVISION 6 OF THE HalfPACT SHIPPING PACKAGE APPLICATION, DOCKET NO. 71-9279, TAC NO. L24642

References:

1. Letter from T.E. Sellmer to Document Control Desk, dated April 30, 2012, subject: Revision 23 of the TRUPACT-II Shipping Package Application, Docket No. 71-9218, and Revision 6 of the HalfPACT Shipping Package Application, Docket No. 71-9279
2. Letter from R.D. Berry to T.E. Sellmer, dated November 6, 2012, subject: Request for Additional Information for Review of TRUPACT-II and HalfPACT
3. Letter from T.E. Sellmer to Document Control Desk, dated December 3, 2012, subject: Response to Request for Additional Information for Revision 23 of the TRUPACT-II Shipping Package Application, Docket No. 71-9218, TAC No. L24643, and Revision 6 of the HalfPACT Shipping Package Application, Docket No. 71-9279, TAC No. L24642
4. Letter from H. Akhavannik to T.E. Sellmer, dated February 20, 2013, subject: Application for TRUPACT-II and HalfPACT Transportation Packages – Second Round Request for Additional Information

Dear Sir or Madam:

Nuclear Waste Partnership LLC, on behalf of the U.S. Department of Energy, hereby submits an amendment to Revision 23 of the application for a Certificate of Compliance (CoC) for the TRUPACT-II Packaging, U.S. Nuclear Regulatory Commission (NRC) Docket No. 71-9218, and Revision 6 to the application for a CoC for the HalfPACT Packaging, NRC Docket No. 71-9279 (References 1, 2, and 3). The amendment is in response to the Second Request for Additional Information (RAI) (Reference 4). The amendment consists of the following documents (page changes):

- TRUPACT-II Safety Analysis Report (SAR), Revision 23
- HalfPACT SAR, Revision 6
- Contact-Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC), Revision 4
- CH-TRU Payload Appendices, Revision 3.

HMSS01

This letter includes the following attachments:

- Attachment A – Responses to RAI
- Attachment B – Summary of Revisions
- Attachment C – Revised Documents (page changes)

Individual responses to the RAI are provided in Attachment A. All technical changes made in response to the RAI are indicated by right-bars in the margin of the documents ("|") and are summarized in Attachment B. Right-bars in the margin of the documents ("|") indicating technical changes made to the documents in the original and subsequent submittals of this application have been retained. The revised documents, in the form of page changes, are provided in Attachment C.

To facilitate implementation, it is requested that the current package CoCs be valid for use one year from the date of issuance of the revised CoCs.

If you have any questions regarding this submittal, please contact Mr. B. A. Day of my staff at (575) 234-7414.

Sincerely,

Todd Sellmer

T. E. Sellmer, Manager
Transportation Packaging

TES:clm

cc: J.R. Stroble, CBFO
H. Akhavannik, USNRC

Responses to NRC Second Round Request for Additional Information (RAI) on Revision 23 of the TRUPACT-II Safety Analysis Report (SAR), Revision 6 of the HalfPACT SAR, Revision 4 of the Contact-Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC), and Revision 3 of the CH-TRU Payload Appendices

Thermal:

3.1 Confirm that temperatures within the ICV remain below the allowable values during hypothetical accident conditions (HAC) if the optional OCV O-ring seal is not installed.

The TRUPACT-II and HalfPACT safety analysis reports (SARs) indicate that the OCV O-ring seal is optional. The CCO-CAL-0003 calculation provides a thermal analysis with the OCV O-ring seal installed. Likewise, the HAC thermal testing was based on the presence of the OCV O-ring seal. Considering the gap between the OCV upper seal flange and OCV lower seal flange without the presence of the OCV O-ring seal, confirm that the outer package components (ceramic fiber tape, etc.) are sufficient to prevent HAC hot gases from affecting the integrity of the ICV.

This information is needed to determine compliance with 10 CFR 71.73.

__Response:__

The torturous path for hot gases around the OCV locking ring and between the OCV seal flanges is such that convective heat transfer through the Z-flange area to the interior of the OCV would be negligible if the OCV O-ring seals (upper containment or lower test) were not present. As demonstrated by HAC fire testing of both the TRUPACT-II and HalfPACT packages, the circuitous Z-flange region and corresponding external and internal thermal protective components were sufficient to protect the OCV O-ring seals. Note that the ICV and OCV containment O-ring seals each have an allowable short-term (up to 8 hour exposure) temperature limit of 360 °F as specified in Section 3.3 of the SARs. The heat transfer path through the OCV flange is entirely dominated by metallic conduction such that there will be insignificant change with or without the OCV O-ring seals in place. Additionally, the ICV O-ring seals are made of the same materials as the OCV O-ring seals and are further removed from the HAC fire such that the ICV O-ring seals would not be compromised even if the convective path past the OCV O-ring seals were significant.

For these reasons, the temperature of the ICV O-ring seals will not change with the presence or absence of the OCV O-ring seals and, therefore, will remain below their allowable temperature.

3.2 Clarify the "no payload" mass calculation presented in Section 5 of CCO-CAL-0003 and specify the minimum weight of the content, CCO, and CCC container that is shipped in the TRUPACT-II and Half PACT packages.

The methodology presented in Section 5 of CCO-CAL-0003 is difficult to follow; it assumes a "no payload" mass in an attempt to calculate more realistic temperatures for a package that weighs less than the HAC test package, which had a payload of 7000 lbs.

a) Table 5-2 provides temperatures associated with "no payload" and Table 5-3 provides calculated temperatures with a CCO payload. Specify the assumed CCO/CCC weight associated with the Table 5-3 TRUPACT-II (and Table 5-6 HalfPACT) results (e.g., it was less than 7000 lbs).

b) Specify the minimum weight of the content, CCO, and CCC container that is shipped in the TRUPACT-II and HalfPACT packages. [Note: Page 4.6-1 of CH-TRU Payload Appendices (Rev. 3, December 2012) indicates that the tare weight of the CCO is 230 lbs. Therefore, for example, it appears that the minimum weight (if empty) associated with the CCO payload for TRUPACT-II and HalfPACT would be approximately 3220 lbs (14 CCO * 230 lb tare weight/CCO) and 1610 lbs (7 CCO * 230 lb tare weight/CCO), respectively.]

This information is needed to determine compliance with 10 CFR 71.73.

Response:

a) The following paragraphs summarize the methodology used to determine bounding HAC temperatures for a CCO payload. This summary utilizes Tables 5-1, 5-2, and 5-3 of calculation CCO-CAL-0003 that correspond to the TRUPACT-II package as a representative example of the methodology. The HalfPACT is treated in an identical manner within calculation CCO-CAL-0003.

1. Table 5-1 starts with component weights (W), specific heats (c_p), and measured component bulk average temperatures (pre-fire, T_p, and maximums, T_m) available from fire testing of a prototypic TRUPACT-II package containing 14, 55-gallon drums filled with concrete to achieve a gross weight per drum of 500 pounds. The observed increases in component temperatures due to the fire test ($\Delta T = T_m - T_p$) are then used in conjunction with weights and specific heats to directly calculate the heat (Q_a) that was absorbed by each packaging and payload component during the fire test ($Q_a = W \times c_p \times \Delta T$). As seen from Table 5-1, very little heat (only 2.3% of the total) was absorbed by the payload itself.

2. Table 5-2 conservatively assumes all the heat that was absorbed by the tested payload (33,815 Btu, total, from Table 5-1) is instead apportioned 100% into the packaging components. This assumption results in the maximum possible amount of heat being absorbed by each packaging component and, thus, the maximum increases possible in packaging component temperatures during a fire, even including those for the bounding case where a payload cannot absorb any heat; i.e., zero payload mass. Comparing Tables 5-1 and 5-2, the increase in ICV structure bulk average

temperature when going from the as-tested, concrete drum payload to the extreme of no payload is insignificant at 190.4 – 186.9 = 3.5 °F. Similarly, other packaging component temperatures are seen to be only modestly affected by the extreme assumption that the payload can absorb no heat. These observations are fully consistent with the fact that the as-tested, 7,000 pound payload absorbed very little heat.

3. Although component bulk average temperature differences between Table 5-1 (with a heat absorbing payload) and Table 5-2 (without a heat absorbing payload) are modest and will clearly not compromise packaging integrity, Table 5-3 is used to similarly adjust measured, fire-induced maximum temperatures for all packaging components. The result is a quantitative demonstration that peak temperatures throughout the packaging remain well within allowable limits even for the bounding case where the payload is assumed to absorb no heat. To address payload temperatures, Table 5-3 also uses a conservative assumption that the maximum CCO 55-gallon drum surface temperature will be equal to the bulk average temperature of the ICV structure. The conservatism of this assumption is evident by considering Table 3.5-4 of the TRUPACT-II SAR where the maximum drum temperature was measured at 170 °F (label identifier TI-7) whereas the corresponding ICV structure bulk average temperature was significantly higher at 186.9 °F (see Table 5-1, including Note 4).

As discussed above, for conservatism, the weights of the CCO components are assumed to be zero for the bounding HAC temperature calculations in Table 5-3 for the TRUPACT-II package and Table 5-6 for the HalfPACT package.

b) The weight of an empty CCO is 230 pounds. Of that weight, approximately half is the weight of the CCC assembly, and half is the weight of the plywood dunnage assemblies and 55-gallon drum. Thus, the minimum CCO payload weight for a TRUPACT-II package is 230 × 14 = 3,220 pounds, and the minimum CCO payload weight for a HalfPACT package is 230 × 7 = 1,610 pounds.

Shielding:

5.1 Provide an additional evaluation adequately analyzing the concentrated source in the most bounding location within the cavity consistent with normal conditions of transport (NCT) in order to identify the most limiting allowable activity.

As part of the previous RAI, staff requested that the applicant provide discussion to address the potential for a highly concentrated source being introduced into a payload/package near or at the container wall during NCT activities. From the applicant's response staff is aware that dose rate measurements are performed to determine the contributions from source material within the package. However, unless the applicant can demonstrate that any concentrated source could not relocate within the cavity under NCT, a bounding source configuration should be used that would produce the highest radiation levels for the surface and at 2 meters away. Moving the source closer to the cavity wall would result in higher surface and 2 meter dose rates.

