71-9204

CHEM-NUCLEAR SYSTEMS, LLC

140 Stoneridge Drive • Columbia, South Carolina 29210 • (803) 256-0450

7 November, 2000
579-219-00

David H. Tiktinsky
Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards, NMSS
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr.Tiktinsky:

Subject: Amendment Request for the CNS 10-160B Certificate No. 9204, submitted 10 May 2000
Reference: Request for Additional Information for Amendment to the Model No. CNS 10-160B Package, issued 29 September 2000

Chem-Nuclear submits the attached response to the Request for Additional Information (RAI). A response to each item of the RAI is included in Attachment 1; the requested reference documents are included in Attachment 3. If the response required a change to previously submitted documents, the change is identified in the response. Since responding to the RAI required numerous changes to Appendix 4.10.2.1 (the primary addition in the previous submittal), a "REVIEW COPY" of the new appendix is submitted as Attachment 2 with changes from the previous version noted with revision marks in the margin. A clean copy of Appendix 4.10.2.1, i.e., with revision marks removed, is included as Attachment 4. When the review is complete and approved, please discard the previous appendix and replace it with the one attached as Attachment 4.

There are several attachments to this letter, as noted above. Each attachment and its purpose are listed below:

<u>Attachment 1</u> – Response to the RAI
<u>Attachment 2</u> – Review Copy of the revised Appendix 4.10.2.1 for Chapter 4
<u>Attachment 3</u> – References requested in the RAI.
<u>Attachment 4</u> - Revised Appendix 4.10.2.1 (for distribution)

As noted in the letter from DOE attached to our 10 May letter, the revision is necessary to support the Battelle Columbus Decommissioning Project. The project expects to begin shipping TRU waste in the first quarter of 2001.

Should you or members of your staff have questions about the responses, please contact Mark Whittaker at (803)758-1898.

Sincerely,

Patrick L. Paquin
General Manager – Engineering and Licensing

Attachments: As stated

NMSS01Public

Attachment 1
Response to the RAI

RESPONSES TO NRC COMMENTS ON REVISION 16 OF THE CNS 10-160B SAFETY ANALYSIS REPORT

4.0 CONTAINMENT

Comment:

4.1 Provide the following reference documents cited in the SAR:

4.1.1 Reference 12.3, Battelle Memorial Institute (BMI), 1993, Memorandum from W.J. Zielenbach to W.J. Madia, Subject: Case RSC-151, JN-1 Criticality System, Battelle Memorial Institute, Columbus, Ohio.

4.1.2 Reference 12.8, McFadden, J.G., "RadCalc for Windows, Version 2.01, Volume II: Technical Manual," Waste Management Federal Services, Inc., Northwest Operations, Richland, Washington.

4.1.3 Reference 12.11, Flaherty, J.E., A. Fujita, C.P. Deltete, and G.J. Quinn, 1986, "A Calculational Technique to Predict Combustible Gas Generation in Sealed Radioactive Waste Containers," GEND 041, EG&G Idaho, Inc., Idaho Falls, Idaho.

4.1.4 Page 4.10.2.1-4, TCP-98-03, Building JN-1 Hot Cell Acceptable Knowledge Document.

4.1.5 Page 4.10.2.1-4, TCP-98-03.1, TRU Waste Process Descriptions.

4.1.6 Page 4.10.2.1-4, TC-OP-01.4, Segregation and Packaging of TRU Waste.

4.1.7 Page 4.10.2.1-5, TC-AP-01.1, TRU Waste Data Package Generation.

4.1.8 Page 4.10.2.1-9, TC-AP-01.2, Calculations Using Radioassay Data.

4.1.9 Page 4.10.2.1-9, DD-98-04, Waste Characterization, Classification, and Shipping Support Technical Basis Document.

These documents are needed in order to verify assumptions made in evaluating contents for shipment in the Model No. CNS 10-160B under 10 CFR Part 71.

Response:

The above listed references are provided as attachments to this RAI response submittal. These represent the latest revisions of these references.

Comment:

4.2 *Integrate specific requirements from the reference documents stated in RAI 4.1 into Appendix 4.10.2.1, "Compliance Methodology for RH-TRU Waste From Battelle Columbus Laboratories (BCL) West Jefferson, OH." [For example, in Section 4.2 of Appendix 4.10.2.1, it is stated that . . . compliance with the requirement associated with sealed container through visual examination at the time for packaging as described in TC-OP-01.4, Segregation and Packaging of TRU Waste. A discussion of what type of visual examination that will be performed should be included in the appendix.]*

Additional details are required in the appendix since the Certificate of Compliance will be conditioned on meeting the requirements in Appendix 4.10.2.1 and the steps that need to be taken in order to ensure that the contents can be safely transported in the package need to be clearly identified in the appendix.

Response:

Appropriate text has been added to Sections 4.2 and 5.2 to provide details on the methods of compliance implemented by BCL to ensure that the contents meet the specified requirements as defined in Appendix 4.10.2.1.

Comment:

4.3 *Revise Section 2.1 of Appendix 4.10.2.1 to indicate that the additional content codes that may be identified in the future would need to reviewed and approved by the NRC prior to authorizing shipment.*

Response:

The amendment to the Safety Analysis Report is applicable only for the current BCL content codes. Section 2.1 of Appendix 4.10.2.1 has been revised to indicate that any additional content codes that may be identified in the future would be submitted to the U.S. Nuclear Regulatory Commission (NRC) for review and approval, with shipments under additional codes authorized only after NRC approval.

Comment:

4.4 *Revise the application to justify the assumption of a 60-day shipping period for calculation of hydrogen gas accumulation.*

Calculations for determining hydrogen gas accumulation inside the containment vessel should assume a shipping period of one year, consistent with the maximum normal operating pressure (MNOP) calculation. Justification of a shorter shipping period should include a discussion of proposed shipping route, expected actual shipping time, and any controls in place to limit shipping time. The applicant *should ensure that the total combustible gas remains less that 5% of the free gas volume in any confined region of the package, as stated in Section 4.5.2.3 of NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Materials."*

Response:

A justification for the 60 day shipping period has been included as Attachment D to Appendix 4.10.2.1.

Comment:

4.5 *Revise Section 4.0 of Appendix 4.10.2.1 to clarify the requirement associated with sharp or heavy objects.*

Section 4.2 of the appendix states that visual examination will be used to ensure compliance with this requirement, but the requirement itself is not clearly identified.

Response:

Text has been added to Section 4.1 of Appendix 4.10.2.1 to clarify the requirement pertaining to sharp or heavy objects. As indicated, sharp or heavy objects in the waste shall be blocked, braced, or suitably packaged as necessary to provide puncture protection for the payload containers packaging these objects.

Comment:

4.6 *Provide justification for the density assumptions stated in Section 10.4.2.2 of Appendix 4.10.2.1, and show how these assumptions were used in the calculation of hydrogen generation rate and maximum allowable decay heat.*

It is not clear that the values assumed for the density of wastes conservatively represents waste materials expected to be present in Battelle-Columbus Laboratories RH-TRU content codes. The applicant should ensure that the total combustible gas remains less than 5% of the free gas volume in any confined region of the package, as stated in Section 4.5.2.3 of NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Materials."

Response:

The text of Section 10.4.2.2 of Appendix 4.10.2.1 was revised to clarify how the waste input parameters are used by the RadCalc program and that the chosen waste densities provide conservative calculations of the maximum allowable decay heats. In addition, text was added to Section 10.3.1 to clarify that the chosen waste densities used in the calculation of void volumes in the confinement layers for content codes BC 321A and BC 321B also provide conservative estimates of the void volumes, and thereby lead to conservative calculations of the maximum allowable hydrogen gas generation rates and maximum allowable decay heat limits, ensuring that the total combustible gas concentration remains less than 5% of the free gas volume in any confined region of the package during the maximum shipping period.

It should be noted that the maximum allowable decay heat limit for BC 321A was revised, as shown in Table 7-1 and Table 10-1 and on page 4.10.2.1-A9, respectively, to reflect the use of a conservative value for bulk density based on actual drum data obtained from BCL. An empirical value was originally used to determine the decay heat limit for BC 321A. A detailed discussion is provided in Section 10.4.2.2 of Appendix 4.10.2.1.

Text was also added to Section 10.1, to clarify the payload assembly requirements associated with decay heat and hydrogen gas generation rate limits. Section 10.5 was added to identify the methods of compliance for the payload assembly requirements. The most restrictive decay heat and hydrogen gas generation limits apply to payloads made up of containers from more than one content code to ensure that the 5% restriction on flammable gas concentration is met.

Comment:

4.7 Provide the chemical compatibility analyses performed for the Battelle-Columbus content codes listed in Attachment A of Appendix 4.10.2.1.

These analyses are needed to ensure that there will be no significant chemical, galvanic, or other reaction among package contents, as required by 10 CFR 71.43(d).

Response:

Chemical compatibility analysis has been performed for each Battelle-Columbus content code to ensure that there will be no significant chemical, galvanic, or other reactions among package contents, as required by Title 10, Code of Federal Regulations, Section 71.43(d) [10 CFR 71.43(d)]. Attachment C to Appendix 4.10.2.1 has been added to provide details associated with the chemical compatibility analysis for all the content codes, and text has been added to Section 6.2 of Appendix 4.10.2.1 to clarify the chemical compatibility of the waste and to refer to Attachment C. Chemical compatibilities in the BCL content codes are ensured for the following reasons:

- BCL has adequate knowledge of processes generating the waste
- All BCL RH-TRU waste is newly packaged
- Incompatible wastes (e.g., explosives, corrosives, reactives, etc.) are not present as a result of segregation processes that have been implemented prior to packaging of the waste

- The waste is either solidified and immobilized (solidified materials) or present in bulk form as a solid (solid materials). In almost all cases, any possible reactions take place before the waste is generated in its final form.

Comment:

4.8 Revise the waste packaging configuration in all content codes in Attachment A of Appendix 4.10.2.1 to state that the steel liner will be open or adequately punctured to allow the free flow of generated gases.

The drum liner should not act as a confinement layer for flammable gases generated during shipment. A closed and filtered, or insufficiently punctured liner should be considered in the calculation of maximum hydrogen generation rate and decay heat. The applicant needs to ensure that the total combustible gas remains less than 5% of the free gas volume in any confined region of the package, as stated in Section 4.5.2.3 of NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Materials."

Response:

The "Additional Criteria" description under each content code in Attachment A of Appendix 4.10.2.1 provides details on venting required for the steel or polyethylene liner. As stated, each liner will be punctured or fitted with a filter with a diffusivity of 3.7E-06 moles/second/mole fraction to allow the free flow of generated gases. The resistance of the filter in the liner is considered in calculating the maximum allowable hydrogen gas generation rate limit for each of the content codes to ensure that the total combustible gas content remains less than 5% of the free gas volume in any confined region of the package. As a result, no revision to Appendix 4.10.2.1 is required to address this comment. Section 8.1 of Appendix 4.10.2.1 provides details on the filter vent specifications for the liner.

Comment:

4.9 Revise Attachment B of Appendix 4.10.2.1 to describe the methodology used to estimate the external dose rates for one millicurie of the source mixture. The description should include assumed packaging configurations and waste matrices, and why these assumptions are conservative with respect to the actual packaging configurations and waste matrices. Describe how the BCLDP computer program uses measured weights and decay heats to determine fissile gram equivalent and decay heat loadings for payload containers.

These descriptions are necessary to ensure that the contents of the Model No. 10-160B are adequately characterized, meet the plutonium limit of 20 curies (10 CFR 71.63), and that the total combustible gas remains less than 5% of the free gas volume in any confined region of the package as stated in Section 4.5.2.3 of

NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Materials."

Response:

Appropriate text has been added to Section 2.0, Attachment B of Appendix 4.10.2.1 to describe the methodology used to estimate the external dose rates for 1 millicurie of the source mixture. In addition, Section 10.3.1 of Appendix 4.10.2.1, as revised, provides detail to clarify that the assumed waste matrices are conservative with respect to the actual waste matrices.

Comment:

4.10 *Revise Attachment B of Appendix 4.10.2.1 to describe how the ORIGEN code is used to determine radioassay properties of RH-TRU wastes and how this determination is conservative with respect to the actual isotopic distribution of the Model No. 10-160B contents. Also, state the version of the ORIGEN code that is used for this application. In addition, provide a sample ORIGEN input used for determining RH-TRU waste isotopic content.*

This information is necessary to ensure that the contents of the Model No. 10-160B are adequately characterized, meet the plutonium limit of 20 Curies (10 CFR 71.63), and that the total combustible gas remains less than 5% of the free gas volume in any confined region of the package as stated in Section 4.5.2.3 of NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Materials."

Response:

Appropriate text has been added to Section 2.0, Attachment B of Appendix 4.10.2.1 to describe how the ORIGEN2 code is used to determine radioassay properties of RH-TRU wastes and how this determination is conservative with respect to the actual isotopic distribution of the 10-160B contents. A sample of the ORIGEN2 input that was used for determining RH-TRU waste isotopic content has also been provided along with this submittal.

5.0 SHIELDING

Comment:

5.1 *Either provide a shielding analysis for the proposed new contents, or show that the proposed new contents are bounded by the previously approved contents with respect to shielding.*

This information is needed to ensure that the package meets the dose rate limit specified in 10 CFR 71.47.

Response:

The source term used for the shielding analysis in the SAR was determined by assuming the dose rate on the cask exterior is at the maximum allowed by 10 CFR 71.47 and by assuming the radionuclide was ^{60}Co. The analysis showed that for the Hypothetical Accident Condition (HAC) the dose rate at 1m was acceptable even if all the lead shielding slumped and no longer shielded the source. A maximum source of the new contents, e.g., TRU, also will not produce an unacceptable 1m dose rate for the HAC. Thus, the new contents are bounded by the previously approved contents.

Example:
For the ^{60}Co source used in the SAR, the maximum allowable shielded dose rate was the most restrictive constraint on the magnitude of the source. For TRU radionuclides, since they primarily produce alpha and beta radiation, the shielded dose rate is not the primary constraint. A more restrictive constraint on TRU is the activity limit of the cask. The 10-160B has an activity limit of 2000 times the A_2 value. As an example, the dose rate from a TRU source was calculated for the HAC. Of the TRU radionuclides found in TRU waste, ^{243}Cm produces one of the highest gamma dose rates per unit activity. To conservatively assess the dose rate from a maximum source, a ^{243}Cm source of 4000 times the A_2 value was used. Under the HAC scenario described in the SAR, the maximum ^{243}Cm source (4000 A_2) results in a 1m dose rate of less than 63 mrem/hr, less than 7% of the limit.

Attachment 2
REVIEW COPY
Revised Appendix 4.10.2.1

Appendix 4.10.2.1

Compliance Methodology for RH-TRU Waste Form
Battelle Columbus Laboratories (BCL)
West Jefferson, OH

1.0 SUMMARY

The purpose of this appendix is to identify acceptable methods of preparation and characterization to qualify remote-handled transuranic (RH-TRU) waste, as defined by the U.S. Department of Energy (DOE) (Ref. 12.1), as payload for transport in the CNS 10-160B cask and to demonstrate that the RH-TRU waste forms at Battelle Columbus Laboratories (BCL), described in this appendix, comply with the payload requirements.

The payload parameters that are controlled in order to ensure safe transport of the RH-TRU waste in the CNS 10-160B cask are as follows:

- Restrictions on the physical and chemical form of RH-TRU waste.
- Restrictions on payload materials to ensure chemical compatibility among all constituents in a particular CNS 10-160B cask (including the parts of the cask that might be affected by the payload).
- Restrictions on the maximum pressure in the CNS 10-160B cask during a 60-day transport period. (As a conservative analysis, the maximum pressure calculations are performed for a period of one year. Attachment D discusses the transport period.)
- Restrictions on the amount of potentially flammable gases that might be present or generated in the payload during a 60-day transport period.
- Restrictions on the layers of confinement for RH-TRU waste materials in the waste containers packaged in the cask.
- Restrictions on the fissile material content for the cask.
- Restrictions on the hydrogen generation rates or the decay heat for the waste containers packaged in the cask.
- Restrictions on the weight for the waste containers and the loaded cask.

This appendix provides allowable methods to prepare payloads to meet these restrictions. The methods for determining or measuring each restricted parameter, the factors influencing the parameter values, and the methods used by BCL for demonstrating compliance, are provided in the following sections.

This appendix also includes the following as attachments:

- Content codes BC 312A, BC 314A, BC 321A, BC 321B, and BC 322A (Attachment A)
- Chemical Lists for the above mentioned content codes (Attachment A)
- Methods for Determining Gas Generation Rates and Decay Heat Values (Attachment B)
- Chemical compatibility analysis for the BCL content codes (Attachment C).
- Shipping Period for TRU Waste in the 10-160B Cask (Attachment D)

2.0 INTRODUCTION

2.1 Purpose

The purpose of this appendix is to describe the acceptable methods that shall be used to prepare and characterize the RH-TRU waste belonging to BCL prior to transport in the CNS 10-160B cask. It incorporates acceptable methods applicable to the content codes listed in Table 3-1 of this appendix. These methods will be expanded, as necessary, to incorporate additional waste content codes that may be identified in the future. Any additional content codes shall be submitted to the NRC for review and approval, with shipments under additional codes authorized only after NRC approval.

Section 2.2 lists the payload parameters that shall be determined for each payload. Section 3.0 describes the relationship between payload parameters and the classification of RH-TRU materials into CNS 10-160B cask payload content codes. Sections 4.0 through 11.0 discuss each payload parameter, the allowable method(s) for demonstrating compliance with the CNS 10-160B cask payload requirements, and the controls that are required for acceptable implementation of these method(s).

2.2 Payload Parameters

The payload parameters addressed in this document include:

- Physical form
- Chemical form and chemical properties
- Chemical compatibility
- Gas distribution and pressure buildup
- Payload container and contents configuration
- Isotopic characterization and fissile content
- Decay heat and hydrogen generation rates
- Weight.

3.0 TRU WASTE PAYLOAD FOR CNS 10-160B CASK

RH-TRU waste is classified into content codes, which give a description of the RH-TRU waste material in terms of processes generating the waste, the packaging methods used in the waste container(s), and the generating site. Content codes for the RH-TRU waste from BCL are provided in Attachment A and are listed in Table 3-1. For each content code, Attachment A provides a listing of all payload parameters, their corresponding limits and restrictions, and the methods used by BCL to meet these limits.

Table 3-1. BCL Content Codes

Content Code	Waste Form Description
BC 312A	Solidified Organic Waste (R&D operations)
BC 314A	Cemented Inorganic Process Solids (R&D operations)
BC 321A	Solid Organic Waste (D&D operations)
BC 321B	Solid Organic Waste (Pool filters and resins)
BC 322A	Solid Inorganic Waste (R&D operations)

D&D = Decontamination and decommissioning.
R&D = Research and development.

The BCL has developed a formal TRU waste certification program that ensures the generation and packaging of waste under rigorous controls and documented procedures, in compliance with all governing regulations. In addition, complete documentation packages, along with quality assurance/quality control records, are generated for all payload containers. All TRU waste generated from the BCL will be packaged under a formal certification program. TRU waste generated from the BCL will comply with all transportation requirements using the following methods:

- Formally documented acceptable knowledge of the processes generating the waste
- Visual examination (VE), including audio/video surveillances of all packaging activities, conducted in accordance with approved procedures that ensure the absence of prohibited items and compliance with packaging requirements
- Data packages generated for all payload containers that document the contents and properties of the waste in the container
- Measurement of required parameters (weight, etc.) to ensure compliance with limits.

4.0 PHYSICAL FORM

4.1 Requirements

The physical form of waste comprising the CNS 10-160B cask payload is restricted to solid or solidified materials in secondary containers or activated reactor components. The total volume of residual liquid in a secondary container is restricted to less than 1% by volume. Secondary containers or components must be shored to prevent movement during accident conditions. Sharp or heavy objects in the waste shall be blocked, braced, or suitably packaged as necessary to provide puncture protection for the payload containers packaging these objects. Sealed containers greater than four liters in size are prohibited.

4.2 Methods of Compliance and Verification

All TRU waste from the BCLDP is newly packaged under procedures and plans that ensure compliance with transportation and other governing regulations. Pursuant to these procedures, compliance with the physical form requirements is ensured by documented acceptable knowledge (AK) and VE.

The BCL uses VE to verify the physical waste form descriptions documented as AK. As waste items are sorted, the BCL VE expert evaluates each waste item for consistency with the AK process description for the waste stream being packaged and determines and documents the physical form and description, and material type(s) and composition (percentage) of the item. The BCL AK expert independently reviews determinations made by the VE expert with respect to waste item assignments to waste streams as defined by the AK process descriptions during the AK confirmation process. AK discrepancy reports are generated with associated corrective actions, as necessary. The BCL also uses VE to ensure absence of prohibited items. As waste items are sorted, the BCL VE expert evaluates each waste item. As identified, any prohibited item is segregated for mitigation or other disposition and is not loaded into a waste container for shipment.

In addition to the generation of inventory loading records for each waste container, the VE documentation includes video/audio records. Video documentation of TRU waste packaging shall be performed at all times when TRU waste is being sorted and packaged under TC-OP-01.4 in the BCL hot cells using two cameras and two videocassette recorders. A microphone feed is provided to verify and verbally note the identification of the waste stream and the container. This process duplicates the information recorded in hardcopy form on the waste container loading record. When TRU waste packages are in the cell, but packaging is not being performed, motion/light sensitive recording equipment shall be left running, with a videocassette in place, to document any movement in the packaging area. This will be used to verify that all packaging was recorded and that no packaging was performed without the proper VE documentation.

The BCLDP TRU WCP will use AK and VE to verify that the liquid content of the payload container complies with the requirements. Packaging personnel shall restrict the presence of free liquids to the extent that is reasonably achievable by pouring, pumping, or aspirating. Free liquids encountered during packaging shall be absorbed. Any liquid in nontransparent inner containers, including pumps or mechanical equipment that may contain an oil reservoir that is not solidified, will be handled by assuming that the container is filled with liquid and the volume will be added to the total liquid documented for the payload container in evaluating compliance with the 1% (volume) limit on free liquids.

BCLDP TRU WCP personnel shall ensure compliance with the requirement associated with sharp or heavy objects through visual examination at the time of packaging as described in TC-OP-01.4, Segregation and Packaging of TRU Waste. BCLDP packaging operations include the practice of size reduction and the use of a 0.015-inch thick steel liner in the 55-gallon drums. Following size reduction, items with the potential to puncture the liner and drum are blocked, braced, or suitably packaged to ensure container integrity.

BCLDP TRU WCP personnel shall ensure compliance with the requirement associated with sealed containers through visual examination at the time of packaging as described in TC-OP-01.4, Segregation and Packaging of TRU Waste. Sealed containers greater than 4 liters identified during the sorting process will be segregated for disposition and shall not be packaged for shipment.

As described in TC-AP-01.1, TRU Waste Data Package Generation, compliance with each of the restrictions on physical form shall be recorded in the payload container data package.

5.0 CHEMICAL FORM AND CHEMICAL PROPERTIES

5.1 Requirements

The chemical properties of the waste are determined by the chemical constituents allowed in a given content code. Specific requirements regarding the chemical form of the waste are as follows:

- Explosives, nonradioactive pyrophorics, compressed gases, and corrosives are prohibited.
- Pyrophoric radionuclides may be present only in residual amounts less than 1 weight percent.
- The total amount of potentially flammable volatile organic compounds (VOCs) present in the headspace of a secondary container is restricted to 500 parts per million (ppm).

5.2 Methods of Compliance and Verification

Compliance with chemical form and chemical property restrictions is demonstrated through process knowledge or sampling programs, if required.

5.2.1 Pyrophoric Materials

Nonradioactive pyrophoric materials (e.g., organic peroxides, sodium metal, and chlorides) shall be segregated and not be packaged into payload containers. Radioactive pyrophoric material (e.g., metallic plutonium and americium), if present in the waste stream, shall be limited to less than 1 percent (weight) of the payload container. In accordance with TC-OP-01.4, Segregation and Packaging of TRU Waste, qualified BCLDP TRU WCP personnel shall use AK information in conjunction with VE, as described in Section 4.2, during waste generation and packaging to verify the absence of nonradioactive pyrophoric materials and compliance with the restriction on radioactive pyrophoric material (e.g., according to records of waste generation processes, nonradioactive pyrophoric materials have not been used). As described in TC-AP-01.1, TRU Waste Data Package Generation, the absence of nonradioactive pyrophorics and compliance with the restriction on radioactive pyrophoric material shall be recorded in the payload container data package. Any nonradioactive pyrophorics encountered during examination shall be segregated and shall not be shipped.

5.2.2 Explosives, Corrosives, and Compressed Gases

In accordance with TC-OP-01.4, Segregation and Packaging of TRU Waste, qualified BCLDP TRU WCP personnel shall use AK information in conjunction with VE, as described in Section 4.2, during waste generation and packaging to verify the absence of explosives, corrosives, and compressed gases. Any unvented compressed gas canisters (including aerosol cans) identified during the packaging of wastes shall be segregated as described in TC-OP-01.4, Segregation and Packaging of TRU Waste. Acids and bases, if found, shall be neutralized. The absence of explosives, unvented compressed gas canisters, and corrosives shall be documented in the payload container data packages by BCLDP TRU WCP personnel as described in TC-AP-01.1, TRU Waste Data Package Generation.

5.2.3 Flammable VOCs

All TRU waste from the BCL is from research and development or decontamination and decommissioning related activities and will be packaged with the generation of complete data packages. The BCL wastes are not expected to have flammable VOCs based on the content codes, the waste packaging process (sorted and repackaged into drums as individual items, which minimizes the introduction of potentially flammable VOCs into the drums), and the lack of a source for potentially flammable VOCs.

6.0 CHEMICAL COMPATIBILITY

6.1 Requirements

Each content code has an associated chemical list (Attachment A) based on AK information. Chemical constituents in a payload container assigned to a given content code shall conform to these approved chemical lists. Chemicals/materials that are not listed are allowed in trace amounts (quantities less than 1 percent [weight]) in a payload container provided that the total quantity of trace chemicals/materials is restricted to less than 5 percent (weight).

Chemical compatibility of a waste with its packaging ensures that chemical reactions will not occur that might pose a threat to the safe transport of a payload in the CNS 10-160B cask.

6.2 Methods of Compliance and Verification

Chemical compatibility analyses for all authorized payloads were performed according to a U.S. Environmental Protection Agency method (Ref. 12.2). Chemical compatibility for the content code chemical lists is ensured by these analyses. The results of these chemical compatibility analyses concluded that the chemicals/materials in each content code and between content codes are chemically compatible. The detailed evaluation of each content code is described in Attachment C. Qualified BCLDP TRU WCP personnel shall document the presence of any chemicals identified during the waste characterization process in the payload container data packages. TC-OP-01.4, Segregation and Packaging of TRU Waste, includes instructions for comparing chemicals noted in the payload container data packages against the chemicals listed in the appropriate content code to ensure the contents of payload containers are compatible.

7.0 GAS DISTRIBUTION AND PRESSURE BUILDUP

7.1 Requirements

Gas distribution and pressure buildup during transport of TRU waste in the CNS 10-160B cask payload are restricted to the following limits:

- The gases generated in the payload must be controlled to prevent the occurrence of potentially flammable concentrations of gases within the payload confinement layers and the void volume of the inner vessel (IV) cavity. Specifically, hydrogen concentrations within the payload confinement layers are limited to 5 percent by volume during a maximum 60-day shipping period (twice the expected shipping time of 30 days, see Attachment D).

- The gases generated in the payload and released into the IV cavity must be controlled to maintain the pressure within the IV cavity below the acceptable packaging design limit of 31.2 pounds per square inch gauge (psig).

7.2 Methods of Compliance and Verification

The primary mechanism for gas generation during TRU waste transportation in the CNS 10-160B cask is by radiolysis of the waste materials. Gas generation from other mechanisms such as chemical, thermal, or biological activity is expected to be insignificant for the TRU waste payload. As discussed in Section 6.0, the chemicals and materials in the TRU waste are compatible and inert, and the restrictions of the materials that can be present in each content code precludes the occurrence of chemical reactions that can produce excessive gas. Gas generation from biological activity is expected to be insignificant given the transportation time, the nature of the waste (solid or solidified), and the environment of the payload (lack of nutrients, lack of water content, etc.). The temperatures of the payload, given the decay heat limits applicable, are expected to be below the normal usage range for the payload materials, resulting in very little potential for gas generation due to thermal decomposition.

Compliance with the CNS 10-160B cask design pressure limit for each content code is analyzed by assuming that all gases generated are released into the IV cavity and by including the contributions from thermal expansion of gases and vapor pressure of atmospheric water.

Table 7-1 shows that the pressure increase during a period of 365 days is below the design pressure limit of 31.2 psig for all the BCL content codes.

Table 7-1. Maximum Pressure Increase Over 365-Day Shipping Period						
Content Code	G_{eff} (RT)[a]	Void Volume (Liters)	Activation Energy (kcal/mole)	Decay Heat Limit (Watts)	G_{eff}[b]	P_{max}[c] (psig)
BC 312A[d]	--	--	--	--	--	--
BC 314A	0.72	1938	0	7.38	0.72	12.09
BC 321A	8.4	1938	2.1	1.54	14.71	24.43
BC 321B	8.4/2.1[e]	1938	2.1	2.69	4.7	17.32
BC 322A	0.024	1938	0	221	0.024	12.08

[a]G value for net gas (molecules per 100 eV) at room temperature (70°F).
[b]Effective G value (molecules per 100 eV) at maximum operating temperature of 168°F calculated using the Arrhenius equation for which activation energy is an input.
[c]Maximum pressure.
[d]This code consists of solidified organics; compliance with pressure limits will be shown by testing.
[e]BC 321B reports 12% cellulosics and 80% resins (remainder being inorganic material) and is reflected in the calculation of the temperature-corrected G_{eff}.

Compliance with the restrictions on flammable gas concentration is discussed in Section 10.0.

8.0 PAYLOAD CONTAINER AND CONTENTS CONFIGURATION

8.1 Requirements

Fifty-five-gallon drums are authorized payload containers in a CNS 10-160B cask. Up to ten 55-gallon drums of RH-TRU waste may be packaged in the cask. Each 55-gallon drum to be packaged in the CNS cask must have a minimum of one filter vent. The minimum filter vent specifications for the 55-gallon drums and drum liners used to package waste inside the drums are provided in Table 8-1.

The test methods used to determine the compliance of filter vents with the performance-based requirements of flow rate, efficiency, and hydrogen diffusivity shall be directed by procedures under a quality assurance program.

Filter vents shall be legibly marked to ensure both (1) identification of the supplier and (2) date of manufacture, lot number, or unique serial number.

Table 8-1. Minimum Filter Vent Specifications

Container Type	Filter Specification			
	Number of Vents Required per Container	Flow Rate (ml/min of air, STP, at 1 inch of water)[a]	Efficiency (percent)	Hydrogen Diffusivity (mol/s/mol fraction at 25°C)
Drum	1	35	99.5	3.70E-6
Drum Liner Filter	1	35	NA[b]	3.70E-6

[a] Filters tested at a different pressure gradient shall have a proportional flow rate (e.g., 35 ml/min at 1 inch of water = 1 L/min at 1 psi).
[b] Filters installed in containers that are overpacked are exempt from the efficiency requirement as the drum must exhibit a ≥99.5 percent efficiency.
NA = Not applicable

8.2 Methods of Compliance and Verification

Procured filter vents at BCL shall be inspected as directed by QD-AP-04.1, Documentation and Control of Purchased Items and Services, to verify compliance with the applicable filter vent specifications specified in the purchase requisition (i.e., visual inspection of certificate of conformance serial numbers to actual filter vents and inspection of filters for physical damage). Under WA-OP-006, Procurement and Inspection of Packagings for Hazardous Materials Shipments, payload containers and liners, if present, shall be visually inspected to ensure that they have been fitted with the required number of filter vents as specified above. Nonconforming filter vents shall be segregated in accordance with QD-AP-15.1, Nonconformance Reporting for Activities, Items and Materials. As described in TC-OP-01.4, Segregation and Packaging of TRU Waste, qualified BCLDP TRU WCP personnel also shall visually inspect payload containers during packaging to ensure that each has been fitted with the correct type and number of filter vents.

Prior to transport, payload container filter vents shall be visually inspected by the Transportation Certification Official (TCO) for damage or defect. If a defect is identified, a nonconformance report shall be issued in accordance with QD-AP-15.1, Nonconformance Reporting for Activities, Items and Materials, and the payload container shall be returned for repackaging or overpacking prior to certification.

9.0 ISOTOPIC CHARACTERIZATION AND FISSILE CONTENT

9.1 Requirements

The CNS 10-160B cask payload allows fissile materials, provided the mass limits of Title 10, Code of Federal Regulations, Section 71.53 are not exceeded. Plutonium content cannot exceed 0.74 Bq (20 curies) per cask.

9.2 Methods of Compliance and Verification

BCLDP TRU WCP personnel will calculate the fissile or fissionable radionuclide content of the payload container as Pu-239 (plutonium-239) fissile gram equivalents (FGE) and as plutonium curies as described in DD-98-04, Waste Characterization, Classification and Shipping Support Technical Basis Document, and TC-AP-01.2, Calculations Using Radioassay Data. These calculations are based on the waste generation source and configuration, which establishes the initial radionuclide compositions based on location and initial use. As described in DD-98-04, Waste Characterization, Classification and Shipping Support Technical Basis Document, assay of samples and dose rate measurements, along with the appropriate isotopic composition, are used to determine the isotopic inventory. The TCO shall evaluate the compliance of the total FGE value and the plutonium curies of payload containers with the maximum limits.

It should be noted that BCLDP accountability records indicate no more than approximately 50 grams of fissile material is dispersed throughout the BCL West Jefferson North facility in low isotopic enrichments (Reference 12.3). Therefore, the drum loading of fissile material will be much lower.

10.0 DECAY HEAT AND HYDROGEN GAS GENERATION RATES

This section describes the logic and methodology used in evaluating payload characteristics that meet the hydrogen gas concentration requirement for each of the RH-TRU content codes for the BCL RH-TRU wastes described in this section.

10.1 Requirements

The hydrogen gas concentration shall not exceed 5% by volume in all void volumes within the CNS 10-160B cask payload during transport up to twice the expecting shipping time of 30 days. A CNS 10-160B Cask payload must be assembled of payload containers belonging to the same or equivalent content code. Payload containers of different content codes with different bounding G values and resistances may be assembled together as a payload, provided the decay heat limit and hydrogen gas generation rate limit for all payload containers within the payload is conservatively assumed to be the same as that of the payload container with the lowest decay heat limit and hydrogen gas generation rate limit.

10.2 Methodology of Ensuring Compliance with Flammable Gas Concentration Limits

As stated in Section 7.2, chemical, biological, and thermal gas generation mechanisms are insignificant in the CNS 10-160B cask. In addition, as shown in Section 5.1, potentially flammable VOCs are restricted to 500 ppm in the headspace of the CNS 10-160B cask secondary containers. Therefore, the only flammable gas of concern for transportation purposes is hydrogen. The concentration of hydrogen within any void volume in a layer of confinement of the payload or in the cask IV has been evaluated during a 60-day shipping period (i.e., twice the expected shipping duration, see Attachment D).

Attachment A provides the RH-TRU waste content codes for the BCL RH-TRU wastes that are included in the authorized payload for the CNS 10-160B cask. Each content code has a unique and completely defined packaging configuration. Modeling the movement of hydrogen from the waste material to the payload voids, using the release rates of hydrogen through the various confinement layers, defines the relationship between generation rate and void concentration. This modeling allows determination of the maximum allowable hydrogen generation rate for a given content code to meet the 5% concentration limit, as detailed in Section 10.3. Based on hydrogen gas generation potential, quantified by hydrogen gas generation G values, the gas concentration limit can be converted to a decay heat limit, as detailed in Section 10.4. The maximum allowable hydrogen generation rates and decay heat limits for the RH-TRU content codes for BCL wastes are listed in Table 10-1.

Table 10-1. Maximum Allowable Hydrogen Gas Generation Rates, Decay Heat Limits, and Total Activity Limits

Content Code	Maximum Allowable Hydrogen Gas Generation Rate, mole/second/drum	Maximum Allowable Hydrogen Gas Generation Rate, moles/second/cask	Maximum Allowable Decay Heat Limit, Watts/Drum	Maximum Allowable Decay Heat Limit, Watts/Cask	Maximum Total Activity Limit Curies/Cask[a]
BC 312A	3.5082E-8	3.5082E-7	_[b]	_[b]	_[b]
BC 314A	3.5082E-8	3.5082E-7	0.738	7.38	1.45E+3
BC 321A	4.093E-8	4.093E-7	0.154	1.54	3.01E+2
BC 321B	4.093E-8	4.093E-7	0.269	2.69	5.76E+2
BC 322A	3.5082E-8	3.5082E-7	22.1	221	4.34E+4

[a]Other limits applicable to the cask (not related to gas generation) shall also be met.
[b]No decay heat limit or activity limit due to unknown G value.

Parameters that govern the maximum allowable hydrogen generation rates and maximum allowable decay heat limits are listed below:

- Waste packaging configuration (i.e., the number and type of confinement layers).
- Release rates of hydrogen from each of these confinement layers.
- Void volume in the IV available for gas accumulation.
- Operating temperature and pressure for the payload in the CNS cask IV during the maximum shipping period.
- Duration of the shipping period (see Attachment D).
- Fraction of the gamma energy absorbed by waste materials that could potentially generate hydrogen.
- Hydrogen generation rates quantified by the G value of a waste material (the number of molecules of hydrogen produced per 100 eV of energy absorbed).

10.3 Determination of Maximum Allowable Hydrogen Generation Rates for Content Codes

The modeling for determination of the maximum allowable generation rates is described below.

10.3.1 Input Parameters

The model parameters that must be quantified include the following:

Waste Packaging Configuration and Release Rates: Each content code has a unique packaging configuration that is completely defined. The waste described by content codes BC 312A, BC 314A, BC 321A, and BC 322A will be placed directly into a 55-gallon drum lined with a steel liner. The waste described by content code BC 321B will also be placed directly into a 55-gallon drum that may be lined with a steel liner or a polyethylene liner. Ten drums will then be placed into the CNS 10-160B cask. Release rates of hydrogen through the drum filters and drum liner filters have been quantified, and are summarized in Table 10-2. (Note that, if used, the polyethylene liner is punctured with a 1-inch diameter hole. The release rate associated with the puncture hole is conservatively assumed to be the same as that of the steel liner filter.) These are based on release rates obtained for filters (Ref. 12.4) at room temperatures. The release rates used in the calculations are the minimum measured values in each case. The release rates in Table 10-2 are shown for two different temperatures. The temperature dependence of these release rates is discussed later in this section.

Void Volumes in Confinement Layers: The void volumes in the confinement layers are content code specific. The void volumes for the layers in the different content codes are based on waste generation processes and the specific contents within the content codes. This section summarizes the void volumes within the confinement layers for the various content codes. In all cases, a conservative (i.e., minimal) void volume has been used.

Table 10-2. Release Rates of Hydrogen

Content Code	Filter Type	Release Rate (mol/sec/mol fraction)	
		T = 233K	T = 348.6K
BC 312A	Drum Liner Filter	2.46×10^{-6}	4.98×10^{-6}
	Drum Filter	2.46×10^{-6}	4.98×10^{-6}
BC 314A	Drum Liner Filter	2.46×10^{-6}	4.98×10^{-6}
	Drum Filter	2.46×10^{-6}	4.98×10^{-6}
BC 321A	Drum Liner Filter	2.46×10^{-6}	4.98×10^{-6}
	Drum Filter	2.46×10^{-6}	4.98×10^{-6}
BC 321B	Drum Liner Filter	2.46×10^{-6}	4.98×10^{-6}
	Drum Filter	2.46×10^{-6}	4.98×10^{-6}
BC 322A	Drum Liner Filter	2.46×10^{-6}	4.98×10^{-6}
	Drum Filter	2.46×10^{-6}	4.98×10^{-6}

Cask Void Volume: The cask will have a payload of 10 drums and a drum carriage. The interior volume of the cask, V_{cask}, is 4438 liters. The volume occupied by the drum carriage, $V_{carriage}$, is 143.2 liters. The external volume of a single drum, V_{drum}, is 235.7 liters. The void volume within the cask is calculated as:

$$V_{V,cask} = V_{cask} - V_{carriage} - 10\, V_{drum}$$

$$V_{V,cask} = 4438 \text{ liters} - 143.2 \text{ liters} - 10\,(235.7 \text{ liters})$$

$$V_{V,cask} = 1938 \text{ liters}$$

Drum Headspace Void Volume: The internal height of the cylindrical 55-gallon drum is 33.25 inches (in.) and the inside diameter is 22.5 in. The internal volume of the drum is thus calculated as:

$$V_{drum,Internal} = \pi \, r^2_{drum,Internal} \, h_{drum,Internal}$$

$$V_{drum,Internal} = \pi \, (\frac{22.5\,in}{2} \, x \, 2.54\,cm/in)^2 (33.25\,in \, x \, 2.54\,cm/in)$$

$$V_{drum,Internal} = 216{,}644\,cm^3 = 216.6\,liters$$

The external height of the cylindrical drum liner is 32.250 in., and the outside diameter is 19.500 in. The external volume of the drum liner is calculated as:

$$V_{liner,external} = \pi \, r^2_{liner,external} \, h_{liner,external}$$

$$V_{liner,external} = \pi \, (\frac{19.5\,in}{2} \, x \, 2.54\,cm/in)^2 (32.25\,in \, x \, 2.54\,cm/in)$$

$V_{liner,external}$ = 157,830cm³ = 157.8 liters

The void volume within the drum headspace, $V_{V,hs}$, is calculated as:

$$V_{V,hs} = V_{drum,Internal} - V_{liner,External}$$

$$V_{V,hs} = 216.6\,liters - 157.8\,liters$$

$$V_{V,hs} = 58.8\,liters$$

Drum Liner Void Volume:

<u>Content Codes BC 321A and BC 321B</u>

These content codes are comprised of combustible, debris type of waste materials. The drum liner thickness is 0.105 in. The external height of the cylindrical drum liner is 32.250 in., and the outside diameter is 19.500 in. The internal dimensions of the rigid liner are thus a height of 32 in. and a diameter of 19.3 in. The internal volume of the drum liner is calculated as:

$$V_{liner,Internal} = \pi \, r^2_{liner,Internal} \, h_{liner,Internal}$$

$$V_{liner,Internal} = \pi \left(\frac{19.3\, in}{2} x\, 2.54\, cm / in\right)^2 (32\, in\, x\, 2.54\, cm / in)$$

$V_{liner,\ Internal}$ = 153,400cm3 = 153.4 liters

For content code BC 321A, BCL waste drum data (waste masses and volumes) for the waste result in a range of bulk densities of the waste material of 0.30 g/cm3 to 0.55 g/cm^3. The bulk density of the waste material, ρ_{bulk}, is conservatively set to the maximum bulk density of this range, 0.55 g/cm^3. The lowest solid material density, ρ_{solid}, for the dominant material in BC 321A, cellulosics, is 1.20 g/cm^3 from Reference 12.5. Thus the minimum void ratio, ε, is calculated as:

$$\varepsilon = 1 - \frac{\rho_{bulk}}{\rho_{solid}}$$

$$\varepsilon = 1 - \frac{0.55}{1.20}$$

ε = 0.542 = 54.2%

Based on the range of densities of 0.09 g/cm^3 to 0.36 g/cm^3 for residential, commercial, and combustible mixed construction debris from Reference 12.5, the conservatively assumed maximum bulk density of the waste material, ρ_{bulk}, in content code BC 321B, is 0.36 g/cm^3. The solid material density, ρ_{solid}, for the dominant material in BC 321B, ion exchange resins, is 0.70 g/cm^3 from Reference 12.5. As above, the minimum void ratio for BC 321B is calculated as:

$$\varepsilon = 1 - \frac{0.36}{0.70}$$

ε = 0.486 = 48.6%

To verify that the assumed bulk density is conservative, bulk densities of the waste material were calculated from BCL representative waste drum data (waste masses and volumes) and compared to the assumed bulk density value. The calculated bulk density for the BCL drums of content code BC 321B ranged from 0.19 g/cm^3 to 0.31 g/cm^3. The calculated void ratio using this maximum bulk density and the solid material density of 0.70 g/cm^3 is:

$$\varepsilon = 1 - \frac{0.31}{0.70}$$

ε = 0.557 = 55.7%

To ensure that the total flammable gas concentration remains below 5% of the free gas volume in any confined region of the packaging during the shipping period, the smallest void ratio calculated above (48.6%) is used for both BC 321A and BC 321B content codes to conservatively calculate the minimum void volume within the rigid liner.

Thus, the minimum void volume within the rigid liner, $V_{V,liner}$, is calculated as:

$$V_{V,liner} = \gamma V_{liner,\ Internal}$$

$$V_{V,liner} = 0.486\ (153.4\ liters)$$

$$V_{V,liner} = 73.6\ liters$$

Content Codes BC 312, BC 314, and BC 322

A conservative void volume of 1 liter within the drum liner is used in the calculations of maximum allowable hydrogen gas generation rates for these content codes.

Pressure: The pressure is assumed to be isobaric and equal to one atmosphere. The mole fraction of hydrogen in each void volume would be smaller if pressurization is considered and would result in a greater maximum allowable hydrogen gas generation rate. Furthermore, the amount of hydrogen gas generated during a sixty day shipping period would be negligible compared to the quantity of air initially present at the time of sealing the CNS 10-160B cask.

Temperature: The input parameter affected by temperature is the release rate through the different confinement layers in the payload containers and the G values for hydrogen. For the RH-TRU waste content codes, these are the filters in the inner containers. These release rates increase with increasing temperature (Ref. 12.6). Therefore, the minimum release rates would be those at the lowest operating temperature. These are the release rates indicated in Table 10-2 for 233K. The minimum decay heat limits are determined by the ratio of the release rates and the G values. In other words, the higher the release rates, the higher the decay heat limit; the higher the G value, the lower the decay heat limit. The dependence of G values on temperature is documented in Section 10.4. For determining the decay heat limit, the temperature that yielded the minimum decay heat limit for each content code was used as the input parameter.

In summary, the temperature dependence of the input parameters was accounted for in the calculation so that, in each case, the minimum possible limit (hydrogen generation rate or decay heat limit) was obtained. This provides an additional margin of safety in the analysis for each content code.

These are the important input parameters for determining the maximum allowable hydrogen generation limits. Other assumptions used in the mathematical analysis are included in Section 10.3.2.

10.3.2 Mathematical Analysis For Determining the Maximum Allowable Hydrogen Gas Generation Rates

The maximum allowable gas generation rate for each content code was calculated using numerical solutions to differential equations, which describe the unsteady-state (i.e., transient) mass balances on hydrogen within each confinement volume of the CNS 10-160B cask. The hydrogen generation rate which will yield 5 volume percent within the innermost layer of confinement is not known a priori and is calculated using an iterative scheme which is described below.

The assumptions that have been made in deriving the governing equations are as follows:

- Hydrogen is an ideal gas and the ideal gas law applies.
- The hydrogen is assumed to be nonreactive with any materials in the payload container.
- Hydrogen gas generation rates are not reduced by depletion of the waste matrix.
- The concentration of hydrogen within each of the layers of confinement prior to transport in the CNS 10-160B cask is assumed to be at steady-state (generation rate equals release rate). This assumption provides an additional margin of safety since the concentrations of hydrogen are maximum at steady-state conditions.

The following list defines the variables which are used in the description of the mathematical framework.

X_1	=	Mole fraction hydrogen within the innermost confinement volume.
X_i	=	Mole fraction hydrogen in the confinement volume "i".
R_{df}	=	The effective release rate of hydrogen across the filter on a drum (L/day).
R_{lh}	=	The effective release rate of hydrogen across the drum liner filter (L/day).
V_i	=	The void volume within confinement layer "i" (L).
t	=	Time (days).
R	=	The gas law constant (0.08206 atm L mol^{-1} K^{-1}).
T	=	Absolute temperature (K).
P	=	Absolute pressure (atm).
CG	=	The hydrogen gas generation rate per innermost confinement layer in one drum (mol/sec).

For brevity in subsequent discussions, a parameter C_1 will be defined as:

$$C_1 = CG \times R \times T / (P \times V_1)$$

The evaluation of maximum allowable hydrogen gas generation rates was performed through iterative calculations until the appropriate hydrogen gas generation rate per drum yielded a concentration of 0.05 mole fraction within the innermost layer of confinement (i.e., within the drum liner void) at the end of the 60-day shipping period.

The generation of hydrogen within the innermost layer, release across confinement layers and accumulation within the confinement volumes during transport were simulated by numerically solving the system of hydrogen mass balance differential equations for each void volume. The applicable systems of differential equations are listed below. The derivation of these equations follows the system of equations.

SYSTEM OF DIFFERENTIAL EQUATIONS

EQUATION	VOID VOLUME
$dX_1/dt = C_1 - R_{lh}(X_1 - X_2)/V_1$	[drum liner]
$dX_2/dt = R_{lh}(X_1 - X_2)/V_2 - R_{df}(X_2 - X_3)/V_2$	[drum headspace]
$dX_3/dt = 10R_{df}(X_2 - X_3)/V_3$	[CNS 10-160B cask IV]

Derivation of the System of Differential Equations

Mass Balance for the Drum Liner Void Volume

$$\frac{dn_1}{dt} = CG - k_{lh}(P_1 - P_2)$$

where,

n_1 = Moles of hydrogen inside drum liner void volume (mol)
k_{lh} = Effective release rate of hydrogen across the drum liner filter (mol/day^{-1} atm H_2^{-1})
P_1 = Partial pressure hydrogen inside drum liner void volume (atm H_2)
P_2 = Partial pressure hydrogen inside drum headspace void volume (atm H_2).

Applying the ideal gas law and assuming isobaric conditions such that P is constant total system pressure, yields:

$$\frac{PV_1}{RT}\frac{dX_1}{dt} = CG - k_{lh}P(X_1 - X_2).$$

Rearranging terms and defining R_{lh} as $k_{lh}RT$ yields the first equation:

$$\frac{dX_1}{dt} = C_1 - \frac{R_{lh}(X_1 - X_2)}{V_1}.$$

Mass Balance for the Drum Headspace Void Volume

$$\frac{dn_2}{dt} = k_{th}(P_1 - P_2) - k_{df}(P_2 - P_3)$$

where,

n_2 = Moles of hydrogen inside canister void volume (mol)
k_{df} = Effective release rate of hydrogen across the filter on the drum (mol/day^{-1} atm H_2^{-1})
P_3 = Partial pressure hydrogen inside CNS 10-160B cask IV void volume (atm H_2)

and the other variables are as defined earlier.

Applying the ideal gas law and assuming isobaric conditions such that P is constant total system pressure, yields:

$$\frac{PV_2}{RT}\frac{dX_2}{dt} = k_{th}P(X_1 - X_2) - k_{df}P(X_2 - X_3).$$

Rearranging terms and defining R_{df} as $k_{df}RT$ yields the second equation:

$$\frac{dX_2}{dt} = \frac{R_{th}(X_1 - X_2)}{V_2} - \frac{R_{df}(X_2 - X_3)}{V_2}.$$

Mass Balance for the CNS 10-160B Cask Void Volume With Ten Drums

$$\frac{dn_3}{dt} = 10\,k_{df}(P_2 - P_3)$$

where,

n_3 = Moles of hydrogen inside CNS 10-160B cask IV void volume (mol).

Applying the ideal gas law and assuming isobaric conditions

$$\frac{PV_3}{RT}\frac{dX_3}{dt} = 10\, k_{df}\, P(X_2 - X_3).$$

Rearranging terms yields the third equation:

$$\frac{dX_3}{dt} = \frac{10\, R_{df}\,(X_2 - X_3)}{V_3}.$$

__Derivation of the Steady-State Concentrations in Confinement Layers__

Prior to transport in the CNS 10-160B cask the concentration of hydrogen within each of the layers of confinement is assumed to be at steady-state. At steady-state the release rates of hydrogen across each layer are equal to the hydrogen gas generation rate. The steady-state concentrations of hydrogen within each volume of confinement were evaluated from the relations below.

At steady-state, the concentration of hydrogen outside the drum is zero (i.e., $X_3 = 0$) and there is no accumulation of hydrogen inside the drum, thus the steady-state hydrogen mass balance for the drum liner void volume becomes:

$$\frac{dX_1}{dt} = 0 = C_1 - \frac{R_{lh}\,(X_1 - X_2)}{V_1}.$$

For the drum headspace, the steady-state hydrogen mass balance becomes:

$$\frac{dX_2}{dt} = 0 = \frac{R_{lh}\,(X_1 - X_2)}{V_2} - \frac{R_{df}\, X_2}{V_2}.$$

Rearranging the terms in the mass balance equation for hydrogen at steady-state inside the drum liner,

$$C_1 V_1 = R_{lh}(X_1 - X_2).$$

Substituting this relation in the steady-state equation for the hydrogen mass balance inside the drum headspace and rearranging terms

$$\frac{R_{lh}(X_1 - X_2)}{V_2} = \frac{C_1 V_1}{V_2} = \frac{R_{df} X_2}{V_2}.$$

Simplifying the previous equation and solving for the steady-state concentration in the drum headspace, X_2, yields

$$X_2 = \frac{C_1 V_1}{R_{df}}.$$

Rearranging the relation for the steady-state hydrogen mass balance inside the drum liner yields:

$$C_1 V_1 + R_{lh} X_2 = R_{lh} X_1.$$

Rearranging terms in the previous equation and solving for the steady-state hydrogen concentration inside the drum liner, X_1, yields

$$X_1 = \frac{C_1 V_1}{R_{lh}} + X_2.$$

The steady-state concentrations were then used to define the initial state of the system (i.e., hydrogen mole fractions within each confinement volume) at the time the CNS 10-160B cask is sealed for transport with a payload of 10 drums.

These systems of differential equations were solved numerically using the Runge-Kutta Fourth Order numerical integration method. Numerical solution implies obtaining the mole fractions of hydrogen in each void volume as a function of time.

For the initial assumed gas generation rate, if the concentration of hydrogen in the innermost void volume is below 0.05 mole fraction, then the hydrogen gas generation rate for the next iteration is increased and the above set of calculations is repeated. If the concentration is greater than 0.05 mole fraction, the gas generation rate for the next iteration is decreased. The evaluation of steady-state hydrogen mole fractions for a given gas generation rate, and simulation of hydrogen generation during transport by numerical integration, continues until two values of the H_2 gas generation are evaluated such that for one rate the hydrogen mole fraction in the innermost volume is less than 0.05 and the other results in a mole fraction greater than 0.05. The maximum allowable hydrogen gas generation is estimated to an accuracy of 10^{-13} mole/sec by refining the gas generation rate interval using the technique of interval halving (Ref. 12.7).

10.4 Determination of Maximum Allowable Decay Limits for Content Codes

The maximum allowable decay heat limit for a content code is determined using RadCalc Software (Reference 12.8). RadCalc for Windows 2.01 is a windows-compatible software program with applications in the packaging and transportation of radioactive materials. Its primary function is to calculate the generation of hydrogen gas by radiolytic production in the waste matrix of radioactive wastes. It contains a robust algorithm that determines the daughter products of selected radionuclides. The various functions in RadCalc for Windows can be used separately or together. The procedure is outlined below.

The first step in the evaluation of decay heat limits involves determining the activities of the radionuclides and daughters and the associated hydrogen gas generation rate at the time of sealing based on an initial isotopic ratio for the waste. The generation of hydrogen gas by radiolysis is a function of the energy absorbed by the waste. The second step in the evaluation of decay heat limits involves iterating on the total activity (decay heat limit) given the activity fractions from step one until the allowable hydrogen gas generation rate is obtained.

10.4.1 Databases and Input Parameters Used For Calculation of Maximum Allowable Decay Heat Limits

10.4.1.1 Radionuclide Databases

RadCalc uses radionuclide information, calculated gamma absorption fractions for selected container types, and G values to determine decay heat values. Radionuclide information is taken from FENDL/D-1.0 database (Ref. 12.9). The following are a list of radionuclide parameters taken from FENDL/D-1.0 and the values they are used to calculate:

- Radionuclide half-lives are used in calculating specific activity
- Average heavy particle, beta-type radiation, and gamma radiation energies per disintegration are used in decay heat and hydrogen gas generation calculations
- Discrete gamma energies and abundances are used in hydrogen gas generation calculations.

RadCalc uses the ORIGEN2 (Ref. 12.10) database for decay calculations. The decay algorithms calculate the activity of the user specified source and daughter products over a specified period of time and the total number of disintegrations accumulated over this same time interval for each radionuclide. Parameters relevant to these calculations include atomic mass, atomic number, and state. These parameters are used for radionuclide identification and conversions. The decay constant and the branching ratios for decay modes are also used in the decay algorithms.

10.4.1.2 Gamma Absorption Fraction Input Parameters

RadCalc uses the total energy emitted by heavy particle and beta-type decay in calculating the volume of hydrogen produced. However, only a percent of gamma energy will be absorbed in the package and the waste. The absorbed gamma energy is a function of energy, waste density, material type, and geometry. The gamma energy absorbed by the waste is a function of the gamma emission strength, the quantity of gamma ray energy which is absorbed by collision with a waste particle, and the number of particles which interact with the gamma ray. Therefore, gamma energy absorption increases with increasing waste density. For a given waste density, a larger container will contain more particles, and therefore a higher percentage of the gamma ray energy would be absorbed than in a smaller container. The total cumulative absorbed dose for all nuclides and decay modes at time, t is evaluated as:

$$D_{total}(t) = \Gamma_{i=1}^{NR} AC_i/\&_i \, (0.82E_i^{\forall} + E_i^{\exists} + E_i^{\ni} + E_i^{x})[1 - exp(-\&_i t)]$$

where,

$D_{total}(t)$ = Total cumulative absorbed dose at time, t (rad)

A = A proportionality constant equal to $1.84x10^{10}$ rad gram MeV^{-1} yr^{-1} Ci^{-1}

C_i = The specific activity of the "i"th nuclide in Curies/gram of waste

$\&_i$ = The decay constant of the "i"th radionuclide (yr^{-1})

NR = Number of radionuclides

$E_i^{\forall}$ = $\forall$ energy in MeV of the "i"th radionuclide extracted from Flaherty et al. (Ref. 12.11)

$E_i^{\exists}$ = Average beta energy in MeV of the "i"th nuclide. The average beta energy is approximately one-third of the sum of the possible beta emissions multiplied by the relative abundance of each emission and were obtained from Flaherty et al. (Ref. 12.11).

E_i^{x} = The absorbed secondary energy in MeV of the "i"th radionuclide. The secondary radiations result from the transition of a radionuclide from an excited state to the ground state and were obtained from Flaherty et al. (Ref. 12.11).

$E_i^{\ni}$ = The absorbed gamma ray energy in MeV of the "i"th nuclide. The fraction of gamma energy that is absorbed by the waste is a function of the waste density and waste container geometry, and is evaluated for each radionuclide "i" as:

$E_i^{\gamma} = \Gamma_j \, n_{ij} \, f_{ij} \, E_{ij}^{\gamma}$

where,

Γ_j = the summation of the fractions of the gamma ray energies absorbed for all gamma emissions of the "i"th nuclide.

n_{ij} = the abundance of the "j"th gamma ray per decay of the "i"th nuclide

f_{ij} = the fraction of energy, of the "j"th gamma ray of the "i"th nuclide that is absorbed in the waste.

E_{ij}^{γ} = the energy in MeV, of the "j"th gamma ray of the "i"th nuclide.

RadCalc uses curve fits obtained from Flaherty et al. (Ref. 12.11) and recalculated using the Monte Carlo N-Particle (MCNP) transport code (Ref. 12.12) for ten containers, for obtaining the absorbed gamma dose.

The CNS cask is not currently recognized by the RadCalc. Therefore, another container with dimensions directly proportional to the cask was used for undertaking the calculations.

10.4.1.3 G Value Data

G values for RH-TRU waste are content specific. G values are determined based on the bounding materials present in the payload. The following G values were used for each of the content codes based on the presence of the bounding materials. The G values at 70°F are adjusted to the maximum operating temperature of the CNS cask (168°F) using the Arrhenius equation.

<u>BC 312A</u>
This content code represents solidified organics and does not have a defined G value.

<u>BC 314A</u>
This content code represents cemented inorganic process solids consisting of solidified cement slugs. It is assumed that water is the dominant hydrogen gas generating material in the waste form and will therefore be the bounding material. The G value for hydrogen from water is 1.6 molecules/100eV. It is also assumed that the moisture content of the waste is 30% and therefore the G value is 30% of the G value for water or 0.48 molecules/100eV (at 70°F).

<u>BC 321A</u>
This content code represents solid organic debris consisting of various combustible and non-combustible items. The dominant material present in this waste is cellulosics (95%) and is therefore considered as the bounding material. The G value for hydrogen associated with cellulosics is 3.2 molecules/100eV (at 70°F).

<u>BC 321B</u>
This content code represents organic pool filter and resin waste consisting of ion exchange resins. The dominant material present in this waste is organic resins (80%). The waste also consists of cellulosics (12%). The effective G value for hydrogen for this content code is the sum of 80% of the G value for

organic resins (1.7 molecules/100eV at 70°F) and 12% of the G value for cellulosics (3.2 molecules/100eV at 70°F), which is 1.74.

BC 322A

This content code represents waste consisting of glass, metal, and solidified and other inorganic materials. It is conservatively assumed that residual water is the dominant hydrogen gas generating material in this waste form and will therefore be the bounding material. The G value for hydrogen from water is 1.6 molecules/100eV. It is also assumed that the moisture content of the waste is 1% and therefore the G value is 1% of the G value for water, or 0.016 molecules/100eV (at 70°F).

10.4.2 Input Parameters

The input parameters can be placed in three groups: (1) container data, (2) waste data, and (3) source data.

10.4.2.1 Container Data

RadCalc requires as input the following parameters associated with the container for which the maximum allowable decay heat limit is being calculated:

Container Type - The payload container for the waste material
Container Dates - Date of generation, date of sealing, and shipping period
Package Void Volume - void volume of the payload container.

A 6- by 6-foot liner with a volume equal to the CNS cask is used to represent the payload container in the RadCalc input file as the RadCalc database does not include the CNS cask. The package void volume for a CNS 10-160B cask is 1938 liters as shown earlier.

10.4.2.2 Waste Data

RadCalc requires as input the following parameters associated with the waste for which the maximum allowable decay heat limit is being calculated:

- Physical Form – liquid, solid, or gas
- Waste Volume – volume of the waste, cm^3
- Waste Mass – mass of the waste, g
- G Value – G value of the waste, molecules per 100 eV

Liquids and gas wastes are prohibited in the CNS 10-160B cask. The volume of the waste is assumed to be 217 liters per drum (the external volume of the waste drum) and 2170 liters for 10 drums in the cask. The waste volume is used by RadCalc, along with the waste mass, to determine the volume of hydrogen generated in the cask. The mass of the waste is calculated based on the assumed bulk density of the waste. The volume of hydrogen generated is directly proportional to the mass of the waste, as discussed in Reference 12.11. The most conservative estimate of the volume of hydrogen (greatest volume) would occur at the highest possible bulk density of the waste. As presented in Section 10.3.1 above, the waste bulk densities for content codes BC 321A and BC 321B are conservatively assumed to be 0.55 g/cm^3 and 0.36 g/cm^3, respectively. A conservative bounding waste bulk density of 1.5 g/cm^3, obtained from Reference 12.5, is used for content codes BC 314A and BC 322A, consisting of cement and metal scrap as bounding materials, respectively. Representative waste drum data for these content codes provide waste bulk densities well below the 1.5 g/cm^3 bounding bulk density used to calculate the decay heat limits. It may also be relevant that an additional level of conservatism is observed in the calculation of the mass of the waste. This mass is calculated based on the total volume of the 10 waste drums (2170 liters) rather than the available internal waste volume of 153.4 liters per drum shown in Section 10.3.1.

Section 10.4.1.3 provides a discussion of the G values for each of the content codes.

10.4.2.3 Source Data

RadCalc requires as input the following parameters associated with the source for which the maximum allowable decay heat limit is being calculated:

Isotopic Composition - List of radionuclides present in the waste
Activity - Reported activities of the listed radionuclides in curies or Becquerel.

10.4.3 Procedure For Determining Maximum Allowable Decay Heat Limits

The necessary inputs are provided to the code prior to initiating a run. A time period of 60 days is conservatively assumed between date of beginning of decay and date of analysis to reflect the shipping period (see Attachment D). The model is run with the initial isotopic composition and activity and the corresponding hydrogen gas generation rate is obtained. It is compared with the maximum allowable hydrogen gas generation rate as obtained from Section 10.3, and the scaling factor is obtained by dividing the maximum allowable hydrogen gas generation rate by the RadCalc obtained rate. The isotopic composition is scaled by this differential factor. This is done on the basis of the assumption that the maximum decay heat occurs at the time of maximum activity which will result in the maximum hydrogen gas generation rate. The model is now run so that the hydrogen gas generation rate will now be equal to the maximum allowable hydrogen gas generation rate. The associated decay heat value will be the maximum decay heat limit as the decay heat limit shares a direct relationship with the hydrogen gas generation rate, independent of time.

The results of the decay heat limit modeling are shown in Table 10-1. Methods for demonstrating compliance of the BCL TRU waste with the decay heat and hydrogen gas generation rate limits are shown in Attachment B.

10.5 Methodology for Compliance with Payload Assembly Requirements

The TCO shall ensure that the CNS 10-160B Cask payload consists of payload containers belonging to the same or equivalent content code. In the event that payload containers of different content codes with different bounding G values and resistances are assembled together in the CNS 10-160B Cask, the TCO shall ensure that the decay heat and hydrogen gas generation rate for all payload containers within the payload are less than or equal to the limits associated with the payload container with the lowest decay heat limit and hydrogen gas generation rate limit.

11.0 WEIGHT

11.1 Requirements

The weight limit for a 55-gallon drum is 1,000 pounds. The weight limit for the loaded cask is 14,500 pounds.

11.2 Methods of Compliance and Verification

In accordance with TC-OP-01.4, Segregation and Packaging of TRU Waste, BCLDP shall weigh each payload container and contents on a calibrated scale to determine the total weight of the payload container. Based on the total measured weight of the individual payload containers, BCLDP shall calculate total assembly weight and evaluate compliance with the maximum loaded cask weight limit.

12.0 REFERENCES

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ATTACHMENT A

REMOTE-HANDLED TRANSURANIC CONTENT CODES AND CHEMICAL LISTS FOR BATTELLE COLUMBUS LABORATORIES

CONTENT CODE: BC 312A

CONTENT DESCRIPTION: Solidified Organic Waste

WASTE DESCRIPTION: This waste consists of solidified organic and inorganic liquid wastes.

GENERATING SOURCES: This waste is generated during research and development activities conducted in Building JN-1.

WASTE FORM: The waste consists primarily of inorganic and organic liquids that have been solidified using Floor Dry. The inorganic liquids included acids and acid solutions, and elemental mercury. The organic liquids included hydraulic oil, waste water, sludge of sand and mixed fission products (dust, small fragments); small items such as tools may also be present; nonhalogenated organic liquids such as glycols, oils, and alcohols.

WASTE PACKAGING: The waste will be placed directly into a 55-gallon drum with no layers of confinement. The drum is lined with a steel liner. Ten drums will then be placed into the CNS 10-160B cask.

METHODS FOR DETERMINATION OF ISOTOPIC CHARACTERIZATION: The isotopic information required to demonstrate compliance with the limits on fissile content, decay heat, and curie content will be determined based on the waste generation source and configuration, which establishes the initial radionuclide compositions based on location and initial use. A combination of assay of samples and modeling the isotopic generation processes results in the establishment of a mixture that characterizes the waste in the content code and the majority of waste at the BCLDP. Using shipping package modeling, dose rate and weight measurements based on the mixture then allows the BCLDP to determine the isotopic inventory. As required, additional radioassay (e.g., confirming gamma spectrometry) will be performed.

FREE LIQUIDS: Liquid waste is prohibited in the drums except for residual amounts in well-drained containers. The total volume of residual liquid in a payload container shall be less than 1 volume percent of the payload container. Waste packaging procedures ensure that free liquids are less than 1 volume percent of the payload container. Absorbents such as Radsorb or diatomaceous earth (e.g., Floor Dry) will be added to any waste matrix that has the potential to dewater after packaging.

EXPLOSIVE/COMPRESSED GASES: Explosives and compressed gases in the payload containers are prohibited by waste packaging procedures. If present, pressurized cans shall be punctured and emptied prior to packaging.

PYROPHORICS: Nonradioactive pyrophorics in the payload containers are prohibited by waste packaging procedures. Waste packaging procedures shall ensure that all pyrophoric radioactive materials are present only in small residual amounts (less than 1 weight percent) in payload containers.

CORROSIVES: Corrosives are prohibited in the payload container. Acids and bases that are potentially corrosive shall be neutralized and rendered noncorrosive prior to being a part of the waste. The physical form of the waste and the waste generating procedures ensure that the waste is in a nonreactive form.

CHEMICAL COMPATIBILITY: A chemical compatibility study has been performed on this content code, and all waste is chemically compatible for materials in greater than trace (>1% by weight) quantities.

ADDITIONAL CRITERIA: Each drum is fitted with a minimum of one filter vent. The steel liner is fitted with a filter with a hydrogen diffusivity of 3.7E-06 mole/second/mole fraction.

MAXIMUM ALLOWABLE HYDROGEN GENERATION RATES - OPTION 1: The maximum allowable hydrogen generation rate limit is 3.5082E-08 moles per second per drum and 3.5082E-07 moles per second per CNS 10-160B cask.

MAXIMUM ALLOWABLE DECAY HEAT LIMIT - OPTION 2: There is no decay heat limit for this content code as no G values have been established. Waste cannot be transported under Option 2.

BATTELLE COLUMBUS LABORATORIES CONTENT CODE BC 312A
SOLIDIFIED ORGANIC WASTE

MATERIALS AND CHEMICALS >1%

DIATOMACEOUS EARTH (FLOOR DRY)
ACIDS AND ACID SOLUTIONS
MERCURY
HYDRAULIC OIL, GLYCOLS, OILS, AND ALCOHOLS
SAND
VERMICULITE
RADSORB
AQUA-SET/PETRO-SET

MATERIALS AND CHEMICALS <1%

METALS (including stainless steel, aluminum, iron, copper, lead, beryllium, and zirconium)

CONTENT CODE: BC 314A

CONTENT DESCRIPTION: Cemented Inorganic Process Solids

WASTE DESCRIPTION: This waste consists of slugs produced from dissolving fuel specimens in an acid solution that was then diluted several times and mixed with cement and water and allowed to solidify in foam cups.

GENERATING SOURCES: This waste is generated during repackaging of the waste materials generated from research and development activities conducted in Building JN-1.

WASTE FORM: The waste consists of slugs produced from dissolving fuel specimens in an acid solution which was then diluted several times and mixed with cement and waster and allowed to solidify in foam cups. The slugs will contain limited amounts of radionuclides from fuel because of this dilution. The waste matrix will also include Floor Dry added during repackaging to absorb any water from condensation or dewatering.

WASTE PACKAGING: The waste will be placed directly into a 55-gallon drum with no layers of confinement. The drum is lined with a steel liner. Ten drums will then be placed into the CNS 10-160B cask.

METHODS FOR DETERMINATION OF ISOTOPIC CHARACTERIZATION: The isotopic information required to demonstrate compliance with the limits on fissile content, decay heat, and curie content will be determined based on the waste generation source and configuration, which establishes the initial radionuclide compositions based on location and initial use. A combination of assay of samples and modeling of the isotopic generation process used in the establishment of a mixture that characterizes the waste in the content code and the majority of waste at the BCLDP. Using shipping package modeling, dose rate and weight measurements based on the mixture then allows the BCLDP to determine the isotopic inventory. As required, additional radioassay (e.g., confirming gamma spectroscopy) will be performed.

FREE LIQUIDS: Liquid waste is prohibited in the drums except for residual amounts in well-drained containers. The total volume of residual liquid in a payload container shall be less than 1volume percent of the payload container. Waste packaging procedures ensure that free liquids are less than 1 volume percent of the payload container. Absorbents such as diatomaceous earth will be added to any waste matrix that has the potential to dewater after packaging.

EXPLOSIVE/COMPRESSED GASES: Explosives and compressed gases in the payload containers are prohibited by waste packaging procedures. If present, pressurized cans shall be punctured and emptied prior to packaging.

PYROPHORICS: Nonradioactive pyrophorics in the payload containers are prohibited by waste packaging procedures. Waste packaging procedures shall ensure that all pyrophoric radioactive materials are present only in small residual amounts (less than 1 weight percent) in payload containers.

CORROSIVES: Corrosives are prohibited in the payload container. Acids and bases that are potentially corrosive shall be neutralized and rendered noncorrosive prior to being a part of the waste. The physical form of the waste and the waste generating procedures ensure that the waste is in a nonreactive form.

CHEMICAL COMPATIBILITY: A chemical compatibility study has been performed on this content code, and all waste is chemically compatible for materials in greater than trace (>1% by weight) quantities.

ADDITIONAL CRITERIA: Each drum is fitted with a minimum of one filter vent. The steel liner is fitted with a filter with a hydrogen diffusivity of 3.7E-06 mole/second/mole fraction.

MAXIMUM ALLOWABLE HYDROGEN GENERATION RATES - OPTION 1: The maximum allowable hydrogen generation rate limit is 3.5082E-08 moles per second per drum and 3.5082E-07 moles per second per CNS 10-160B cask.

MAXIMUM ALLOWABLE DECAY HEAT LIMIT - OPTION 2: The maximum allowable decay heat limit is 0.738 watts per drum and 7.38 watts per CNS 10-160B cask.

BATTELLE COLUMBUS LABORATORIES CONTENT CODE BC 314A
CEMENTED INORGANIC PROCESS SOLIDS

MATERIALS AND CHEMICALS >1%

DIATOMACEOUS EARTH (FLOOR DRY)
CEMENT SLUGS

MATERIALS AND CHEMICALS <1%

NITRIC ACID
WATER

CONTENT CODE: BC 321A

CONTENT DESCRIPTION: Solid Organic Waste

WASTE DESCRIPTION: This waste consists of a variety of combustible and noncombustible items.

GENERATING SOURCES: This waste is generated from activities supporting the decontamination and decommissioning of Building JN-1 under the Battelle Columbus Laboratories Decommissioning Project (BCLDP).

WASTE FORM: The waste may include combustible items such as cloth and paper products (e.g., from the cleanup of spills), rags, coveralls and booties, plastic, cardboard, rubber, wood, surgeons gloves, and Kimwipes. The waste may also include filter waste (e.g., dry box filters, HEPA filters, and filter cartridges); noncombustible Benelex and Plexiglas neutron shielding, blacktop, concrete, dirt, and sand; leaded gloves and aprons comprised of Hypalon rubber and lead oxide impregnated neoprene; and small amounts of metal waste. The waste may also include particulate and sludge-type organic process solids immobilized/solidified with Portland cement, vermiculite, Aqua-Set, or Petro-Set.

WASTE PACKAGING: The waste will be placed directly into a 55-gallon drum with no layers of confinement. The drum is lined with a steel liner. Ten drums will then be placed into the CNS 10-160B cask.

METHODS FOR DETERMINATION OF ISOTOPIC CHARACTERIZATION: The isotopic information required to demonstrate compliance with the limits on fissile content, decay heat, and curie content will be determined based on the waste generation source and configuration, which establishes the initial radionuclide compositions based on location and initial use. A combination of assay of samples and modeling of the isotopic generation process, results in the establishment of a mixture that characterizes the waste in the content code and the majority of waste at the BCLDP. Using shipping package modeling, dose rate and weight measurement based on the mixture then allows the BCLDP to determine the isotopic inventory. As required, additional radioassay (e.g., confirming gamma spectroscopy) will be performed.

FREE LIQUIDS: Liquid waste is prohibited in the drums except for residual amounts in well-drained containers. The total volume of residual liquid in a payload container shall be less than 1 volume percent of the payload container. Waste packaging procedures ensure that free liquids are less than 1 volume percent of the payload container. Absorbents such as Radsorb or diatomaceous earth will be added to any waste matrix that has the potential to dewater after packaging.

EXPLOSIVE/COMPRESSED GASES: Explosives and compressed gases in the payload containers are prohibited by waste packaging procedures. If present, pressurized cans shall be punctured and emptied prior to packaging.

PYROPHORICS: Nonradioactive pyrophorics in the payload containers are prohibited by waste packaging procedures. Waste packaging procedures shall ensure that all pyrophoric radioactive materials are present only in small residual amounts (less than 1 weight percent) in payload containers.