This information is needed to confirm compliance with 10 CFR 71.47 and 71.87(j).

Response:

The allowable content source term has been reduced to address the potential for reconfiguration of source material within payload containers under NCT. The revised limits require that the combined sum of the sum of fractions for the gamma and the neutron source terms be less than or equal to 0.9 in lieu of 1.0. As shown below, potential reconfiguration of the source material in the TRU waste payload containers under NCT is highly improbable and will not cause a significant change in the limiting package dose rate values.

DOE TRU waste packaging guidance and site-specific waste acceptance criteria documents direct the preparation of CH-TRU waste payload containers to ensure safe and compliant ALARA payload container dose rates during characterization activities, intra-site transport operations, generator site storage, Type B package loading and transport processes, and WIPP repository disposal sequences. By definition, CH-TRU waste payload container surface dose rates cannot exceed 200 mrem/hr. The CH-TRAMPAC and the WIPP Land Withdrawal Act impose this payload container surface dose rate requirement. The absence of payload containers (approximately 400,000 processed at WIPP from over 29,000 TRUPACT-II and HalfPACT package shipments) exceeding the payload container surface dose rate requirement when surveyed after receipt at WIPP is a strong indicator that dose rate changes during handling and shipment, even at the payload container level, are insignificant. This indicator is important because any change in the payload container surface dose rate translates into a much smaller corresponding change in the limiting 2-meter package dose rate.

For example, the surface dose rate on a 55-gallon drum with an initially centered point source that moves 2/3 of the distance to the inner surface of the drum (i.e., 7.5 inches) would increase by $[(11.25^2/3.75^2) \times 100] - 100 = 800\%$, and full translation of the centered source all the way to the inner surface of the drum would nearly infinitely increase its surface dose rate. Comparatively, the limiting 2-meter dose rate of a HalfPACT containing seven 55-gallon drums, with initially centered and concentrated

^{60}Co sources that each moved the full distance to the inner surface of the drums, would increase by only [(0.139/0.113) × 100] – 100 = 23% (see Figure 1 and Figure 2), as determined by the ratio of allowable activity determined through additional MCNP runs for each configuration to satisfy the limiting 2-meter dose rate of 10 mrem/hr. As such, the sensitivity of the payload container surface dose rate is exceedingly greater than the sensitivity of the package's limiting 2-meter dose rate to an equivalent amount of source movement. Further, the 0.113 Ci of allowable activity for seven 55-gallon drums containing fully offset sources is only [(0.123/0.113) × 100] – 100 = 9% lower than that allowed by the Generic case analysis results presented in Section 5.1-2 of the TRUPACT-II SAR, which assume all activity is in a single centered source location (see Figure 3).

The occurrence of all drums having initially centered sources with full source reconfiguration to the worst location under NCT is not considered a credible scenario. However, even if it were assumed to occur, a very modest increase in the limiting 2-meter dose rate would result.

To address the highly improbable reconfiguration of source material within payload containers under NCT, Step 10 in Section 5.5.6 of the TRUPACT-II SAR and Section 3.3.2.1 of the CH-TRAMPAC have been revised to require that the combined sum of the sum of fractions for the gamma and the neutron source term be less than or equal to 0.9, in lieu of 1.0, effectively allowing a 10% administrative margin for the limiting 2-meter package dose rate.

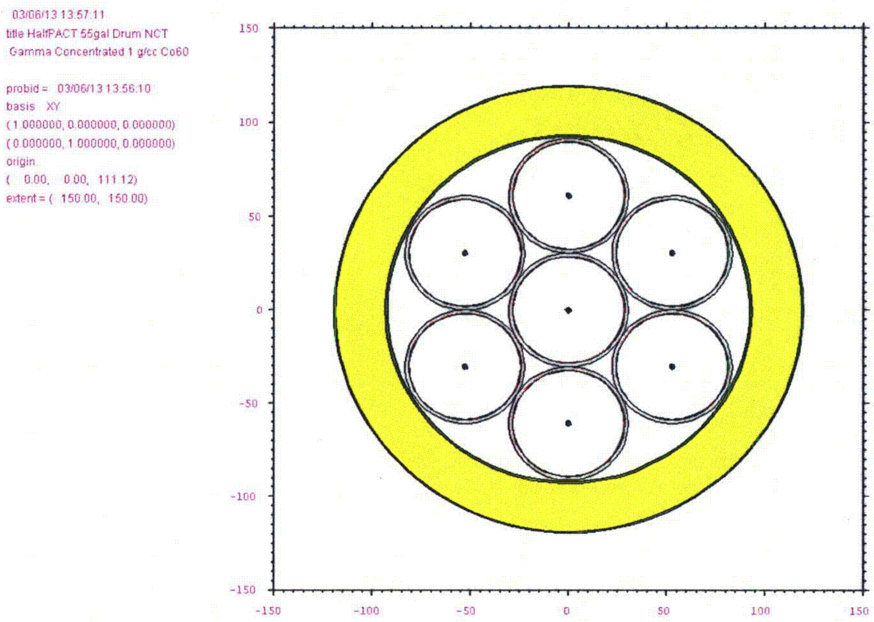


Figure 1 – 55-gallon Drum Centered Source in HalfPACT
[^{60}Co allowable activity to meet 10 mrem/hr @ 2 meters = 0.139 Ci]

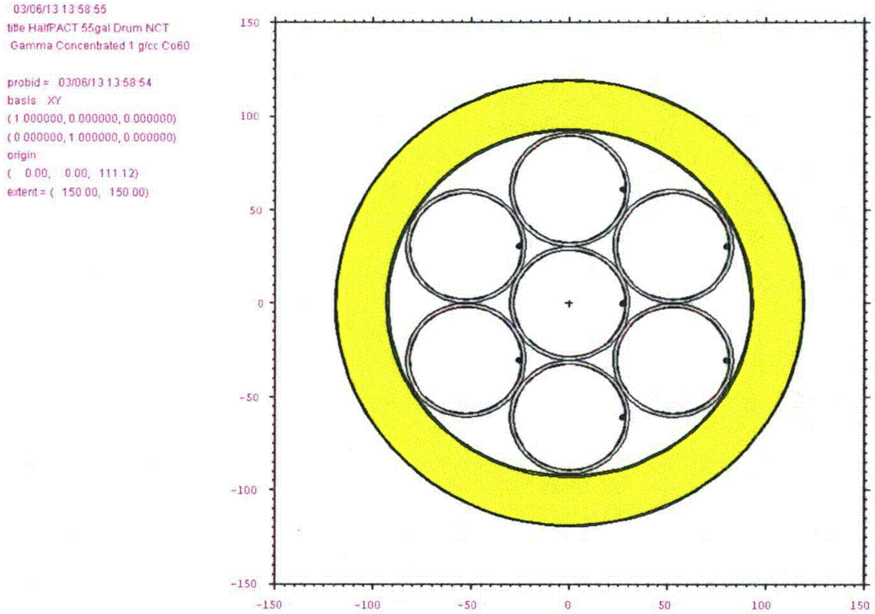


Figure 2 – 55-gallon Drum Offset Source in HalfPACT
[^{60}Co allowable activity to meet 10 mrem/hr @ 2 meters = 0.113 Ci]

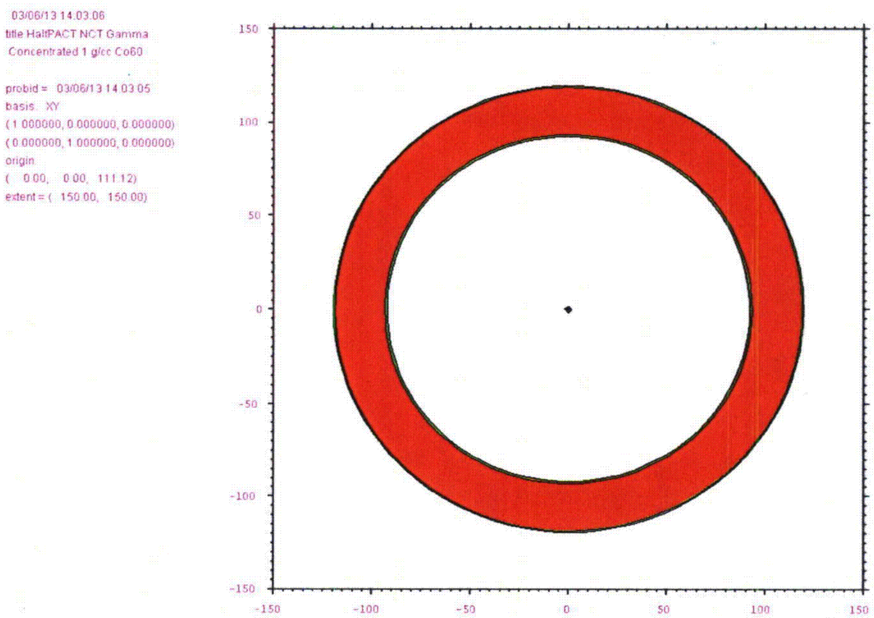


Figure 3 – Generic Case in HalfPACT (Section 5.3.1.2 of TRUPACT-II SAR)
[^{60}Co allowable activity to meet 10 mrem/hr @ 2 meters = 0.123 Ci]

5.2 Confirm that the ratio used in Section 5.4.4 of the SAR involves dividing the limiting allowable activity by the allowable activity in order to obtain the allowable dose rate.

Section 5.4.4 of the SAR provides details regarding the methodology used to determine the allowable dose rates for NCT and HAC conditions. This section specifies that the dose rates are determined by taking the ratio of the allowable activity and limiting allowable activity for each case. If the ratio is incorrectly taken as presented in the text the surface dose rates would exceed the exclusive use limits presented in 10 CFR 71.47. Please revise the wording in the text to confirm the ratio relationship between allowable and limiting allowable activities in Section 5.4.4.

This information is needed to determine compliance with 10 CFR 71.35.