CORROSIVES: Corrosives are prohibited in the payload container. Acids and bases that are potentially corrosive shall be neutralized and rendered noncorrosive prior to being a part of the waste. The physical form of the waste and the waste generating procedures ensure that the waste is in a nonreactive form.

CHEMICAL COMPATIBILITY: A chemical compatibility study has been performed on this content code, and all waste is chemically compatible for materials in greater than trace (>1% by weight) quantities.

ADDITIONAL CRITERIA: Each drum is fitted with a minimum of one filter vent. The steel liner is fitted with a filter with a hydrogen diffusivity of 3.7E-06 mole/second/mole fraction.

MAXIMUM ALLOWABLE HYDROGEN GENERATION RATES - OPTION 1: The maximum allowable hydrogen generation rate limit is 4.093E-08 moles per second per drum and 4.093E-07 moles per second per CNS 10-160B cask.

MAXIMUM ALLOWABLE DECAY HEAT LIMIT - OPTION 2: The maximum allowable decay heat limit is 0.154 watts per drum and 1.54 watts per CNS 10-160B cask.

BATTELLE COLUMBUS LABORATORIES CONTENT CODE BC 321A
SOLID ORGANIC WASTE

MATERIALS AND CHEMICALS >1%

BLACKTOP (ASPHALT)
CELLULOSICS
RUBBER
DIATOMACEOUS EARTH (FLOOR DRY)
GLASS
IRON-BASED METAL/ALLOYS
PAPER
PLASTIC
RADSORB
CLOTH
CARDBOARD
WOOD
KIMWIPES
FILTERS
BENELEX
PLEXIGLAS
NEOPRENE
PORTLAND CEMENT
VERMICULITE
AQUA-SET/PETRO-SET
OTHER INORGANICS

MATERIALS AND CHEMICALS <1%

METALS (including aluminum, lead, zirconium, stainless steel, and carbon steel)
CONCRETE
SOIL

CONTENT CODE: BC 321B

CONTENT DESCRIPTION: Solid Organic Waste

WASTE DESCRIPTION: This waste consists of a variety of combustible and noncombustible items.

GENERATING SOURCES: This waste is generated during the change-out of resins in the Transfer/Storage Pool filtering system in Building JN-1 (Hot Cell Laboratory).

WASTE FORM: The waste may include filter waste (e.g., pool filters); nuclear grade resin, resin bags, paper, rubber gloves, Floor Dry bags, seals, hoses, valves, and clamps.

WASTE PACKAGING: The waste will be placed directly into a 55-gallon drum with no layers of confinement. The drum may be lined with a steel or polyethylene liner. Ten drums will then be placed into the CNS 10-160B cask.

METHODS FOR DETERMINATION OF ISOTOPIC CHARACTERIZATION: The isotopic information required to demonstrate compliance with the limits on fissile content, decay heat, and curie content will be determined based on the waste generation source and configuration, which establishes the initial radionuclide compositions based on location and initial use. A combination of assay of samples and modeling the isotopic generation process results in the establishment of a mixture that characterizes the waste in the content code. Using shipping package modeling, dose rate and weight measurements based on the mixture then allows the BCLDP to determine the isotopic inventory. As required, additional radioassay (e.g., confirming gamma spectrometry) will be performed.

FREE LIQUIDS: Liquid waste is prohibited in the drums except for residual amounts in well-drained containers. The total volume of residual liquid in a payload container shall be less than 1 volume percent of the payload container. Waste packaging procedures ensure that free liquids are less than 1 volume percent of the payload container. Absorbents such as Radsorb or diatomaceous earth will be added to any waste matrix that has the potential to dewater after packaging.

EXPLOSIVE/COMPRESSED GASES: Explosives and compressed gases in the payload containers are prohibited by waste packaging procedures. If present, pressurized cans shall be punctured and emptied prior to packaging.

PYROPHORICS: Nonradioactive pyrophorics in the payload containers are prohibited by waste packaging procedures. Waste packaging procedures shall ensure that all pyrophoric radioactive materials are present only in small residual amounts (less than 1 weight percent) in payload containers.

CORROSIVES: Corrosives are prohibited in the payload container. Acids and bases that are potentially corrosive shall be neutralized and rendered noncorrosive prior to being a part of the waste. The physical form of the waste and the waste generating procedures ensure that the waste is in a nonreactive form.

CHEMICAL COMPATIBILITY: A chemical compatibility study has been performed on this content code, and all waste is chemically compatible for materials in greater than trace (>1% by weight) quantities.

ADDITIONAL CRITERIA: Each drum is fitted with a minimum of one filter vent, and the steel or polyethylene liner, if present, is either punctured or fitted with a filter with a hydrogen diffusivity of 3.7E-06 mole/second/mole fraction.

MAXIMUM ALLOWABLE HYDROGEN GENERATION RATES - OPTION 1: The maximum allowable hydrogen generation rate limit is 4.093E-8 moles per second per drum and 4.093E-7 moles per second per CNS 10-160B cask.

MAXIMUM ALLOWABLE DECAY HEAT LIMIT - OPTION 2: The maximum allowable decay heat limit is 0.269 watts per drum and 2.69 watts per CNS 10-160B cask.

BATTELLE COLUMBUS LABORATORIES CONTENT CODE BC 321B
SOLID ORGANIC WASTE

MATERIALS AND CHEMICALS >1%

CELLULOSICS (≤12 weight %)
RUBBER
DIATOMACEOUS EARTH (FLOOR DRY)
ION EXCHANGE RESIN (≤80 weight %)
IRON-BASED METAL/ALLOYS
RADSORB
RESIN BAGS
FILTERS
OTHER INORGANICS

MATERIALS AND CHEMICALS <1%

METALS (including aluminum, lead, zirconium, stainless steel, and carbon steel)

CONTENT CODE: BC 322A

CONTENT DESCRIPTION: Solid Inorganic Waste

WASTE DESCRIPTION: This waste consists of a variety of glass and metal materials.

GENERATING SOURCES: This waste is generated during repackaging of the waste materials generated from research and development activities conducted in Building JN-1.

WASTE FORM: The waste consists primarily of glass and metal debris. Glass debris includes laboratory glassware, windows, leaded glass windows, and various glass apparatus. Metal items may include deteriorated berry cans, cable, wire, planchets, signs, valves, piping, strapping, tools, foils, sheeting, fixtures, equipment (e.g., pumps or motors that have had all oil or any other free liquids removed up to an allowance of 1%), hardware (e.g., nuts, bolts, brackets), specimen vials, fuel rod cladding, metallurgical mounts, and lead lined tubing. Metals of construction include stainless steel, aluminum, iron, copper, lead, beryllium, and zirconium.

WASTE PACKAGING: The waste will be placed directly into a 55-gallon drum with no layers of confinement. The drum is lined with a steel liner. Ten drums will then be placed into the CNS 10-160B cask.

METHODS FOR DETERMINATION OF ISOTOPIC CHARACTERIZATION: The isotopic information required to demonstrate compliance with the limits on fissile content, decay heat, and curie content will be determined based on the waste generation source and configuration, which establishes the initial radionuclide compositions based on location and initial use. A combination of assay of samples and modeling of the isotopic generation process used in the establishment of a mixture that characterizes the waste in the content code and the majority of waste at the BCLDP. Using shipping package modeling, dose rate and weight measurements based on the mixture then allows the BCLDP to determine the isotopic inventory. As required, additional radioassay (e.g., confirming gamma spectroscopy) will be performed.

FREE LIQUIDS: Liquid waste is prohibited in the drums except for residual amounts in well-drained containers. The total volume of residual liquid in a payload container shall be less than 1 volume percent of the payload container. Waste packaging procedures ensure that free liquids are less than 1 volume percent of the payload container. Absorbents such as diatomaceous earth (e.g., Floor Dry) will be added to any waste matrix that has the potential to dewater after packaging.

EXPLOSIVE/COMPRESSED GASES: Explosives and compressed gases in the payload containers are prohibited by waste packaging procedures. If present, pressurized cans shall be punctured and emptied prior to packaging.

PYROPHORICS: Nonradioactive pyrophorics in the payload containers are prohibited by waste packaging procedures. Waste packaging procedures shall ensure that all pyrophoric radioactive materials are present only in small residual amounts (less than 1 weight percent) in payload containers.

CORROSIVES: Corrosives are prohibited in the payload container. Acids and bases that are potentially corrosive shall be neutralized and rendered noncorrosive prior to being a part of the waste. The physical form of the waste and the waste generating procedures ensure that the waste is in a nonreactive form.

CHEMICAL COMPATIBILITY: A chemical compatibility study has been performed on this content code, and all waste is chemically compatible for materials in greater than trace (>1% by weight) quantities.

ADDITIONAL CRITERIA: Each drum is fitted with a minimum of one filter vent. The steel liner is fitted with a filter with a hydrogen diffusivity of 3.7E-06 mole/second/mole fraction.

MAXIMUM ALLOWABLE HYDROGEN GENERATION RATES - OPTION 1: The maximum allowable hydrogen generation rate limit is 3.5082E-8 moles per second per drum and 3.5082E-7 moles per second per CNS 10-160B cask.

MAXIMUM ALLOWABLE DECAY HEAT LIMIT - OPTION 2: The maximum allowable decay heat limit is 22.1 watts per drum and 221 watts per CNS 10-160B cask.

BATTELLE COLUMBUS LABORATORIES CONTENT CODE BC 322A
SOLID INORGANIC WASTE

MATERIALS AND CHEMICALS >1%

CEMENT
DIATOMACEOUS EARTH (FLOOR DRY)
GLASS
METALS (including stainless steel, aluminum, iron, copper, lead, beryllium, and zirconium)
IRON-BASED METAL/ALLOYS
OTHER INORGANICS

MATERIALS AND CHEMICALS <1%

CARBON TETRACHLORIDE
1,1,1-TRICHLOROETHANE
TRICHLOROETHYLENE

ATTACHMENT B

METHODOLOGY FOR DETERMINATION OF DECAY HEATS AND HYDROGEN GAS GENERATION RATES FOR REMOTE-HANDLED TRANSURANIC (RH-TRU) CONTENT CODES FOR BATTELLE COLUMBUS LABORATORIES

1.0 INTRODUCTION

All Battelle Columbus Laboratories Decommissioning Project (BCLDP) remote-handled transuranic (RH-TRU) waste to be transported in the CNS 10-160B cask shall comply with the 5% (by volume) limit on hydrogen concentration during transport. If a bounding G value and decay heat limit have been established for the approved content code, compliance with the decay heat limit shall be evaluated pursuant to this attachment for the individual containers under the content code. If compliance with the decay heat limit cannot be demonstrated, the hydrogen generation rate of the container shall be determined as outlined in this attachment and compared to the hydrogen gas generation rate limit specified for that approved content code. If the container meets the limit, it is eligible for shipment if all other transportation requirements are met. If the container does not meet the limit, it cannot be shipped and shall be segregated for repackaging or other mitigation measures.

2.0 DECAY HEAT METHODOLOGY

This section describes the general features of nondestructive assay methods used in conjunction with acceptable knowledge by the BCLDP.

The overall methodology for the determination of the radioassay properties is described in DD-98-04, Waste Characterization, Classification, and Shipping Support Technical Basis Document and is summarized in Figure 1. Under the methodology, the isotopic content for an identified TRU waste stream is determined by a combination of (1) representative waste stream sample analyses, (2) conservative application of the Oak Ridge Isotope Generation and Depletion (ORIGEN2) code values for isotopes expected to be present, but not represented by the sample analyses, and (3) assessment of cesium (Cs)-137 content of a payload container based on external radiation field measurements and calculation of TRU isotopic content using a ratio of radionuclides based on known Cs-137 content. The determinations are verified on an approved, periodic basis by sample submission to the BCLDP Radioanalytical Laboratory for gamma and/or alpha spectroscopy. The results of the implementation of the DD-98-04 methodology provide the data inputs to the computer program (spreadsheet) used by the TRU Waste Transportation Certification Official to determine the parameters of interest for each payload container (including fissile grams equivalent and decay heat).

Since the gamma rays emitted by radionuclides can be readily detected and quantified by common measurement techniques, i.e., as a dose rate, emitted gamma are used to model the quantity of isotopes present in a standard waste stream. Verifying samples are analyzed for both gamma and alpha emitters. Because isotopes other than gamma emitters are known to be present, laboratory measurements of the isotopic distribution are combined with a computer-generated distribution of account for required isotopes, e.g., per U.S. Department of Transportation requirements. The measured isotopic distribution is based on laboratory analysis (alpha and gamma spectroscopy) of air, smear and material samples taken from throughout the accessible work areas of Building JN-1. Using the measured distribution as a base, the remaining isotopes are scaled according to the distribution generated by the ORIGEN2 computer code, which models the production and decay of fission and activation products of commercial nuclear power plant fuel. Commercial fuel best characterizes the overwhelming majority of the isotopes present, by isotope and relative ratio.

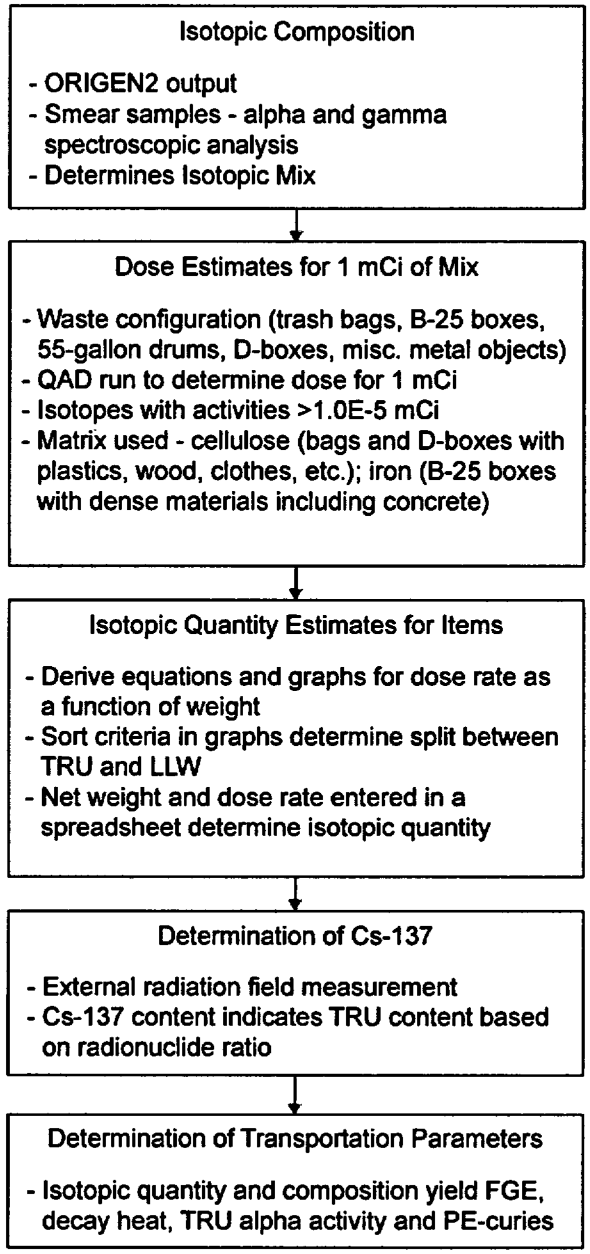

Figure 1

BCLDP Methodology for Determination of Radioassay Properties for RH-TRU Waste

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The "JN standard isotopic mixture" used in the model is representative of the composition of the majority of radioactive waste generate in all areas of the BCL facility, except the pool. Waste from the pool is separately characterized based on sample results. In addition to the pool waste, other waste streams may be encountered that do not match the JN standard isotopic mix. In such cases, the newly characterized waste will be characterized based on specific analytical results (alpha and gamma spectroscopy).

A given quantity of the JN standard isotopic mixture is used as the radioactive material source with the QAD computer shielding code to generate external gamma ray interaction rates for various package and form weights. These interaction rates are used to generate interaction rates-to-weight conversion equations for each package and waste form. The equations are incorporated into spreadsheets so that activity content, in millicuries, for individual packages and waste forms can be calculated. Spreadsheets are also used to calculate TRU interaction rate levels, and plots of these values as a function of net container weight are provided for each container type to simplify field sorting and packaging.

Required QAD inputs include source and package dimensions including any shielding materials, and quantities of individual isotopes that make up the source (i.e., JN standard isotopic mixture). QAD calculations are performed for a range of representative weights for each package. Specific package models include field sort waste bag, metal case, IP-2 147-cubic-feet box, standard D-box, 55-gallon drum, and standard B-25 box models. The final packaging configuration for BCL TRU waste is the 55-gallon drum.

Waste matrices are modeled as either cellulose or iron. The cellulose matrix represents the varied composition of the bag and D-box models, which are composed of plastics, wood, cloth, etc., and are similar to cellulose in their electronic configuration. The iron matrix is used for the B-25 box and 55-gallon drum models, which include a range of more dense materials, including concrete. The choice of waste matrices is conservative as the physical properties of cellulose and iron relative to radiological parameters are well characterized. It is important to note that the representative weights for 55-gallon drum, for example, correspond to a density much less than the density of iron (7.86 g/cm^3), on the close order of less than 1.0 g/cm^3.

As detailed in DD-98-04, estimated uncertainties associated with the container weight, Cs-137 activity based on measurement of decay gammas emanating from the container, and estimation of inventories of other radionuclides and total transuranics based on measured or predicted ratios to Cs-137 activity have been factored into the determinations of an upper bounding uncertainty for the methodology.

The application of the ORIGEN2 code in the proposed BCLDP TRU Waste Certification Program methodology for determining radioassay properties for RH-TRU wastes is conservative. In addition, associated measurement errors and assumptions have been conservatively estimated to determine a total error that is bounding for the methodology. The following subsection provides details on the application of the ORIGEN2 code for determining the radioassay properties.

Application of ORIGEN2 Code

The ORIGEN2 code (RSIC Code Package CCC-371) is used in the DD-98-04 methodology. Characterization of the JN standard isotopic distribution depended upon whether available data existed to permit estimation of the normalized activity ratio (to Cs-137 activity) for the isotopes of interest. Where sufficient data were available, a lognormal fit was used. Where insufficient data was available, the results of a series of ORIGEN2 software analyses were employed.

For Am-241, Cm-244, Co-60, Cs-134, Eu-154, Np-237, Pu-238, Pu-239/-240, Sb–125, Sr-90, U-234, and U-238, as many as 69 samples from the anticipated waste stream were available. A two-parameter (μ, σ) lognormal distribution was fitted to these data. The mean parameter (μ) estimated for each studied isotope represented its assumed normalized activity ratio (to Cs-137) in the standard isotopic distribution. The estimated spread parameter (σ) was used in considering the total uncertainty associated with the waste characterization.

For the isotopes of interest, the computer code ORIGEN2 was used to estimate their normalized activity ratio (to Cs-137). Specifically, values were assumed for enrichments, burn-up, and decay consistent with the processed used to generate the waste stream being classified. These values were then applied as parameters within the ORIGEN2 software, producing estimates of the activities of the various isotopes of interest.

Professional judgement consensus center, low, and high values were identified for each of these three parameters: enrichment, burn up, and decay. Taken together, these three values were meant to represent the central tendency and distribution (i.e., practical range) of the enrichment, burn up, and decay of potential waste streams. A deliberate choice was made to underestimate the decay time so as to make the resultant values conservative.

Twenty-seven iterations of ORIGEN2 software code would be required to consider each combination of these three values for each of three parameters (i.e., $3^3 = 27$). Additional code runs would be necessary, moreover, to provide some measure of the uncertainty associated with the application of ORIGEN2 in estimating the normalized activity ratios of the remaining isotopes of interest. Latin Hypercube sampling is an alternative approach, allowing for effective integration of computer code but with fewer runs. In order to apply these values in the context of a Latin Hypercube design, an assumed distribution is required for each parameter considered in the design. Because the low and high values for each parameter were not symmetric in relation to the center value, a skewed distribution was selected. The lognormal represents a skewed distribution that can be readily applied without additional mathematical complication. The log-transformed center value was assumed to represent the distribution's log mean, and its log standard deviation was derived by averaging the deviations of the log-transformed low and high values from the log mean. Specifically, the average deviation was assumed to represent 1.645 (i.e., the 0.95 quantile of a standard normal distribution) times the log-standard deviation. Doing so is equivalent to assuming the low and high values represent, on average, a range from the 5^{th} to the 95^{th} percentile of the distribution.

In using the ORIGEN2 software code to characterize the normalized activity ratios for the isotopes without available data, the Latin Hypercube employed in the DD-98-04 methodology assumed that values for enrichment, burn up, and decay and software together represent a 'black-box' estimation of normalized activity ratios. Using this approach, a series of replicate designs is applied. The mean result from each replicate design is considered when estimating the mean and variance in normalized activity.

Four replicates of a five-sample Latin Hypercube design were developed thereby providing 20 analysis runs. The distribution of each parameter was divided into five partitions of equal probability. Latin Hypercube sampling, then, insures that a random value of each partition is included in each of the five replicated designs, while minimizing the total number of required analysis runs.

The mean result across the 20 ORIGEN2 runs (or equivalently, the mean of the mean results determined for the four replicated designs) estimated for each studied isotope represents its assumed normalized activity ratio (to Cs-137) in the standard isotopic distribution. Though ORIGEN2 reports activities for all the isotopes of interest, only the results for those isotopes without sufficient available sample data are retained. The ORIGEN2 results and those based on available data are comparable. The estimated variance in mean result across the four replicate designs—a measure of the uncertainty associated with using the ORIGEN2 software to characterize isotope activity—is used in considering the total uncertainty associated with the waste characterization.

3.0 OBJECTIVES OF THE GAS GENERATION TESTING

The maximum allowable hydrogen gas generation rates for the RH-TRU content codes for the BCLDP are provided in Table 10-1 of this appendix. Compliance with the hydrogen gas generation rate shall be demonstrated by testing. Compliance with the requirements of this test plan should be documented in site-specific procedures under a documented quality assurance program.

4.0 GAS GENERATION TEST METHODOLOGY

The following sections describe how compliance with the limit on the hydrogen gas generation rate will be implemented for each authorized content code for BCLDP.

Demonstration of Compliance With Hydrogen Gas Generation Limit

During the course of the testing, the headspace gas of the selected waste containers will be sampled and analyzed to determine the concentrations of hydrogen and other gases that are produced by radiolysis or present when the waste was packaged. Sampling lines that communicate with the headspace of the waste containers will be installed. Samples of the headspace gas will be withdrawn periodically and analyzed using a gas chromatograph and/or a mass spectrometer. The analytical results will be used to calculate the hydrogen gas generation rate. The measured hydrogen gas generation rate will be compared to the appropriate hydrogen gas generation limits for each content code to evaluate compliance with transportation requirements.

Because all layers of confinement in all the containers have been vented since the time of generation and the containers have been in a vented condition for a period of time, steady-state hydrogen concentrations exist within all void volumes inside a container. At steady-state conditions, the rate of gas generation by radiolysis equals the release rate of gas across each layer of confinement. The measured hydrogen gas concentration in the headspace gas will be used to calculate the hydrogen gas generation rate.

The hydrogen gas generation rate of the waste container is calculated from the measured hydrogen gas concentration using the following relationship:

$$C_g = X_H \; x \; L_{CF}$$

where,

C_g = the hydrogen gas generation rate (mole/sec)
X_H = the measured concentration of hydrogen gas in the waste container headspace (mole fraction)
L_{CF} = diffusion characteristic of the waste container filter.

The rate shall be compared to the appropriate limit for the content code. The container shall be qualified for shipment only if the limit is met.

Another method may also be used when the final waste form is a solid monolith of evaporated/solidified inorganic wastes (BC 312A or 314A) that will be directly placed into drums. Process controls will be used to ensure homogeneity of the sludge. A small sample of the waste will be analyzed for its gas generation properties. The hydrogen gas generation rate for the drum can then be determined based on the mass of waste in the drum. For example, a sludge sample can be placed in a sealed test chamber of known volume. The concentration of hydrogen will be measured in the chamber after an elapsed period of time, and the following relationship will be used to calculate the hydrogen gas generation rate from the sample:

$$C_{g,sample} = \frac{X\,P\,V_{chamber}}{R\,T\,\Delta t}$$

where,

$C_{g,sample}$	=	hydrogen gas generation rate from sample (mol/sec)
X	=	mole fraction hydrogen in the test chamber
P	=	absolute ambient pressure (atm)
$V_{chamber}$	=	volume of the test chamber (L)
R	=	gas law constant (0.08206 atm L mol^{-1} K^{-1})
T	=	absolute ambient temperature (K)
)t	=	elapsed time (sec).

The hydrogen gas generation rate will be calculated on a drum basis using the following relationship:

$$C_{g,drum} = C_{g,sample}\frac{m_{drum}}{m_{sample}}$$

where,

$C_{g,drum}$	=	hydrogen gas generation rate in drum (mol/sec)
m_{drum}	=	mass of waste form in drum (g)
m_{sample}	=	mass of sample (g).

The actual drum hydrogen gas generation rate will be compared to the maximum allowable hydrogen generation rate limit in Table 10-1 of this appendix.

ATTACHMENT C

CHEMICAL COMPATIBILITY ANALYSIS OF BATTELLE COLUMBUS LABORATORIES CONTENT CODES

1.0 INTRODUCTION

This attachment describes the method used for demonstrating chemical compatibility within a given content code, and among all content codes at Battelle Columbus Laboratories (BCL) for the CNS 10-160B Cask payload. The chemical compatibility analyses cover normal conditions of transport as well as hypothetical accident conditions, as described in this attachment.

2.0 METHODOLOGY FOR CHEMICAL COMPATIBILITY ANALYSES

All information for the chemical compatibility study is maintained in databases. The chemicals reported for each content code by BCL are classified into reaction groups as defined by the U.S. Environmental Protection Agency (EPA) document "A Method for Determining the Compatibility of Hazardous Wastes" (EPA 600/2-80-076, 1980, Ref. 3.1).

A database program was developed to evaluate the chemical compatibility of the waste. With this program, potential incompatibilities can be assessed by content code or by other parameters. Potential incompatibilities are those defined in the EPA document, which identifies combinations of chemical groups that may react to create adverse conditions, listed in Section 2.1. All such combinations have been entered into a reference database to be used in assessing the chemical compatibility of a given list of chemicals. The logic of the program used in evaluating the chemical compatibility by content code is described in detail below.

As an initial step, the program indexes the databases according to content code. The program will then locate the first reaction group in the content code and pick the highest concentration of any chemical in that group. The group is then paired with every other group in the database to check for incompatibility. If a potential incompatibility is found, it is printed out along with the corresponding content codes. After finding all potential incompatibilities for that content code, the program moves on to another content code until all content codes have been processed.

To ensure accuracy, the databases were printed and checked against the original submittal forms from BCL. The list of potential chemical incompatibilities reported by the program was hand checked using the EPA document as a reference to assure proper functioning of the program. All potential chemical incompatibilities were then evaluated on a case-by-case basis to identify which, if any, of the reactions could occur, given the nature of the waste and the chemical constituents.

2.1 Chemical Compatibility Evaluation of RH-TRU Waste Content Codes

Content codes are classified as chemically "incompatible" if the <u>potential</u> exists for any of the following reactions:

- Corrosion
- Explosion
- Heat generation
- Gas generation (flammable gases) by chemical interactions
- Pressure build up (nonflammable gases) by chemical interactions
- Toxic by-product generation.

As stated earlier, a comprehensive list of all possible chemicals present in the waste for each content code has been produced. These chemical components are determined by examining the process technology, and by comprehensive analyses of the process knowledge. Under this system, all chemical inputs into the system are accounted for, even though all of these components may not be a part of the waste. For example, a chemical list might include both acids and bases, even though the two groups have been neutralized prior to placement in a payload container.

The chemical concentration levels are reported as either Trace (T) (<1% by weight), Minor (M) (1-10%), or Dominant (D) (>10%). Each chemical list is divided into groups based on chemical properties and structure (e.g., acids, caustics, metals, etc.). Table 1 lists all the groups and their number designations. As noted in the table, the groups and examples listed are only for illustrative purposes, and do not necessarily represent components of waste materials in a CNS 10-160B Cask payload. If incompatible groups are combined, the possibility exists for the reactions listed above. For example, a reaction between Group 1 (Acids, Mineral, Non-oxidizing) and Group 10 (Caustics) could result in heat generation. Incompatibilities have been defined within each content code, and where mixing of content codes could occur under hypothetical accident conditions.

Interactions between compounds present in trace quantities (<1 percent by weight) and compounds present in concentrations $\geq$ 1 percent by weight (i.e., D x T, M x T, or T x T) do not pose an incompatibility problem for the following reasons:

- Most trace chemicals reported by the sites are in concentrations well below the trace limit of 1 weight percent.

- The trace chemicals are usually dispersed in the waste, which further dilutes concentrations of these materials.

- Total trace chemicals within a payload container are limited to less than 5 weight percent.

- Trace chemicals that might be incompatible with minor and dominant materials/chemicals would have reacted during the waste treatment process prior to placement in payload containers.

TABLE 1

EPA LIST OF CHEMICAL GROUPS AND MATERIALS*

GROUP NUMBER	GROUP NAME	EXAMPLE
1	Acids, Mineral, Non-Oxidizing	Hydrochloric Acid
2	Acids, Mineral, Oxidizing	Nitric Acid (>1%)
3	Acids, Organic	Acetic Acid
4	Alcohols and Glycols	Methanol
5	Aldehydes	Formaldehyde
6	Amides	Acetamide
7	Amines, Aliphatic and Aromatic	Aniline
8	Azo Compounds, Diazo Compounds and Hydrazines	Hydrazine
9	Carbamates	Carbaryl
10	Caustics	Sodium Hydroxide
11	Cyanides	Potassium Cyanide
12	Dithiocarbamates	Maneb
13	Esters	Vinyl Acetate
14	Ethers	Tetrahydrofuran
15	Fluorides, Inorganic	Potassium Fluoride
16	Hydrocarbons, Aromatic	Toluene
17	Halogenated Organics	Carbon Tetrachloride
18	Isocyanates	Methyl Isocyanate
19	Ketones	Acetone
20	Mercaptans and other Organic Sulfides	Carbon Disulfide
21	Metals, Alkali and Alkaline Earth, Elemental	Metallic Sodium

*Modified from "A Method for Determining the Compatibility of Hazardous Wastes," Reference 3.1.

NOTE: The chemical groups and materials listed in this table are a comprehensive listing of chemical compounds that may be incompatible. This is not meant to infer that all the listed chemical compounds and materials are present in TRU waste.

TABLE 1
EPA LIST OF CHEMICAL GROUPS AND MATERIALS*
(CONTINUED)

GROUP NUMBER	GROUP NAME	EXAMPLE
22	Metals, other Elemental and Alloys in the form of Powders, Vapors or Sponges	Titanium
23	Metals, other Elemental and Alloys as Sheets, Rods, Moldings, Drops, etc.	Aluminum
24	Metals and Metal Compounds, Toxic	Beryllium
25	Nitrides	Sodium Nitride
26	Nitriles	Acetonitrile
27	Nitro Compounds	Dinitrobenzene
28	Hydrocarbons, Aliphatic, Unsaturated	Butadiene
29	Hydrocarbons, Aliphatic, Saturated	Cyclohexane
30	Peroxides and Hydroperoxides Organic	Acetyl Peroxide
31	Phenols, Cresols	Phenol
32	Organophosphates, Phosphothioates, and Phosphodithioates	Malathion
33	Sulfides, Inorganic	Zinc Sulfide
34	Epoxides	Epoxybutane

*Modified from "A Method for Determining the Compatibility of Hazardous Wastes," Reference 3.1.

NOTE: The chemical groups and materials listed in this table are a comprehensive listing of chemical compounds that may be incompatible. This is not meant to infer that all the listed chemical compounds and materials are present in TRU waste.

TABLE 1
EPA LIST OF CHEMICAL GROUPS AND MATERIALS*

(CONTINUED)

GROUP NUMBER	GROUP NAME	EXAMPLE
101	Combustible and Flammable Materials, Miscellaneous	Cellulose
102	Explosives	Ammonium Nitrate
103	Polymerizable Compounds	Acrylonitrile
104	Oxidizing Agents, Strong	Hydrogen Peroxide
105	Reducing Agents, Strong	Metallic Sodium
106	Water and Mixtures Containing Water	Water
107	Water Reactive Substances	Sulfuric Acid (>70%)

*Modified from "A Method for Determining the Compatibility of Hazardous Wastes," Reference 3.1.

NOTE: The chemical groups and materials listed in this table are a comprehensive listing of chemical compounds that may be incompatible. This is not meant to infer that all the listed chemical compounds and materials are present in TRU waste.

- The waste is either solidified and immobilized (solidified materials) or present in bulk form as a solid (solid materials) with very little residual liquids. Any interactions in the waste would be limited to solid or solidified materials, which are in a stable form. In almost all cases, any possible reactions take place before the waste is generated in its final form.

Potential incompatibilities between minor and dominant compounds have been analyzed on a case-by-case basis. As mentioned earlier, some chemicals listed as being present in the waste would have reacted prior to becoming part of the waste. For example, a site listing a caustic (Group 10) and an acid (Group 1) in their waste has only the neutralized product present in an immobilized form. Further reactions of this type do not occur once the waste is generated in its final form.

Waste content codes that are allowed for transportation in the CNS 10-160B Cask are described in the Remote-Handled Transuranic Content Codes and Chemical Lists for BCL (Attachment A). Chemical incompatibilities do not exist in content codes listed in Attachment A. This has been ensured by a knowledge of the processes generating the wastes and the chemical compatibility analysis. The following section details the chemical compatibility analysis for the different content codes in Attachment A. This analysis includes the chemical compatibility of each content code (i.e., within individual waste containers) and the compatibility of the CNS 10-160B Cask payload during hypothetical accident condition (i.e., between individual waste canisters with different content codes).

2.2 Chemical Compatibility of Each Content Code

Chemical compatibility has been analyzed for the different content codes based on the chemical constituents within each content code. Tables 2 through 6 list the chemicals present in each of the content codes in Attachment A.

Because the TRU waste from the sites is very well characterized, chemical reactions and incompatibilities are not anticipated in the final waste form. Waste is typically segregated prior to or upon placement in payload containers, and the segregated wastes are then assigned to different appropriate content codes. The similarity of wastes placed in a single container for a given content code reduces the potential for chemical reactions and incompatibilities. In addition, transportation requirements on the waste form prevent many potential incompatibilities. The restriction on the presence of free liquid requires liquid waste constituents to be solidified and/or present only in trace quantities. Prohibition of caustic substances requires all acids and bases to be neutralized prior to or in conjunction with solidification processes, further precluding potential reactivity of waste constituents. Furthermore, prior to transportation, the wastes have typically been emplaced in the payload containers for a sufficient period of time so that any potential reactions would have already taken place.

Despite the fact that chemical reactions and incompatibilities are not expected, the use of the EPA methodology allows for a complete analysis of all potential incompatibilities. For each content code, potential incompatible combinations were identified, and each of these was evaluated on a case-by-case basis. It was determined that the required processing, prior to placing the waste in the waste containers, and the final form of the waste, obviated the potential incompatibility in each case. Therefore, it was concluded that the chemicals/materials in each content code are chemically compatible. The detailed evaluation of each content code and resolution of the potential incompatibilities is described below.

Attachment A lists five content codes from BCL: BC 312A, BC 314A, BC 321A, BC 321B, and BC 322A. The chemicals present in these content codes are listed in Tables 2 through 6. A detailed chemical compatibility evaluation for each content code is presented below.

CONTENT CODE: BC 312A - SOLIDIFIED ORGANIC WASTE

Brief Description - This waste content code describes solidified organic and inorganic wastes, including acids, acid solutions, elemental mercury, hydraulic oil, waste water, sludge (sand and mixed fission products), glycols, oils, and alcohols solidified with Floor Dry. Small items such as tools may be included in the waste.

Chemical Compatibility Analyses - Eighteen potential chemical incompatibilities, listed in Table 7, were found in this content code. The first sixteen potential chemical incompatibilities involve the presence of either inorganic or organic acids with other waste constituents. Because all corrosives are prohibited in the waste, all acids will be neutralized prior to being placed in the waste. The restriction on free liquids also precludes any potential chemical incompatibilities involving acids, as all acids or acid solutions are solidified with Floor Dry. Furthermore, five of these first sixteen potential incompatibilities involve trace constituents, which are not a chemical compatibility concern, as previously stated. The remaining two potential incompatibilities involve water and mixtures containing water (Group 106), and the restriction on free liquids precludes these incompatibilities from being an issue in this waste form. Therefore, there are no incompatibilities for the transportation of this waste.

CONTENT CODE: BC 314A - CEMENTED INORGANIC PROCESS SOLIDS

Brief Description - The waste described by this content code includes slugs produced from dissolving fuel specimens in an acid solution that was then diluted several times and mixed with cement and allowed to solidify in foam cups. The slugs contain limited amounts of radionuclides from fuel because of the dilution. The waste matrix also includes Floor Dry added during packaging to absorb any water from condensation or dewatering.

Chemical Compatibility Analyses - Only one potential incompatibility, listed in Table 7, was identified for this content code. The combination of oxidizing mineral acids (Group 2) and water or mixtures containing water (Group 106) has the potential for generating heat. The restriction placed on free liquids, however, would preclude such a reaction from occurring. The acids would also be neutralized prior to placement in the payload container. Furthermore, both constituents are present only in trace concentrations, and therefore are not a significant concern. There are no incompatibilities for the transportation of this waste.

CONTENT CODE: BC 321A - SOLID ORGANIC WASTE

Brief Description - The waste in this content code may include combustible items such as cloth and paper products (e.g., from the cleanup of spills), rags, coveralls and booties, plastic, cardboard, rubber, wood, surgeon's gloves, and Kimwipes. The waste may also include filter waste (e.g., dry box filters, HEPA filters, and filter cartridges); noncombustible Benelex and Plexiglas neutron shielding, blacktop, concrete, dirt, and sand; leaded gloves and aprons comprised of Hypalon rubber and lead oxide impregnated neoprene; small amounts of metal waste; particulate and sludge-type organic process solids immobilized/solidified with Portland cement, vermiculite, Aquaset, or Petroset.

Chemical Compatibility Analyses - No potential chemical incompatibilities were identified for this content code.

CONTENT CODE: BC 321B - SOLID ORGANIC WASTE

Brief Description - The waste in this content code may include filter waste (e.g., pool filters), nuclear grade resin, resin bags, paper, Floor Dry bags, seals, hoses, valves, and clamps.

Chemical Compatibility Analyses - No potential chemical incompatibilities were identified for this content code.