Response:

The allowable activity was calculated to determine the activity required to meet each of the individual dose rate requirements for NCT @surf, NCT @2m, and HAC @1m. The limiting allowable activity was determined by selecting the smallest of the allowable activity values such that the most restrictive dose rate requirement (10 mrem/hr for NCT @2m) was met. To determine the actual dose rate for the NCT @surf and HAC @1m based on the limiting allowable activity, it was necessary to scale the allowable dose rates as follows:

$$\text{Dose Rate for NCT @surf} = \left[\frac{\text{Limiting Allowable Activity for NCT @2m}}{\text{Allowable Activity for NCT @surf}}\right] \times \text{Allowable Dose Rate for NCT @surf}$$

$$\text{Dose Rate for HAC @1m} = \left[\frac{\text{Limiting Allowable Activity for NCT @2m}}{\text{Allowable Activity for HAC @1m}}\right] \times \text{Allowable Dose Rate for HAC @1m}$$

Correcting for round-off of significant digits, the results presented in Tables 5.1-1 through 5.1-7 of the TRUPACT-II SAR are consistent with the use of the above equations and values presented in Tables 5.4-4 through 5.4-10.

The last sentence in Section 5.4.4 of the TRUPACT-II SAR has been revised to clarify the ratio by replacing "the ratio of the allowable activity and limiting allowable activity" with "the ratio of the limiting allowable activity to the allowable activity".

5.3 Provide adequate justification for the use of interpolation for DCF values for gamma energies from 2.0 MeV to 10 MeV, and justify the use of zirconium as the source material for use in the specified gamma energy range.

In the response to the initial RAI 5.5, the applicant stated that only a subset of cases were analyzed from 0.5 MeV up to 2.0 MeV in order to limit the number of distributed source shielding analyses. This data was then used and applied to gamma energies up to 10 MeV. As part of the responses, the applicant stated, in part, that the results between 1.5 MeV and 2.0 MeV were small and trending toward an asymptotic result as the gamma energy increased. However, the corresponding figures (Figure 5.5-5 and 5.5-6) in the SAR provided no data beyond 2.0 MeV. In addition, it is evident that different materials display different properties depending on energy levels. As such staff identified other materials in a separate reference ("Radiation Shielding" J. Kenneth Shultis and Richard E. Faw) such as carbon and beryllium that exhibited smaller mass interaction coefficients at the 5.0 MeV and 10.0 MeV ranges.

This information is needed to determine compliance with 10 CFR 71.47 and 10 CFR 71.51.

Response:

The use of zirconium-based 2 MeV DCF values for gamma energies ranging from 2 MeV to 10 MeV is appropriate because the 1.5 and 2 MeV values asymptotically approach a value that changes insignificantly with increasing energy. To further confirm that assertion, an additional case was run to evaluate the DCF for an upper energy level of 10 MeV for the CCO, per the methodology outlined in Section 5.5 and 5.5.2 of the TRUPACT-II SAR. The results are presented in Figure 4 for comparison with Figure 5.5-6 of the TRUPACT-II SAR. The 10 MeV zirconium results are essentially identical to the 2 MeV zirconium results utilized as the basis of the CCO DCF, demonstrating that the 2 MeV-based DCF determinations are appropriate to account for energies up to 10 MeV.

With regard to other materials that have lower mass attenuation coefficients, CHG-CAL-0002 was provided in the previous RAI response to demonstrate how zirconium compares with other common TRU waste materials from a self-shielding perspective. Those comparisons were provided for ^{137}Cs and ^{60}Co gamma sources and demonstrated that zirconium was well-behaved as a reasonable surrogate. Considering the conservative assumptions used to establish the distributed source limits and associated DCF methodology, particularly the use of the lowest single payload container density to establish the DCF for the entire payload, minor variations in attenuation properties for other non-dominant and/or obscure materials in TRU waste are not of concern. However, to demonstrate that the current methodology is robust, the CHG-CAL-0002 methodology was extended to include results for 2, 3, 5, and 10 MeV gamma energies, which are provided in Figure 5, Figure 6, Figure 7, and Figure 8 for the limiting 2-meter package dose rate location.

As shown in Figures 5 and 6, zirconium is bounding of other common TRU waste materials as it produces the largest dose rates for 2 and 3 MeV gamma sources. At 5 MeV, per Figure 7, zirconium is within 10% of the least effective common TRU waste materials from a self-shielding perspective. Although, per Figure 8, the deviation between zirconium and nylon and wood is more pronounced (~30%), the theoretical densities of these materials are so low that dominant quantities would limit the source density to less than 2 g/cc and correspondingly limit the DCF to a small (<1.5) correction factor. Of further significance, the current CH-TRU waste inventory of known radionuclides listed in Table 3.1-2 of the CH-TRAMPAC contains no radionuclides that have gamma energies in excess of 3 MeV, and there are no known radionuclides (per PCNUDAT) with gamma energies in excess of 5 MeV that have half-lives greater than 7 days.

Therefore, the use of zirconium as a surrogate self-shielding material for TRU waste is appropriate, bounding up to 3 MeV, within 10% of the least effective common TRU waste material up to 5 MeV, and irrelevant to gamma energies beyond 5 MeV due to the extremely short half-lives of radionuclides that produce those gamma energies.

To address the unlikely condition of the dose rate of distributed source material being dominated by high energy gammas and/or the self-attenuation of light elements that are less effective than zirconium, Step 10 in Section 5.5.6 of the TRUPACT-II SAR and Section 3.3.2.1 of the CH-TRAMPAC have been revised (consistent with the RAI 5.1 response) to require that the combined sum of the sum of fractions for the gamma and the neutron source term is less than or equal to 0.9, in lieu of 1.0, effectively allowing a 10% administrative margin for the limiting 2-meter package dose rate.

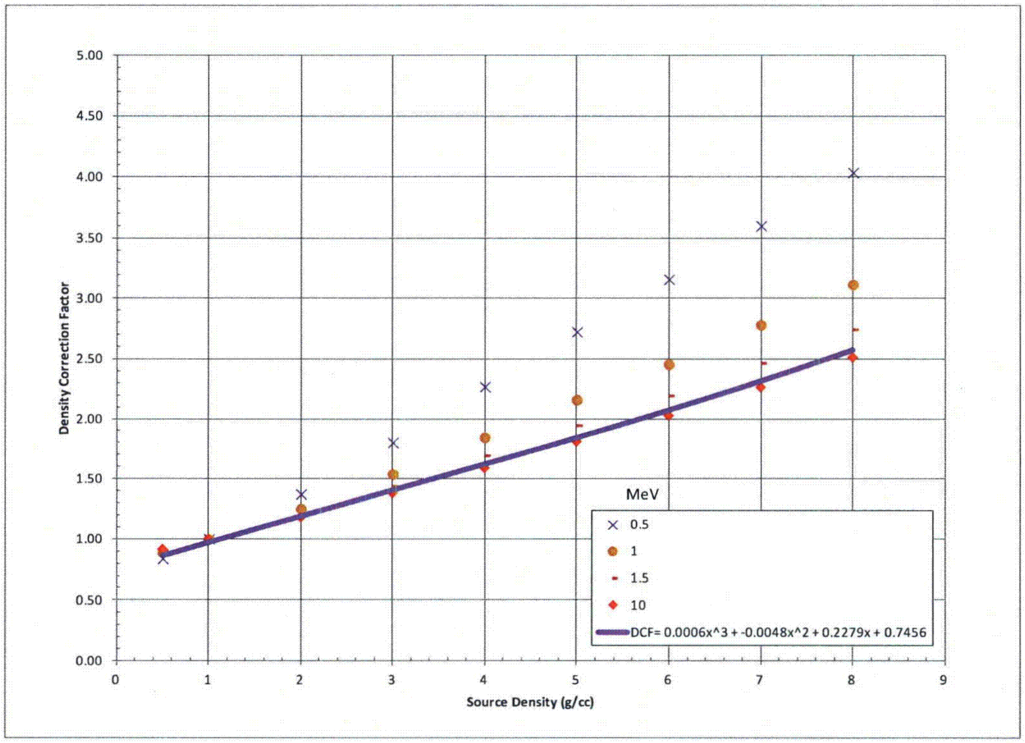


Figure 4 – HalfPACT CCO Payload DCF (Evaluated up to 10 MeV)

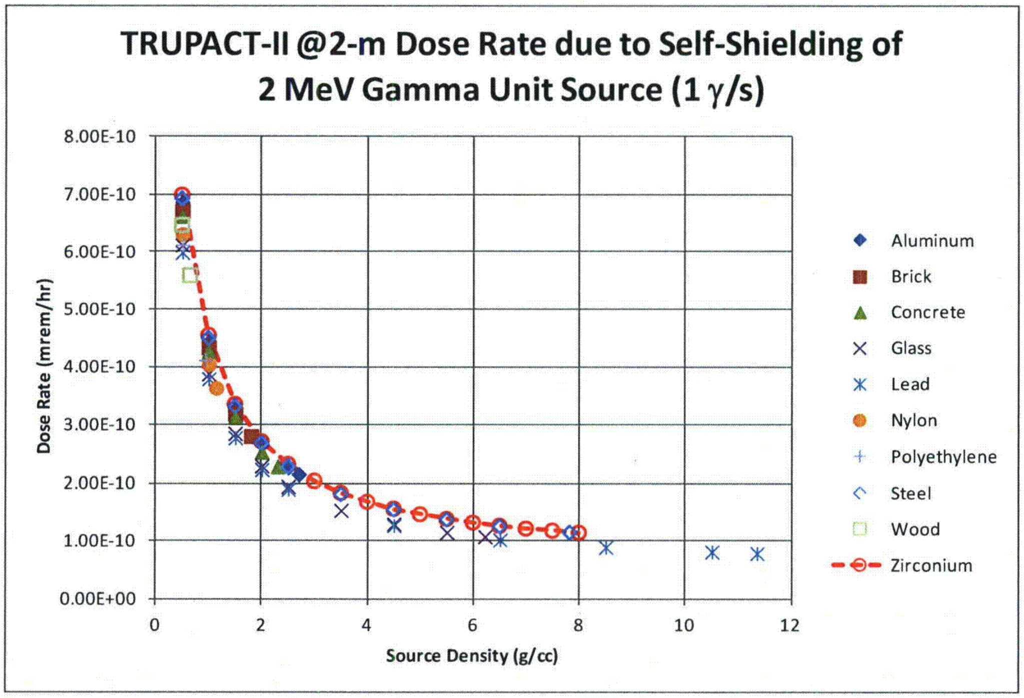


Figure 5 – 2 MeV Dose Rate Comparison

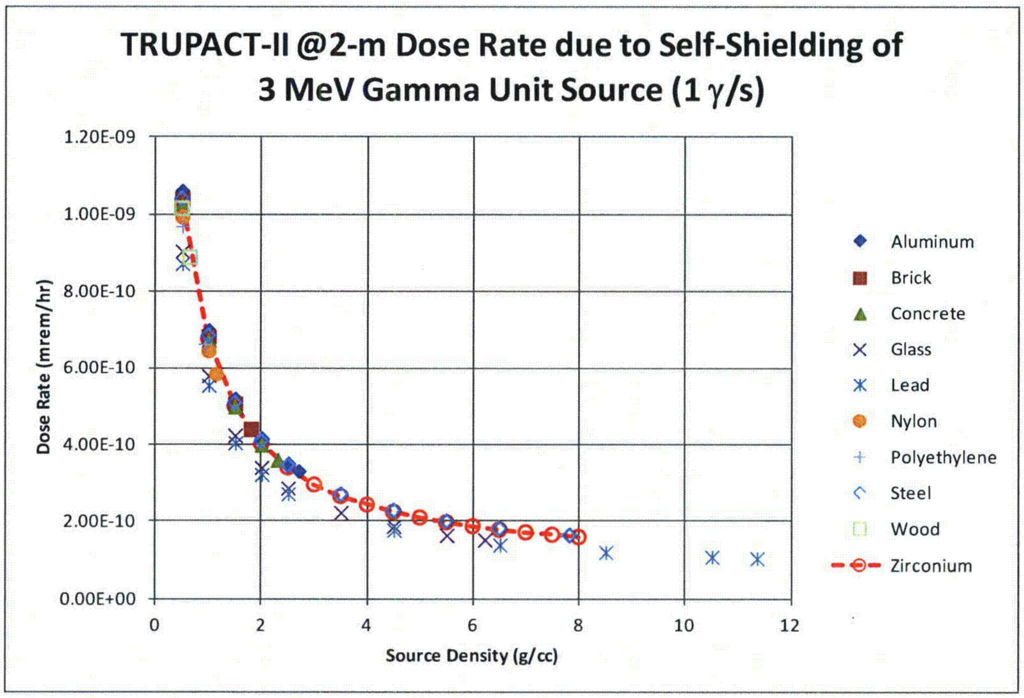


Figure 6 – 3 MeV Dose Rate Comparison

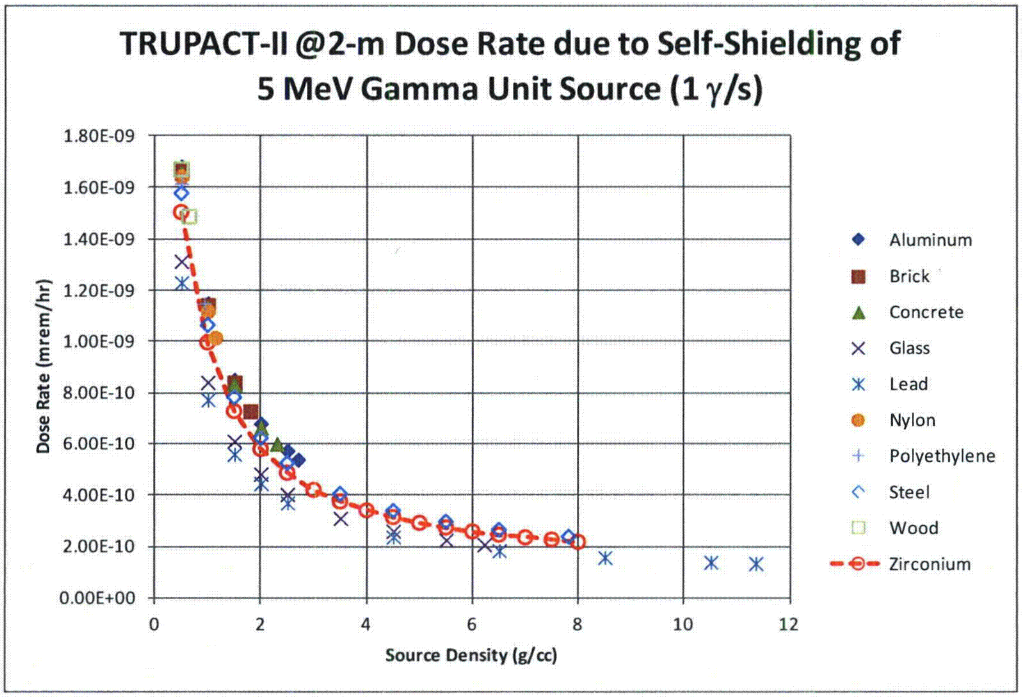


Figure 7 – 5 MeV Dose Rate Comparison

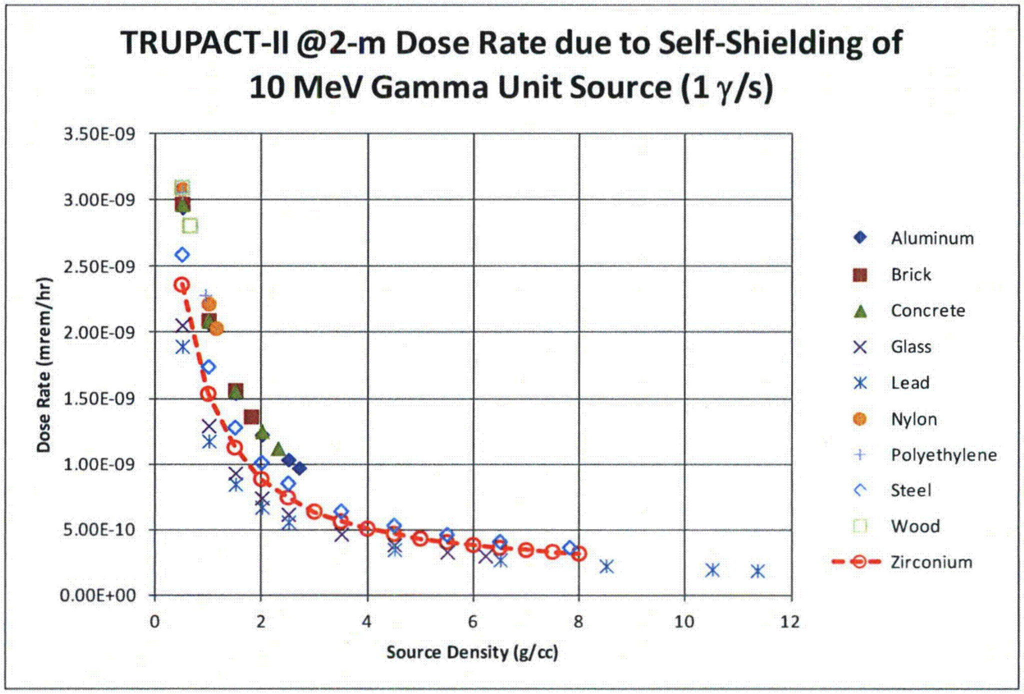


Figure 8 – 10 MeV Dose Rate Comparison

TRUPACT-II SAR, Revision 23, March 2013			
Section	**Page**	**Change Description**	**Justification**
General		Revised title page, spine, and headers of changed pages for revision and date.	Administrative change. No impact to safety basis.
5.4.4	5.4-4	Revised last sentence in 2nd paragraph from "…the ratio of the allowable activity and limiting allowable activity" to "…the ratio of the limiting allowable activity to the allowable activity".	Editorial change to clarify the scaling ratio in response to RAI 5.2. No impact to safety basis.
5.5.6	5.5-30	Revised list item 10 from "…less than or equal to 1.0." to "…less than or equal to 0.9." Revised last row of Table 5.5-16 in comment column from "Authorized for Transport, $F \leq 1$" to "Authorized for Transport, $F \leq 0.9$".	To provide a 10% administrative margin on the activity limit to ensure dose rate compliance. Enhances safety basis in response to RAI 5.1 and RAI 5.3.
5.5.6	5.5-32	Revised last row of Table 5.5-17 in comment column from "Authorized for Transport, $F \leq 1$" to "Authorized for Transport, $F \leq 0.9$".	Editorial change for consistency with revision to sum of sum of fractions requirement for dose rate compliance. No impact to safety basis.
5.5.6	5.5-33	Revised list item 10 from "…so the package meets the activity limits" to "…so the package does not meet the activity limits".	Editorial change for consistency with revision to sum of sum of fractions requirement for dose rate compliance. No impact to safety basis.
5.5.6	5.5-34	Revised last row of Table 5.5-18 in comment column from "Authorized for Transport, $F \leq 1$" to "Unauthorized for Transport, $F > 0.9$".	Editorial change for consistency with revision to sum of sum of fractions requirement for dose rate compliance. No impact to safety basis.

HalfPACT SAR, Revision 6, March 2013			
Section	**Page**	**Change Description**	**Justification**
General		Revised title page and spine for revision and date.	Administrative change. No impact to safety basis.

CH-TRAMPAC, Revision 4, March 2013			
Section	**Page**	**Change Description**	**Justification**
General		Revised title page, spine, and headers of changed pages for revision and date.	Administrative change. No impact to safety basis.
3.3.2.1	3.3-1	Revised first sentence from "...must be less than equal to one..." to "...must be less than or equal to 0.9..."	To provide a 10% administrative margin on the activity limit to ensure dose rate compliance. Enhances safety basis in response to RAI 5.1 and RAI 5.3.
3.3.2.1	3.3-2	Revised equation from $\sum_{i=1}^{m} \frac{s_{G_i}}{S_{G_i}} + \sum_{j=1}^{n} \frac{s_{N_j}}{S_{N_j}} \leq 1$ to $\sum_{i=1}^{m} \frac{s_{G_i}}{S_{G_i}} + \sum_{j=1}^{n} \frac{s_{N_j}}{S_{N_j}} \leq 0.9$	To provide a 10% administrative margin on the activity limit to ensure dose rate compliance. Enhances safety basis in response to RAI 5.1 and RAI 5.3.