CONTENT CODE: BC 322A - SOLID INORGANIC WASTE

Brief Description - The waste described by this content code consists primarily of glass and metal debris. Glass debris includes laboratory glassware, windows, leaded glass windows, and various glass apparatus. Metal items may include deteriorated berry cans, cable, wire, planchets, signs, valves, piping, strapping, tools, foils, sheeting, fixtures, equipment (e.g., pumps or motors that have had all oil or other free liquids removed to $<1\%$), hardware (e.g., nuts, bolts, brackets), specimen vials, fuel rod cladding, metallurgical mounts, and lead lined tubing. Metals of construction include stainless steel, aluminum, iron, copper, lead, beryllium, and zirconium.

Chemical Compatibility Analyses - Two potential chemical incompatibilities, listed on Table 7, were identified for this code. Both potential incompatibilities involve the reaction of halogenated organic liquids (Group 17) with metals in various forms (Groups 22 and 23). In both cases, the potential reaction will not take place because the halogenated organics will be solidified to meet the restriction on free liquids in the payload container. Furthermore, the halogenated organics are found only in trace concentrations, and are therefore, not a significant chemical reaction concern. Therefore, there are no incompatibilities for the transportation of this waste.

2.3 Chemical Compatibility During Hypothetical Accident Conditions

The hypothetical accident condition for chemical compatibility is defined as a situation where all the individual waste containers within the CNS 10-160B Cask are breached during an accident. The waste from individual waste containers is assumed to intimately mix, but there is no breaching of the CNS 10-160B Cask inner vessel containment boundary. The following analysis of chemical compatibility is extended across all BCL content codes.

As with the chemical compatibility analysis within each content code, chemical reactions and incompatibilities are not anticipated between content codes or waste forms. Restrictions on the presence of free liquid requires liquid waste constituents to be solidified and/or present only in trace quantities. Prohibition of caustic substances requires all acids and bases to be neutralized prior to or in conjunction with solidification processes, further precluding potential reactivity of waste constituents.

The database management program was used to evaluate the potential chemical incompatibility conditions that may occur during an accident. The analysis assumed that mixing of any one content code could occur with any other content code during the accident.

Twenty-five potential incompatibilities, listed on Table 8, were identified for BCL under the hypothetical accident conditions of mixing all site content codes. These exclude the potential incompatibilities that can be present within a content code, since these were covered in Section 2.2. Each of the potential incompatibilities was evaluated on a case-by-case basis. It was determined that the required processing, prior to placing the waste in the waste containers, and the final form of the waste, obviated the potential incompatibility in each case. Therefore, it was concluded that the chemicals/materials across the BCL content codes are chemically compatible for the transportation of waste from BCL. The detailed evaluation and resolution of the potential incompatibilities is described in subsequent text.

The first 21 potential incompatibilities involve either inorganic acids (Groups 1 and 2) or organic acids (Group 3). As all corrosives have been neutralized prior to placement in the payload container and all liquids are either solidified or meet the restriction on free liquids, these reactions cannot occur. Potential incompatibilities 22 and 23 involve the presence of halogenated organics (Group 17) which must be solidified or meet the restriction on free liquids. Furthermore, the halogenated organics are present only in trace quantities, and therefore would not be a reactivity concern even if present due to the low concentration. Potential incompatibilities 24 and 25, similarly, involve the presence of water or mixtures containing water, which would be solidified to meet transportation requirements, and would therefore not be available in a chemically reactive form. Therefore, none of the 25 potential incompatibilities is a concern for the transportation of BCL waste under hypothetical accident conditions.

This is the comprehensive chemical compatibility analysis for the waste content codes listed in Attachment A. This analysis demonstrates that only compatible content codes will be transported in the CNS 10-160B Cask.

3.0 REFERENCES

3.1 Hatayama, H. K., Chen, J.J., de Vera, E.R., Stephens, R.D., Storm, D.L., "A Method for Determining the Compatibility of Hazardous Wastes," EPA-600/2-80-076, EPA, Cincinnati, Ohio, 1980.

TABLE 2

BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES

CONTENT CODE BC 312A

SOLIDIFIED ORGANIC WASTE

GROUP 1:	ACIDS, MINERAL, NON-OXIDIZING (Constituents reacted prior to loading in payload containers.)	D
GROUP 2:	ACIDS, MINERAL, OXIDIZING (Constituents reacted prior to loading in payload containers.)	D
GROUP 3:	ACIDS, ORGANIC (Constituents reacted prior to loading in payload containers.)	D
GROUP 4:	ALCOHOLS AND GLYCOLS	D
GROUP 22:	METALS, OTHER ELEMENTAL AND ALLOYS, IN THE FORM OF POWDERS, VAPORS, OR SPONGES	
	ALUMINUM	T
	ZIRCONIUM	T
GROUP 23:	METALS, OTHER ELEMENTAL AND ALLOYS, AS SHEETS, RODS, MOLDINGS, DROPS, ETC.	
	ALUMINUM	T
	COPPER	T
	IRON	T
	LEAD	T
	STAINLESS STEEL	T
	ZIRCONIUM	T
GROUP 24:	METALS AND METAL COMPOUNDS, TOXIC	
	BERYLLIUM	T
	COPPER	T
	LEAD	T
	MERCURY	D
	ZIRCONIUM	T

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 2
(CONTINUED)

**BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES**

CONTENT CODE BC 312A

SOLIDIFIED ORGANIC WASTE
(CONTINUED)

GROUP 101:	COMBUSTIBLE AND FLAMMABLE MATERIALS, MISCELLANEOUS	
	HYDRAULIC OIL	D
	OIL	D
GROUP 106:	WATER AND MIXTURES CONTAINING WATER	
	ACID SOLUTIONS	D
OTHER INORGANIC		
	SAND	D
OTHER SOLIDIFICATION MATERIAL/ABSORBENTS		
	DIATOMACEOUS EARTH (Floor Dry)	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 3

**BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES**

CONTENT CODE BC 314A

CEMENTED INORGANIC PROCESS SOLIDS

GROUP 2:	ACIDS, MINERAL, OXIDIZING (Constituents reacted prior to loading in payload containers.)	
	NITRIC ACID	T
GROUP 106:	WATER AND MIXTURES CONTAINING WATER	
	WATER	T
OTHER INORGANIC		
	CEMENT SLUGS	D
OTHER SOLIDIFICATION MATERIAL/ABSORBENTS		
	DIATOMACEOUS EARTH (Floor Dry)	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 4

**BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES**

CONTENT CODE BC 321A

SOLID ORGANIC WASTE

GROUP 22: METALS, OTHER ELEMENTAL AND ALLOYS IN THE FORM OF POWDERS, VAPORS, OR SPONGES

ALUMINUM	T
ZIRCONIUM	T

GROUP 23: METALS, OTHER ELEMENTAL AND ALLOYS AS SHEETS, RODS, MOLDINGS, DROPS, ETC.

ALUMINUM	T
CARBON STEEL	T
IRON-BASED METAL/ALLOYS	D
LEAD	T
STAINLESS STEEL	T
ZIRCONIUM	T

GROUP 24: METALS AND METAL COMPOUNDS, TOXIC

LEAD	T
ZIRCONIUM	T

GROUP 101: COMBUSTIBLE AND FLAMMABLE MATERIALS, MISCELLANEOUS

BENELEX	D
BLACKTOP (ASPHALT)	D
CARDBOARD	D
CELLULOSICS	D
CLOTH	D
FILTERS	D
KIMWIPES	D
NEOPRENE	D
PAPER	D
PLASTIC	D
PLEXIGLAS	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 4
(CONTINUED)

BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES

CONTENT CODE BC 321A

SOLID ORGANIC WASTE
(CONTINUED)

GROUP 101: COMBUSTIBLE AND FLAMMABLE MATERIALS, MISCELLANEOUS (CONTINUED)

RUBBER	D
WOOD	D

OTHER INORGANIC

CONCRETE	T
FILTERS	D
GLASS	D
SOIL	T

OTHER ORGANIC

FILTERS	D
NEOPRENE	D
SOIL	T

OTHER SOLIDIFICATION MATERIAL/ABSORBENTS

AQUASET	D
DIATOMACEOUS EARTH (Floor Dry)	D
PETROSET	D
PORTLAND CEMENT	D
RADSORB	D
VERMICULITE	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 5

**BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES**

CONTENT CODE BC 321B

SOLID ORGANIC WASTE

GROUP 22:	METALS, OTHER ELEMENTAL AND ALLOYS IN THE FORM OF POWDERS, VAPORS, OR SPONGES	
	ALUMINUM	T
	ZIRCONIUM	T
GROUP 23:	METALS, OTHER ELEMENTAL AND ALLOYS AS SHEETS, RODS, MOLDINGS, DROPS, ETC.	
	ALUMINUM	T
	CARBON STEEL	T
	IRON-BASED METAL/ALLOYS	D
	LEAD	T
	STAINLESS STEEL	T
	ZIRCONIUM	T
GROUP 24:	METALS AND METAL COMPOUNDS, TOXIC	
	LEAD	T
	ZIRCONIUM	T
GROUP 101:	COMBUSTIBLE AND FLAMMABLE MATERIALS, MISCELLANEOUS	
	CELLULOSICS	D
	FILTERS	D
	ION EXCHANGE RESIN	D
	PAPER	D
	PLASTIC	D
	RESIN BAGS	M
	RUBBER	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 5
(CONTINUED)

BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES

CONTENT CODE BC 321B

SOLID ORGANIC WASTE
(CONTINUED)

OTHER INORGANIC	
FILTERS	D
OTHER ORGANIC	
FILTERS	D
OTHER SOLIDIFICATION MATERIAL/ABSORBENTS	
DIATOMACEOUS EARTH (Floor Dry)	D
RADSORB	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 6

**BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES**

CONTENT CODE BC 322A

SOLID INORGANIC WASTE

GROUP 17:	HALOGENATED ORGANICS	
	CARBON TETRACHLORIDE	T
	1,1,1-TRICHLOROETHANE	T
	TRICHLOROETHYLENE	T
GROUP 22:	METALS, OTHER ELEMENTAL AND ALLOYS, IN THE FORM OF POWDERS, VAPORS, OR SPONGES	
	ALUMINUM	D
	ZIRCONIUM	D
GROUP 23:	METALS, OTHER ELEMENTAL AND ALLOYS, AS SHEETS, RODS, MOLDINGS, DROPS, ETC.	
	ALUMINUM	D
	COPPER	D
	IRON	D
	IRON-BASED METAL/ALLOYS	D
	LEAD	D
	STAINLESS STEEL	D
	ZIRCONIUM	D
GROUP 24:	METALS AND METAL COMPOUNDS, TOXIC	
	BERYLLIUM	D
	COPPER	D
	LEAD	D
	ZIRCONIUM	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 6
(CONTINUED)

**BATTELLE COLUMBUS LABORATORIES
LIST OF CHEMICALS AND MATERIALS
IN RH-TRU WASTE CONTENT CODES**

CONTENT CODE BC 322A

SOLID INORGANIC WASTE
(CONTINUED)

OTHER INORGANICS	
CEMENT	D
GLASS	D
OTHER SOLIDIFICATION MATERIAL/ABSORBENTS	
DIATOMACEOUS EARTH (Floor Dry)	D

D = Dominant Component (>10% by wt.)
M = Minor Component (1 - 10% by wt.)
T = Trace Component (<1% by wt.)
T1 = Trace Component (<0.1% by wt.)
T2 = Trace Component (low ppm range)
T3 = Trace Component (<1 ppm range)

TABLE 7

SUMMARY OF POTENTIAL INCOMPATIBILITIES FOR BCL WASTE CONTENT CODES

Content Code	Potential Chemical Compatibility Reaction	Concentration of Reactants*	Reaction Code #
BC 312A	Acids, Mineral, Non-Oxidizing x Alcohols and Glycols (1 x 4)	D x D	H
	Acids, Mineral, Non-Oxidizing x Metals, Other Elemental and Alloys as Powders, Vapors, or Sponges (1 x 22)	D x T	GF H F
	Acids, Mineral, Non-Oxidizing x Metals, Other Elemental and Alloys as Sheets, Rods, Drops, Moldings, etc. (1 x 23)	D x T	GF H F
	Acids, Mineral, Non-Oxidizing x Metals and Metal Compounds, Toxic (1 x 24)	D x D	S
	Acids, Mineral, Non-Oxidizing x Combustible and Flammable Materials, Miscellaneous (1 x 101)	D x D	H G
	Acids, Mineral, Non-Oxidizing x Water and Mixtures Containing Water (1 x 106)	D x D	H
	Acids, Mineral, Oxidizing x Acids, Organic (2 x 3)	D x D	G H
	Acids, Mineral, Oxidizing x Alcohols and Glycols (2 x 4)	D x D	H F
	Acids, Mineral, Oxidizing x Metals, Other Elemental and Alloys as Powders, Vapors, or Sponges (2 x 22)	D x T	GF H F
	Acids, Mineral, Oxidizing x Metals, Other Elemental and Alloys as Sheets, Rods, Drops, Moldings, etc. (2 x 23)	D x T	GF H F
	Acids, Mineral, Oxidizing x Metals and Metal Compounds, Toxic (2 x 24)	D x D	S
	Acids, Mineral, Oxidizing x Combustible and Flammable Materials, Miscellaneous (2 x 101)	D x D	H F GT

TABLE 7
(CONTINUED)

SUMMARY OF POTENTIAL INCOMPATIBILITIES FOR BCL WASTE CONTENT CODES

Content Code	Potential Chemical Compatibility Reaction	Concentration of Reactants*	Reaction Code #
BC 312A (Continued)	Acids, Mineral, Oxidizing x Water and Mixtures Containing Water (2 x 106)	D x D	H
	Acids, Organic x Alcohols and Glycols (3 x 4)	D x D	H P
	Acids, Organic x Metals, Other Elemental and Alloys as Powders, Vapors, or Sponges (3 x 22)	D x T	GF
	Acids, Organic x Metals and Metal Compounds, Toxic (3 x 24)	D x D	S
	Metals, Other Elemental and Alloys as Powders, Vapors, or Sponges x Water and Mixtures Containing Water (22 x 106)	T x D	GF H
	Metal Compounds, Toxic x Water and Mixtures Containing Water (24 x 106)	D x D	S
BC 314A	Acids, Mineral, Oxidizing x Water and Mixtures Containing Water (2 x 106)	T x T	H
BC 321A	No Potential Chemical Reactions Identified		
BC 321B	No Potential Chemical Reactions Identified		
BC 322A	Halogenated Organics x Metals, Other Elemental and Alloys as Powders, Vapors, or Sponges (17 x 22)	T x D	H E
	Halogenated Organics x Metals, Other Elemental and Alloys as Sheets, Rods, Drops, Moldings, etc. (17 x 23)	T x D	H F

* Concentration of Reactants: T = Trace (<1% by wt.), T1 = Trace (<0.1%), T2 = Trace (low ppm range), T3 = Trace (<1 ppm range), M = Minor (1-10%), and D = Dominant (>10%).

Reaction Code: H = heat generation, S = solubilization of toxic substances, F = fire, GF = flammable gas generation, G = non-flammable gas generation, P = violent polymerization, GT = toxic gas generation, E = explosion.

TABLE 8

SUMMARY OF POTENTIAL INCOMPATIBLE CONDITIONS FOR THE HYPOTHETICAL ACCIDENT FOR BCL WASTE CONTENT CODES

Case History No.	Content Codes	Potential Chemical Compatibility Reaction	Concentration of Reactants*	Reaction Code #
1	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 322A	Alcohols and Glycols (Group 4)	T	H
2	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 322A	Halogenated Organics (Group 17)	T	H GT
3	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 322A	Ketones (Group 19)	T	H
4	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 321A BC 321B BC 322A	Metals, Other Elemental and Alloys as Powders, Vapors, or Sponges (Group 22)	T T D	GF H F
5	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 321A BC 321B BC 322A	Metals, Other Elemental and Alloys as Sheets, Rods, Drops, Moldings, etc. (Group 23)	D T D	GF H F
6	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 321A BC 321B BC 322A	Metals and Metal Compounds, Toxic (Group 24)	T T D	S
7	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 321A BC 321B	Combustible and Flammable Materials, Miscellaneous (Group 101)	D D	H G

TABLE 8
(CONTINUED)

SUMMARY OF POTENTIAL INCOMPATIBLE CONDITIONS FOR THE HYPOTHETICAL ACCIDENT FOR BCL WASTE CONTENT CODES

Case History No.	Content Codes	Potential Chemical Compatibility Reaction	Concentration of Reactants*	Reaction Code #
8	BC 312A	Acids, Mineral, Non-Oxidizing (Group 1)	D	
	BC 314A	Water and Mixtures Containing Water (Group 106)	T	H
9	BC 314A	Acids, Mineral, Oxidizing (Group 2)	T	
	BC 312A	Acids, Organic (Group 3)	D	G H
10	BC 312A BC 314A	Acids, Mineral, Oxidizing (Group 2)	D T	
	BC 312A BC 322A	Alcohols and Glycols (Group 4)	D T	H F
11	BC 312A BC 314A	Acids, Mineral, Oxidizing (Group 2)	D T	
	BC 322A	Hydrocarbons, Aromatic (Group 16)	T	H F
12	BC 312A BC 314A	Acids, Mineral, Oxidizing (Group 2)	D T	
	BC 322A	Halogenated Organics (Group 17)	T	H F GT
13	BC 312A BC 314A	Acids, Mineral, Oxidizing (Group 2)	D T	
	BC 322A	Ketones (Group 19)	T	H F
14	BC 312A BC 314A	Acids, Mineral, Oxidizing (Group 2)	D T	
	BC 312A BC 321A BC 321B BC 322A	Metals, Other Elemental and Alloys as Powders, Vapors, or Sponges (Group 22)	T T T D	GF H F

TABLE 8
(CONTINUED)

SUMMARY OF POTENTIAL INCOMPATIBLE CONDITIONS FOR THE HYPOTHETICAL ACCIDENT FOR BCL WASTE CONTENT CODES

Case History No.	Content Codes	Potential Chemical Compatibility Reaction	Concentration of Reactants*	Reaction Code #
15	BC 312A	Acids, Mineral, Oxidizing (Group 2)	D	
	BC 314A		T	
	BC 312A	Metals, Other Elemental and Alloys as	T	GF H F
	BC 321A	Sheets, Rods, Drops, Moldings, etc.	D	
	BC 321B	(Group 23)	D	
	BC 322A		D	
16	BC 312A	Acids, Mineral, Oxidizing (Group 2)	D	
	BC 314A		T	
	BC 312A	Metals and Metal Compounds, Toxic	D	S
	BC 321A	(Group 24)	T	
	BC 321B		T	
	BC 322A		D	
17	BC 312A	Acids, Mineral, Oxidizing (Group 2)	D	
	BC 314A		T	
	BC 312A	Combustible and Flammable Materials,	D	H F GT
	BC 321A	Miscellaneous (Group 101)	D	
	BC 321B		D	
18	BC 312A	Acids, Mineral, Oxidizing (Group 2)	D	
	BC 314A		T	
	BC 312A	Water and Mixtures Containing Water	D	H
	BC 314A	(Group 106)	T	
19	BC 312A	Acids, Organic (Group 3)	D	
	BC 322A	Alcohols and Glycols (Group 4)	T	H P
20	BC 312A	Acids, Organic (Group 3)	D	
	BC 321A	Metals, Other Elemental and Alloys as	T	GF
	BC 321B	Powders, Vapors, or Sponges (Group 22)	T	
	BC 322A		D	

TABLE 8
(CONTINUED)

SUMMARY OF POTENTIAL INCOMPATIBLE CONDITIONS FOR THE HYPOTHETICAL ACCIDENT FOR BCL WASTE CONTENT CODES

Case History No.	Content Codes	Potential Chemical Compatibility Reaction	Concentration of Reactants*	Reaction Code #
21	BC 312A	Acids, Organic (Group 3)	D	
	BC 321A	Metals and Metal Compounds, Toxic	T	S
	BC 321B	(Group 24)	T	
	BC 322A		D	
22	BC 322A	Halogenated Organics (Group 17)	T	
	BC 312A	Metals, Other Elemental and Alloys as	T	H E
	BC 321A	Powders, Vapors, or Sponges (Group 22)	T	
	BC 321B		T	
23	BC 322A	Halogenated Organics (Group 17)	T	
	BC 312A	Metals, Other Elemental and Alloys as	T	H F
	BC 321A	Sheets, Rods, Drops, Moldings, etc.	D	
	BC 321B	(Group 23)	D	
24	BC 312A	Metals, Other Elemental and Alloys as	T	
	BC 321A	Powders, Vapors, or Sponges (Group 22)	T	
	BC 321B		T	
	BC 322A		D	
	BC 312A	Water and Mixtures Containing Water	D	GF H
	BC 314A	(Group 106)	T	
25	BC 312A	Metal Compounds, Toxic (Group 24)	D	
	BC 321A		T	
	BC 321B		T	
	BC 322A		D	
	BC 312A	Water and Mixtures Containing Water	D	S
	BC 314A	(Group 106)	T	

* Concentration of Reactants: T = Trace (<1% by wt.), T1 = Trace (<0.1%), T2 = Trace (low ppm range), T3 = Trace (<1 ppm range), M = Minor (1-10%), and D = Dominant (>10%).

Reaction Code: H = heat generation, S = solubilization of toxic substances, F = fire, GF = flammable gas generation, G = non-flammable gas generation, P = violent polymerization, E = explosion, GT = toxic gas generation.

Attachment D

Shipping Period for TRU Waste in the 10-160B Cask

1.0 INTRODUCTION

This Attachment presents the basis for the shipping period for Battelle RH-TRU wastes from the time of cask closure until cask opening. This shipping period is used in the analysis of the gas generation in the 10-160B cask.

Two different shipping plans are expected for the Battelle wastes. In Plan A, wastes will be shipped in the 10-160B cask from the Battelle West Jefferson, OH site to the DOE Hanford site for interim storage. When the WIPP site is ready to receive RH-TRU waste, the stored waste will be shipped from Hanford to WIPP. In Plan B, RH-TRU wastes will be shipped directly to the WIPP from Battelle with no interim storage. While the shipments are in transit, under either plan, a satellite tracking system will be operational to monitor progress and provide direct communication between the driver and the transport dispatcher.

2.0 EXPECTED SHIPPING PERIOD

The expected shipping period is the amount of time from the sealing of the cask at the loading facility until the opening of the cask at the unloading facility. It consists of : the time from cask sealing to the release of the transport unit from the loading facility, the expected transit time, and the time from arrival at the unloading facility until the cask is opened. For assessing the expected shipping period, it will be assumed that there are no delays.

2.1 Loading

The loading process from cask sealing to unit release includes health physics surveys, installing the upper impact limiter, and vehicle inspections. The time from cask sealing until the unit is released for travel has been accomplished in less than four (4) hours. To be conservative, a one-day (24 hour) duration will be assumed.

2.2 Transit

The longest route for either Plan A or Plan B is from Battelle to Hanford, 2275 miles. All Battelle RH-TRU shipments will be made with two drivers. Using two drivers, on an appropriate rotational schedule, the truck can travel for twenty-four (24) hours per day for up to seven days. Assuming an average speed of 45 mph, which includes time for vehicle inspections, fueling, meals, and driver relief, the duration of the trip is expected to be 51 hours. Again, to be conservative, the transit duration will be assumed to be three days (72 hours).

2.3 Unloading

The unloading process includes receipt survey and security checks, positioning of the trailer in the RH unloading area, removal of the cask from the trailer to a transfer cart, positioning of the cask in the cask unloading room, and removal of the lid. This process has been accomplished in less than eight (8) hours. Again, to be conservative, the unloading duration will be assumed to be one day (24 hours).

2.4 Total

The total expected shipping period, with no delays, is less than 65 hours. For the purpose of this analysis, a conservative period of 5 days (120 hours) will be assumed.

3.0 SHIPPING DELAYS

The maximum shipping time will be assumed to be the sum of the expected shipping time and the time for delays which could extend the shipping time. These delays are: loading delays; transit delays due to weather or road closures, shipping vehicle accidents, mechanical delays, or driver illness; and unloading delays. Each of these delays are assessed below.

3.1 Loading Delays

There are a number of situations that could extend the time between cask sealing and truck release. These include: loading preceding a holiday weekend, problems with a leak test, and handling equipment failure. Both the leak test problem and the handling equipment failure should be resolvable by replacing or obtaining temporary equipment. Each of these situations is unlikely to cause more than a two day delay. The holiday weekend could cause a delay of three days, i.e., from Friday afternoon until Tuesday. It is very unlikely that more than two of the three loading delays could occur on the same shipment, so a total of five days seems a reasonably conservative assessment for a loading delay.

3.2 Transit Delays

Transit delays due to weather, e.g., a road closed due to snow, are unlikely to cause a delay of more than five days. A road closure due to a vehicle accident or a roadway or bridge failure would result in re-routing which could add up to two days to the transit time. A transit time delay due to weather or road closure will be assumed to be five days.

Transit delays due to an accident with the truck could cause a lengthy delay. Response time for notification and to take immediate corrective action is assumed to be one day. (The use of the on-board satellite communication system will facilitate an early response.) Accident mitigation may require transferring the cask to a different trailer using cranes and other heavy equipment. Mitigation is assumed to take five days for a total accident delay of six days.

Mechanical problems with the truck or trailer could also cause multi-day delays. Significant failures may require a replacement tractor or trailer. An appropriate response to a mechanical failure is assumed to take four days.

Driver illness could also cause transit delays. If a driver it too ill to continue, a replacement driver will be brought in. A two day delay is assessed for bringing in a replacement driver.

3.3 Unloading Delay

An unloading delay will occur if the truck arrives just before a holiday weekend. This could result in a four day delay. Additionally, a delay due to unloading equipment failure could occur. Repair of such equipment should not require more than four days. The unloading delay will be conservatively assumed to be five days. If an unanticipated situation occurs that would result in a much longer delay, the cask can be vented.

3.4 Total Delay

The total delay, i.e., the sum of the delay times for each of the delay types, is 27 days. This assumes that each type of delay occurs on the same shipment.

4.0 MAXIMUM SHIPPING PERIOD

The maximum shipping period, as the sum of the expected shipping period and the total delay, is 32 days. This period assumes that each of the possible shipping delays occurs on the same shipment, a very unlikely occurrence. Further, for additional conservatism, the assumed maximum will be nearly doubled to 60 days. Thus, a 60 day shipping period will be used in all analysis of gas generation in the sealed cask.

Attachment 3
Requested References

Technical Basis Document

Newly Generated Waste
Process Descriptions

October 27, 1999

TCP-98-03.1

UNCONTROLLED COPY

Prepared for:

Battelle Columbus Laboratories
Decommissioning Project (BCLDP)
Columbus, Ohio

Prepared by:

WASTREN, Inc.
1333 W. 120th Avenue, Suite 300
Westminster, Colorado 80234

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Prepared By:

K. Peters
WASTREN, Inc.

10/27/99
Date

This report, ***TCP-98-03.1, Newly Generated Waste Process Descriptions***, has been reviewed and approved by the following.

Approved By:

J. Eide
Manager, Waste Management Operations

10/27/99
Date

1.0 INTRODUCTION

Transuranic (TRU) waste generated by the Battelle Columbus Laboratories Decommissioning Project (BCLDP) will be characterized to address the objectives of the U.S. Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) TRU Waste Characterization Program. Program requirements for TRU waste characterization are provided in the WIPP *Transuranic Waste Characterization Quality Assurance Program Plan* (QAPP). Implementation of these requirements is described in the *Transuranic Waste Characterization Quality Assurance Project Plan for the BCLDP TRU Waste Certification Program* (QAPjP). The QAPP and QAPjP require that a consistent, defensible, and auditable record of characterization information is collected, reviewed, and managed by the BCLDP for TRU waste. This record of information is referred to as acceptable knowledge (AK).

This Technical Basis Document, in conjunction with the *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document* and the AK Process Descriptions, has been developed to document the AK information used to characterize BCLDP TRU waste streams for disposal at WIPP as required by the QAPjP. Appendix A of this document will be maintained to show the summarization and characterization of each TRU waste stream identified in the AK Process Descriptions. Before packaging of each waste stream, an AK Process Description shall be written to describe the Acceptable Knowledge Process. These Process descriptions shall be numbered as TCP-98-03.1.1, TCP-98-03.1.2 and so on. A summary of each new AK Process Description shall be added to Appendix A of this document.

2.0 HISTORY

TRU waste is being generated during the decontamination and decommissioning of the Building JN-1 Hot Cell Laboratory at the West Jefferson North campus. The BCLDP has developed a logical sequence of AK progressing from the general facility history and mission to waste-specific information. Several hundred sources of documentation were reviewed to prepare TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document*. The primary purpose of TCP-98-03 is to present the TRU waste management information required by the QAPjP, including:

- Maps of the West Jefferson North site and Building JN-1 Hot Cell Laboratory facility
- Summaries of the history and mission for the site and laboratory
- Descriptions of the historical laboratory operations and waste management practices
- Type and quantity of potentially TRU waste contained in JN-1

During the AK review for TCP-98-03, potential TRU waste materials were identified and grouped into categories based primarily on the matrix of the waste. The waste was then characterized as it existed in the building, knowing that many of the materials (hydraulic oil, liquids, etc.) would require further processing to be eligible for disposal at WIPP. In addition, non-waste materials (e.g., light bulbs, leaded glass, and lead shielding) were characterized in advance of remediation. This materials assessment and the supporting AK source documentation will be used as the basis for subsequent TRU waste stream segregation and characterization activities. TCP-98-03 also provides the basis for the following:

- Defense waste justification
- Spent nuclear fuel and high level waste discussions
- JN-1 Hot Cell Laboratory standard facility radionuclide distribution

AK Process Descriptions which describe waste generating processes and characterize TRU waste streams have been developed to document the TRU waste stream AK information required by the QAPjP. The AK Process Descriptions are prepared in accordance with TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation*, to create an auditable record and road map to the original sources of AK. In addition to describing the current TRU waste generating processes, the AK Process Descriptions define the inventory to be processed and the original waste generating activities. Each process waste stream is described in detail including:

- Description of the waste matrix
- Process flow diagrams
- Waste stream identification number
- Generation area
- Projected waste stream volume and generation dates
- Radionuclides
- U.S. Environmental Protection Agency (EPA) Hazardous Waste Numbers (HWNs)
- TRUCON Content Codes
- Summary Category and Matrix Parameter Category (MPC)
- Waste Material Parameters and weight ranges
- Resource Conservation and Recovery Act (RCRA) characterization rationale
- Toxic Substance Control Act (TSCA) waste determination

Appendix A of this document will be maintained to provide a current list of BCLDP TRU process waste streams, identify streams that are compatible for packaging in the same container, and document the confirmation analyses requirements. This information will be incorporated in the TRU Waste Stream Profile Forms and Waste Stream Summary Reports in accordance with TC-AP-01.1.1, *Completion of TRU Waste Stream Profile Form.*

3.0 References

TCP-98-02, *Transuranic Waste Characterization Quality Assurance Project Plan for the BCLDP TRU Waste Certification Program,* Battelle Columbus Laboratories Decommissioning Project.

TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document,* Battelle Columbus Laboratories Decommissioning Project.

TC-AP-01.1.1, *Completion of TRU Waste Stream Profile Form*, Battelle Columbus Laboratories Decommissioning Project.

TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation,* Battelle Columbus Laboratories Decommissioning Project.

DOE/WIPP. 1996. *Transuranic Waste Characterization Quality Assurance Program Plan,* Interim Change. CAO-94-1010.

TCP-98-03.1.1, *Repackaging of JN-1 Transfer/Storage Pool Filter Change-Out Waste*

TCP-98-03.1.2, *Repackaging of Building JN-1 Clean-UP Waste Containers*

APPENDIX A TRU Waste Streams and Analysis Requirements

Waste Stream ID	Waste Stream Description	TRUCON	Required Analysis[a]	EPA HWNs	MPC	Waste Material Parameters and Weight %		Reference
3211-01	Pool Water Filter Resin	BC121	1, 2, 3, 4	D004,D005,D006, D007,D008,D009, D011	S3211	Organic Matrix (resin) Other Inorganic Material Cellulosics	70-80% 20-30% <5%	TCP-98-03.1.1
5410-01	Pool Water Prefilter and Debris	BC121	1	D004,D005,D006, D007,D008,D009, D011	S5410	Other Inorganic Material Organic Matrix Plastic Cellulosics Rubber Iron-based metal/alloys	59-69% 6-16% 3-13% 2-12% 2-12% <10%	TCP-98-03.1.1
5410-02	TRI-NUC Filters	SQ121 (CH) BC121 (RH)	1	D004,D005,D006, D007,D008,D009, D011	S5410	Iron-based Metals/Alloys Aluminum-based Metals Plastics Other Inorganic Materials Organic Matrix	47% <1% 41% 6% 6%	TCP-98-03.1.2
5190-01	Inorganic Debris	SQ122 (CH) BC122 (RH)	1	None	S5190	Other Inorganic Material Iron Based Metal/Alloys Other Metals	0-71% 0-29% <1%	TCP-98-03.1.2
5190-02	Hazardous Inorganic Debris	SQ122 (CH) BC122 (RH)	1	D005,D007,D008, D009,D011,F001, F002,F003,F005	S5190	Other Inorganic Material Iron Based Metal/Alloys Other Metals	0-71% 0-29% <1%	TCP-98-03.1.2
5390-01	Organic Debris	SQ121 (CH) BC121 (RH)	1	None	S5390	Plastic Rubber Cellulosics Iron-based Metal/Alloys Aluminum-based Metal Other Inorganic Material	0-79% 0-5% 0-12% <1% 0-1% 0-2%	TCP-98-03.1.2
5390-02	Hazardous Organic Debris	SQ121 (CH) BC121 (RH)	1	D005,D007,D008 D009,D011,F001, F002,F003,F005	S5390	Plastic Cellulosics Rubber Other Inorganic Material Iron-Based Metal/Alloys Aluminum-Based Metal Soil Concrete	0-49% 42-95% 0-3% 0-2% <1% <1% <1% <1%	TCP-98-03.1.2
3150-01	Slugs	SQ122 (CH) BC122 (RH)	1,2,3,4	D004,D005,D006, D007,D008,D009, D011	S3150	Inorganic Matrix Plastics (residual styrofoam)	100% <1%	TCP-98-03.1.2

Notes: a. 1 = Headspace gas
2 = Solid sample total VOCs
3 = Solid sample total SVOCs
4 = Solid sample total Metals

Technical Basis Document

Acceptable Knowledge Process Description

Repackaging of JN-1 Transfer/Storage Pool Filter Change-Out Waste

March 10, 1999

TCP-98-03.1.1

UNCONTROLLED COPY

Prepared for:

Battelle Columbus Laboratories
Decommissioning Project (BCLDP)
Columbus, Ohio

Prepared by:

WASTREN, Inc.
1333 W. 120th Avenue, Suite 314
Westminster, Colorado 80234

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Prepared By:

K. Peters
Wastren, Inc.

8/3/99
Date

This report, ***TCP-98-03.1.1, Acceptable Knowledge Process Description - Repackaging of JN-1 Transfer/Storage Pool Filter Change-Out Waste***, has been reviewed and approved by the following.

Approved By:

J. Eide
Manager, Waste Management Operations

8/3/99
Date

LIST OF ACRONYMS & ABBREVIATIONS

AK	Acceptable Knowledge
BCLDP	Battelle Columbus Laboratories Decommissioning Project
EPA	Environmental Protection Agency
JN-1	West Jefferson North Hot Cell Laboratory (Building JN-1)
PCB	polychlorinated biphenyls
QAPjP	TRU Waste Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RH	Remote Handled
TRU	Transuranic
TSCA	Toxic Substances Control Act
WCP	Waste Certification Program
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

This Acceptable Knowledge (AK) Process Description describes the operation to be performed by the Battelle Columbus Laboratories Decommissioning Project Transuranic Waste Certification Program (BCLDP TRU WCP) to repackage 34 drums of resin waste. This waste was originally generated during the change-out of resins in the Transfer/Storage Pool filtering system in Building JN-1 (Hot Cell Laboratory). In addition to describing the historical change-out procedure, this report summarizes the repackaging methodology and describes the inputs to and outputs from this process.

The purpose of this report is to provide the AK information required by TCP-98-02, *Transuranic Waste Characterization Quality Assurance Project Plan (QAPjP) for the BCLDP TRU WCP*[(1)], to describe TRU waste generating processes and characterize TRU waste streams generated by these processes. This report was prepared in accordance with TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation*[(3)], to create an auditable record that serves as a road map to the sources of AK used to describe the processes and characterize each TRU waste stream.