CH-TRU Payload Appendices, Revision 3, March 2013			
Section	**Page**	**Change Description**	**Justification**
General		Revised title page and spine for revision and date.	Administrative change. No impact to safety basis.

ATTACHMENT C – Revised Documents (page changes)

(One Hard Copy and One CD[1] – Document Control Desk)
(Five Hard Copies and One CD[1] – H. Akhavannik)

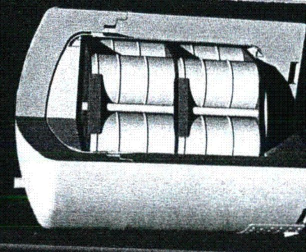
- TRUPACT-II SAR, Revision 23, March 2013
    - Title page and spine
    - Pages 5.4-3 and 5.4-4
    - Pages 5.5-29 through 5.5-34
- HalfPACT SAR, Revision 6, March 2013
    - Title page and spine
- CH-TRAMPAC, Revision 4, March 2013
    - Title page and spine
    - Pages 3.3-1 and 3.3-2
- CH-TRU Payload Appendices, Revision 3, March 2013
    - Title page and spine

[1] CD contains a PDF version of the complete documents listed in Attachment C.

TRUPACT-II

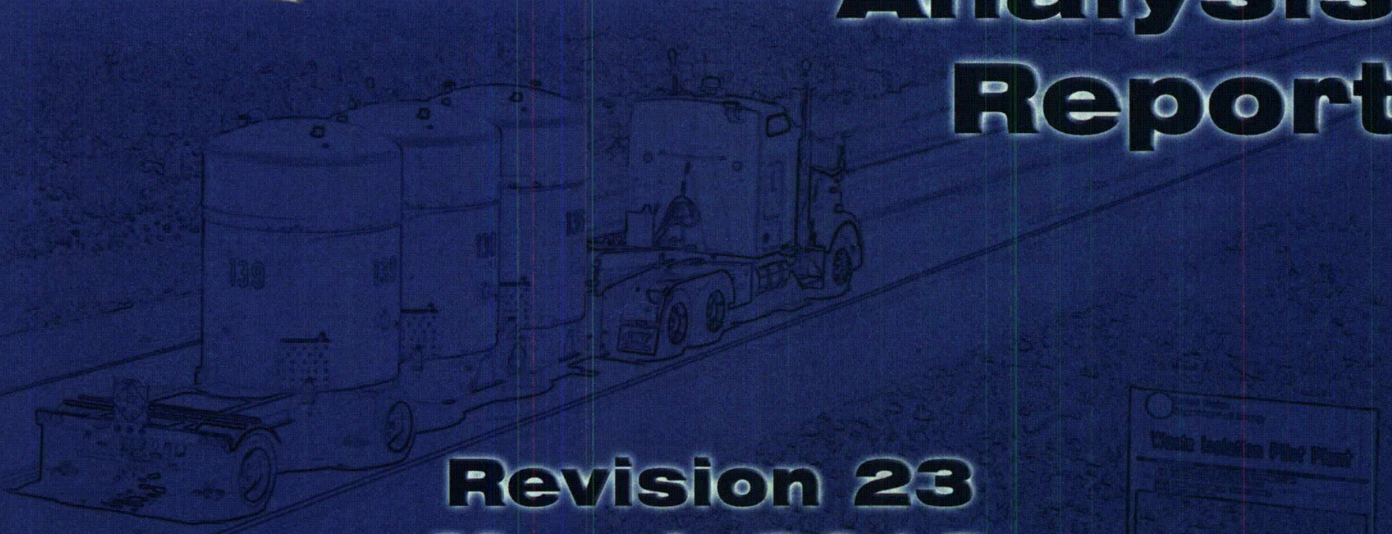
Revision 23
March 2013

Safety
Analysis
Report



TRUPACT-II

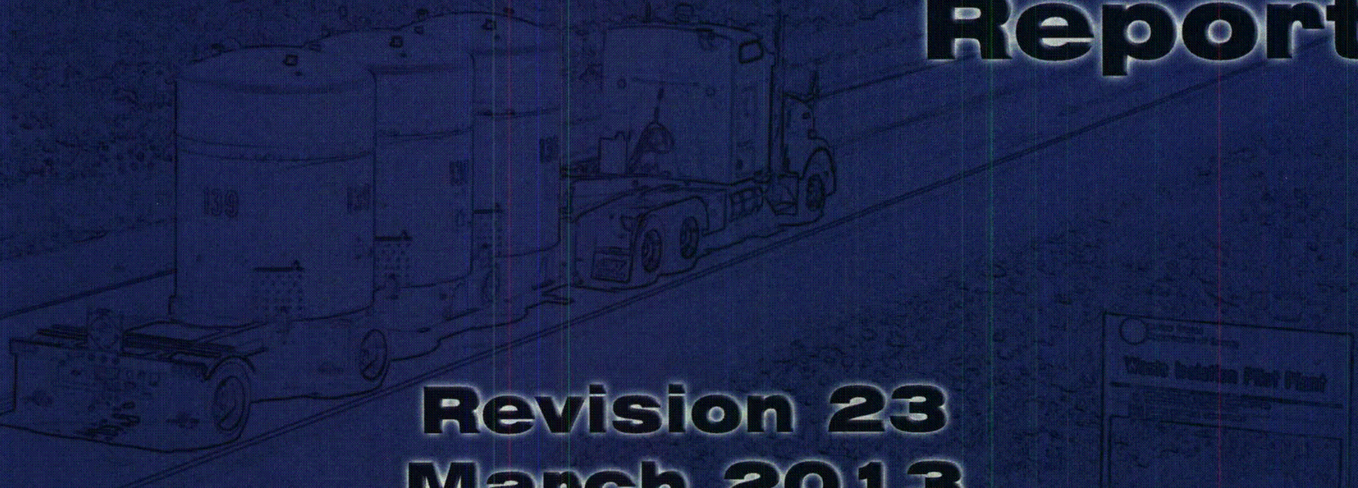
Safety Analysis Report



Revision 23
March 2013

TRUPACT-II

Safety Analysis Report



Revision 23
March 2013

Table 5.4-3 – Gamma Flux-to-Dose Rate Conversion Factors from ANSI/ANS 6.1.1-1977

γ-Energy (MeV)	DFg(E) (γ/cm²-s to mrem/hr)	γ-Energy (MeV)	DFg(E) (γ/cm²-s to mrem/hr)
0.01	3.96E-03	1.4	2.51E-03
0.03	5.82E-04	1.8	2.99E-03
0.05	2.90E-04	2.2	3.42E-03
0.07	2.58E-04	2.6	3.82E-03
0.10	2.83E-04	2.8	4.01E-03
0.15	3.79E-04	3.25	4.41E-03
0.20	5.01E-04	3.75	4.83E-03
0.25	6.31E-04	4.25	5.23E-03
0.30	7.59E-04	4.75	5.60E-03
0.35	8.78E-04	5	5.80E-03
0.40	9.85E-04	5.25	6.01E-03
0.45	1.08E-03	5.75	6.37E-03
0.50	1.17E-03	6.25	6.74E-03
0.55	1.27E-03	6.75	7.11E-03
0.60	1.36E-03	7.5	7.66E-03
0.65	1.44E-03	9	8.77E-03
0.70	1.52E-03	11	1.03E-02
0.80	1.68E-03	13	1.18E-02
1	1.98E-03	15	1.33E-02

5.4.4 External Radiation Levels

The MCNP5 models used to determine external radiation levels use segmented surface detectors to calculate the radial dose rates on the surface of the package and at 2 meters from the surface of the package for NCT and at 1 meter from the surface of the package for HAC. The surface detectors for NCT are either axially aligned with the source centerline when a single source or tier of sources exist or axially aligned with a plane that is midway between upper and lower tiers of sources. The axial alignment of the surface detectors is to minimize the aggregate distance from the source(s) to the detector and to report the maximum dose rate.

Dose rates and the associated statistical error are computed based on a 1 par/s source strength. The source strengths for 1 Curie (Ci) of ^{60}Co and ^{252}Cf are 7.3991E+10 γ/s and 3.8038E+09 n/s, respectively, based on the data provided in Section 5.2, *Source Specification*. Conservatively accounting for the statistical error, an activity allowable (par/s) is then determined for the gamma and neutron sources to meet each of the regulatory dose rate limits by dividing the allowable dose rate by the product of the calculated dose rate and one plus the error. The activity limit (Ci) to meet each regulatory dose rate limit is then determined by dividing the allowable activity (par/s) by the source strength (par/s/Ci). Finally, the NCT and HAC dose rates associated with the limiting activity are then determined by multiplying the allowable dose rate by the ratio of the limiting allowable activity to the allowable activity for each case (NCT at surface, NCT at 2 meters, HAC at 1 meter).

5.4.4.1 Generic

The TRUPACT-II dose rates and statistical errors computed for the Generic concentrated gamma and neutron sources with 1 par/s source strength are provided in Table 5.4-4. The dose rates based on the limiting allowable activity (i.e., the NCT at 2 meters values) are provided in Table 5.1-1.

Table 5.4-4 – TRUPACT-II – Generic Dose Rates for 1 par/s Source

Case	Nuclide	Source Strength (par/s/Ci)	Calculated Dose Rate (mrem/hr)	Tally Error	Allowable Activity (par/s)	Allowable Activity (Ci)
NCT @ surface						
tng001.i	^{60}Co	7.3991E+10	8.55E-09	0.2%	2.34E+10	0.316
tnn001.i	^{252}Cf	3.8038E+09	6.41E-07	0.2%	3.11E+08	0.082
NCT @ 2m						
tng001.i	^{60}Co	7.3991E+10	1.11E-09	0.3%	9.01E+09	**0.122**
tnn001.i	^{252}Cf	3.8038E+09	7.76E-08	0.3%	1.28E+08	**0.034**
HAC @ 1m						
thg001.i	^{60}Co	7.3991E+10	1.16E-08	0.7%	8.54E+10	1.155
thn001.i	^{252}Cf	3.8038E+09	7.97E-07	0.5%	1.25E+09	0.328

5.5.6 Determination of Acceptable Activity

The TRUPACT-II and/or HalfPACT package activity limits for the Generic, CCO, 6PO, 12PO, and SCA payloads (as applicable to the authorized payload containers for each packaging) shall be determined per the following to ensure compliance with 10 CFR §71.47 and §71.51:

1. Determine the list of radionuclides and associated activity (Ci) for each in the package contents.
2. Optionally determine if the package contents are eligible to be considered a distributed source as follows:

   Case A: For 55-gallon drums, 6POs, 12POs, SCAs, and CCOs, the package contents may be considered distributed if the measured surface dose rate of each payload container in the package varies by less than a factor of 10 from the average surface dose rate of all payload containers in the package.

   Case B: For 85-gallon drums, 100-gallon drums, SWBs and TDOP, the package contents may be considered distributed if the contents in each payload container in the package meet the definition of "distributed throughout" from NUREG-1608 and have a volume of at least 7.5 ft^3.

   Case C: For payloads with 55-gallon drums overpacked in an SWB or TDOP, the package contents may be considered distributed if the measured surface dose rate of each 55-gallon drum in the package varies by less than a factor of 10 from the average surface dose rate of all drums in the package.
3. If considered a distributed source, determine the density (ρ, g/cc) of the contents in each payload container in the package and note the minimum density value.
4. For each gamma-emitting radionuclide in the contents, obtain all discrete gamma energies and intensities from Kinsey[1] (or an equivalent nuclear structure and decay database), ignoring energies less than 0.15 MeV or energies with associated intensities less than 0.1%. Radionuclides with photon energies above 10 MeV with intensities greater than or equal to 0.1% are not acceptable for transport.
5. For each discrete gamma energy, determine its source strength (γ/s).
6. For each discrete gamma energy, determine the ratio of its source strength to the allowable activity determined by logarithmically interpolating from Table 5.5-2, Table 5.5-8, Table 5.5-10, Table 5.5-12, or Table 5.5-14, as applicable to the configuration (package, payload container, and source type). Calculate the sum of fractions for the gamma source term by adding the ratios defined above. If the source is distributed, optionally obtain the allowable activity by calculating the DCF based on the minimum payload container density value and multiplying the unit-density allowable activity by the DCF.
7. For each neutron-emitting radionuclide in the contents, obtain the neutron source spectrum from ED-042[3] (or an equivalent nuclear reference or Sources[2] analysis), ignoring energies less than 0.10 MeV or energies that contribute less than 1% of the total source strength. Radionuclides with neutron energies above 15 MeV that contribute greater than or equal to 1% of the total source strength are not acceptable for transport.

8. For each neutron energy interval, determine its source strength (n/s).
9. For each neutron energy interval, determine the ratio of its source strength to the allowable activity determined by logarithmically interpolating from Table 5.5-3, Table 5.5-9, Table 5.5-11, Table 5.5-13, or Table 5.5-15, as applicable to the configuration (package, payload container, and source type). Calculate the sum of fractions for the neutron source term by adding the ratios defined above.
10. For the payload, ensure that the combined sum of the sum of fractions for the gamma and the neutron source term is less than or equal to 0.9.

5.5.6.1 Acceptable Activity Examples

5.5.6.1.1 Concentrated ^{60}Co Source in 55-gallon Drums in TRUPACT-II

A TRUPACT-II payload consists of 55-gallon drums, each containing a concentrated ^{60}Co source of 0.005 Ci in the form of a metal capsule 1 cm in diameter and 3 cm long.

1. The radionuclide is ^{60}Co with a total activity of 14x0.005=0.07 Ci.
2. The content is not a distributed source.
3. NA
4. See Table 5.5-16.
5. See Table 5.5-16.
6. See Table 5.5-16 (using Table 5.5-2 values).
7. NA
8. NA
9. NA
10. The sum of fractions is equal to 0.574, so the package meets the activity limits.

Table 5.5-16 – Acceptable Activity Example #1

Gamma Energy (MeV)	Intensity (%)	Strength (γ/s)	Allowable Fraction	Comment
0.34693	7.6000E-03	0.0000E+00	0.00E+00	Ignored: Intensity < 0.1%
0.82628	7.6000E-03	0.0000E+00	0.00E+00	Ignored: Intensity < 0.1%
1.173237	9.9974E+01	2.5893E+09	2.70E-01	
1.332501	9.9986E+01	2.5896E+09	3.04E-01	
2.15877	1.1100E-03	0.0000E+00	0.00E+00	Ignored: Intensity < 0.1%
2.505	2.0000E-06	0.0000E+00	0.00E+00	Ignored: Intensity < 0.1%
Total			5.74E-01	Authorized for Transport, F ≤ 0.9

5.5.6.1.2 Distributed ^{252}Cf Source in CCOs in HalfPACT

A HalfPACT payload consists of CCOs, containing debris waste contaminated with a ^{252}Cf source term totaling 0.02 Ci. The dose rates of the CCOs range from 50 to 100 mrem/hr.

1. The radionuclide is ^{252}Cf with a total activity of 0.02 Ci.
2. The content is a distributed source under Case A.
3. Minimum contents weight of an individual CCO is 50 lb. Minimum density is $[(50\ lb)/(709\ in^3)]x[(27.68\ g/cm^3)/(1\ lb/in^3)] = 1.95\ g/cm^3$.
4. See Table 5.5-17.
5. See Table 5.5-17.
6. See Table 5.5-17 (using Table 5.5-8 values):

   $$DCF = 0.0006*\rho^3 - 0.0048*\rho^2 + 0.2279*\rho + 0.7456 = 1.17$$
7. See Table 5.5-17.
8. See Table 5.5-17:

   Specific Activity = 540 Ci/g
9. See Table 5.5-17 (using Table 5.5-9 values).
10. The sum of fractions is equal to 0.617, so the package meets the activity limits.

Table 5.5-17 – Acceptable Activity Example #2

Gamma Energy (MeV)	Intensity (%)	Strength (γ/s)	Allowable Fraction	Comment
0.0434	1.4800E-02	0.0000E+00	0.00E+00	Ignored: Energy < 0.15 MeV Intensity < 0.1%
0.1002	1.3000E-02	0.0000E+00	0.00E+00	Ignored: Energy < 0.15 MeV Intensity < 0.1%
0.1545	5.0400E-04	0.0000E+00	0.00E+00	Ignored: Intensity < 0.1%
Total Gamma			0.00E+00	DCF has no effect due to screening
Neutron Energy (MeV)	**Strength (n/s/g)**	**Strength (n/s)**	**Allowable Fraction**	**Comment**
0.5	1.8000E+11	6.6667E+06	2.10E-02	
1	2.7100E+11	1.0037E+07	6.27E-02	
2	5.3600E+11	1.9852E+07	1.59E-01	
3	4.1000E+11	1.5185E+07	1.32E-01	
4	2.7300E+11	1.0111E+07	9.55E-02	
6	2.6600E+11	9.8519E+06	1.00E-01	
8	8.5300E+10	3.1593E+06	3.26E-02	
10	2.4400E+10	9.0370E+05	9.45E-03	
15	8.3600E+09	3.0963E+05	4.61E-03	
Total Neutron			6.17E-01	DCF not applicable to neutrons
Total Gamma & Neutron			6.17E-01	Authorized for Transport, F ≤ 0.9

5.5.6.1.3 Concentratred ^{137}Cs and ^{239}Pu Sources in CCOs in HalfPACT

A HalfPACT payload consists of CCOs, containing debris waste contaminated with a ^{137}Cs source term totaling 0.75 Ci and 2,660 grams of ^{239}Pu totaling 167.3 Ci.

1. The radionuclides are ^{137}Cs and ^{239}Pu with a total activity of 0.75 and 167.3 Ci, respectively.
2. The content is not a distributed source.
3. NA
4. See Table 5.5-18.
5. See Table 5.5-18 (using Table 5.5-8 values).
6. See Table 5.5-18.
7. See Table 5.5-18.
8. See Table 5.5-18:

   ^{239}Pu Specific Activity = 0.0629 Ci/g
9. See Table 5.5-18 (using Table 5.5-9 values).
10. The sum of fractions is equal to 0.952, so the package does not meet the activity limits.

Table 5.5-18 – Acceptable Activity Example #3

Gamma Energy (MeV)①	**Intensity (%)①**	**Strength (γ/s)**	**Allowable Fraction**	**Comment**
0.2835	5.8000E-04	0.0000E+00	0.00E+00	^{137}Cs - Ignored: Intensity < 0.1%
0.661657	8.5100E+01	2.3615E+10	9.51E-01	^{137}Cs
0.129296	6.3100E-03	0.0000E+00	0.00E+00	^{239}Pu - Ignored: Energy < 0.15 MeV
0.375054	1.5540E-03	0.0000E+00	0.00E+00	^{239}Pu - Ignored: Intensity < 0.1%
0.413713	1.4660E-03	0.0000E+00	0.00E+00	^{239}Pu - Ignored: Intensity < 0.1%
Total Gamma			9.51E-01	
Neutron Energy (MeV)	**Strength (n/s/g)**	**Strength (n/s)**	**Allowable Fraction**	**Comment**
0.5	1.7300E+00	4.6014E+03	1.45E-05	
1	1.7100E+00	4.5482E+03	2.82E-05	
2	9.2900E+00	2.4709E+04	1.99E-04	
3	1.8800E+01	5.0004E+04	4.45E-04	
4	6.8400E+00	1.8193E+04	1.76E-04	
6	2.8500E-01	7.5804E+02	7.84E-06	
8	4.5800E-04	1.2182E+00	1.27E-08	
10	9.6600E-05	2.5693E-01	2.70E-09	
15	2.2800E-05	6.0643E-02	9.01E-10	
Total Neutron			8.71E-04	
Total Gamma & Neutron			9.52E-01	Unauthorized for Transport, F > 0.9

Note:

① For conciseness, only ^{239}Pu gamma energies greater than 0.1 MeV with associated intensities greater than 0.001% are listed in the table.