2.0 HISTORY

In 1971 and 1972 the High Bay (also known as JN-1B) was constructed to house the High Energy Cell, Transfer/Storage Pool, and supporting areas. The High Energy Cell and pool were specifically designed to accommodate the receipt, storage, transfer, and examination of entire fuel assemblies which was not feasible before this time. Prior to the construction of the High Bay, shipments of radioactive materials were received at the loading dock and introduced directly into the cells.[(2)]

After shipping casks containing fuel assemblies were cleaned in the Washdown Room, a 50-ton crane was used to transfer the casks into the Transfer/Storage Pool. Once in the pool, the casks were opened and the fuel assemblies were moved into the High Energy Cell through a transfer canal in the west wall of the pool. The pool was also used to store radioactive materials for the Hot Cell Laboratory.[(2)] In some instances, materials were stored for extended periods of time. For instance, defense-related N-reactor pressure tubes were received and stored in the pool from 1981 to 1987.[P043,P044]

The Transfer/Storage Pool measures 20 by 20 feet and is 49 feet deep. The pool contained nearly 150,000 gallons of water replenished from a 1,500-gallon tank of deionized water. The pool water was filtered by an ion-exchange system in the Pump Room. The system consisted of 12 ion-exchange columns each containing CM-2 regenerated mixed bed ion exchange resin (two 5-pound bags) and two cellulose/glass fiber cartridge prefilters. Pool water passed through the prefilters to remove particulates then through the resin beds to remove minerals, salts, and other ions.[C015,C017,P002,P025]

When the radiation levels at contact on the ion-exchange tanks rose to approximately 200 mR/hr, the resins and prefilter were changed-out in accordance with procedure HL-OP-010, *Changing Resins and Filters in JN-1B Pump Room.* Figure 2-1 illustrates the process used to change-out the filter system resins.[P002,P042]

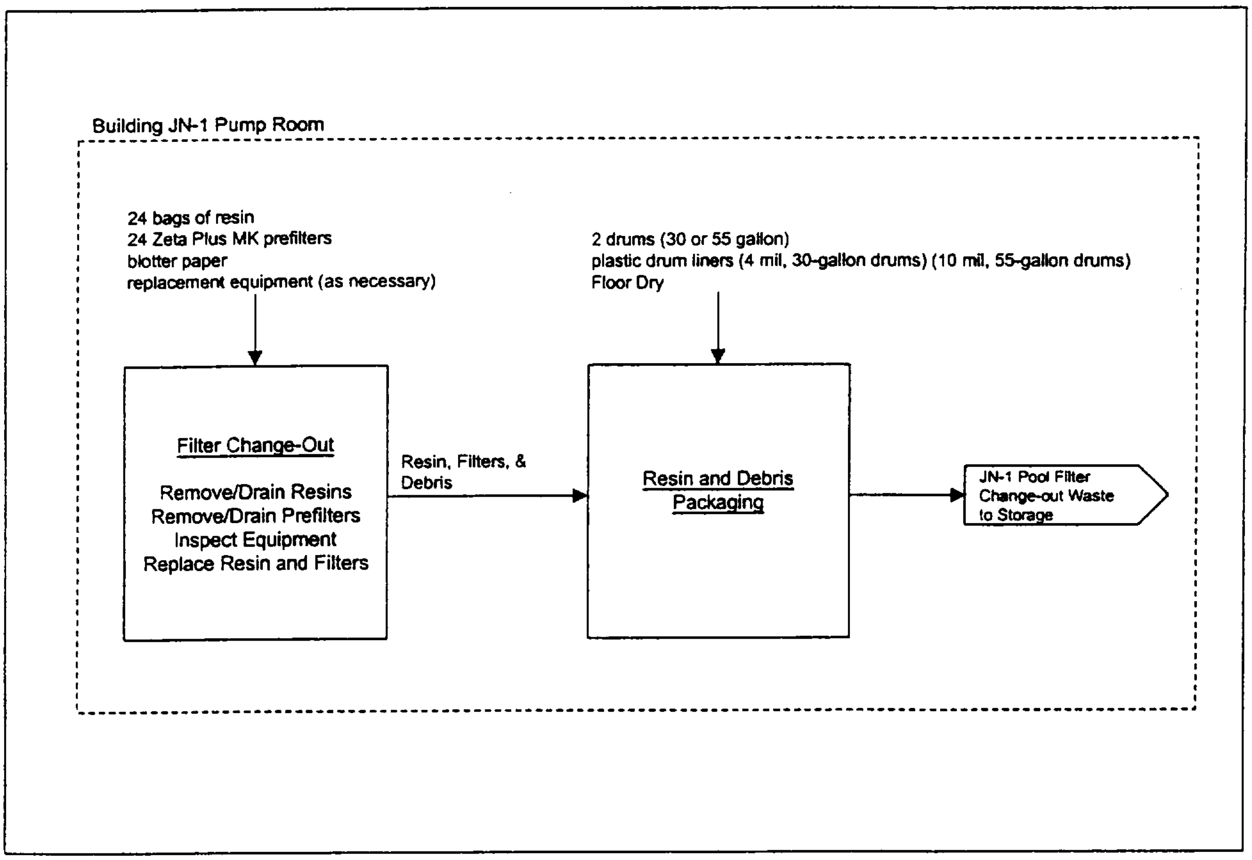

Figure 2-1. Change-Out of JN-1 Transfer/Storage Pool Filter Resins.

During the change-out operation, the resin bags (2) and composite (glass fiber/cellulose/melamine resin) prefilters (2) were removed from each of the ion-exchange canisters. The resin bags and filters were allowed to drain then placed in 30- or 55-gallon drums lined with polyethylene bags (4 mil and 10 mil, respectively). Approximately, 10 pounds of Floor Dry absorbent (diatomaceous earth) was placed in the bottom of the liner and on top of the resin waste. In addition to the resin and filters, the drums may contain other miscellaneous material used during the process including blotter paper used to cover the floor, rubber gloves, Floor Dry bags, and equipment parts (seals, hoses, valves, clamps, etc.) that were replaced as necessary. The current inventory consists of 34 containers stored in Waste Shed and Waste Storage Vault. Some of the drums have been over packed due to the corrosion of the original containers.[C015,C016,C018,P002,P042]

3.0 PROCESS DESCRIPTION

Repackaging of the resin change-out waste will be performed in the Mechanical Test Cell in Building JN-1. The containers will be transferred using drum dollies from the Waste Shed and the Waste Storage Vault into the Mechanical Test Cell through the Controlled Access Area. Figure 3-1 summarizes the process to be used to repackage the resin change-out waste.[C016]

Once the drums are in the Mechanical Test Cell, the containers will be opened and the contents will be transferred into 90-mil polyethylene rigid liners (no other confinement layers are to be used). The waste will be transferred to the liners either remotely using the manipulators in the cell or directly by personnel using tong, scoop, or vacuum techniques. The prefilters and other debris (including the original liners) will be segregated from the resins and placed in separate 90-mil (or thicker) rigid polyethylene liners. For the filters and debris waste, approximately 10 pounds of a 50:50 mixture of Floor-Dry and Radsorb will be added to the bottom of the liner to absorb any liquids that might be generated by dewatering or condensation. The waste will be inspected and packaged in accordance with TC-OP-01.4, *Segregation and Packaging of TRU Waste*, to verify AK and identify and segregate prohibited items.[(4),C016]

After the rigid liners are placed in 55-gallon drums, each drum is representatively sampled for the appropriate waste stream and surveyed to determine if the package is TRU in accordance with DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis*[(6)], and to validate the JN-1 Pool mix is the correct waste stream model to use. The containers determined to be low level, empty drums, and empty Floor Dry bags will be managed in accordance with BCLDP-90-1, *The BCLDP Low-Level Waste Certification Plan*[(5)]. TRU pool water prefilters and debris (Waste Stream 5410-01) and TRU pool water filter resin (Waste Stream 3211-01) will be certified for disposal at the Waste Isolation Pilot Plant (WIPP).

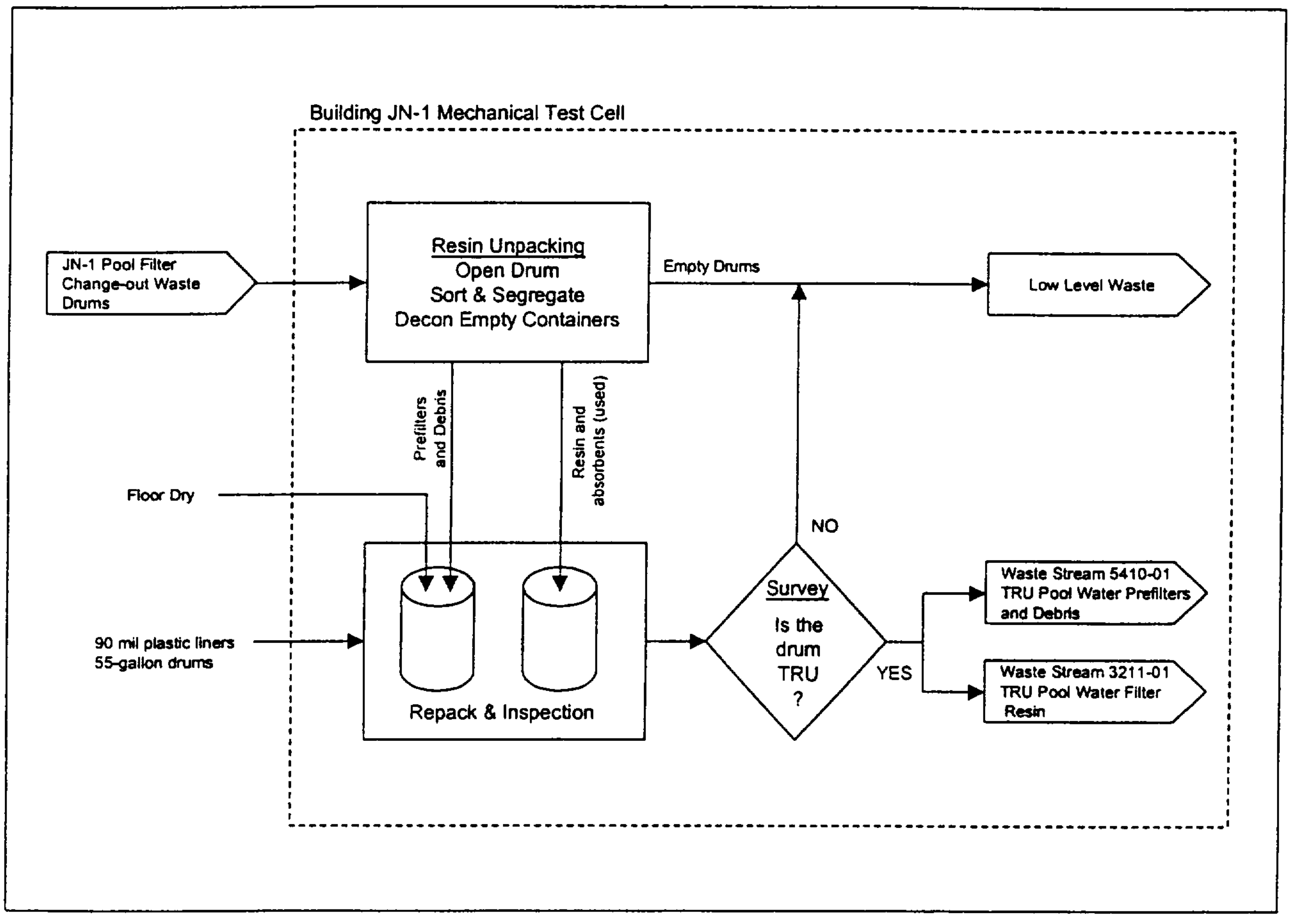

Figure 3-1. Repackaging of Resin Change-Out Waste.

4.0 Pool Water Filter Resin Waste Stream Summary

Waste Stream ID:	3211-01
Generation Building:	Building JN-1, Mechanical Test Cell[C016]
Waste Stream Volume (Projected):	1.0 m^3 [C018]
Generation Dates (Projected):	April 1999 – July 1999
EPA Hazardous Waste Numbers:	D004, D005, D006, D007, D008, D009, D011[(D006)]
Radionuclides:	JN-1 Pool Cleanup Isotopic Mix[(6)]
TRUCON Content Codes:	BC121 (RH-TRU)
Summary Category:	S3000[(7)]
Matrix Parameter Category:	S3211[(7)]

4.1 Waste Stream Description

The pool water filter resins were generated during repackaging of the waste materials generated from the change out of the system used to filter the water in the Transfer/Storage Pool. This stream includes nuclear grade resin, muslin (cotton) resin bags, and Floor Dry segregated during this process. Table 4-1 presents the matrix parameter category and waste material parameters for this waste stream.[C015,C016]

*Table 4-1. **Pool Water Filter Resin Waste Matrix.***[C018]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight % (Range)
3211-01, Pool Water Filter Resin	S3211, Organic Resin	Organic Matrix (resin) Other Inorganic Materials Cellulosics	70-80% 20-30% <5%

Waste Stream 3211, Pool Water Filters Resin: This waste consists of ion-exchange resin contained in bags which was used for deionizing the Transfer/Storage Pool water. The CM-2 Regenerated Mixed Bed Resin used was contained in muslin bags.[(2),P025] The waste matrix will also include Floor Dry (diatomaceous earth) used as an absorbent during the original packaging of this waste and 10 lbs. Of absorbent (50:50 Floor-Dry and Radsorb) added during repackaging to absorb any water from condensation or dewatering.[D003 P042]

4.2 Characterization Rationale

The resin wastes are characterized based on knowledge of the material (inputs) and knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

4.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23) or toxicity (40 CFR 261.24), however D004, D005, D006, D007, D008, D009, and D011 have been conservatively assigned due to these constituents being detected at low concentrations in the pool water[D005] and supporting analytical data.[D006]

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, any free liquid would be water and absorbents have been added to the resins to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable waste (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to the resins to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream do not meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. Based upon AK information a composite sample was taken from a resin drum. Both the Total and TCLP analytical results detected the presence of several RCRA regulated metals in small amounts[D006]. Based upon this date and the QAPP requirement, D004, D005, D006, D007, D008, D009 and D011 will be conservatively added to Waste Stream ID 3211-01.

4.2.2 Listed Hazardous Waste

The material in this waste stream is not, or was not mixed with, a waste listed in 40 CFR 261, Subpart D as a hazardous waste from non-specific sources (40 CFR 261.31), as a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). These resins did not come in contact with listed solvents. Therefore, this waste stream is not a listed hazardous waste.

4.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 3211-01, is not a TSCA regulated waste.

5.0 Pool Water Prefilter and Debris Waste Stream Summary

Waste Stream ID:	5410-01
Generation Building:	Building JN-1, Mechanical Test Cell[C016]
Waste Stream Volume (Projected):	0.8 m^3 [C018]
Generation Dates (Projected):	April 1999 – July 1999
EPA Hazardous Waste Numbers:	D004, D005, D006, D007, D008, D009, D011[(D006)]
Radionuclides:	JN-1 Pool Cleanup Isotopic Mix[(6)]
TRUCON Content Codes:	BC121 (RH-TRU)
Summary Category:	S5000[(7)]
Matrix Parameter Category:	S5410[(7)]

5.1 Waste Stream Description

The pool water filters and debris consists of the materials (except resins and Floor Dry) generated during repackaging of the waste materials generated from the change out of the resins in the system used to filter the water in the Transfer/Storage Pool. Table 5-1 presents the matrix parameter category and waste material parameters for this waste stream.[C015,C016,C017]

Table 5-1. ***Pool Water Prefilters and Debris.***[C018 D003]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight % (Range)
5410-01, Pool Water Prefilters and Debris	S5410, Composite Filter Debris	Other Inorganic Material	59-69%
		Organic Matrix	6-16%
		Plastic	3-13%
		Cellulosics	2-12%

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight % (Range)
		Rubber	2-12%
		Iron-based metal/alloys	<10%

Waste Stream 5410, Pool Water Prefilters and Debris: This waste consists of the cartridge prefilters and debris generated during the change-out of resin used for filtering the Transfer/Storage Pool water. The filter matrix is composed of glass and cellulose fibers combined with melamine resin. The end caps are polypropylene and the filters are placed in the canisters with rubber gaskets (butyl/nitrile).[C017] Other debris that may be present from the original packaging may include paper (blotter paper and Floor Dry bags), plastic liners, rubber gaskets, muslin resin bags, rubber gloves, and other miscellaneous plastic, cellulosic, and metal materials. The waste matrix will also include Floor Dry (diatomaceous earth) and RadSorb added during repackaging to absorb any water from condensation or dewatering.[C015,C016,P042]

5.2 Characterization Rationale

The prefilter and debris wastes are characterized based on knowledge of the material (inputs) and knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

5.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23) or toxicity (40 CFR 261.24), however D004, D005, D006, D007, D008, D009, and D011 have been conservatively assigned due to these constituents being detected at low concentrations in the pool water[D005] and supporting analytical data.[D006]

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, any free liquid would be water and absorbents have been added to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.300. This material is not an oxidizer as defined in 49 CFR 173.151. The materials in this waste stream are therefore not ignitable wastes (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. This waste contains absorbents that have been added to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream do not meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. Based upon AK information, a composite sample was taken from a filter drum. Both the Total and TCLP analytical results detected the presence of several RCRA regulated metals in small amounts.[(D006)] Based upon this data and the QAPP requirement, D004, D005, D006, D007, D008, D009, and D011 will be conservatively added to Waste Stream ID 5410-01.

5.2.2 Listed Hazardous Waste

The material in this waste stream is not, or was not mixed with, a waste listed in 40 CFR 261, Subpart D as a hazardous waste from non-specific sources (40 CFR 261.31), as a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). These resins did not come in contact with listed solvents. Therefore, this waste stream is not a listed hazardous waste.

5.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5410-01, is not a TSCA regulated waste.

6.0 References and AK Sources

1. TCP-98-02, *Transuranic Waste Characterization Quality Assurance Project Plan for the BCLDP TRU Waste Certification Program.*

2. TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document.*

3. TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation.*

4. TC-OP-01.4, *Segregation and Packaging of TRU Waste.*

5. BCLDP-90-1, *The BCLDP Low-Level Waste Certification Plan.*

6. DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis.*

7. DOE 1995. *DOE Waste Treatability Group Guidance.* DOE/LLW-217

TABLE 6-1. Acceptable Knowledge Source Documents

Ref No.	Title / Author	Summary	Date
C015	Interview Record of Max Berchtold, BCL, conducted by Kevin Peters. WASTREN, Inc.	Discussion of the process used to change-out the JN-1 Pool filter resins.	1999. February 19.
C016	Interview Record of Scott Kitts, BCL, conducted by Kevin Peters. WASTREN, Inc.	Discussion of the planned methodology to be used to repackage ion exchange resins and prefilters generated during the change-out of the JN-1 Pool filtering system resin beds in the JN-1 Pump Room.	1999. February 24.
C017	Interview Record of Pete Wilson, Cuno Industrial Filters, conducted by Kevin Peters. WASTREN, Inc.	Description of JN-1 Pool filtering system prefilters and estimated composition of the prefilters based on Cuno specifications and information from a Cuno Technical Service Representative.	1999. March 4.
C018	Letter to AK Record authored by Kevin Peters. WASTREN, Inc.	Estimates of Waste Material Parameter Weights for packaged JN-1 pool filter resins and debris and assigning Matrix Parameter Categories based on manufactures information MSDSs and interviews.	1999. March 5.
P002	Fuel Storage Pool, Pump Room and Washdown Room JN-1B. Decontamination and Decommissioning Operations. Louis B. Myers, Max B. Berchtold, and James L. Stickel.	This report describes general operations and configuration of the fuel storage pool, pump room, and washdown room in JN-1B. Operations include fuel storage (assemblies, strongbacks, rod bundles, rod holders and tools), deionization of pool water, and washing of casks. Attachments include 1996 update, miscellaneous drawings/photos, and health physics survey reports and data (including isotopics).	1995. January.
P025	Miscellaneous Materials Safety Data Sheets (MSDSs). Authored by Manufacturers.	Miscellaneous MSDS sheets collected from numerous sources collected during AK research at the West Jefferson site.	
P042	Decontamination and Decommissioning Operations Hot Laboratory Operating Procedure, Changing Resins and Filters in JN-1B Pump Room (HL-OP-010). Battelle Columbus Laboratories.	Procedure describing the method used to change out the resins in the JN-1 Pool Filtering System, including inputs, outputs, and packaging descriptions.	1993. June 4. Revision 1

Ref No.	Title / Author	Summary	Date
P043	Final Report on Research to Develop and Evaluate effects of Hydrogen on Irradiated Pressure Tube Toughness. Battelle Columbus Laboratories. L.M. Lowry and A.A. Lawrence.	This report and attachments documents research performed for Battelle Pacific Northwest Division on N-reactor pressure tubes. This research was defense related and documents the receipt, storage, and examination of these materials from 1981 to 1986. Additionally, the report documents that these materials were stored in the Transfer/Storage Pool supporting the defense waste determination for the pool resins and other related streams.	1986 August 15
P044	Final Report on Research to Develop and Evaluate effects of Hydrogen on Irradiated Pressure Tube Toughness. Battelle Columbus Laboratories. L.M. Lowry.	This report and attachments documents research performed Battelle Pacific Northwest Division on N-reactor pressure tubes. This research was defense related and documents the receipt, storage, and examination of these materials as late as 1987. Additionally, the report documents that these materials were stored in the Transfer/Storage Pool supporting the defense waste determination for the pool resins and other related streams.	1987 September 28
D003	Letter to AK Record authored by Kevin Peters, Wastren, Inc.	This report recalculates the material parameter weights for pool filter resin and debris, assuming a 50/50 mixture of Floor-Dry and Radsorb	1999 April 8
D006	Letter to AK Record authored by Kevin Peters, Wastren, Inc.	This letter was written to address the detection of RCRA metals in samples taken of the Transfer/Storage pool filters and resins. The data indicates the presence of several RCRA metals. Based upon this data, D004, D005, D006, D007, D008, D009, and D011 will be conservatively added to the filter and resin waste streams used to filter the pool water (3211-01, 5410-01, and 5410-02).	1999 June 29

Technical Basis Document

Acceptable Knowledge Process Description

Repackaging of Building JN-1 Clean-Up Waste Containers

September 1999

TCP-98-03.1.2

UNCONTROLLED COPY

Prepared for:

Battelle Columbus Laboratories
Decommissioning Project (BCLDP)
Columbus, Ohio

Prepared by:

WASTREN, Inc.
1333 W. 120th Avenue, Suite 300
Westminster, Colorado 80234

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APPROVAL PAGE

Prepared By:

K. Peters　　　　　　　　10/15/99
WASTREN, Inc.　　　　　　Date

This report, ***TCP-98-03.1.2, Acceptable Knowledge Process Description – Repackaging of Building JN-1 Clean-Up Waste Containers***, has been reviewed and approved by the following.

Approved By:

J. Eide　　　　　　　　　10/15/99
Manager, Waste Management Operations　　Date

1.0 INTRODUCTION

This Technical Basis Document describes waste packaging operations to be performed by the Battelle Columbus Laboratories Decommissioning Project (BCLDP) Transuranic Waste Certification Program (TRU WCP). Specifically, this document describes the process implemented to repackage drums, hoppers, and cans of materials generated during clean-up operations in the following areas of the Building JN-1 Hot Cell Laboratory:

- High Energy Cell (HEC)
- Low Level Cell (LLC)
- High Level Cell (HLC)
- Alpha-Gamma Cells
- Controlled Access Area (CAA)

This waste consists of materials either generated originally in these areas or moved into these areas during the historical operations described in TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document.*

This report provides an auditable record that serves as a road map to the sources of acceptable knowledge (AK) used to describe the process and characterize each TRU waste stream in accordance with TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation*[(3)]. The purpose of this document is to identify the historical origin of the waste materials and describe the newly-generated TRU waste process, and to characterize the TRU waste streams that will be generated by this process as required by TCP-98-02, *Transuranic Waste Characterization Quality Assurance Project Plan (QAPjP) for the BCLDP TRU WCP*[(1)]. The TRU waste stream characterization is based on review of the Building JN-1 waste inventories to be repackaged by this operation. Appendices A, B, C, and D describe these waste inventories.

2.0 HISTORY

This section provides a brief summary of the historical operations associated with the Building JN-1 waste to be repackaged by this process. TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document*, provides a more comprehensive description of operations in the Hot Cell Laboratory.

During historical clean-up operations of the Building JN-1 hot cells and supporting areas, debris waste has been placed into a variety of containers and placed into storage for future processing. The waste to be repackaged by this process consists of the following inventories generated during these clean-up campaigns:

- **59 Drums** of waste generated in the HEC and CAA during the Mid-1980s (Appendix A).[C021,U022]
- **24 Hoppers (casks)** of waste from the HEC, LLC, HLC, and Alpha-Gamma Cells. All but seven are loaded with waste cans (Appendix B).[C024,P008]
- **113 Berry Cans** from the HCL generated from December 1988 through February 1989 (Appendix C).[C024,P017]
- **165 Berry Cans** from the Alpha-Gamma Cells (except cells 5 and 6) generated from June to September 1999 (Appendix D).[C024]

2.1 High Energy Cell and Transfer/Storage Pool

In 1971 and 1972 the High Bay (also known as JN-1B) was constructed to house the HEC, Transfer/Storage Pool, and supporting areas. The HEC and pool were specifically designed to accommodate the receipt, storage, transfer, and examination of entire fuel assemblies, which was not feasible before this time. Prior to the construction of the High Bay, shipments of radioactive materials were received at the loading dock and introduced directly into the hot cells.[(2)]

After shipping casks containing fuel assemblies were received at the High Bay, the casks were cleaned in the Washdown Room. After cleaning, a 50-ton crane was used to transfer the casks into the Transfer/Storage Pool. Once in the pool, the casks were opened and the fuel assemblies were moved into the HEC through a transfer canal in the west wall of the pool. The pool was also used to store radioactive materials for the Hot Cell Laboratory.[(2)] In some instances, materials were stored for extended periods of time. For instance, defense-related N-reactor pressure tubes were received and stored in the pool from 1981 to 1987.[(8)]

Once in the HEC, several nondestructive examinations were performed on the assemblies, bundles, and rods. Fuel assemblies would be weighed, measured, temperature measured, photographed, and video taped. Holes were then cut into the nozzle/cap of the assembly and the rods (encased by the cladding) would be removed. Each rod would be photographed, weighed, measured, and tested. The nondestructive examination included eddy current, profilometry, horizontal and vertical bow, and gamma scan. Fission gases were collected and analyzed from a hole drilled in the cladding. These examinations accounted for approximately 90 percent of the work performed in the cell. Other activities included studies and characterization of Three Mile Island (TMI) resins used to decontaminate water, effects of Cobalt-60 on instrumentation, and fuel rod compaction. Fuel rods were cut into 4-foot lengths using a tubing cutter or an abrasive wheel (non-fuel containing materials only), placed in transfer casks, and transferred to the High Level Cell for destructive testing.[2]

The Transfer/Storage Pool measures 20 by 20 feet and is 49 feet deep. The pool contained nearly 150,000 gallons of water replenished from a 1,500-gallon tank of deionized water. The pool water was filtered by an ion-exchange system in the Pump Room. The system consisted of 12 ion-exchange columns, each containing CM-2 regenerated mixed bed ion exchange resin (two 5-pound bags) and two cellulose/glass fiber cartridge prefilters. Pool water passed through the prefilters to remove particulates, then through the resin beds to remove minerals, salts, and other ions.[2,8] The repackaging of the prefilters and resin are addressed in TCP-98-03.1.1, *Acceptable Knowledge Process Description, Repackaging of JN-1 Transfer/Storage Pool Filter Change-Out Waste*, and are not included in the inventory described by this document.

Starting in 1995, an effort was begun to drain and evaporate the water contained in the pool. In June of that same year, metal debris from the bottom of the pool was removed. Metal debris such as spent fuel pieces, wire, nuts, and bolts were removed from the bottom of the pool using magnet and gripper techniques. The bottom of the pool was then vacuumed using a Tri Nuclear Corporation UFV-100 underwater vacuum system. This process removed the silt settled on the pool bottom and cleaned the walls of the pool. The water in the pool was then polished using the ion-exchange system in the pump room to reduce the activity of the pool water.[D004,P045,P046,P047]

Transfer of pool water began in November 1995. The water was pumped through a Tri-Nuc filter and ion-exchange resin bed into three 10,000-gallon tanks. The tank water was then sampled, released, and evaporated into the atmosphere. The tanks and filtering systems used for this operation were leased from Diversified Systems, Inc. The filtering system was taken from the site at the completion of the transfer. The only materials remaining in the inventory are the used Tri-Nuc filters. (see Section 4.0).[D004]

2.2 Controlled Access Area

The primary purpose of the CAA was to support operations conducted in the HLC, LLC, Mechanical Test Cell (MTC), and Alpha-Gamma Cells. Equipment, specimens, and other materials were moved in and out of the cells through a number of ports and doors. A crane was used to move heavy equipment into the HLC through the main cell door. In addition to material transfer capabilities, the area was used to service manipulator arms, and for special projects, drum compaction, and equipment and specimen decontamination.[2]

A repair bench in the area was used to repair and service manipulators. The repair bench was accessible by four glove holes through a window for shielding. The manipulators fit through five other holes in the window and rested on a device that controlled their movement to accommodate repair. The contaminated portion of the arm was generally repaired inside the CAA. A portable 55-gallon drum compactor was operated in a plastic enclosure located next to the MTC door. The purpose of the plastic enclosure was to contain airborne contamination which was vented to the CAA HEPA filter bank.[2]

During operations, the CAA was in constant use and was exposed to contamination from the cells it supported. For this reason, the wastes packaged from this area could be contaminated with chemicals and radionuclides from any of the hot cells.[2]

2.3 High Level and Low Level Cells

The HLC and LLC were the original cells constructed in JN-1 in 1955. These cells consist of two main cells located above grade level with two subterranean cells (subcells) located directly below. The LLC and HLC are separated by a shielding wall, and were designed to provide shielding for 10,000 curies and 10 million curies of a 1-Mev gamma emitter, respectively. Entrance into each cell was gained through hydraulically operated steel doors in the CAA. Nondestructive examination, destructive testing, and material preparation were conducted in the cells. Operations performed included rod marking, sectioning, defueling, visual examination, and measurement. In addition, gamma scan, tensile, fission gas, rod void volume, fuel bulk density, autoradiography, and burst testing analyses were conducted.[2]

In 1988 and 1989, waste materials remaining in the HLC were compacted into metal cans and transferred to the LLC where they were gamma scanned (see Appendix C).

2.4 Alpha Gamma Cells

The Alpha-Gamma Cells consist of 10 interconnected cells located in the basement under the shipping and receiving dock at the JN-1 facility. The original nine cells (Cells 1-9) were constructed in 1964 to support metallography testing of fuel rod specimens. The room adjacent to Cell 1 was constructed as an evaporator room for low level radioactive liquids. Cell 10 was added in this area in the early 1970s.[2]

Cells 1, 2, 3, and 10 were dedicated to support metallography operations. In the LLC, 1-3/4 inch diameter specimens (Metmounts) of fuel rods were prepared and transported to Cell 3 (through Cell 4). Cell 3 is considered the most contaminated cell, and the two grinders the most contaminated equipment in the basement. The Metmounts were ground to the desired thickness in Cell 3; polished, washed (alcohol and water), and acid etched in Cell 2; and hardness tested and photographed using a Metallograph in Cell 1. In the early 1970s, the equipment in Cell 1 was abandoned and operations were transferred to Cell 10 where a new Metallograph was installed.(2)

Cells 5 and 6 were designed and constructed to prepare Californium-252 sources. Cells 5 and 6 were not used until the mid-1970s when the californium source program was initiated, and have not been used for any other projects. Wastes generated in Cells 5 and 6 will not be TRU and are not eligible for disposal at the Waste Isolation Pilot Plant (WIPP).(2)

Cell 7 was used primarily to prepare burnup fuel samples for disposal. Fuel samples from burnup analysis in the High Level Cell were transferred into Cell 7 through a port in the floor of the back dock. The cladding was removed from the fuel and returned to the HLC through the same port. The fuel was dissolved with nitric acid, diluted, mixed with cement, and allowed to solidify in foam cups (referred to as slugs).(2)

In Cell 8, unclad fuel samples were tested for thermal conductivity. The test instrument consisted of a two-foot diameter plate with a small electric furnace at the center. The sample was placed in the furnace and heated. The sample was exposed to a laser beam which was directed to a detector for analysis.

X-ray diffraction testing of Metmounts was performed in Cell 9. The samples were brought into the cell through pass-through ports from Cell 4 and the crystalline structure of the specimens were analyzed.(2)

3.0 PROCESS DESCRIPTION

Repackaging of the waste containers will be performed in the MTC, HEC, and LLC in Building JN-1. The containers will be transferred into these areas for unpacking, sorting, and packaging. Figure 3-1 summarizes the process used to repackage this waste.[C019,C023]

The MTC will be used primarily for unloading and segregating the inventory of drum generated during the clean-up of the HEC and CAA. In addition, the drum compactor in the MTC may be used to compact the waste during packaging. The HEC will be used primarily to unload and repack the waste stored in hoppers. A forklift and the overhead crane will be used to place the hoppers in the HEC for unloading. The LLC will be used to primarily to repackage the

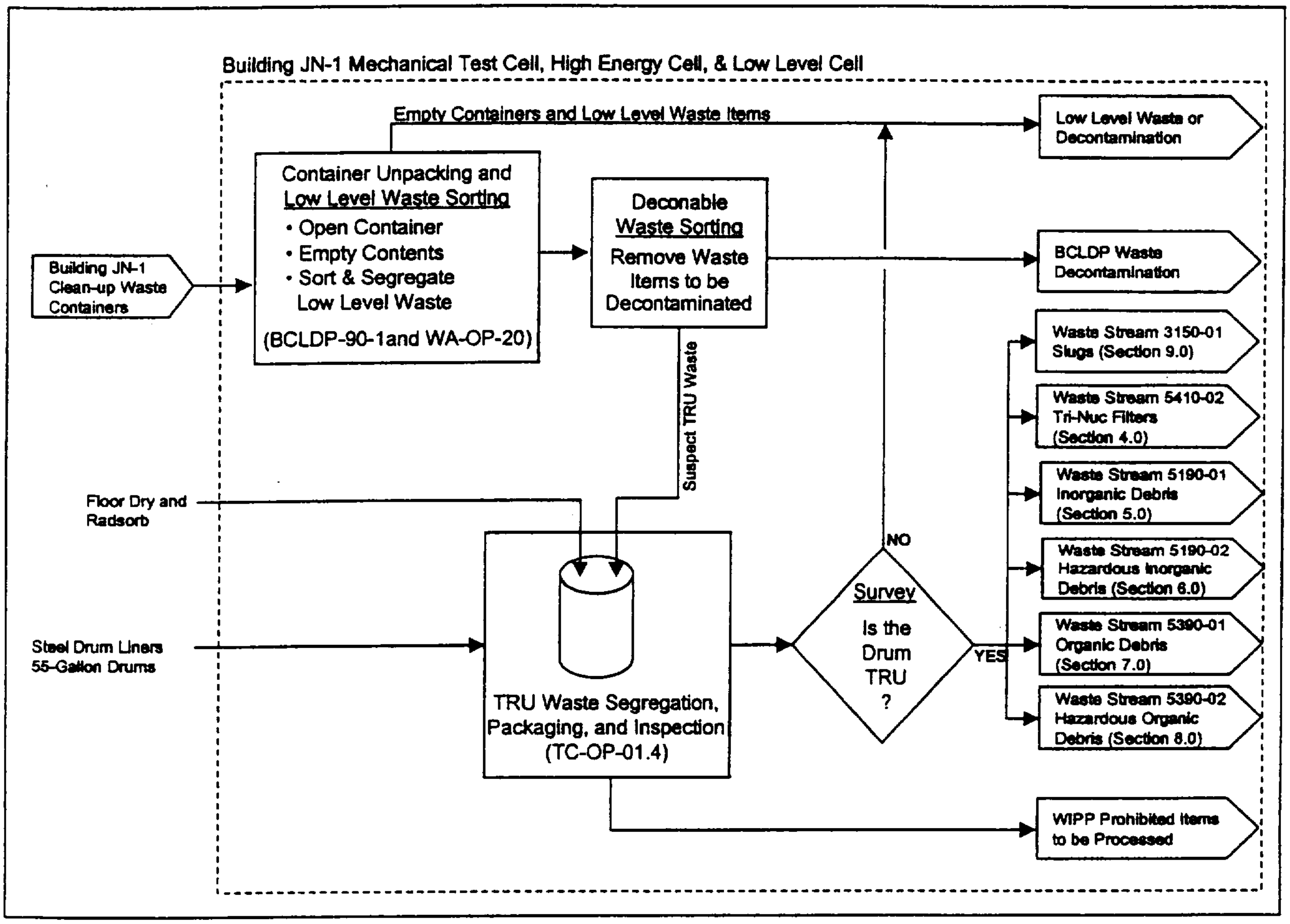

Figure 3-1. Repackaging of JN-1 Clean-Up Waste Containers

berry can inventories including the berry cans from the clean-up of the HLC and the cans of waste recently repackaged from the clean-up of the Alpha-Gamma Cells.[C023]

Once the containers have been opened, the contents will be transferred onto sorting tables. Low level waste materials will be segregated and managed in accordance with BCLDP-90-1, *The BCLDP Low-Level Waste Certification Plan*[(5)], and WA-OP-20, *Identification, Segregation, Separation and Documentation of Low Level Waste.*[(10)]

Waste meeting the acceptance criteria of TC-OP-01.1, *Acceptance Criteria for Sonatol Treatment*, will be segregated and staged for decontamination by Sonatol treatment or other decontamination process. Hazardous wastes not eligible for Sonatol treatment that can be decontaminated (i.e., light bulbs and lead metal) will be separated for additional processing. The remaining waste will be packaged into UN/1A2/X400/S/99 drums with .015 steel drum liners.

Each liner lid and drum shall be equipped with a Nucfil-013 drum filter installed per WA-OP-006, *Procurement and Inspections of Packagings for Hazardous Materials Shipments*. No other confinement layers shall be used in the packaging of these waste streams. During packaging the waste will be inspected in accordance with TC-OP-01.4, *Segregation and Packaging of TRU Waste,* to verify AK and identify prohibited items. Any discovered prohibited items (e.g., liquids, compressed gases, and pyrophoric materials) will be segregated and are not eligible for disposal at WIPP without further processing.[(4),(9),U023]

Based on a review of the inventory, six potential TRU waste streams have been identified; Tri-Nuc Filters (Section 4.0), Inorganic Debris (Section 5.0), Hazardous Inorganic Debris (Section 6.0), Organic Debris (Section 7.0), Hazardous Organic Debris (Section 8.0), and Slugs (Section 9.0). Volume reduction, including compaction, will be performed to minimize the number of containers generated by this process. Even though these waste materials should be dry, approximately 10 pounds of absorbent material will be added to the bottom of the liners as a precaution to absorb any liquid that may be generated from condensation or dewatering.[C020,C021,P025,U022]

As the liners are placed in 55-gallon drums, each drum will be surveyed to determine if the package is TRU in accordance with DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis.* [(6)] The containers determined to be low level will be managed in accordance with BCLDP-90-1, *The BCLDP Low-Level Waste Certification Plan.*[(5)]

4.0 TRI-NUC FILTERS

Waste Stream ID:	5410-02
Generation Building:	Building JN-1; MTC, HEC, and LLC[C019,C023]
Waste Stream Volume (Projected):	0.4 m^3 [C021]
Generation Dates (Projected):	October 1999 – December 1999
EPA Hazardous Waste Numbers:	D004, D005, D006, D007, D008, D009, D011[D005,D006]
Radionuclides:	JN-1 Pool Cleanup Isotopic Mix[(6)]
TRUCON Content Codes:	SQ121 (CH-TRU), BC121 (RH-TRU)[(4)]
Summary Category:	S5000[(7)]
Matrix Parameter Category:	S5410[(7)]

4.1 Waste Stream Description

The Tri-Nuc filters cartridges were generated during repackaging of the waste materials generated from the change out of filter cartridges from the underwater vacuum system used to clean the surfaces and water of the Transfer/Storage Pool. This stream includes Tri-Nuc filter cartridges generated during this process. Table 4-1 presents the matrix parameter category and waste material parameters for this waste stream.[C019,C022,P045]

Table 4-1. Tri-Nuc Filter Waste Matrix.[C021,C022]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight %
5410-02, Tri-Nuc Filters	S5410, Composite Filter Debris	Iron-based Metals/Alloys	47%
		Aluminum-based Metals/Alloys	<1%
		Plastics	41%
		Other Inorganic Materials	6%
		Organic Matrix	6%

Waste Stream 5410-02, Tri-Nuc Filters: This waste consists of filter cartridges used in the underwater vacuum system for cleaning the surfaces and filtering the water of the Transfer/Storage Pool. The cartridges are 30" long and 6" in diameter and consist of media enclosed within a stainless steel screen shroud, and aluminum screen reinforced plastisol end caps. The filter media is composed of polypropylene , melt brown reinforced typar, and is available in 0.3, 1, 5, 10, and 20 micron mesh sizes. Weighted stainless steel stips run the length of the filter and are bonded to the end caps. The number of strips varies with the filter size, from 2 strips with 0.3 microns to 3 with 20 microns. The waste matrix will also include Floor Dry (diatomaceous earth) and Radsorb (50:50 mix) added to each liner.[C019, C020,P046,U022]

4.2 Characterization Rationale

The filter wastes are characterized based on knowledge of the material and knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

4.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23), or toxicity for organics or metals (40 CFR 261.24), however D004, D005, D006, D007, D008, D009, and D011 have been conservatively assigned due to these constituents being detected at low concentrations in the pool water[D005] and supporting analytical data.[D006]

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, any free liquid would be water and absorbents have been added to the filters to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable wastes (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to the filters to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream should not meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. The sources of AK reviewed identified no source of toxic compounds except for a single sample of pool water that detected lead at a concentration of less than 10 parts per billion.[D005] Even though the levels were extremely low, TC-AP-03.1 requires the assignment EPA HWNs to TRU waste streams if the review of AK documentation identifies the presence of constituents specified in 40 CFR 261, Subpart C. Based upon this AK information, a single composite sample was taken of the filter and resin waste streams (5410-01 & 3211-01). Both the Total and TCLP analytical results detected presence of several RCRA regulated metals in small amounts.[D006] Based upon this data and the QAPP requirement, D004, D005, D006, D007, D008, D009, and D011 will be conservatively added to Waste Stream ID 5410-02.