HalfPACT

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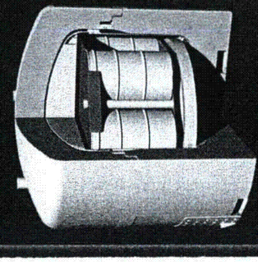
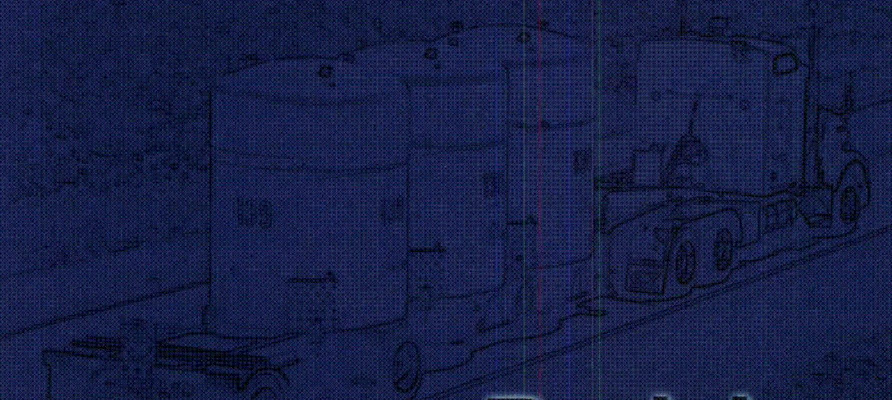
Safety Analysis Report



HalfPACT

Safety Analysis Report



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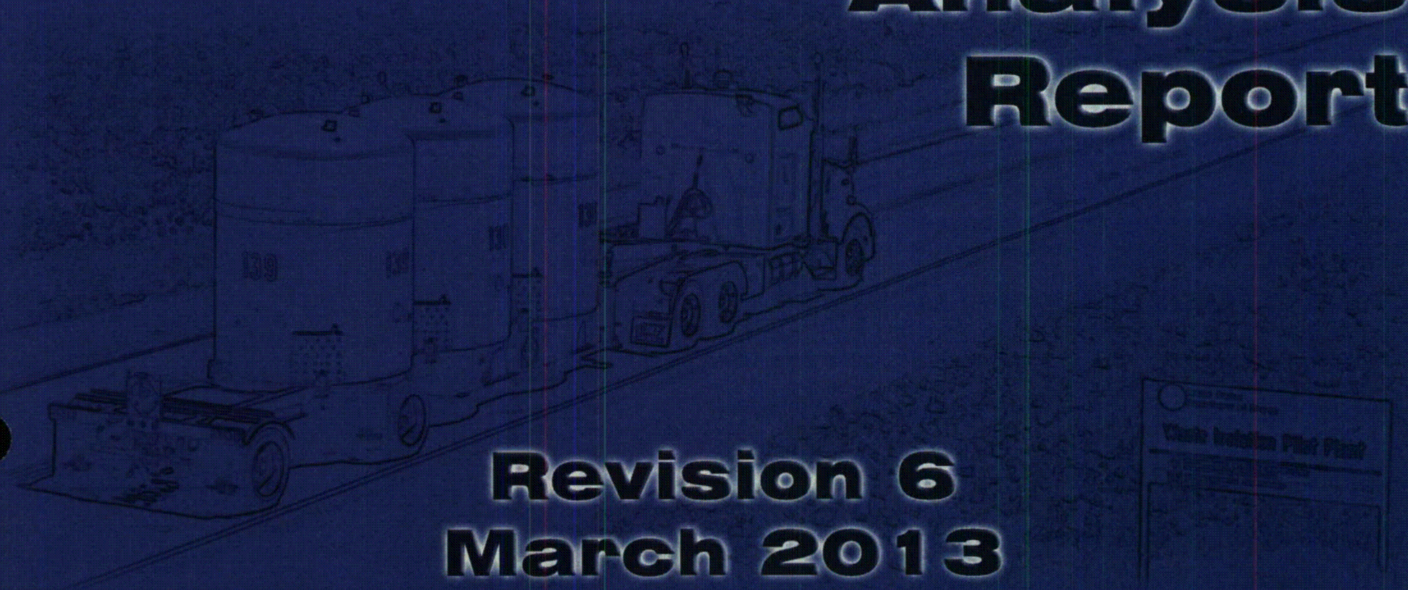
HalfPACT

Safety Analysis Report



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CH-TRAMPAC

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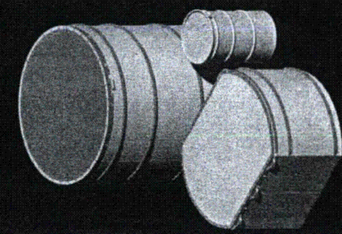