4.2.2 Listed Hazardous Waste

The material in this waste stream is not, or was not mixed with, a waste listed in 40 CFR 261, Subpart D as a hazardous waste from non-specific sources (40 CFR 261.31), as a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). These filters did not come in contact with listed solvents. Therefore, this waste stream is not a listed hazardous waste.[2]

4.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5410-02, is not a TSCA regulated waste.

5.0 INORGANIC DEBRIS

Waste Stream ID: 5190-01
Generation Building: Building JN-1; MTC, HEC, and LLC[C019,C023]
Waste Stream Volume (Projected): 1.0 m^3 [C021,C024]
Generation Dates (Projected): October 1999 – December 1999
EPA Hazardous Waste Numbers: None[(2)]
Radionuclides: JN-1 Standard Isotopic Mix[(6)]
TRUCON Content Codes: SQ122 (CH-TRU), BC122 (RH-TRU)[(4)]
Summary Category: S5000[(7)]
Matrix Parameter Category: S5190[(7)]

5.1 Waste Stream Description

Inorganic debris consists of glass and metal materials generated during repackaging of the waste materials generated from research and development activities conducted in Building JN-1. Table 5-1 presents the matrix parameter category and waste material parameters for this waste stream.[(2),C019]

Table 5-1. Inorganic Debris Waste Matrix.[C021,C024]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight % (Range)
5190-01, Inorganic Debris	S5190, Inorganic Debris	Other Inorganic Material	0-71%
		Iron-based Metal/Alloys	0-29%
		Other Metals	<1%

Waste Stream 5190-01, Inorganic Debris: This waste consists primarily of glass and metal debris generated during research and development activities conducted in Building JN-1. Glass debris includes laboratory glassware, windows, and various glass apparatus. Appendices A, B, C, and D list items that may be contained in this waste stream. Metal debris determined to be unsuitable for decontamination will also be included in this waste stream. Metal items may include deteriorated berry cans, cable, wire, planchets, sign, valves, piping, strapping, tools, foil, sheeting, fixtures, equipment, hardware (e.g. nuts, bolts, brackets, etc), fuel rod cladding, and metmounts. Metals of construction include stainless steel, aluminum, iron, copper, beryllium, and zirconium (Zircaloy). The waste matrix will also include Floor Dry added during repackaging to absorb any water from condensation or dewatering.[(2),C019,C020,C024,U022]

5.2 Characterization Rationale

Inorganic debris wastes are characterized based on knowledge of the material and knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

5.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23) or toxicity (40 CFR 261.24).[2]

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable wastes (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. This waste contains absorbents that have been added to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream do not meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. Organic debris are visually examined prior to or during repackaging to ensure no residue is present, or these wastes meet the definition of empty container (40 CFR 261.7). Therefore, waste stream 5190-01 does not exhibit the characteristic of toxicity (D004-D043).

5.2.2 Listed Hazardous Waste

The material in this waste stream is not, or was not mixed with, a waste listed in 40 CFR 261, Subpart D as a hazardous waste from non-specific sources (40 CFR 261.31), as a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). Organic debris are visually examined prior to or during repackaging to ensure no residue is present, or these wastes meet the definition of empty container (40 CFR 261.7). Any contact with listed solvents is considered incidental. Therefore, this waste stream is not a listed hazardous waste. [2]

5.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5190-01, is not a TSCA regulated waste.

6.0 HAZARDOUS INORGANIC DEBRIS

Waste Stream ID: 5190-02
Generation Building: Building JN-1; MTC, HEC, and LLC[C019,C023]
Waste Stream Volume (Projected): < 0.2 m^3 [C021,C024]
Generation Dates (Projected): October 1999 – December 1999
EPA Hazardous Waste Numbers: D005, D007, D008, D009, D011, F001, F002, F003, F005[(2)]
Radionuclides: JN-1 Standard Isotopic Mix[(6)]
TRUCON Content Codes: SQ122 (CH-TRU), BC122 (RH-TRU)[(4)]
Summary Category: S5000[(7)]
Matrix Parameter Category: S5190[(7)]

6.1 Waste Stream Description

Hazardous inorganic debris consists of the materials generated during repackaging of the waste materials generated from research and development activities conducted in Building JN-1. Table 6-1 presents the matrix parameter category and waste material parameters for this waste stream.[(2), C019]

Table 6-1. Hazardous Inorganic Debris Waste Matrix.[C021,C024]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight % (Range)
5190-02, Hazardous Inorganic Debris	S5190, Inorganic Debris	Other Inorganic Material	0-71%
		Iron-Based Metal/Alloys	0-29%
		Other Metals	<1%

Waste Stream 5190-02, Hazardous Inorganic Debris: This waste consists of glass and metal debris which is visibly contaminated with hazardous waste, generated during research and development activities conducted in Building JN-1. Glass debris which includes broken laboratory glassware, windows, light bulbs, leaded glass windows, and various glass apparatus. This stream may also include metal items such as cable, wire, planchets, signs, valves, piping, strapping, tools, foil, sheeting, fixtures, equipment (e.g. pumps, motors, etc. which have had all oil or any other free liquids removed), hardware (e.g. nuts, bolts, brackets, etc), specimen vials, fuel rod cladding, metmounts, and lead lined tubing. Metals of construction include stainless steel, aluminum, iron, copper, beryllium, lead, and zirconium (Zircaloy). Appendices A, B, C, and D list items that may be packaged as part of this waste stream. The waste matrix will also include Floor Dry added during repackaging to absorb any liquid from condensation or dewatering.[(2), C019,C020,C024,U022]

6.2 Characterization Rationale

Hazardous inorganic debris wastes are characterized based on knowledge of the material and knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

6.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23), or toxicity for organics (40 CFR 261.24), but may exhibit the characteristics of toxicity for metals due to surface contamination or the materials of construction. [2]

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable wastes (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. This waste contains absorbents that have been added to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream may meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. This waste group may exhibit the characteristic of toxicity for barium, chromium, lead, mercury, and silver.

Barium sulfate, chromic acid, potassium dichromate, mercury, and silver nitrate were used in various processes in Building JN-1. Leaded glass contains 90% lead, and analyitical data for leaded glass windows indicates barium above the toxicity characteristic level. Metal debris with lead exhibit the characteristic of toxicity for lead. Inorganic debris containing lead, or barium, or debris visibly contaminated, are potentially contaminated with these materials. Therefore, waste stream 5190-02 is assigned EPA Hazardous Waste Numbers D005, D007, D008, D009, and D011 since a representative sample of this waste cannot be obtained for verification purposes.

Benzene, carbon tetrachloride, methyl ethyl ketone, and trichloroethylene were used in Building JN-1. These compounds were typically used as solvents. Therefore visibly contaminated inorganic debris is regulated as a listed hazardous waste and not a characteristic waste since these compounds are specifically addressed in the treatment standards for listed hazardous waste.

6.2.2 Listed Hazardous Waste

The material in this waste stream has been characterized as a listed hazardous waste because it may have been mixed with spent solvents listed in 40 CFR 261, Subpart D. Based on acceptable knowledge documentation reviewed the material is not, or was not mixed with, a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). (2)

Carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, acetone, methanol, benzene, and methyl ethyl ketone were used in laboratory operations for cleaning and degreasing. Visibly contaminated inorganic debris are potentially contaminated with these spent solvents. Therefore waste stream 5190-02 is assigned EPA Hazardous waste numbers F001, F002, F003, and F005. (2)

6.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5190-02, is not a TSCA regulated waste.

7.0 ORGANIC DEBRIS

Waste Stream ID: 5390-01
Generation Building: Building JN-1; MTC, HEC, and LLC[C019,C023]
Waste Stream Volume (Projected): 1.2 m^3 [C021,C024]
Generation Dates (Projected): October 1999 – December 1999
EPA Hazardous Waste Numbers: None[(2)]
Radionuclides: JN-1 Standard Isotopic Mix[(6)]
TRUCON Content Codes: SQ121 (CH-TRU), BC121 (RH-TRU)[(4)]
Summary Category: S5000[(7)]
Matrix Parameter Category: S5390[(7)]

7.1 Waste Stream Description

Organic debris consists of the materials generated during repackaging of the waste materials generated from research and development activities conducted in Building JN-1. Table 7-1 presents the matrix parameter category and waste material parameters for this waste stream.[(2),C019]

Table 7-1. Organic Debris Waste Matrix.[C021,C024]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight % (Range)
5390-01, Organic Debris	S5390, Organic Debris	Plastic	0-79%
		Rubber	0-5%
		Cellulosics	0-12%
		Iron-Based Metal/Alloys	<1%
		Aluminum-based Metal/Alloys	0-1%
		Other Inorganic Material	0-2%

Waste Stream 5390-01, Organic Debris: This waste consists primarily of plastic or rubber debris material including polyethylene, polyvinyl chloride, nylon, styrofoam, Tygon, plexiglass, and neoprene. Wood debris with no signs of hazardous waste contamination may also be included. Waste items may include non-deteriorated sheeting, hose/tubing, respirators, boots, rain suits, o-rings, electrical cords, safety glasses, plexiglass panels, plywood, and pallets. Appendices A, B, C, and D list items that may be packaged as part of this waste stream. The waste matrix will also include Floor Dry (diatomaceous earth) and Radsorb added during repackaging to absorb any water from condensation or dewatering.[(2),C019,C020,C024,U022]

7.2 Characterization Rationale

Organic debris wastes are characterized based on knowledge of the material and knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

7.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23) or toxicity (40 CFR 261.24).[2]

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable waste (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. This waste contains absorbents that have been added to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream do not meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. Organic debris are visually examined prior to or during repackaging to ensure no residue is present, or these wastes meet the definition of empty container (40 CFR 261.7). Therefore, waste stream 5390-01 does not exhibit the characteristic of toxicity (D004-D043).

7.2.2 Listed Hazardous Waste

The material in this waste stream is not, or was not mixed with, a waste listed in 40 CFR 261, Subpart D as a hazardous waste from non-specific sources (40 CFR 261.31), as a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). Organic debris are visually examined prior to or during repackaging to ensure no residue is present, or these wastes meet the definition of empty container (40 CFR 261.7). Any contact with listed solvents is considered incidental. Therefore, this waste stream is not a listed hazardous waste. [2]

7.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5390-01, is not a TSCA regulated waste.

8.0 HAZARDOUS ORGANIC DEBRIS

Waste Stream ID: 5390-02
Generation Building: Building JN-1; MTC, HEC and LLC[C019,C023]
Waste Stream Volume (Projected): 2.0 m^3 [C021,C024]
Generation Dates (Projected): October 1999 – December 1999
EPA Hazardous Waste Numbers: D005, D007, D008, D009, D011, F001, F002, F003, F005[(2)]
Radionuclides: JN-1 Standard Isotopic Mix[(6)]
TRUCON Content Codes: SQ121 (CH-TRU), BC121 (RH-TRU)[(4)]
Summary Category: S5000[(7)]
Matrix Parameter Category: S5390[(7)]

8.1 Waste Stream Description

Hazardous organic debris consists of the materials generated during repackaging of the waste materials generated from research and development activities conducted in Building JN-1. Table 8-1 presents the matrix parameter category and waste material parameters for this waste stream.[(2),C019]

Table 8-1. Hazardous Organic Debris Waste Matrix.[C021,C024]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight % (Range)
5390-02, Hazardous Organic Debris	S5390, Organic Debris	Plastic	0-49%
		Cellulosics	42-95%
		Rubber	0-3%
		Other Inorganic Material	0-2%
		Iron-Based Metal/Alloys	<1%
		Aluminum-Based Metal	<1%
		Soil	<1%
		Concrete	<1%

Waste Stream 5390-02, Hazardous Organic Debris: This waste consists of paper or cloth debris materials, including canvas, leather, porous materials, and materials such as plastic, wood, or rubber debris including polyethylene, polyvinyl chloride, nylon, styrofoam, Tygon, plexiglass, and neoprene which are visibly contaminated with hazardous waste (sludge, powder, or caked material). Waste items may include janitorial and spill cleanup materials (e.g. wipes, rags, mop heads, protective clothing), vacuum bags, HEPA filters, blue prefilter pads[C023], respirator cartridges, plywood, pallets, packing material, hose/tubing, cardboard, masking tape, rope, paint chips, and deteriorated plastic bags and sheeting. Appendix A, lists items designated to be packaged as part of this waste stream. The waste matrix will also include Floor Dry(diatomaceous earth) and Radsorb (50:50 mix) added during repackaging to absorb any water from condensation or dewatering.[(2),C019,C020,C024,U022]

8.2 Characterization Rationale

Hazardous organic debris wastes are characterized based on knowledge of the material, knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

8.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23) or toxicity for organics (40 CFR 261.24), but may exhibit the characteristics of toxicity for metals due to surface contamination.(2)

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable waste (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents are added to wastes having the potential of generating free liquids (e.g., wet wipes). The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream may meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. This waste group may exhibit the characteristic of toxicity for barium, chromium, lead, mercury, and silver.

Barium sulfate, chromic acid, potassium dichromate, mercury, and silver nitrate were used in various processes in Building JN-1. Paper, cloth, porous materials, or visibly contaminated wood, plastic or rubber debris are potentially contaminated with these materials. Therefore, waste stream 5390-02 is assigned EPA Hazardous Waste Numbers D005, D007, D008, D009, and D011 since a representative sample of this waste cannot be obtained for verification purposes.

Benzene, carbon tetrachloride, methyl ethyl ketone, and trichloroethylene were used in Building JN-1. These compounds were typically used as solvents. Therefore contaminated organic debris is regulated as a listed hazardous waste and not a characteristic waste since these compounds are specifically addressed in the treatment standards for listed hazardous waste.

8.2.2 Listed Hazardous Waste

The material in this waste stream is characterized as a listed hazardous waste because it may have been mixed with spent solvents listed in 40 CFR 261, Subpart D. Based on acceptable knowledge documentation reviewed the material is not, or was not mixed with, a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33).[2]

Carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, acetone, methanol, benzene, and methyl ethyl ketone were used in laboratory operations for cleaning and degreasing. This organic debris is potentially contaminated with these spent solvents. Therefore waste stream 5390-02 is assigned EPA Hazardous waste numbers F001, F002, F003, and F005.[2]

8.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5390-02, is not a TSCA regulated waste.

9.0 SLUGS

Waste Stream ID: 3150-01
Generation Building: Building JN-1; MTC, HEC, and LLC[C023,(2)]
Waste Stream Volume (Projected): 0.4 m^3 [C024]
Generation Dates (Projected): October 1999 – December 1999
EPA Hazardous Waste Numbers: D004, D005, D006, D007, D008, D009, D011[D005,D006]
Radionuclides: JN-1 Standard Isotopic Mix[(6)]
TRUCON Content Codes: SQ122 (CH-TRU), BC122 (RH-TRU)[(4)]
Summary Category: S3000[(7)]
Matrix Parameter Category: S3150[(7)]

9.1 Waste Stream Description

Slugs consist of the solidified acid solutions containing dissolved fuel materials generated during repackaging of the waste materials generated from research and development activities conducted in Building JN-1. Table 4-1 presents the matrix parameter category and waste material parameters for this waste stream.[C024]

Table 9-1. Slugs Waste Matrix.[C021,C022]

Waste Stream	Matrix Parameter Category	Waste Material Parameters	Weight %
3150-01, Slugs	S3150, Solidified Homogenous Solid	Inorganic Matrix	100%
		Plastics (residual styrofoam)	<1%

Waste Stream 3150-01, Slugs: Slugs were produced in Alpha-Gamma Cell 7 from dissolving of burnup fuel specimens in an acid solution which was then diluted several times and mixed with cement and water and allowed to solidify in styrofoam cups. The slugs will contain only limited amounts of dissolved fuel because of the dilution.[(2)] . Appendices B and D identify hoppers and cans containing the burnup slugs. The waste matrix will also include Floor Dry added during repackaging to absorb any liquid from condensation or dewatering. The stryrofoam cups will be segregated from the slugs prior to final packaging.[C019,C023,C024]

9.2 Characterization Rationale

The slugs are characterized based on knowledge of the material and knowledge of the processes generating the waste, and visual examination. This section provides a RCRA hazardous and TSCA waste determination for this waste stream.

9.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23), or toxicity for organics or metals (40 CFR 261.24), however D004, D005, D006, D007, D008, D009, and D011 have been conservatively assigned due to these constituents being detected at low concentrations in the pool water[D005] and supporting analytical data.[D006]

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, any free liquid would be water and absorbents have been added to the filters to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable wastes (D001).

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to the filters to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).

Toxicity: The materials in this waste stream should not meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. Since there were no sources of AK available to identify the precise composition of the metals and alloys exposed to the acids, the EPA HWNs for dissolved the metals detected in the

Transfer/Storage pool water, filters, and resins will be conservatively assigned to this waste stream pending confirmation sampling.

9.2.2 Listed Hazardous Waste

The material in this waste stream is not, or was not mixed with, a waste listed in 40 CFR 261, Subpart D as a hazardous waste from non-specific sources (40 CFR 261.31), as a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). These filters did not come in contact with listed solvents. Therefore, this waste stream is not a listed hazardous waste.[2]

9.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5410-02, is not a TSCA regulated waste.

10.0 REFERENCES AND AK SOURCES

1. TCP-98-02, *Transuranic Waste Characterization Quality Assurance Project Plan for the BCLDP TRU Waste Certification Program.*

2. TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document.*

3. TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation.*

4. TC-OP-01.4, *Segregation and Packaging of TRU Waste.*

5. BCLDP-90-1, *The BCLDP Low-Level Waste Certification Plan.*

6. DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis.*

7. DOE 1995. *DOE Waste Treatability Group Guidance.* DOE/LLW-217.

8. TCP-98-03.1.1, *Acceptable Knowledge Process Description, Repackaging of JN-1 Transfer/Storage Pool Filter Change-Out Waste.*

9. WA-OP-006, *Procurement and Inspections of Packagings for Hazardous Materials Shipments.*

10. WA-OP-20, *Identification, Segregation, Separation and Documentation of Low Level Waste.*

TABLE 10-1. Acceptable Knowledge Source Documents

Ref. No.	Source/Author	Summary	[illegible]
C019	Interview Record of Scott Kitts, BCL, conducted by Kevin Peters. WASTREN, Inc.	This interview focused on the inventory of drums generated during clean-up operations in the CAA and HEC. In addition, a discussion of the planned methodology to be used to repackage these drums of waste, is included.	1999. April 27.
C020	Letter to AK Record authored by Kevin Peters. WASTREN, Inc.	This letter includes the assumptions used in assigning waste streams to the current drum inventory of materials to be repackaged in the Mechanical Test Cell of Building JN-1. The inventory was derived from Waste Packaging Loading Records (see U022) for 60 drums of waste generated during Building JN-1 cleanup campaigns conducted in the mid 1980s in the CAA and HEC.	1999. May 7.

No.	Title/Author	Summary	Date
C021	Letter to AK Record authored by Kevin Peters. WASTREN, Inc.	This letter includes the assumptions and the inventory list used in calculating waste stream volumes and estimating waste material parameter categories for the inventory of drums generated during the clean-up of the HEC and CAA. To determine the total volumes of waste generated for each waste stream, volumes for individual items were calculated	1999. May 7.
C022	Interview Record of Tim Warden, Tri Nuclear Corporation, conducted by Scott Smith. WASTREN, Inc.	Tim Warden a Technical Representative with Tri Nuclear Corporation was interviewed to determine the materials of construction for the Tri-Nuc filters used during the cleaning and draining of the Storage/Transfer Pool in JN-1. Also included are the estimates for the Waste Material Parameters for these filters based on the dissassembly and weighing of the materials by BCLDP personnel.	1999. May 10.
C023	Interview Record of Scott Kitts, David GarberBCL, conducted by Kevin Peters. WASTREN, Inc.	This interview focused on the inventory of containers that will be repackaged in the HEC, LLC, and MTC, including the activities planned for each of the cells. Also includes manufacturer's information of the composition of the PolyKlean Blue filter pads contained in the inventory.	1999. September 20.
C024	Letter to AK Record authored by Kevin Peters. WASTREN, Inc.	This letter includes the assumptions and the inventory lists used in calculating waste stream volumes and estimating waste material parameter categories for the inventory of containers to be repackaged in the MTC, LLC, and HEC. To determine the total volumes of waste generated for each waste stream, volumes for individual items were calculated using the inventory documentation. This information expands of the inventory described in C021.	1999. September 22.
D004	Telephone Ineterview Record of Cidney Voth, BCL, conducted by Kevin Peters. WASTREN, Inc.	This interview was conducted to describe the operations involved with the draining of the JN-1 Transfer/Storage Pool Water and to resolve a discrepancy relating to the date when this activity was completed. In an interview with Gene Sands and George Kirsch (C014) the interviewer was informed that the evaporation of the pool was completed in 1989. Based on review of subsequent AK documentation it was determined that this activity was not completed until the mid 1990s. Cidney Voth was interviewed and documentation provided that verified the operation was performed between 1995 and 1997.	1999. April 27.
D005	Letter to AK Record authored by Kevin Peters. WASTREN, Inc.	This letter was written due to the discovery of analytical data of water from the Transfer/Storage pool prior to removal of the water. The data indicates the presence of low concentrations of lead. Based on this data D008 will be conservatively added to the filter and resin waste streams used to filter the water (3211-01,5410-01, and 5410-02).	1999. May 12.
D006	Letter to AK Record authored by Kevin Peters. WASTREN, Inc.	This letter was written to address the detection of RCRA metals in samples taken of the Transfer/Storage poll filters and resins. The data indicates the presence of several RCRA metals. Based upon this data D004, D005, D006, D007, D008, D009, and D011 will be consevatively added to the filter and resin waste streams used to filter the pool water (3211-01, 5410-01, and 5410-02).	1999 June 29.

P008	West Jefferson North Hopper Location and Contents. Myers, Louis B., and Max B. Berchtold. Battelle Columbus Laboratories.	This report describes the contents of 24 waste hoppers stored in JN-3, JN-1B (High Bay), and the Waste Storage Shed. Attachments include logbook entries of specific materials placed into certain hoppers.	1995. June.
P017	Low Level Cell JN-1A. Myers, Louis B., Max B. Berchtold, Thomas A. Beddick, Paul D. Faust, and Paul A. Tomin. Battelle Columbus Laboratories.	This report describes the operations and configuration of the Low Level Cell (LLC) in JN-1A. Projects included fuel cutting, grinding, tensile tests of cobalt samples, and gamma scanning of waste containers filled in the HLC. Attachments include a 1996 update, logbook pages describing the packaging of approximately 100 waste (berry) cans (December 1988 to February 1989), logbook pages of a study verifying the contents of the containers (July 1991), and radioassay results. Limited information relating to projects and dates.	1994. August.
P025	Miscellaneous Materials Safety Data Sheets (MSDSs). Authored by Manufacturers.	Miscellaneous MSDS sheets collected from numerous sources collected during AK research at the West Jefferson site.	Various.
P045	Decontamination and Decommissioning Operations, Decontamination and Decommisioning Operating Procedure, Operation of the Underwater Vacuum System UFV-100 (DD-OP-315). Battelle Columbus Laboratories.	Procedure describing the method used to filter/vacuum the JN-1 Transfer/Storage Pool. Also attached is Revision 0 of this procedure (September 12, 1991) that was never implemented.	1995. August 24. Revision 1
P046	Assembly and Operating Instructions, Underwater Filter/Vacuum Units (Models UFV-100 & UFV-260). Tri Nuclear Corporation.	Manufacturers instructions for operating the equipment used to filter/vacuum the JN-1 Transfer/Storage Pool. Includes drawings and specifications for the Tri-Nuc filters (waste stream 5410-01).	1994. December 16.
P047	Decontamination and Decommissioning Operations, Health Physics Operating Procedure, Removal of Objects From Contaminated Pools and Tanks (HP-OP-031). Battelle Columbus Laboratories.	Procedure describing the method used to remove objects from the bottom of the JN-1 Transfer/Storage Pool prior to vacuuming and draining.	1996. March 14.
U022	Waste Package Loading Record Battelle Columbus Laboratories.	The Waste Package Loading Records describe the contents of 60 drums of waste generated by clean-up operations in the CAA and HEC. These records will be used to determine the waste streams to be generated during repackaing, including volume, matrix parameter category, and waste material parameter for each stream.	1997. October. To 1999. March.
U023	Requisition for Purchase, 55-gallon Steel Drum Liners Battelle Columbus Laboratories.	This requisition for the 55-gallon drum liners includes the specification for the liners to be used to package and compact TRU waste.	1999. February 18.

Appendix A

HEC AND CAA DRUM INVENTORY

This appendix includes the current drum inventory of materials to be repackaged in the Mechanical Test Cell of Building JN-1. The inventory was derived from Waste Packaging Loading Records for 60 drums of waste generated during Building JN-1 cleanup campaigns conducted in the mid 1980s. Information provided on the Waste Package Loading Record includes:

- Package or drum number,
- Item number,
- Item description,
- Material type,
- Material composition percentage,
- Loading date, and
- Summary or comments.

The itemized information provided on each Waste Package Loading Record was input to an Excel spreadsheet to aid in analysis of the materials. Information not provided on the Waste Packaging Loading Record is indicated in the spreadsheet as N/P. Packing dates highlighted in the spreadsheet indicate the drum inventory was limited due to high alpha content encountered during investigation, and the drum contents were partially segregated.[C019,U022]

Of the 60 drums, 9 were identified which require further investigation prior to repackaging. Seven drums were listed as containing concrete or cement. Two drums were listed as containing resins. These drums require additional investigation and special handling, and will be segregated for later repackaging.[C019]

The contents for the remaining 51 drums were reviewed to determine the drum repackaging waste streams, the waste stream waste matrix compositions, and estimate the number of drums potentially generated for each waste stream. Each item listed was reviewed by description and material composition. Items composed of multiple materials were theoretically split and listed on separate lines of the spreadsheet. Individual items were then evaluated and assigned estimated repackaging destinations. Items assumed capable of decontamination are designated 'Sonatol' in the 'Repack Action' column of the spreadsheet. Items listed as 'TRU' are assumed to be TRU waste and assigned the predicted drum repack waste stream number. Items that may require special treatment, or further investigation during packaging, such as the paint roller from drum 1584 are designated with 'Segregate' in the 'Repack Action' column.[C020,C021]

Eight additional drums from Building JN-1 have been identified for repackaging in this process. However, inventory records are not available. Two of the drums contain vacuum bags and the remaining six are assumed to contain materials similar to those listed in this inventory as the waste was generated from the same area.[C019]

Appendix A
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
654	1	Metal/Paper	40/60	Tri-Nuc Filter # 47 -- HPS # J-11,891	8 lbs.	N/P	10/03/1997	TRU	S5410-02
654	2	Metal/Paper	40/60	Tri-Nuc Filter # 65 -- HPS # J-12,548	8 lbs.	N/P	10/03/1997	TRU	S5410-02
654	3	Metal/Paper	40/60	Tri-Nuc Filter # 57 -- HPS # J-12,367	8 lbs.	N/P	10/03/1997	TRU	S5410-02
654	4	Metal/Paper	40/60	Tri-Nuc Filter # 51 -- HPS # J-12,026	8 lbs.	N/P	10/03/1997	TRU	S5410-02
654	5	Metal/Paper	40/60	Tri-Nuc Filter # 58 -- HPS # J-12,410	8 lbs.	N/P	10/03/1997	TRU	S5410-02
654	6	Metal/Paper	40/60	Tri-Nuc Filter # 66 -- HPS # J-12,601	8 lbs.	N/P	10/03/1997	TRU	S5410-02
654	7	Metal/Paper	40/60	Tri-Nuc Filter # 59 -- HPS # J-12,431	8 lbs.	N/P	10/03/1997	TRU	S5410-02
1504	1	Metal	100	Tri-Nuc filter # 13 from SDSBC-1504	N/P	N/P	06/26/1998	TRU	S5410-02
1504	2	Metal	100	Tri-Nuc filter # 17 from SDSBC-1504	N/P	N/P	06/26/1998	TRU	S5410-02
1504	3	Metal	100	Tri-Nuc filter # 21from SDSBC-1504	N/P	N/P	06/26/1998	TRU	S5410-02
1504	4	Metal	100	Tri-Nuc filter # 16 from SDSBC-1504	N/P	N/P	06/26/1998	TRU	S5410-02
1504	5	Metal	100	Tri-Nuc filter # 1 from SDSBC-1504	N/P	N/P	06/26/1998	TRU	S5410-02
1504	6	Metal	100	Berry can # 1	N/P	N/P	06/26/1998	Sonatol	
1504	6	Paper	100	Trash from can #1, SDSBC-1504				TRU	S5390-02
1504	7	Metal	100	Berry can # 2	N/P	N/P	06/26/1998	Sonatol	
1504	7	Paper	100	Trash from can # 2, SDSBC-1504				TRU	S5390-02
1504	8	Metal	100	Berry can # 3	N/P	N/P	06/26/1998	Sonatol	
1504	8	Paper	100	Trash from can # 3, SDSBC-1504				TRU	S5390-02
1504	9	Metal	100	Berry can # 4	N/P	N/P	06/26/1998	Sonatol	
1504	9	Paper	100	Trash from can # 4, SDSBC-1504				TRU	S5390-02
1504	10	Metal	100	Berry can # 22	N/P	N/P	06/26/1998	Sonatol	
1504	10	Paper	100	Trash from can # 22, SDSBC-1504				TRU	S5390-02
1504	11	Metal	100	Berry can # 7	N/P	N/P	06/26/1998	Sonatol	
1504	11	Paper	100	Trash from can # 7, SDSBC-1504				TRU	S5390-02
1504	12	Metal/Plastic	95/5	Arm bag ring	N/P	N/P	06/26/1998	Sonatol	
1504	13	Metal/Plastic	80/20	Caulk gun	N/P	N/P	06/26/1998	Segregate	
1504	14	Metal	100	Bottom of strong back	N/P	N/P	06/26/1998	Sonatol	
1504	15	Metal	100	Small metal rod (bent)	N/P	N/P	06/26/1998	Sonatol	
1505	1	Metal	100	Tri-Nuc Filter #5	N/P	N/P	06/26/1998	TRU	S5410-02
1505	2	Metal	100	Tri-Nuc Filter #6	N/P	N/P	06/26/1998	TRU	S5410-02
1505	3	Metal	100	Tri-Nuc Filter # 8	N/P	N/P	06/26/1998	TRU	S5410-02
1505	4	Metal	100	Tri-Nuc Filter #9	N/P	N/P	06/26/1998	TRU	S5410-02
1505	5	Metal	100	Tri-Nuc Filter # 10	N/P	N/P	06/26/1998	TRU	S5410-02
1505	6	Metal	100	Tri-Nuc Filter # 11	N/P	N/P	06/26/1998	TRU	S5410-02
1505	7	Metal	100	Tri-Nuc Filter # 14	N/P	N/P	06/26/1998	TRU	S5410-02

Appendix
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1505	8	Metal	100	Tri-Nuc Filter # 15	N/P	N/P	06/26/1998	TRU	S5410-02
1505	9	Metal/Plastic	95/5	Arm bag ring	N/P	N/P	06/26/1998	Sonatol	
1508	1	Metal/Plastic	98/2	Electrolux vacuum from SDSBC-1508	N/P	N/P	07/01/1998	Sonatol	
1508	2	Metal/Plastic	95/5	Electrolux vacuum from SDSBC-1508	N/P	N/P	07/01/1998	Sonatol	
1508	3	Metal	100	Berry can # 8-43	N/P	N/P	07/01/1998	Sonatol	
1508	3	Plastic	100	Plastic from can # 8-43, SDSBC-1508				TRU	S5390-01
1508	4	Metal	100	Berry can # 8-48	N/P	N/P	07/01/1998	Sonatol	
1508	4	Plastic	100	Plastic from can # 8-48, SDSBC-1508				TRU	S5390-01
1508	5	Metal	100	Berry can # 8-17	N/P	N/P	07/01/1998	Sonatol	
1508	5	Paper	100	Trash from can # 8-17, SDSBC-1508				TRU	S5390-02
1508	6	Metal	100	Berry can # 8-8	N/P	N/P	07/01/1998	Sonatol	
1508	6	Paper/Plastic	50/50	Plastic and tape from can # 8-8, SDSBC-1508				TRU	S5390-02
1508	7	Metal	100	Berry can # 8-15	N/P	N/P	07/01/1998	Sonatol	
1508	7	Unknown	100	Contents can # 8-15, SDSBC-1508				TRU	S5390-02
1508	8	Metal	100	Berry can # 8-13	N/P	N/P	07/01/1998	Sonatol	
1508	8	Unknown	100	Contents can # 8-13, SDSBC-1508				TRU	S5390-02
1508	9	Metal	100	Berry can # 8-20	N/P	N/P	07/01/1998	Sonatol	
1508	9	Unknown	100	Contents can # 8-20, SDSBC-1508				TRU	S5390-02
1508	10	Metal	100	Berry can # 8-6	N/P	N/P	07/01/1998	Sonatol	
1508	10	Plastic	100	Plastic from can # 8-6, SDSBC-1508				TRU	S5390-01
1508	11	Metal	100	Berry can # 8-3	N/P	N/P	07/01/1998	Sonatol	
1508	11	Plastic	100	Plastic from can # 8-3, SDSBC-1508				TRU	S5390-01
1508	12	Metal/Plastic	95/5	4 - arm bag rings	N/P	N/P	07/01/1998	Sonatol	
1509	1	Metal	100	Berry can	N/P	N/P	07/01/1998	Sonatol	
1509	1	Plastic	100	Plastic from berry can, SDSBC-1509				TRU	S5390-01
1509	2	Metal/Plastic	95/5	Arm bag ring	N/P	N/P	07/01/1998	Sonatol	
1509	3	Metal	100	Berry can # 8-50	N/P	N/P	07/01/1998	Sonatol	
1509	3	Plastic	100	Plastic from can # 8-50, SDSBC-1509				TRU	S5390-01
1509	4	Metal	100	Berry can # 8-11	N/P	N/P	07/01/1998	Sonatol	
1509	4	Unknown	100	Contents can # 8-11, SDSBC-1509				TRU	S5390-02
1509	5	Metal	100	Berry can # 8-16	N/P	N/P	07/01/1998	Sonatol	
1509	5	Unknown	100	Contents can # 8-16, SDSBC-1509				TRU	S5390-02
1509	6	Metal	100	Berry can # 8-9	N/P	N/P	07/01/1998	Sonatol	
1509	6	Paper	100	Contents can # 8-9, SDSBC-1509				TRU	S5390-02
1509	7	Metal	100	Berry can	N/P	N/P	07/01/1998	Sonatol	

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1509	7	Paper	100	Berry can contents, SDSBC-1509				TRU	S5390-02
1509	8	Metal	100	Berry can # 8-12	N/P	N/P	07/01/1998	Sonatol	
1509	8	Unknown	100	Contents can # 8-12, SDSBC-1509				TRU	S5390-02
1509	9	Metal	100	Berry can	N/P	N/P	07/01/1998	Sonatol	
1509	9	Paper	100	Berry can contents, SDSBC-1509				TRU	S5390-02
1509	10	Metal	100	Berry can	N/P	N/P	07/01/1998	Sonatol	
1509	10	Paper	100	Berry can contents, SDSBC-1509				TRU	S5390-02
1509	11	Metal	100	Aluminum can # 8-44	N/P	N/P	07/01/1998	Sonatol	
1509	12	Metal	100	Aluminum can # 8-45	N/P	N/P	07/01/1998	Sonatol	
1509	13	Metal	100	Berry can	N/P	N/P	07/01/1998	Sonatol	
1509	13	Paper	100	Berry can contents, SDSBC-1509				TRU	S5390-02
1509	14	Metal	100	Can of parrafin	N/P	N/P	07/01/1998	Segregate	
1509	14	Organic Liquid	100	Parrafin from SDSBC-1509				Segregate	
1509	15	Metal	100	Berry can	N/P	N/P	07/01/1998	Sonatol	
1509	15	Paper	100	Berry can contents, SDSBC-1509				TRU	S5390-02
1509	16	Wood	100	4" x 4" x 14" block, from SDSBC-1509	N/P	N/P	07/01/1998	TRU	S5390-01
1542	1	Metal	100	Fuel rod milling device	N/P	N/P	07/14/1998	Sonatol	
1542	2	Metal	100	Fuel assembly handling device	N/P	N/P	07/14/1998	Sonatol	
1542	3	Metal	100	Nut cracking device	N/P	N/P	07/14/1998	Sonatol	
1542	4	Metal	100	8" x 8" stainless steel mounting bracket	N/P	N/P	07/14/1998	Sonatol	
1542	5	Metal	100	Fission punch value (valve?)	N/P	N/P	07/15/1998	Sonatol	
1542	6	Metal/Plastic	80/20	Digital scale	N/P	N/P	07/15/1998	Sonatol	
1542	7	Metal	100	Fuel pipe clamp	N/P	N/P	07/15/1998	Sonatol	
1542	8	Metal	100	Load cell	N/P	N/P	07/15/1998	Sonatol	
1542	9	Metal	100	Hooks & cable	N/P	N/P	07/15/1998	Sonatol	
1542	10	Metal	100	Hooks & cable	N/P	N/P	07/15/1998	Sonatol	
1542	11	Metal	100	Vice & valve on I-beam	N/P	N/P	07/15/1998	Sonatol	
1542	12	Metal	100	Vice on plate	N/P	N/P	07/15/1998	Sonatol	
1542	13	Metal	100	Aluminum plate	N/P	N/P	07/15/1998	Sonatol	
1542	14	Metal	100	Aluminum channel - 1' long	N/P	N/P	07/15/1998	Sonatol	
1542	15	Metal	100	cage for co pellets	N/P	N/P	07/15/1998	Sonatol	
1542	16	Metal/Plastic	95/5	Arm bag rings - (3) total of rings	N/P	N/P	07/15/1998	Sonatol	
1542	17	Metal	100	Fission punch drill	N/P	N/P	07/15/1998	Sonatol	
1542	18	Metal	100	Scissors	N/P	N/P	07/15/1998	Sonatol	
1543	1	Metal	100	Bottom of a strong back	N/P	N/P	07/15/1998	Sonatol	
1543	2	Metal	100	Stainless steel can w/ spacer	N/P	N/P	07/15/1998	Sonatol	

Appendix
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1543	3	Metal	100	S hook	N/P	N/P	07/15/1998	Sonatol	
1543	4	Metal	100	Load cell	N/P	N/P	07/15/1998	Sonatol	
1543	5	Metal	100	Plumb bob	N/P	N/P	07/15/1998	Sonatol	
1543	6	Metal	100	2" x 8" Aluminum plate	N/P	N/P	07/15/1998	Sonatol	
1543	7	Metal	100	Impact wrench (drill)	N/P	N/P	07/15/1998	Sonatol	
1543	8	Metal	100	3' x 1" aluminum conduit	N/P	N/P	07/15/1998	Sonatol	
1543	10	Metal	100	1/4" metal hook	N/P	N/P	07/15/1998	Sonatol	
1543	11	Metal	100	1' x 1' stainless steel sheet	N/P	N/P	07/15/1998	Sonatol	
1543	12	Metal/Plastic	95/5	Arm bag rings - total of 4 rings in drum	N/P	N/P	07/15/1998	Sonatol	
1543	13	Metal	100	Hydraulic cutters	N/P	N/P	07/15/1998	Sonatol	
1543	14	Metal	100	Tension scale	N/P	N/P	07/15/1998	Sonatol	
1543	15	Metal	100	Shackel w/ steel strap	N/P	N/P	07/15/1998	Sonatol	
1543	16	Metal	100	ID # 8-29 magnet w/ brace	N/P	N/P	07/15/1998	Sonatol	
1543	17	Metal	100	Aluminium locking plate	N/P	N/P	07/15/1998	Sonatol	
1543	29	Metal/Plexigl	80/20	U shape sheet metal w/ plexiglass	N/P	N/P	07/21/1998	Sonatol	
1548	1	Metal	100	Fission gas drill	N/P	N/P	07/21/1998	Sonatol	
1548	2	Metal	100	Go-no go guage	N/P	N/P	07/21/1998	Sonatol	
1548	3	Metal	100	Berry can				TRU	S5390-01
1548	3	Plastic	100	Berry can contents, SDSBC-1548	N/P	N/P	07/21/1998	Sonatol	
1548	4	Metal	100	Berry can				TRU	S5390-01
1548	4	Plastic	100	Berry can contents, SDSBC-1548	N/P	N/P	07/21/1998	Sonatol	
1548	5	Metal	100	Berry can				TRU	S5390-01
1548	5	Plastic	100	Berry can contents, SDSBC-1548				TRU	S5390-02
1548	6	Cloth/Plastic	53/47	Berry can contents, SDSBC-1548	N/P	N/P	07/21/1998	Sonatol	
1548	6	Metal	100	Berry can				TRU	S5390-02
1548	7	Cloth/Plastic /Wood	47/47/6	Berry can contents, SDSBC-1548	N/P	N/P	07/21/1998	Sonatol	
1548	7	Metal	100	Berry can				TRU	S5190-01
1548	8	Glass	100	Berry can contents, SDSBC-1548	N/P	N/P	07/21/1998	Sonatol	
1548	8	Metal	100	Berry can	N/P	N/P	N/P	TRU	S5410-02
1551	1	Metal/Paper	82/20	Tri-Nuc filters	1.5 lbs.	115 lbs.		TRU	S5390-02
1552	1	Paper	100	Compactable from SDSBC-1552	13.5 lbs.	115 lbs.		TRU	S5390-01
1552	1	Plastic	100	Compactable from SDSBC-1552	1.5 lbs.	115 lbs.		TRU	S5390-02
1552	2	Paper	100	Compactable from SDSBC-1552	3.5 lbs.	115 lbs.		TRU	S5390-01
1552	2	Plastic	100	Compactable from SDSBC-1552	5 lbs.	115 lbs.	08/04/1998	Sonatol	
1552	3	Metal/Rubber	95/5	Clamshell heater					

Appendix A
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1552	4	Metal	100	Trashcan	4.5 lbs.	115 lbs.	08/04/1998	Sonatol	
1552	4	Plastic	100	Plastic from trashcan in SDSBC-1552	0.5 lbs.	115 lbs.		TRU	S5390-01
1553	1	Metal	100	Electric motor	N/P	110 lbs.	08/04/1998	Sonatol	
1553	2	Metal	100	Galvanized tash can	N/P	110 lbs.	08/04/1998	Sonatol	
1553	2	Paper	100	Paper from trashcan in SDSBC-1553		110 lbs.		TRU	S5390-02
1553	3	Rubber/Plastic	70/30	Manipulator sleeve	N/P	110 lbs.	08/04/1998	TRU	S5390-01
1553	4	Paper	100	Compactable from SDSBC-1553		110 lbs.		TRU	S5390-02
1553	4	Plastic	100	Compactable from SDSBC-1553		110 lbs.		TRU	S5390-01
1554	1	Metal	100	Metal	160 lbs.	152 lbs.	08/04/1998	Sonatol	
1555	1	Paper	100	Compactable from SDSBC-1555	4 lbs.	67 lbs.		TRU	S5390-02
1555	1	Plastic	100	Compactable from SDSBC-1555	6 lbs.	67 lbs.		TRU	S5390-01
1556	1	Paper	100	Compactable from SDSBC-1556		210 lbs.		TRU	S5390-02
1556	1	Plastic	100	Compactable from SDSBC-1556		210 lbs.		TRU	S5390-01
1556	2	Metal	100	Metal	N/P	210 lbs.	08/04/1998	Sonatol	
1557	1	Metal	100	Metal	280 lbs.	N/P	08/04/1998	Sonatol	
1558	1	Metal	100	Metal	N/P	188 lbs.	08/04/1998	Sonatol	
1558	2	Metal/Plastic	90/10	Vacuum w/ hose from SDSBC-1558		188 lbs.		Sonatol	
1558	3	Paper	100	Compactable from SDSBC-1558		188 lbs.		TRU	S5390-02
1558	3	Plastic	100	Compactable from SDSBC-1558		188 lbs.		TRU	S5390-01
1559	1	Metal	100	Metal	N/P	177 lbs.	08/05/1998	Sonatol	
1560	1	Paper/Plastic /Soil/Concrete	50/40 /5/5	Vacuum filter w/ compactable	30 lbs.	N/P	08/04/1998	TRU	S5390-02
1561	1	Glass	100	Compactable from SDSBC-1561		206 lbs.		TRU	S5190-02
1561	1	Metal	100	Comapactable from SDSBC-1561		206 lbs.		TRU	S5190-02
1561	1	Paper	100	Comapactable	N/P	206 lbs.	08/06/1998	TRU	S5390-02
1561	1	Plastic	100	Comapactable from SDSBC-1561		206 lbs.		TRU	S5390-01
1562	1	Metal	100	Angle iron, grating, crushed cans, lathe parts	N/P	125 lbs.	08/07/1998	Sonatol	
1563	1	Paper	100	Compactable from SDSBC-1563				TRU	S5390-02
1568	1	Plastic	100	Compactable from SDSBC-1563				TRU	S5390-01
1563	2	Metal	100	Metal	N/P	N/P	08/07/1998	Sonatol	
1565	1	Metal/Plastic	70/30	Strainer basket, lifting staps, tygon tubing	N/P	92 lbs.	09/12/1998	TRU	S5390-02
1565	1	Unknown	100	Black bag of unknown from SDSBC-1565		92 lbs.		Segregate	
1566	1	Metal	90	Metal	N/P	91 lbs.	08/12/1998	Sonatol	

Appendix
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1566	2	Paper	100	Compactable from SDSBC-1566		91 lbs.		TRU	S5390-02
1566	2	Rubber	100	Compactable from SDSBC-1566		91 lbs.		TRU	S5390-01
1567	1	Paper	100	Compactable from SDSBC-1567		190 lbs.		TRU	S5390-02
1567	1	Plastic	100	Compactable	N/P	190 lbs.	08/13/1998	TRU	S5390-01
1569	1	Metal	100	Metal	N/P	N/P	08/13/1998	Sonatol	
1570	1	Plastic	100	Compactable	N/P	189 lbs.	08/14/1998	TRU	S5390-01
1573	1	Paper	100	Compactable from SDSBC-1573	1 lbs.	85 lbs.		TRU	S5390-02
1573	1	Plastic	100	Compactable	19 lbs.	85 lbs.	08/17/1998	TRU	S5390-01
1575	1	Paper	100	Compactable from SDSBC-1575	11 lbs.	810 lbs.		TRU	S5390-02
1575	1	Plastic/Paper	90/10	Compactable	99 lbs.	810 lbs.	08/17/1998	TRU	S5390-02
1577	1	Metal/Concrete	20/80	Sweeper from HEC	890 lbs.	N/P	08/17/1998	Sonatol	
1578	1	Cloth	100	Compactable from SDSBC-1578				TRU	S5390-02
1578	1	Plastic	100	Compactable from SDSBC-1578				TRU	S5390-01
1578	2	Metal	100	Metal	N/P	N/P	08/18/1998	Sonatol	
1580	1	Rubber	100	3' x 6' mat - used on HEC floor, from SDSBC-1580				TRU	S5390-01
1580	2	Metal/Cloth	50/50	Strap, come along, from SDSBC-1580				TRU	S5390-02
1580	3	Metal	100	Skill saw	N/P	N/P	08/25/1998	Sonatol	
1580	4	Metal	100	Heat gun	N/P	N/P	08/25/1998	Sonatol	
1580	5	Metal/Rubber	60/40	Motor w/ flexible shaft	N/P	N/P	08/25/1998	Sonatol	
1580	6	Metal/Glass	95/5	Welders hood	N/P	N/P	08/25/1998	Sonatol	
1580	7	Metal	100	Large 'C' clamp	N/P	N/P	08/25/1998	Sonatol	
1580	8	Metal/Rubber	85/15	Dremel tool	N/P	N/P	08/25/1998	Sonatol	
1580	9	Metal	100	Vice	N/P	N/P	08/25/1998	Sonatol	
1580	10	Metal	100	Approximately 15' if cable w/ hook	N/P	N/P	08/25/1998	Sonatol	
1580	11	Metal	100	Approximately 7' if cable w/ 5' of chain	N/P	N/P	08/25/1998	Sonatol	
1580	12	Metal	100	Dust pan	N/P	N/P	08/25/1998	Sonatol	
1580	13	Metal/Rubber	95/5	3/8" drill	N/P	N/P	08/25/1998	Sonatol	
1580	14	Paper	100	Cardboard tube, from SDSBC-1580				TRU	S5390-02
1580	15	Metal	100	1' x 1' metal plate	N/P	N/P	08/25/1998	Sonatol	
1580	16	Plastic/Paper	95/5	Roll of duct tape, from SDSBC-1580				TRU	S5390-02
1580	17	Metal	100	Grease gun	N/P	N/P	08/25/1998	Segregate	
1580	18	Plastic	100	Polyethylene 250 ml. Bottle, from SDSBC-1580				TRU	S5390-01

Appendix A
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1580	19	Metal	100	Welding rods - approximately 10, from SDSBC-1580				Segregate	
1580	20	Metal	100	Scissors	N/P	N/P	08/25/1998	Sonatol	
1580	21	Metal/Cloth	90/10	Magic marker, from SDSBC-1580				TRU	S5390-02
1580	22	Metal	100	Quart can lid	N/P	N/P	08/25/1998	Sonatol	
1580	23	Metal	100	Wire w/ hook - approximately 2' long	N/P	N/P	08/25/1998	Sonatol	
1580	24	Metal	100	Shackel w/ hook	N/P	N/P	08/25/1998	Sonatol	
1580	25	Metal	100	Large 'C' clamp	N/P	N/P	08/25/1998	Sonatol	
1580	26	Wood/Glass /Liquid	90/5/5	2' level, from SDSBC-1580				TRU	S5390-01
1580	27	Metal	100	8" piece of angle iron	N/P	N/P	08/25/1998	Sonatol	
1580	28	Metal	100	1' x 1/2" rod	N/P	N/P	08/25/1998	Sonatol	
1580	29	Metal	100	Allen wrench	N/P	N/P	08/25/1998	Sonatol	
1580	30	Metal	100	3 - arm bag rings	N/P	N/P	08/25/1998	Sonatol	
1580	31	Metal	100	15' cable w/ hook	N/P	N/P	08/25/1998	Sonatol	
1582	1	Metal/Plastic	10/90	HEPA hose	N/P	214 lbs.	08/19/1998	TRU	S5390-01
1583	1	Wood	100	Wood from SDSBC-1583		183 lbs.		TRU	S5390-01
1583	2	Nylon	100	Rope	N/P	183 lbs.	08/24/1998	TRU	S5390-01
1583	3	Paper	100	Comapactable from SDSBC-1583		183 lbs.		TRU	S5390-02
1583	3	Plastic	100	Comapactable	N/P	183 lbs.	08/24/1998	TRU	S5390-01
1584	1	Paper	100	Compactable from SDSBC-1584		107 lbs.		TRU	S5390-02
1584	1	Plastic	100	Compactable from SDSBC-1584		107 lbs.		TRU	S5390-01
1584	2	Glass/Metal	90/10	Flood lights from SDSBC-1584		107 lbs.		Sonatol	
1584	3	Metal	100	Metal pin	N/P	107 lbs.	08/24/1998	Sonatol	
1584	4	Metal	100	Metal pin	N/P	107 lbs.	08/24/1998	Sonatol	
1584	5	Plastic	100	Paint roller from SDSBC-1584		107 lbs.		Segregate	
1586	1	Cloth	100	Cloth from MBNBC-1586	2.1 lbs.			TRU	S5390-02
1586	1	Metal	100	Berry cans	18.9 lbs.	N/P	08/25/1998	TRU	S5190-01
1589	1	Metal/Paper /Cloth	10/5/85	Prefilters	N/P	N/P	08/27/1998	TRU	S5390-02
1592	1	Cloth	100	Compactable from SDSBC-1592		135 lbs.		TRU	S5390-02
1592	1	Plastic/Cloth	100	Compactable	N/P	135 lbs.	08/28/1998	TRU	S5390-02
1617	1	Metal	100	Berry can lid	N/P	N/P	N/P	TRU	S5190-01
1617	2	Paper/Metal	98/2	Prefilter from SDSBC-1617				TRU	S5390-02
1618	1	Metal	100	Metal	N/P	N/P	N/P	Sonatol	
1618	2	Plastic	100	Compactable from SDSBC-1618				TRU	S5390-01

Appendix
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1618	3	Metal	100	Metal tube	1 lbs.	N/P	09/02/1998	Sonatol	
1618	4	Metal	100	Metal pins	2 lbs.	N/P	09/02/1998	Sonatol	
1621	1	Metal/Paper	10/90	HEPA filters	N/P	N/P	N/P	TRU	S5390-02
1621	2	Wood	100	Wood from SDSBC-1621				TRU	S5390-01
1622	1	Metal	100	Berry cans	N/P		09/08/1998	Sonatol	
1622	1	Paper	100	Compactable from can in SDSBC-1622				TRU	S5390-02
1622	1	Plastic	100	Compactable from can in SDSBC-1622				TRU	S5390-01
1623	1	Metal/Paper /Plastic	80/10 /10	2- Electrolux vacuums w/ compactable waste	N/P	N/P	09/08/1998	Sonatol	
1624	1	Wood	100	Wood	N/P	178 lbs.	09/09/1998	TRU	S5390-01
1624	2	Glass	100	Compactable from SDSBC-1624		178 lbs.		TRU	S5190-02
1624	2	Paper	100	Comapactable from SDSBC-1624		178 lbs.		TRU	S5390-02
1624	2	Plastic	100	Comapactable from SDSBC-1624		178 lbs.		TRU	S5390-01
1632	1	Paper	100	Compactable	N/P	N/P	09/14/1998	TRU	S5390-02
1632	1	Plastic	100	Compactable from SDSBC-1632				TRU	S5390-01
1633	1	Metal	100	Berry cans	N/P	N/P	09/14/1998	TRU	S5190-01
1633	1	Paper	100	Berry can contents, SDSBC-1633				TRU	S5390-02
1633	2	Rubber	100	Rubber hoses from SDSBC-1633				TRU	S5390-01
1634	1	Metal	100	Metal	N/P	N/P	09/14/1998	Sonatol	
1634	1	Plastic	100	Compactable from SDSBC-1634				TRU	S5390-01
1636	1	Glass/Rubber	5/95	Light bulbs from SDSBC-1636				Sonatol	S5122c
1636	2	Metal	100	Scrap metal	N/P	N/P	09/14/1998	Sonatol	
1636	3	Wood	100	Wood from SDSBC-1636				TRU	S5390-01
1671	1	Metal	100	Large rod marking device	N/P	N/P	12/09/1998	Sonatol	
1671	2	Metal	100	Eddie current device piece	N/P	N/P	12/09/1998	Sonatol	
1671	3	Metal	100	1 1/2' x 2' aluminum plate	N/P	N/P	12/09/1998	Sonatol	
1671	4	Metal	100	Tool box	N/P	N/P	01/20/1999	Sonatol	
1671	5	Metal	100	Angle iron w/ electric box	N/P	N/P	01/20/1999	Sonatol	
1671	6	Metal	100	Rod marking device head	N/P	N/P	01/20/1999	Sonatol	
1671	7	Metal	100	Parts to rod marking device	N/P	N/P	01/20/1999	Sonatol	
1683	1	Metal	100	Berry can.	N/P	N/P	12/09/1998	Sonatol	
1683	1	Plastic	100	Arm bag from SDNBC-1683				TRU	S5390-01
1683	1	Plastic/Soil	50/50	Sweeper bag from SDNBC-1683				TRU	S5390-02
1683	2	Metal	100	Berry can.	N/P	N/P	12/09/1998	Sonatol	
1683	3	Plastic	100	Loose arm bag from SDNBC-1683				TRU	S5390-01
1683	4	Plastic	100	Loose arm bag (2) from SDNBC-1683				TRU	S5390-01

Appendix A
JN-1 Drum Repackaging Inventory

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1683	5	Metal	100	Berry can.	N/P	N/P	12/09/1998	Sonatol	
1683	5	Paper	100	Trash from berry can in SDNBC-1683				TRU	S5390-02
1683	6	Metal	100	Berry can.	N/P	N/P	12/09/1998	Sonatol	
1683	6	Paper	100	Trash from berry can in SDNBC-1683				TRU	S5390-02
1683	7	Metal	100	Berry can	N/P	N/P	12/09/1998	Sonatol	
1683	7	Paper	100	Trash from berry can in SDNBC-1683				TRU	S5390-02
1683	8	Metal	100	Small motor	N/P	N/P	12/09/1998	Sonatol	
1683	9	Metal	100	Berry can	N/P	N/P	12/15/1998	Sonatol	
1683	9	Paper	100	Trash from berry can in SDNBC-1683				TRU	S5390-02
1683	10	Metal	100	Horizontal drilling motor	N/P	N/P	12/15/1998	Sonatol	
1683	11	Metal	100	Berry cans (3)	N/P	N/P	01/20/1999	Sonatol	
1683	11	Paper	100	Trash from berry cans (3) in SDNBC-1683				TRU	S5390-02
1726	1	Plastic	100	5 gallon bucket of plexiglass from SDSBC 1726	20 lbs.			TRU	S5390-01
1726	2	Paper/Cloth	10/90	2 - 4" pre rough filters from SDSBC-1726	2 lbs.			TRU	S5390-02
1726	3	Metal/Rubber	50/50	Electric cord	1 lbs.	N/P	02/26/1999	Sonatol	
1726	4	Rubber	100	Belt from SDSBC-1726	1 lbs.			TRU	S5390-01
1726	5	Wood	100	9 wood pieces from SDSBC-1726	1 lbs.			TRU	S5390-01
1726	6	Metal	100	Aluminum manipulator finger	1 lbs.	N/P	02/26/1999	Sonatol	
1726	7	Metal	100	Zircalloy 6" piece of thimble tube	1 lbs.	N/P	02/16/1999	Sonatol	
1726	8	Metal	100	Berry can	0.1 lbs.	N/P	03/01/1999	Sonatol	
1726	8	Paper	100	Berry can trash from SDSBC-1726	0.1 lbs.			TRU	S5390-02
1726	8	Rubber	100	Arm bag from berry can, in SDSBC-1726	0.8 lbs.			TRU	S5390-01
1726	9	Metal/Rubber	50/50	3 Flexible shaft cables	1 lbs.	N/P	03/01/1999	Sonatol	
1726	10	Metal	100	Electric motor & gear box - from eddy current device	(5 + 3) = 8 lbs.	N/P	03/04/1999	Sonatol	
1726	11	Cloth	100	Berry can trash from SDSBC-1726	0.4 lbs.			TRU	S5390-02
1726	11	Glass	100	Berry can trash from SDSBC-1726	.05 lbs.			TRU	S5190-02
1726	11	Metal	100	Berry can	0.05 lbs.	N/P	03/09/1999	Sonatol	
1726	11	Plastic	100	Trash from berry can, in SDSBC-1726	0.4 lbs.			TRU	S5390-01
1726	11	Plastic	100	Vacuum hose from SDSBC-1726	2 lbs.			TRU	S5390-01
1726	11	Wood	100	Berry can trash from SDSBC-1726	0.1 lbs.			TRU	S5390-01
1726	12	Plastic	100	5' red air hose from SDSBC-1726	1 lbs.			TRU	S5390-01
1726	13	Metal/Rubber	50/50	4' multi conductor electric cord.	1 lbs.	N/P	03/17/1999	Sonatol	
1726	14	Metal	100	Berry can	*3 lbs.*	N/P	03/17/1999	Sonatol	

Drum Number	Item	Material	%	Description	Item Weight	Drum Weight	Pack Date	Repack Action	New Stream
1726	14	Misc.	100	Berry can trash from SDSBC-1726	*3 lbs.*			TRU	S5390-02
1726	15	Plexiglass	100	5 gallon bucket of plexiglass from SDSBC 1726	30 lbs.			TRU	S5390-01
1726	16	Metal	100	Berry can	*7 lbs.*	N/P	03/22/1999	Sonatol	
1726	16	Misc.	100	Berry can trash from SDSBC-1726	*7 lbs.*			TRU	S5390-02
1726	17	Metal/Rubber	50/50	10' multi conductor electric cord.	1 lbs.	N/P	03/23/1999	Sonatol	
1726	18	Plexiglass	100	Berry can bucket aligner from SDSBC-1726	2 lbs.			TRU	S5390-01
1726	19	Metal	100	Empty berry can	1 lbs.	N/P	03/24/1999	Sonatol	
1726	20	Metal	100	Vacuum nozzle	1 lbs.	N/P	03/24/1999	Sonatol	
1727	1	Metal/Rubber	50/50	5 Flex shaft cable (fm cutoff whl.)	1 lbs.	N/P	02/18/1999	Sonatol	
1727	2	Metal	100	3 - 5" x 12"plates from sabatoge unit	1 lbs.	N/P	02/18/1999	Segregate	
1727	3	Plastic	100	2 - 5 gallon buckest of plexiglass from SDNBC-1727	20 lbs.			TRU	S5390-01
1727	4	Metal	100	Bottom of storage canister	1 lbs.	N/P	02/19/1999	Sonatol	
1727	5	Metal/Rubber	60/40	Welding cable & head	5 lbs.	N/P	02/19/1999	TRU	S5390-01

Appendix B

HEC, LLC, HLC, AND A-GC HOPPER (CASK) INVENTORY

This appendix includes the hopper (cask) inventory of materials to be repackaged in the High Energy Cell of Building JN-1. The inventory was derived from logbook data included in the Decontamination and Decommissioning Report. The waste was originally generated from the HEC, LLC, HLC, and Alpha-GammaCells.[C024,P008] Information recorded for the inventory includes:

- Package number,
- Item number,
- Item description,
- Material type,
- Material composition percentage, and
- Loading date.

The itemized information provided was input to an Excel spreadsheet to aid in evaluation of the materials. The inventory spreadsheets include containers not included in the waste stream designations or volume calculations. One hopper (cask) listed in the spreadsheet is not included as it is listed as empty.[C024,P008]

Since the volumes of individual hoppers or casks vary, and the inventories of these containers contain limited information, items were not assigned to specific waste streams. The waste distribution is based on those determined from the berry can inventories. Volume percentages for each stream were calculated based on the total volumes of each berry can inventory stream. The volumes the cask streams were then calculated based on an average volume of 4 cubic foot per cask.[C024]

Appendix B

Hopper (Cask) Repackaging Inventory

Hopper (Cask) No.	Origin	Original Contents
1	HLC	Cans of compacted waste
2	HLC	Cans of compacted waste
3	HLC	Cans of compacted waste
4	HLC/LLC	B40 - soft, compatable waste wipes, etc.
		A30 - miscellaneous metal
		B17 - nonmetallic
		B22 - soft, nonmetallic, plastic, table wipes, etc.
		A21 - soft, nonmetallic, plastic, wipes, etc.
		B44 - soft, nonmetallic, sweeper bags, table wipes, etc.
		B45 - soft, nonmetallic, cords, poly tubing, wipes, etc.
		B39 - miscellaneous solid, noncompatable waste, cladding
5		Waste storage cans 5-1 - 5-13, 5-15 - 21
		NAC # 1 spacer, triple quart can w/ bum up cement slug debris
6	A/G	Cans of compacted waste plus three gallon cans
7	HLC	Cans of compacted waste
8	HLC	Cans of compacted waste
9	JN-3 Pool	35 waste storage cans.
10		One piece Combustion Engineering cruciform control rod
11		28 1-inch pieces of control rod, 13 .125-inch and 4 .042-inch poison rod pieces
12	JN-3 Pool	Uncompacted waste from the HEC
13	JN-3 Pool	Compacted waste from HLC
14		One piece Combustion Engineering cruciform control rod, fuel assembly bottom nozzle
15		24 canisters of bum up cement slugs labeled 25-48
16	JN-3 Pool	23 canisters of bum up cement slugs labeled 1-6 and 8-24
EX-16		15.5 inch by 48-inch aluminum canister containing two pieces of Combustion Engineering cruciform control rod
17	HEC	Uncompacted waste from the HEC
17A	JN-3 Pool	B-53 - Miscellaneous metal
		B-54 - N/C Metal
		B-51 - Compactable
		B-55 - Compactable
		B-59 - Soft material, table wipes, sweeper bags, etc.
		B-41 - N/C Metal solids
		B-43 - N/C soft wipes, etc.
		B-58 - Compactable waste, sling, sweeper hose, etc.
		B-4 - aluminum vials
		B-10 - Miscellaneous metal
		B-13 - sweeper hoses
		B-19 - Berry can lids
		B-21 - Blue filters
		B-23 - Miscellaneous metal
		B-24 - Blue filters
		B-29 - Towels and miscellaneous wipes
		B-32 - Blue filters
		B-37 - Miscellaneous metal
		A-1 - Misc. metal

Appendix B

Hopper (Cask) Repackaging Inventory

Hopper (Cask) No.	Origin	Original Contents
		A-2 - Non metallic
		A-7 - Alum vials
		A-11 - Misc. metal
		A-18 - Alum vials
		A-24 - Wooden pieces
		A-31 - Misc. metal
		B-52 - Blue filters
		B-50 - Blue filters
		Fifteen other miscellanous cans
18	JN-3 Pool	A-3 - Non metallic
		A-4 - Misc. metal
		A-5 - Misc. metal
		A-6 - Misc. metal
		A-9 - Alum vials
		A-10 - Misc. metal
		A-15 - Misc. metal
		A-16 - Non metallic
		A-17 - Blue filters
		A-19 - Nonmetallic
		A-25 - Misc. metal
		A-26 - Nonmetallic
		A-27 - Misc. metal
		A-28 - Misc. metal
		B-1 - Fuel rod claddings
		B-2 - Fuel rod claddings
		B-3 - Misc. metal
		B-5 - Nonmetallic
		B-6 - alum vials & steel caps
		B-8 - Nonmetallic
		B-9 - Misc. metal
		B-12 - Misc. metal
		B-14 - Misc. metal
		B-16 - Nonmetallic
		B-19 - Blue filters
		B-20 - Sweeper bags
		B-27 - Blue filters & sweeper bags
		B-29 - Towels and miscellaneous wipes
		B-30 - Misc. metal
		B-33 - Sweeper bags
		B-34 - Blue filters
		B-35 - Blue filters
		B-36 - Misc metal
		B-38 - Blue filters
19	JN-3 Pool	Forty Two waste storage cans of misc materials
20	JN-3 Pool	Twenty Three waste storage cans of misc materials
21	HEC	Cans of uncompacted waste
22	HEC	Cans of uncompacted waste
23	JN-3 Pool	Tri-Nuc Filter # 2

Appendix B

Hopper (Cask) Repackaging Inventory

Hopper (Cask) No.	Origin	Original Contents
		Tri-Nuc Filter # 3
		Tri-Nuc Filter # 3
		Tri-Nuc Filter # 4
		Tri-Nuc Filter # 7
		Tri-Nuc Filter # 18
		Tri-Nuc Filter # 19
		Fuel Grid Plate
		Burn-Up Slu # 74
		Sweeper Bag
		Drill Chunk 5 inch Bolt
		Rags
		Cloth towels and sweeper bag
		plastic,cloth wood,magnet, misc.metal
		Berry Can Unknown Contents
		Berry Can Unknown Contents
		rags/towels
		rags/tape

Appendix C

HLC BERRY CAN INVENTORY

This appendix includes the berry can inventory of materials to be repackaged in the Low Level Cell of Building JN-1. The inventory was derived from logbook data included in the Decontamination and Decommissioning Reports. The waste was originally generated from the HLC from December 1988 through February 1989. [C024,P017] Information recorded for the inventory includes:

- Package number,
- Item number,
- Item description,
- Material type,
- Material composition percentage, and
- Loading date.

The itemized information provided was input to an Excel spreadsheet to aid in evaluation of the materials. The berry can inventories were evaluated with the following methodology. The listed contents of each container were reviewed for material compositions. Items composed of the same waste material parameter category material were grouped together and listed with the material compositions and estimated volume percentages in the spreadsheets. For example, items such as towels, rope, and wood from the same container, would be grouped as one entry in the spreadsheet with the material category of cellulosics.[C024]

The estimated volume percent for each spreadsheet entry was determined based on the original inventory percentages provided, the description of the items, and the number of items in each container. The volume of each can is assumed to be one gallon.[C024]

The spreadsheet entries were then evaluated and assigned to repackaging waste streams. Items assumed capable of decontamination are assigned to the 'Sonatol' stream. Items that may require special treatment, or further investigation during packaging, such as liquids or soils, are designated with 'Segregate' in the 'Waste Stream' column.[C024]

HLC Berry Can Repackaging Inventory

Original Can No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol .(gal.)	Waste Stream
S1	14-Sep-88	Plastic & towels.	Coth	80	0.80	5390-02
S1	14-Sep-88	Plastic & towels.	Plastic	20	0.20	5390-02
S10	20-Sep-88	Wipes and towels.	Cloth	50	0.50	5390-02
S10	20-Sep-88	Wipes and towels.	Paper	50	0.50	5390-02
S100	26-Jan-88	Paper, and sweeper hose.	Cloth/Rubber/ Wire	50	0.50	5390-02
S100	26-Jan-89	Paper, and sweeper hose.	Paper	50	0.50	5390-02
S101	26-Jan-89	Cut up tubes, spec. cans (can is 75% full).	Metal	75	0.75	5190-01
S102	26-Jan-89	Metal graphic mounts whole and broken.	Plastic	100	1.00	5390-01
S103	26-Jan-89	3 inch diameter tubes and rings (can is 75% full).	Metal	75	0.75	Sonatol
S104	30-Jan-89	Compacted filters.	Paper	100	1.00	5390-02
S106	08-Feb-89	Metal and wood.	Metal	60	0.60	Sonatol
S106	08-Feb-89	Metal and wood.	Wood	40	0.40	5390-01
S108	08-Feb-89	Metal and wood.	Metal	95	0.95	Sonatol
S108	08-Feb-89	Metal and wood.	Wood	5	0.05	5390-01
S109	08-Feb-89	Metal, elec. cords, rubber hose, cut off wheels.	Metal	45	0.45	Sonatol
S109	08-Feb-89	Metal, elec. cords, rubber hose, cut off wheels.	Plastic	10	0.10	5390-01
S109	08-Feb-89	Metal, elec. cords, rubber hose, cut off wheels.	Rubber	45	0.45	5390-01
S11	28-Oct-88	Metal vials, glass, misc. metal.	Glass	5	0.05	5190-01
S11	28-Oct-88	Metal vials, glass, misc. metal.	Metal	95	0.95	Sonatol
S110	08-Feb-89	Cut up metal.	Metal	100	1.00	5190-01
S111	30-Jan-89	Wood, rubber, metal, sweeper bag, elec. wire.	Debris/Paper	25	0.25	5390-02
S111	30-Jan-89	Wood, rubber, metal, sweeper bag, elec. wire.	Metal	2	0.02	5190-01
S111	30-Jan-89	Wood, rubber, metal, sweeper bag, elec. wire.	Rubber	60	0.60	5390-01

Appendix C

HLC Berry Can Repackaging Inventory

Original Can No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol .(gal.)	Waste Stream
S111	30-Jan-89	Wood, rubber, metal, sweeper bag, elec. wire.	Wire	10	0.10	5390-01
S111	30-Jan-89	Wood, rubber, metal, sweeper bag, elec. wire.	Wood	3	0.03	5390-01
S112	08-Feb-89	Elec. cord, paper, wire.	Electric Cord	90	0.90	5390-02
S112	08-Feb-89	Elec. cord, paper, wire.	Paper	10	0.10	5390-02
S113	30-Jan-89	Cut up tubes, straps, scrap.	Metal	100	1.00	5190-01
S12	28-Oct-88	Wipes, sweeper bags, debris.	Paper	100	1.00	5390-02
S13	31-Oct-88	Motor, vials, cut off wheel, misc. metal.	Metal	100	1.00	Sonatol
S14	31-Oct-88	Wires, towels, vials, sweeper bag.	Cloth	20	0.20	5390-02
S14	31-Oct-88	Wires, towels, vials, sweeper bag.	Paper	80	0.80	5390-02
S15	02-Nov-88	Cut up metal cans.	Metal	100	1.00	5190-01
S16	02-Nov-88	Cut up metal cans, broken mirrors.	Glass	5	0.05	5190-01
S16	02-Nov-88	Cut up metal cans, broken mirrors.	Metal	95	0.95	5190-01
S18	03-Nov-88	Cut and crushed berry buckets.	Metal	100	1.00	5190-01
S19	03-Nov-88	Cut and crushed berry buckets.	Metal	100	1.00	5190-01
S2	14-Sep-88	Burst samples, specimen cans, glass.	Debris	1	0.01	5390-02
S2	14-Sep-88	Burst samples, specimen cans, glass.	Glass	1	0.01	5190-01
S2	14-Sep-88	Burst samples, specimen cans, glass.	Metal	98	0.98	5190-01
S20	07-Nov-88	Tools, vials, crushed cans.	Metal	100	1.00	Sonatol
S21	03-Nov-88	Tools, vials, misc. metal.	Metal	100	1.00	Sonatol
S22	03-Nov-88	Arm bags, sweeper bags, wipes.	Debris/Paper	70	0.70	5390-02
S22	03-Nov-88	Arm bags, sweeper bags, wipes.	Plastic	30	0.30	5390-02
S23	07-Nov-88	Arm bags, sweeper bags.	Debris/Paper	40	0.40	5390-02
S23	07-Nov-88	Arm bags, sweeper bags.	Plastic	60	0.60	5390-01
S24	07-Nov-88	Misc. metal, trays for furnaces.	Metal	100	1.00	Sonatol
S25	07-Nov-88	Wipes, plastic, sweeper bags.	Debris/Paper	85	0.85	5390-02
S25	07-Nov-88	Wipes, plastic, sweeper bags.	Plastic	15	0.15	5390-02
S26	07-Nov-88	Crushed cans, Al., elec. wire.	Metal	90	0.90	5190-01
S26	07-Nov-88	Crushed cans, Al., elec. wire.	Plastic/Rubber	10	0.10	5390-01
S27	07-Nov-88	Misc. metal, poison rod clad, tensil specs. (can 75% full)	Metal	75	0.75	Sonatol
S28	08-Nov-88	Cut up and crushed berry buckets.	Metal	100	1.00	5190-01