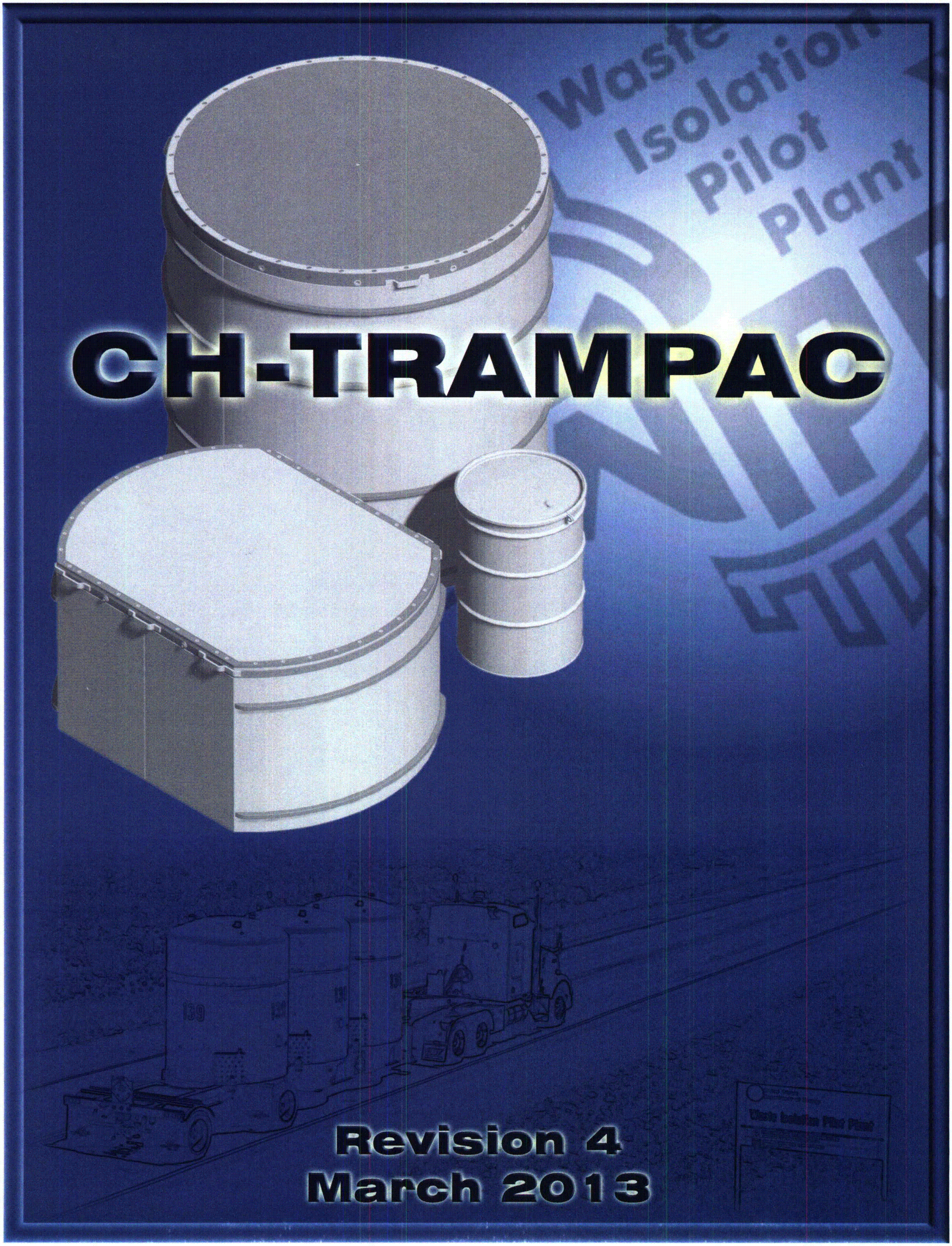

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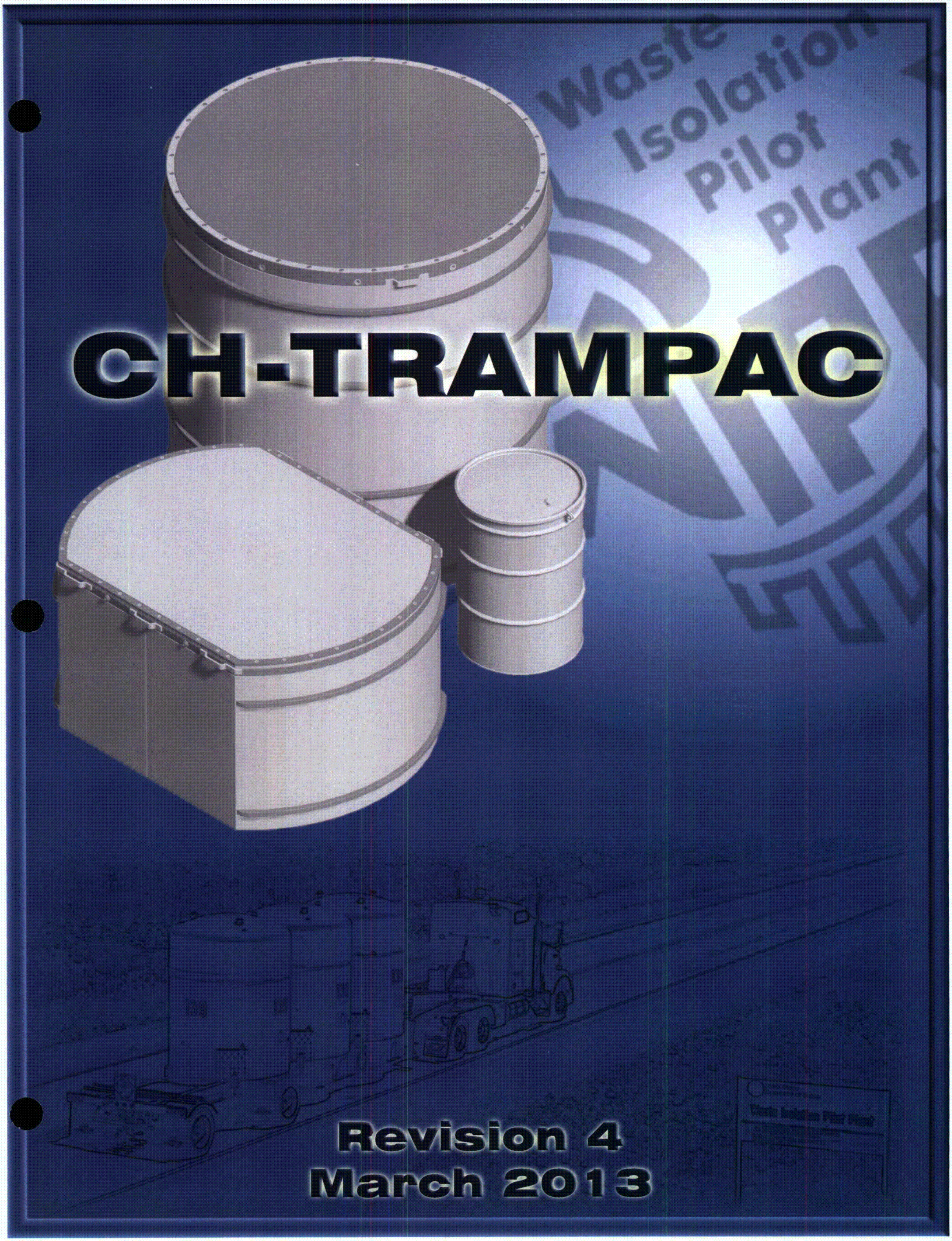

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3.3 Activity Limits

3.3.1 Requirements

3.3.1.1 Generic, Standard Pipe Overpack, Shielded Container, and Criticality Control Overpack

The TRUPACT-II and HalfPACT are limited to a specific maximum total activity when packaging payloads of either Generic (55-gallon drums, 85-gallon drums, 100-gallon drums, SWBs, and TDOP), 6-in. standard pipe overpacks, 12-in standard pipe overpacks, shielded containers, or CCOs. Each payload shall be acceptable for shipment only if the determined activity plus the error (i.e., one standard deviation) meets the specific limit as determined by the procedure provided in Section 5.5.6 of the TRUPACT-II SAR[1].

3.3.1.2 S100 and S300 Pipe Overpack

The TRUPACT-II and HalfPACT are limited to a maximum total activity of 406 curies (Ci) when packaging payloads of either S100 or S300 pipe overpacks. The S100 and S300 pipe overpack payloads are limited to sealed neutron sources in the forms specified in Table 4.2-1 of Appendix 4.2 and Table 4.4-1 of Appendix 4.4, respectively, of the CH-TRU Payload Appendices[6]. Each payload shall be acceptable for shipment only if the determined activity plus the error (i.e., one standard deviation) meets this limit.

3.3.1.3 S200 Pipe Overpack

The contents of each S200 pipe overpack are limited to the radionuclides and associated activities listed in Table 4.3-2 of Appendix 4.3 of the CH-TRU Payload Appendices for both the S200-A and S200-B shield insert configurations. Each S200 pipe overpack shall be acceptable for shipment only if the determined activity plus the error (i.e., one standard deviation) meets the applicable limit.

3.3.1.4 10^5 A_2

As described in Section 2.7.7, *Deep Water Immersion*, of the TRUPACT-II and HalfPACT SARs, a payload shall be acceptable for transport only if the activity plus error (i.e., one standard deviation) is less than or equal to 10^5 A_2 curies. A_2 values are defined in 10 CFR §71.

3.3.2 Methods of Compliance and Verification

Compliance with the activity requirements is similar to the compliance methodology described in Section 3.1.2. The activity of the payload shall be calculated from the isotopic composition and quantity of radionuclides comprising the payload.

3.3.2.1 Generic, Standard Pipe Overpack, Shielded Container, and Criticality Control Overpack

The combined sum of "partial fractions" for the gamma and neutron source terms present in the package must be less than or equal to 0.9, or

$$\sum_{i=1}^{m} \frac{s_{G_i}}{S_{G_i}} + \sum_{j=1}^{n} \frac{s_{N_j}}{S_{N_j}} \leq 0.9$$

where, for a particular payload container mix, s_{G_i} is the actual gamma source strength of the discrete gamma energy "i", S_{G_i} is the allowable activity of the discrete gamma energy "i", s_{N_j} is the actual neutron source strength of the neutron energy interval "j", and S_{N_j} is the allowable activity of the neutron energy interval "j". The limits for discrete gamma energies and neutron energy intervals are determined by the procedure provided in Section 5.5.6 of the TRUPACT-II SAR[1].

3.3.2.2 S100 and S300 Pipe Overpack

The total payload activity plus error (i.e., one standard deviation) shall be used to determine compliance with the 406 Ci payload activity limit.

3.3.2.3 S200 Pipe Overpack

The sum of "partial fractions" for any combination of radionuclides present in each S200 pipe overpack must be less than or equal to one, or

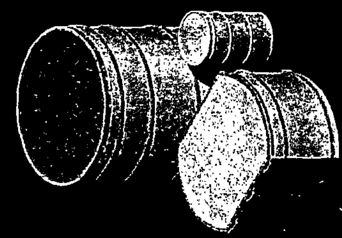
$$\sum_{i=1}^{n} \frac{a_i}{A_{GN_i}} \leq 1$$

where, for a particular payload container mix, a_i is the actual curie content of isotope "i" and A_{GN_i} is the limiting curie content of radionuclide "i". The limits for individual radionuclides for each S200 pipe overpack are specified in Table 4.3-2 of Appendix 4.3 of the CH-TRU Payload Appendices.

3.3.2.4 10^5 A_2

The total payload activity plus error (i.e., one standard deviation) shall be used to determine compliance with the 10^5 A_2 payload activity limit.

CH-TRU Payload Appendices



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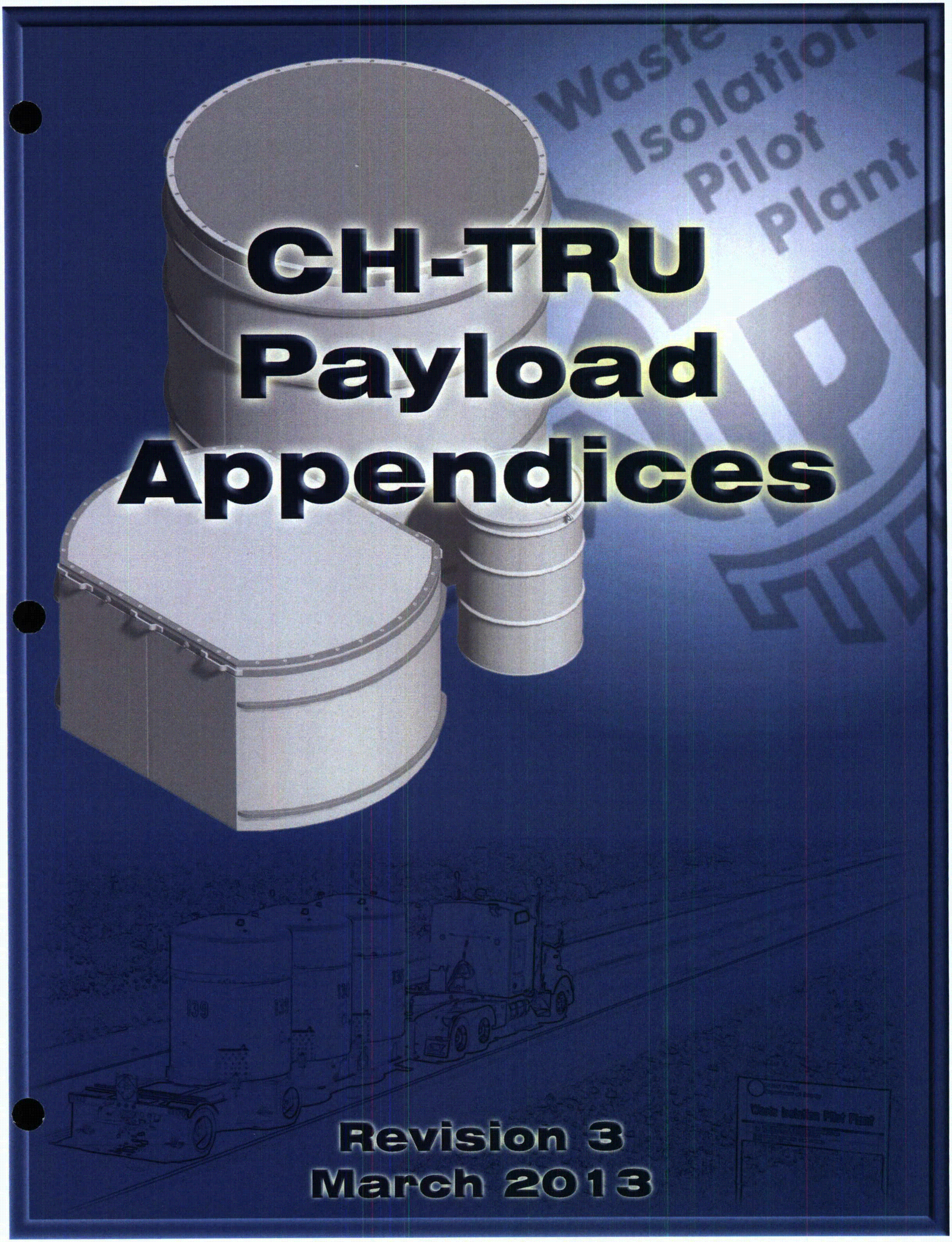

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