HLC Berry Can Repackaging Inventory

Original Can No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol .(gal.)	Waste Stream
S29	08-Nov-88	Compacted plastic vials, plexiglass, rope.	Fiber	10	0.10	5390-01
S29	08-Nov-88	Compacted plastic vials, plexiglass, rope.	Plastic	90	0.90	5390-01
S3	15-Sep-88	Wipes, towels, plastic vials, Dri-rite.	Cloth	40	0.40	5390-02
S3	15-Sep-88	Wipes, towels, plastic vials, Dri-rite.	Dri-rite	5	0.05	5190-02
S3	15-Sep-88	Wipes, towels, plastic vials, Dri-rite.	Paper	40	0.40	5390-02
S3	15-Sep-88	Wipes, towels, plastic vials, Dri-rite.	Plastic	15	0.15	5390-02
S30	08-Nov-88	Elec. cords, vials, filter, cut off wheels.	Metal	30	0.30	Sonatol
S30	08-Nov-88	Elec. cords, vials, filter, cut off wheels.	Paper	10	0.10	5390-02
S30	08-Nov-88	Elec. cords, vials, filter, cut off wheels.	Rubber/Wires	60	0.60	5390-01
S31	09-Nov-88	Misc. metal, glass.	Glass	10	0.10	5190-01
S31	09-Nov-88	Misc. metal, glass.	Metal	90	0.90	5190-01
S32	09-Nov-88	Cut up and compressed berry buckets.	Metal	100	1.00	5190-01
S33	09-Nov-88	Wipes, towels, sweepings.	Cloth	35	0.35	5390-02
S33	09-Nov-88	Wipes, towels, sweepings.	Debris	15	0.15	5390-02
S33	09-Nov-88	Wipes, towels, sweepings.	Paper	50	0.50	5390-02
S34	09-Nov-88	Aluminum vials.	Metal	100	1.00	Sonatol
S35	28-Nov-88	Wrenches, sockets, misc. solid metal.	Metal	100	1.00	Sonatol
S36	30-Nov-88	Aluminum vials.	Metal	100	1.00	Sonatol
S37	09-Nov-88	Metal cans and tubes, glass bulbs.	Glass	15	0.15	5190-02
S37	09-Nov-88	Metal cans and tubes, glass bulbs.	Metal	85	0.85	Sonatol
S38	30-Nov-88	Cut up solid metal.	Metal	100	1.00	5190-01
S39	01-Dec-88	Cut and crushed metal cans and boxes.	Metal	100	1.00	5190-01
S4	15-Sep-88	Towels, wipes, sweeper bag.	Cloth	25	0.25	5390-02
S4	15-Sep-88	Towels, wipes, sweeper bag.	Debris	10	0.10	5390-02
S4	15-Sep-88	Towels, wipes, sweeper bag.	Paper	65	0.65	5390-02
S40	23-Nov-88	Metal wire, vial, junk.	Metal	100	1.00	Sonatol
S41	23-Nov-88	Tools, conduit, vials.	Metal	100	1.00	Sonatol
S43	23-Nov-88	Paper, plastic, wood, cut off wheel.	Paper	70	0.70	5390-02
S43	23-Nov-88	Paper, plastic, wood, cut off wheel.	Plastic	25	0.25	5390-02
S43	23-Nov-88	Paper, plastic, wood, cut off wheel.	Wood	5	0.05	5390-02
S44	23-Nov-88	Crushed metal.	Metal	100	1.00	5190-01
S45	28-Nov-88	Wires, wipes, teflon tubing.	Metal	25	0.25	Sonatol

Appendix C

HLC Berry Can Repackaging Inventory

Original Can No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol .(gal.)	Waste Stream
S45	28-Nov-88	Wires, wipes, teflon tubing.	Paper	35	0.35	5390-02
S45	28-Nov-88	Wires, wipes, teflon tubing.	Plastic	40	0.40	5390-02
S46	28-Nov-88	Crushed metal cans.	Metal	100	1.00	5190-01
S47	29-Nov-88	Misc. metal pieces.	Metal	100	1.00	5190-01
S48	30-Nov-88	Cut up and crushed cans.	Metal	100	1.00	5190-01
S5	15-Sep-88	Wipes, plastic vials.	Paper	95	0.95	5390-02
S5	15-Sep-88	Wipes, plastic vials.	Plastic	5	0.05	5390-02
S50	29-Nov-88	Metal vials, pieces of wood.	Metal	80	0.80	Sonatol
S50	29-Nov-88	Metal vials, pieces of wood.	Wood	20	0.20	5390-01
S51	03-Jan-89	Table wipes.	Paper	100	1.00	5390-02
S52	26-Jan-89	Cladding, vials, rod (can is 75% full).	Metal	75	0.75	Sonatol
S53	27-Dec-88	Metal, tensil samples, poison rods, towel.	Cloth	75	0.75	5390-02
S53	27-Dec-88	Metal, tensil samples, poison rods, towel.	Metal	25	0.25	Sonatol
S54	13-Dec-88	Drill press parts, ultrasonic cleaner.	Metal	100	1.00	Sonatol
S55	20-Dec-88	Tools, WT. OA plug, misc. metal (can is 75% full).	Metal	75	0.75	Sonatol
S56	23-Dec-88	Al. and steel vials.	Metal	100	1.00	Sonatol
S57	28-Dec-88	Al. and steel vials.	Metal	100	1.00	Sonatol
S59	07-Dec-88	Small metal pieces, tygon.	Metal	70	0.70	5190-01
S59	07-Dec-88	Small metal pieces, tygon.	Plastic	30	0.30	5390-01
S6	20-Sep-88	Table wipes, sweeper bags.	Debris	4	0.04	5390-02
S6	20-Sep-88	Table wipes, sweeper bags.	Paper	96	0.96	5390-02
S60	07-Dec-88	Floor sweepings, water ? Filter.	Debris	80	0.80	5390-02
S60	07-Dec-88	Floor sweepings, water ? Filter.	Filter	20	0.20	5390-02
S61	28-Dec-88	Al. and steel tubes (can is 2/3 full).	Metal	67	0.67	Sonatol
S62	07-Dec-88	Floor sweepings (can 75% full).	Debris	56.25	0.56	5390-02
S62	07-Dec-88	Floor sweepings (can 75% full).	Plastic	18.75	0.19	5390-02
S63	07-Dec-88	Crushed cans.	Metal	100	1.00	5190-01
S64	07-Dec-88	Towels, wipes, sweeper bags.	Cloth	25	0.25	5390-02
S64	07-Dec-88	Towels, wipes, sweeper bags.	Debris	15	0.15	5390-02
S64	07-Dec-88	Towels, wipes, sweeper bags.	Paper	60	0.60	5390-02
S65	11-Jan-89	Cut up cans.	Metal	100	1.00	5190-01

HLC Berry Can Repackaging Inventory

Original Can No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol .(gal.)	Waste Stream
S66	09-Jan-89	Wipes, towels, sweeper bag.	Cloth	20	0.20	5390-02
S66	09-Jan-89	Wipes, towels, sweeper bag.	Debris	15	0.15	5390-02
S66	09-Jan-89	Wipes, towels, sweeper bag.	Paper	65	0.65	5390-02
S67	10-Jan-89	Wipes, towels, arm bag, sweeper bag.	Debris	15	0.15	5390-02
S67	10-Jan-89	Wipes, towels, arm bag, sweeper bag.	Paper	70	0.70	5390-02
S67	10-Jan-89	Wipes, towels, arm bag, sweeper bag.	Plastic	15	0.15	5390-02
S68	12-Jan-89	Filters and plastic.	Filter	95	0.95	5390-02
S68	12-Jan-89	Filters and plastic.	Plastic	5	0.05	5390-02
S69	12-Jan-89	Arm bags.	Plastic	100	1.00	5390-01
S7	20-Sep-88	Filter frames, wipes, sweeper bags.	Debris	4	0.04	5390-02
S7	20-Sep-88	Filter frames, wipes, sweeper bags.	Paper	96	0.96	5390-02
S70	12-Jan-89	Filters, plastic bags, wires.	Fiberglass	60	0.60	5390-02
S70	12-Jan-89	Filters, plastic bags, wires.	Metal	5	0.05	Sonatol
S70	12-Jan-89	Filters, plastic bags, wires.	Paper	20	0.20	5390-02
S70	12-Jan-89	Filters, plastic bags, wires.	Plastic	15	0.15	5390-02
S71	12-Jan-89	Filters, plastic bags.	Paper	80	0.80	5390-02
S71	12-Jan-89	Filters, plastic bags.	Plastic	20	0.20	5390-02
S72	13-Jan-89	Filters, plastic bags.	Paper	40	0.40	5390-02
S72	13-Jan-89	Filters, plastic bags.	Plastic	60	0.60	5390-02
S73	13-Jan-89	Plastic, filters, elec. cords, sweeper bags.	Debris	5	0.05	5390-02
S73	13-Jan-89	Plastic, filters, elec. cords, sweeper bags.	Fiberglass	45	0.45	5390-02
S73	13-Jan-89	Plastic, filters, elec. cords, sweeper bags.	Metal	5	0.05	5390-02
S73	13-Jan-89	Plastic, filters, elec. cords, sweeper bags.	Paper	40	0.40	5390-02
S73	13-Jan-89	Plastic, filters, elec. cords, sweeper bags.	Plastic	5	0.05	5390-02
S74	18-Jan-89	Metal and wood.	Metal	35	0.35	Sonatol
S74	18-Jan-89	Metal and wood.	Wood	65	0.65	5390-01
S75	18-Jan-89	Arm bags.	Plastic	100	1.00	5390-01
S76	18-Jan-89	Filter, armbags, misc. metal, fire brick.	Firebrick	15	0.15	5190-02
S76	18-Jan-89	Filter, armbags, misc. metal, fire brick.	Metal	15	0.15	Sonatol

Appendix C

HLC Berry Can Repackaging Inventory

Original Can No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol .(gal.)	Waste Stream
S76	18-Jan-89	Filter, armbags, misc. metal, fire brick.	Paper	35	0.35	5390-02
S76	18-Jan-89	Filter, armbags, misc. metal, fire brick.	Plastic	35	0.35	5390-01
S77	18-Jan-89	Water filters, plastic, glass, poly funnels.	Filter	30	0.30	5390-02
S77	18-Jan-89	Water filters, plastic, glass, poly funnels.	Glass	5	0.05	5190-02
S77	18-Jan-89	Water filters, plastic, glass, poly funnels.	Plastic	65	0.65	5390-02
S78	13-Jan-89	Crushed cans, machine parts.	Metal	100	1.00	5190-01
S79	18-Jan-89	Crushed metal boxes, vials.	Metal	100	1.00	5190-01
S8	20-Sep-88	Paper, 1 metal tube.	Metal	2	0.02	Sonatol
S8	20-Sep-88	Paper, 1 metal tube.	Paper	98	0.98	5390-02
S80	18-Jan-89	Crushed cans, vials, misc. metal.	Metal	100	1.00	5190-01
S81	26-Jan-89	Metal graphic mounts, plastic, vials.	Metal	20	0.20	Sonatol
S81	26-Jan-89	Metal graphic mounts, plastic, vials.	Plastic	80	0.80	5390-01
S82	13-Jan-89	Cut up metal (surveillance capsules)	Metal	100	1.00	5190-01
S83	26-Jan-89	Crushed cans and tackle boxes.	Metal	100	1.00	5190-01
S84	26-Jan-89	Cut up metal, cladding.	Metal	100	1.00	5190-01
S85	26-Jan-89	Crushed cans, misc. metal.	Metal	100	1.00	5190-01
S86	26-Jan-89	Metal graphic mounts, vials, sweeper bags.	Debris	5	0.05	5390-02
S86	26-Jan-89	Metal graphic mounts, vials, sweeper bags.	Metal	20	0.20	Sonatol
S86	26-Jan-89	Metal graphic mounts, vials, sweeper bags.	Paper	20	0.20	5390-02
S86	26-Jan-89	Metal graphic mounts, vials, sweeper bags.	Plastic	55	0.55	5390-01
S87	26-Jan-89	Crushed buckets and tackle boxes.	Metal	100	1.00	5190-01
S88	26-Jan-89	Crushed berry buckets.	Metal	100	1.00	5190-01
S89	30-Jan-89	Cut and crushed metal.	Metal	100	1.00	5190-01
S9	20-Sep-98	Filters, sweeper bags, plastic vials.	Paper	90	0.90	5390-02
S9	20-Sep-98	Filters, sweeper bags, plastic vials.	Plastic	10	0.10	5390-02
S90	30-Jan-89	Firebricks and wood.	Firebrick	50	0.50	5190-01
S90	30-Jan-89	Firebricks and wood.	Wood	50	0.50	5390-01

HLC Berry Can Repackaging Inventory

Original Can No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol .(gal.)	Waste Stream
S94	30-Jan-89	Cut up metal tubes (can 50% full).	Metal	50	0.50	5190-01
S95	30-Jan-89	Crushed tackle boxes, plastic vials.	Metal	98	0.98	5190-01
S95	30-Jan-89	Crushed tackle boxes, plastic vials.	Plastic	2	0.02	5390-01
S96	30-Jan-89	Wood	Wood	100	1.00	5390-01
S97	30-Jan-89	Compact, sweeper hose, wood, plastic.	Cloth/Rubber /Wire	25	0.25	5390-02
S97	30-Jan-89	Compact, sweeper hose, wood, plastic.	Paper	25	0.25	5390-02
S97	30-Jan-89	Compact, sweeper hose, wood, plastic.	Plastic	25	0.25	5390-02
S97	30-Jan-89	Compact, sweeper hose, wood, plastic.	Wood	25	0.25	5390-02
S98	30-Jan-89	Cut up expanded metal.	Metal	100	1.00	5190-01
S99	30-Jan-89	Wood and wipes.	Paper	5	0.05	5390-02
S99	30-Jan-89	Wood and wipes.	Wood	95	0.95	5390-02

Appendix D

ALPHA-GAMMA CELLS BERRY CAN INVENTORY

This appendix includes the berry can inventory of materials to be repackaged in the Low Level Cell of Building JN-1. The inventory was derived from Waste Package Loading Records for 206 cans of waste from the Alpha-Gamma Cells generated from June to September 1999.[C024] Information recorded for the inventory includes:

- Package number,
- Item number,
- Item description,
- Material type,
- Material composition percentage, and
- Loading date.

The itemized information provided was input to an Excel spreadsheet to aid in evaluation of the materials. The inventory spreadsheets include containers not included in the waste stream designations or volume calculations. Of the 205 berry cans from the Alpha-Gamma cells, 40 will require further investigation, or treatment before repackaging. This includes 35 cans originally generated in Cells 5 and 6, and five cans containing liquids.[C024]

The berry can inventories were evaluated with the following methodology. The listed contents of each container were reviewed for material compositions. Items composed of the same waste material parameter category material were grouped together and listed with the material compositions and estimated volume percentages in the spreadsheets. For example, items such as towels, rope, and wood from the same container, would be grouped as one entry in the spreadsheet with the material category of cellulosics.[C024]

The estimated volume percent for each spreadsheet entry was determined based on the original inventory percentages provided, the description of the items, and the number of items in each container. The volume of each can is assumed to be one gallon.[C024]

The spreadsheet entries were then evaluated and assigned to repackaging waste streams. Items assumed capable of decontamination are assigned to the 'Sonatol' stream. Items that may require special treatment, or further investigation during packaging, such as liquids or soils, are designated with 'Segregate' in the 'Waste Stream' column.[C024]

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
1-07-AGC	Berry	1	25-Aug-99	Aluminum lid	Aluminum	5	0.05	Sonatol
07-16-AGC	Sm. Berry	7	19-Jul-99	Aluminum foil	Aluminum	5	0.05	5190-02
07-32-AGC	Sm. Berry	7	21-Jul-99	Aluminum foil	Aluminum	25	0.25	5190-02
07-42-AGC	Sm. Berry	7	23-Jul-99	Aluminum foil	Aluminum	20	0.20	5190-02
07-50-AGC	Sm. Berry	7	28-Jul-99	Aluminum foil	Aluminum	20	0.20	5190-02
07-60-AGC	Sm. Berry	7	05-Aug-99	Light socket	Aluminum	10	0.10	Sonatol
08-02-AGC	Sm. Berry	8	09-Aug-99	Rod	Aluminum	10	0.10	Sonatol
03-01-AGC	Berry	3	18-Jun-99	Manipulator arm part	Aluminum/metal	20	0.20	Sonatol
03-07-AGC	Berry	3	07-Jul-99	Manipulator arm part	Aluminum/metal	20	0.20	Sonatol
04-07-AGC	Berry	4	07-Jul-99	Manipulator arm parts	Aluminum/Metal	25	0.25	Sonatol
1-04-AGC	Berry	1	13-Jun-99	Cotton Balls	Cellulosics	25	0.25	5390-02
1-07-AGC	Berry	1	25-Aug-99	Cotton Balls	Cellulosics	5	0.05	5390-02
02-01-AGC	Berry	2	12-Jul-99	Chem wipes	Cellulosics	50	0.50	5390-02
02-02-AGC	Sm. Berry	2	12-Jul-99	Cotton Balls	Cellulosics	1	0.01	5390-02
02-03-AGC	Sm. Berry	2	12-Jul-99	Cotton Balls	Cellulosics	5	0.05	5390-02
02-04-AGC	Sm. Berry	2	12-Jul-99	Cotton Balls	Cellulosics	5	0.05	5390-02
02-07-AGC	Berry	2	12-Jul-99	Absorb. Pad, teri towels	Cellulosics	40	0.40	5390-02
02-08-AGC	Berry	2	12-Jul-99	Teri towels, cardboard	Cellulosics	60	0.60	5390-02
02-09-AGC	Sm. Berry	2	12-Jul-99	Cotton Balls	Cellulosics	5	0.05	5390-02
02-09-AGC	Sm. Berry	2	12-Jul-99	Cotton Balls	Cellulosics	5	0.05	5390-02
02-10-AGC	Sm. Berry	2	12-Jul-99	Teri towels	Cellulosics	50	0.50	5390-02
02-11-AGC	Berry	2	13-Jul-99	Teri towels, wipes, cotton balls	Cellulosics	40	0.40	5390-02
02-12-AGC	Berry	2	13-Jul-99	Wipes	Cellulosics	40	0.40	5390-02
02-17-AGC	Lg. Berry	2	16-Aug-99	Decon rags	Cellulosics	50	0.50	5390-02
03-01-AGC	Berry	3	18-Jun-99	Sand paper, wipes	Cellulosics	20	0.20	5390-02
03-02-AGC	Sm. Berry	3	07-Jul-99	Cotton Balls	Cellulosics	5	0.05	5390-02
03-03-AGC	Sm. Berry	3	07-Jul-99	Cotton Balls	Cellulosics	5	0.05	5390-02
03-04-AGC	Sm. Berry	3	07-Jul-99	Terri towels	Cellulosics	100	1.00	5390-02
03-05-AGC	Sm. Berry	3	07-Jul-99	Terri towels, cardboard	Cellulosics	100	1.00	5390-02
03-06-AGC	Sm. Berry	3	07-Jul-99	Terri towels, cardboard	Cellulosics	100	1.00	5390-02
03-08-AGC	Berry	3	07-Jul-99	Teri towels, sand paper, cardboard	Cellulosics	40	0.40	5390-02
03-08-AGC	Berry	3	07-Jul-99	paper, cardboard	Cellulosics	20	0.20	5390-02
03-10-AGC	Lg. Berry	3	07-Jul-99	Decon rags	Cellulosics	50	0.50	5390-02
03-10-AGC	Lg. Berry	3	07-Jul-99	Decon rags	Cellulosics	50	0.50	5390-02
04-01-AGC	Berry	4	06-Jul-99	Teri towels, cardboard	Cellulosics	100	1.00	5390-02

Appendix D

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
04-02-AGC	Berry	4	06-Jul-99	Teri towels, cardboard	Cellulosics	100	1.00	5390-02
04-03-AGC	Berry	4	06-Jul-99	Teri towels	Cellulosics	100	1.00	5390-02
04-04-AGC	Berry	4	06-Jul-99	Teri towels, cardboard	Cellulosics	100	1.00	5390-02
04-05-AGC	Berry	4	06-Jul-99	Teri towels, cardboard, cotton balls	Cellulosics	50	0.50	5390-02
04-06-AGC	Berry	4	07-Jul-99	Sand paper, wipes, rags, teri towels	Cellulosics	85	0.85	5390-02
04-07-AGC	Berry	4	07-Jul-99	Sand paper	Cellulosics	25	0.25	5390-02
04-09-AGC	Berry	4	15-Jul-99	Rag	Cellulosics	10	0.10	5390-02
04-10-AGC	Lg. Berry	4	16-Aug-99	Yellow decon rags	Cellulosics	100	1.00	5390-02
04-11-AGC	Sm. Berry	4	16-Aug-99	Masking tape	Cellulosics	25	0.25	5390-02
AG-04-A	Sm. Berry	4	14-Jul-99	Teri wipes	Cellulosics	50	0.50	5390-02
AG-04-BAG5	Sm. Bag	4	14-Jul-99	Paint brush, ruler	Cellulosics	30	0.30	5390-02
06-06-AGC	Sm. Berry	6	01-Sep-99	String	Cellulosics	10	0.10	Segregate
07-09-AGC	Sm. Berry	7	19-Jul-99	Chem wipes	Cellulosics	20	0.20	5390-02
07-10-AGC	Sm. Berry	7	19-Jul-99	Chem wipes, rags	Cellulosics	50	0.50	5390-02
07-14-AGC	Sm. Berry	7	19-Jul-99	Rag	Cellulosics	25	0.25	5390-02
07-25-AGC	Sm. Berry	7	20-Jul-99	Chem wipes	Cellulosics	25	0.25	5390-02
07-26-AGC	Sm. Berry	7	20-Jul-99	Chem wipes	Cellulosics	25	0.25	5390-02
07-30-AGC	Sm. Berry	7	21-Jul-99	Teri towels	Cellulosics	20	0.20	5390-02
07-31-AGC	Sm. Berry	7	21-Jul-99	Rag, teri towels	Cellulosics	20	0.20	5390-02
07-32-AGC	Sm. Berry	7	21-Jul-99	String, teri towels	Cellulosics	40	0.40	5390-02
07-33-AGC	Sm. Berry	7	21-Jul-99	Rope, string, teri towels	Cellulosics	50	0.50	5390-02
07-37-AGC	Sm. Berry	7	23-Jul-99	Teri towels	Cellulosics	25	0.25	5390-02
07-38-AGC	Sm. Berry	7	23-Jul-99	String, teri towels	Cellulosics	75	0.75	5390-02
07-40-AGC	Sm. Berry	7	23-Jul-99	Teri towels	Cellulosics	25	0.25	5390-02
07-41-AGC	Sm. Berry	7	23-Jul-99	String, teri towels	Cellulosics	32	0.32	5390-02
07-42-AGC	Sm. Berry	7	23-Jul-99	Teri towels	Cellulosics	15	0.15	5390-02
07-43-AGC	Sm. Berry	7	23-Jul-99	Teri towels	Cellulosics	25	0.25	5390-02
07-44-AGC	Sm. Berry	7	23-Jul-99	Teri towels	Cellulosics	20	0.20	5390-02
07-50-AGC	Sm. Berry	7	28-Jul-99	String, teri towels	Cellulosics	20	0.20	5390-02
07-51-AGC	Sm. Berry	7	27-Jul-99	String, teri towels	Cellulosics	20	0.20	5390-02
07-53-AGC	Sm. Berry	7	30-Jul-99	String	Cellulosics	5	0.05	5390-01
07-63-AGC	Berry	7	26-Aug-99	Rags	Cellulosics	100	1.00	5390-02
07-64-AGC	Berry	7	26-Aug-99	Rags	Cellulosics	100	1.00	5390-02
07-65-AGC	Berry	7	26-Aug-99	Rags	Cellulosics	100	1.00	5390-02
07-66-AGC	Berry	7	26-Aug-99	Rags	Cellulosics	100	1.00	5390-02

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
07-67-AGC	Berry	7	26-Aug-99	Rags	Cellulosics	100	1.00	5390-02
07-68-AGC	Berry	7	26-Aug-99	Rags	Cellulosics	95	0.95	5390-02
08-02-AGC	Sm. Berry	8	09-Aug-99	Large Q-tips	Cellulosics	20	0.20	5390-02
08-05-AGC	Sm. Berry	8	12-Aug-99	Pencil, masking tape	Cellulosics	10	0.10	5390-02
08-06-AGC	Sm. Berry	8	12-Aug-99	Pencil, ruler, paper	Cellulosics	80	0.80	5390-02
08-07-AGC	Sm. Berry	8	12-Aug-99	Photograph	Cellulosics	5	0.05	5390-02
08-09-AGC	Sm. Berry	8	12-Aug-99	Paper, cotton swab, floor sweepings	Cellulosics	50	0.50	5390-02
08-10-AGC	Sm. Berry	8	13-Aug-99	Wedge, picture, cotton ball	Cellulosics	75	0.75	5390-02
AGC-VAC-BAG	Berry	All	27-Aug-99	Vacuum bag	Cellulosics	100	1.00	5390-02
AGC-VAC-BAG-1	Berry	All	27-Aug-99	Vacuum prefilter	Cellulosics	100	1.00	5390-02
07-55-AGC	Sm. Berry	7	03-Aug-99	String, heater flask w/ elec. Cord (may contain asbestos)	Cellulosics/Copper	100	1.00	5390-02
02-18-AGC	Lg. Berry	2	16-Aug-99	Broken glass trays	Glass	100	1.00	5190-01
04-07-AGC	Berry	4	07-Jul-99	Crushed light	Glass	25	0.25	5190-02
07-11-AGC	Sm. Berry	7	19-Jul-99	Crushed light bulb	Glass	3	0.03	5190-02
07-14-AGC	Sm. Berry	7	19-Jul-99	Crushed light bulb	Glass	5	0.05	5190-02
07-16-AGC	Sm. Berry	7	19-Jul-99	Crushed light bulb	Glass	5	0.05	5190-02
07-18-AGC	Sm. Berry	7	19-Jul-99	Crushed light bulb	Glass	4	0.04	5190-02
07-19-AGC	Sm. Berry	7	20-Jul-99	Light bulb pieces, bottle pieces	Glass	25	0.25	5190-02
07-20-AGC	Sm. Berry	7	20-Jul-99	Broken glass pieces	Glass	20	0.20	5190-01
07-21-AGC	Sm. Berry	7	20-Jul-99	Broken glass pieces	Glass	20	0.20	5190-01
07-23-AGC	Sm. Berry	7	20-Jul-99	Broken glass pieces	Glass	5	0.05	5190-01
07-25-AGC	Sm. Berry	7	20-Jul-99	Broken glass pieces	Glass	5	0.05	5190-02
07-26-AGC	Sm. Berry	7	20-Jul-99	Light bulb pieces	Glass	5	0.05	5190-02
07-27-AGC	Sm. Berry	7	20-Jul-99	Broken glass pieces	Glass	20	0.20	5190-01
07-28-AGC	Sm. Berry	7	21-Jul-99	Broken glass pieces	Glass	25	0.25	5190-01
07-29-AGC	Sm. Berry	7	21-Jul-99	Broken glass pieces	Glass	20	0.20	5190-01
07-30-AGC	Sm. Berry	7	21-Jul-99	Broken glass pieces	Glass	5	0.05	5190-02
07-31-AGC	Sm. Berry	7	21-Jul-99	Glass tubing, broken glass	Glass	20	0.20	5190-02
07-38-AGC	Sm. Berry	7	23-Jul-99	Sample tube	Glass	10	0.10	5190-02
07-39-AGC	Sm. Berry	7	23-Jul-99	Broken glass, sample tube	Glass	35	0.35	5190-01
07-40-AGC	Sm. Berry	7	23-Jul-99	Broken glass	Glass	25	0.25	5190-02
07-42-AGC	Sm. Berry	7	23-Jul-99	Broken glass	Glass	20	0.20	5190-02
07-43-AGC	Sm. Berry	7	23-Jul-99	Broken Glass	Glass	25	0.25	5190-02
07-44-AGC	Sm. Berry	7	23-Jul-99	Broken glass	Glass	20	0.20	5190-02

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
07-45-AGC	Sm. Berry	7	26-Jul-99	Broken glass	Glass	25	0.25	5190-01
07-46-AGC	Sm. Berry	7	26-Jul-99	Broken glass	Glass	25	0.25	5190-01
07-48-AGC	Berry	7	27-Jul-99	Broken glass beaker	Glass	5	0.05	5190-02
07-51-AGC	Sm. Berry	7	27-Jul-99	Broken glass pieces	Glass	15	0.15	5190-02
07-54-AGC	Sm. Berry	7	03-Aug-99	Bronken light bulb pieces	Glass	10	0.10	5190-02
07-56-AGC	Sm. Berry	7	03-Aug-99	Broken glass pieces	Glass	80	0.80	5190-01
07-57-AGC	Sm. Berry	7	05-Aug-99	Glass shards	Glass	20	0.20	5190-01
07-59-AGC	Sm. Berry	7	05-Aug-99	Broken glass	Glass	30	0.30	5190-01
07-60-AGC	Sm. Berry	7	05-Aug-99	Glass shards and pieces	Glass	30	0.30	5190-01
07-62-AGC	Sm. Berry	7	13-Aug-99	Broken glass	Glass	33	0.33	5190-01
08-05-AGC	Sm. Berry	8	12-Aug-99	Sample beaker, shard	Glass	15	0.15	5190-02
03-06-AGC	Berry	3	07-Jul-99	Crushed Light Bulb	Glass/metal	10	0.10	5190-02
02-13-AGC	2L Nalgene	2	12-Aug-99	Bottles with residue	Liquid	NA		Segregate
02-14-AGC	2L Nalgene	2	12-Aug-99	Bottles with liquids	Liquid	NA		Segregate
02-15-AGC	2L Nalgene	2	12-Aug-99	Bottles with solvent	Liquid	NA		Segregate
02-16-AGC	Acrylic Jar	2	27-Aug-99	Acid	Liquid	NA		Segregate
1-04-AGC	Berry	1	13-Jun-99	Metmount holder & washer	Metal	50	0.50	Sonatol
02-05-AGC	Berry	2	12-Jul-99	Metmount holders	Metal	50	0.50	Sonatol
02-06-AGC	Berry	2	12-Jul-99	Metmount holders	Metal	50	0.50	Sonatol
02-07-AGC	Berry	2	12-Jul-99	Metmount holders	Metal	20	0.20	Sonatol
02-08-AGC	Berry	2	12-Jul-99	Metmount holders	Metal	40	0.40	Sonatol
02-09-AGC	Sm. Berry	2	12-Jul-99	Metmount holder, washer	Metal	45	0.45	Sonatol
02-10-AGC	Sm. Berry	2	12-Jul-99	Metmount holders	Metal	50	0.50	Sonatol
02-11-AGC	Berry	2	13-Jul-99	Plate (2"x3")	Metal	20	0.20	Sonatol
02-12-AGC	Berry	2	13-Jul-99	Allen wrench	Metal	10	0.10	Sonatol
03-01-AGC	Berry	3	18-Jun-99	Grinder part	Metal	20	0.20	Sonatol
03-03-AGC	Sm. Berry	3	07-Jul-99	Metal Spacer	Metal	25	0.25	Sonatol
03-07-AGC	Berry	3	07-Jul-99	Vice grips (2), metal wheel	Metal	40	0.40	Sonatol
03-08-AGC	Berry	3	07-Jul-99	Vice grips, plate	Metal	20	0.20	Sonatol
03-09-AGC	Sm. Berry	3	07-Jul-99	Metal	Metal	100	1.00	5190-01
04-09-AGC	Berry	4	15-Jul-99	Berry can lid	Metal	10	0.10	Sonatol
AG-04-BAG1	Sm. Bag	4	14-Jul-99	Steel bracket 2' long	Metal	100		Sonatol
AG-04-BAG2	Sm. Bag	4	14-Jul-99	Steel ready rod 1.5' long	Metal	100		Sonatol
AG-04-BAG3	Sm. Bag	4	14-Jul-99	Steel angle 1' long	Metal	100		Sonatol
AG-04-BAG4	Sm. Bag	4	14-Jul-99	Steel angles 1' long (2)	Metal	100		Sonatol

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
07-09-AGC	Sm. Berry	7	19-Jul-99	Bracket	Metal	20	0.20	Sonatol
07-27-AGC	Sm. Berry	7	20-Jul-99	Bracket	Metal	20	0.20	Sonatol
07-29-AGC	Sm. Berry	7	21-Jul-99	Cable	Metal	5	0.05	Sonatol
07-30-AGC	Sm. Berry	7	21-Jul-99	Bracket	Metal	10	0.10	Sonatol
07-37-AGC	Sm. Berry	7	23-Jul-99	Bracket	Metal	10	0.10	Sonatol
07-38-AGC	Sm. Berry	7	23-Jul-99	Metal hook	Metal	10	0.10	Sonatol
07-46-AGC	Sm. Berry	7	26-Jul-99	Cable	Metal	5	0.05	Sonatol
07-47-AGC	Sm. Berry	7	26-Jul-99	Hook	Metal	10	0.10	Sonatol
07-53-AGC	Sm. Berry	7	30-Jul-99	Screws, clamp	Metal	10	0.10	Sonatol
07-54-AGC	Sm. Berry	7	03-Aug-99	Clamps	Metal	10	0.10	Sonatol
07-56-AGC	Sm. Berry	7	03-Aug-99	Small rod	Metal	20	0.20	Sonatol
07-59-AGC	Sm. Berry	7	05-Aug-99	Bracket	Metal	10	0.10	Sonatol
07-60-AGC	Sm. Berry	7	05-Aug-99	Metal clip	Metal	10	0.10	Sonatol
07-61-AGC	Sm. Berry	7	06-Aug-99	Scale readoust	Metal	5	0.05	Sonatol
08-01-AGC	Sm. Berry	8	09-Aug-99	Metal pieces	Metal	20	0.20	5190-01
08-02-AGC	Sm. Berry	8	09-Aug-99	Allen wrench, tweezers	Metal	10	0.10	Sonatol
08-05-AGC	Sm. Berry	8	12-Aug-99	Manipulator spring, brackets, reflector	Metal	35	0.35	Sonatol
08-06-AGC	Sm. Berry	8	12-Aug-99	Large reflector	Metal	10	0.10	Sonatol
08-07-AGC	Sm. Berry	8	12-Aug-99	Allen wrench	Metal	5	0.05	Sonatol
08-10-AGC	Sm. Berry	8	13-Aug-99	Metal washer	Metal	5	0.05	Sonatol
AG-04-BAG5	Sm. Bag	4	14-Jul-99	3 in 1 oil (75% full of oil)	Metal/Oil	35		Segregate
07-58-AGC	Sm. Berry	7	05-Aug-99	Light socket with cord	Metal/Rubber	100	1.00	5390-01
AG-04-A	Sm. Berry	4	14-Jul-99	Light fixture w/ cord	Metal/Rubber/Glass	25	0.25	5390-02
04-09-AGC	Berry	4	15-Jul-99	Brush	Metal/Wood/Plastic	10	0.10	5390-02
1-07-AGC	Berry	1	25-Aug-99	Copper disk and weight	Other inorganic	5	0.05	Sonatol
04-07-AGC	Berry	4	07-Jul-99	Concrete chips	Other inorganic	25	0.25	5190-02
1-07-AGC	Berry	1	25-Aug-99	Bag with paint chips	Other organic	5	0.05	Segregate
1-01-AGC	Sm. Berry	1	16-Jun-99	Metmounts (4)	Plastic	100	1.00	5390-01
1-02-AGC	Sm. Berry	1	17-Jun-99	Sleeving	Plastic	100	1.00	5390-01
1-03-AGC	Sm. Berry	1	18-Jun-99	Sleeving	Plastic	100	1.00	5390-01
1-04-AGC	Berry	1	13-Jun-99	Lid	Plastic	25	0.25	5390-02
1-06-AGC	Berry	1	25-Aug-99	Bags	Plastic	100	1.00	5390-01

Appendix D

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
1-07-AGC	Berry	1	25-Aug-99	Sample Bottles, Metmounts (21), petri dishes, bags,	Plastic	80	0.80	5390-02
02-01-AGC	Berry	2	12-Jul-99	Sleeving	Plastic	50	0.50	5390-02
02-02-AGC	Sm. Berry	2	12-Jul-99	Metmounts (23),lids, bottle	Plastic	99	0.99	5390-02
02-03-AGC	Sm. Berry	2	12-Jul-99	Bottles (8)	Plastic	95	0.95	5390-02
02-04-AGC	Sm. Berry	2	12-Jul-99	Bottles (7)	Plastic	95	0.95	5390-01
02-05-AGC	Berry	2	12-Jul-99	Sleeving	Plastic	50	0.50	5390-01
02-06-AGC	Berry	2	12-Jul-99	Sleeving	Plastic	50	0.50	5390-01
02-07-AGC	Berry	2	12-Jul-99	Sleeving, rope (nylon)	Plastic	40	0.40	5390-02
02-09-AGC	Sm. Berry	2	12-Jul-99	Metmount, lid, bottle	Plastic	50	0.50	5390-02
02-11-AGC	Berry	2	13-Jul-99	Bottles	Plastic	40	0.40	5390-02
02-12-AGC	Berry	2	13-Jul-99	Bottles, tygon tubing	Plastic	50	0.50	5390-02
02-17-AGC	Lg. Berry	2	16-Aug-99	Plastic bag	Plastic	50	0.50	5390-02
03-01-AGC	Berry	3	18-Jun-99	Sleeving, lid	Plastic	20	0.20	5390-02
03-02-AGC	Sm. Berry	3	07-Jul-99	Bottles (8)	Plastic	95	0.95	5390-02
03-03-AGC	Sm. Berry	3	07-Jul-99	Bottles (3)	Plastic	50	0.50	5390-02
03-07-AGC	Berry	3	07-Jul-99	Lid, bottle	Plastic	40	0.40	5390-01
03-08-AGC	Berry	3	07-Jul-99	bottle	Plastic	10	0.10	5390-02
04-05-AGC	Berry	4	06-Jul-99	Sleeving, bottle (empty)	Plastic	35	0.35	5390-01
04-06-AGC	Berry	4	07-Jul-99	Bottle (empty)	Plastic	10	0.10	5390-02
04-08-AGC	Berry	4	09-Jul-99	Sleeving	Plastic	100	1.00	5390-01
04-09-AGC	Berry	4	15-Jul-99	Bag, lid, met mounts, tygon tubing	Plastic	70	0.70	5390-02
04-11-AGC	Sm. Berry	4	16-Aug-99	Probe sleeving	Plastic	75	0.75	5390-02
AG-04-A	Sm. Berry	4	14-Jul-99	Bottle (empty)	Plastic	25	0.25	5390-02
AG-04-BAG5	Sm. Bag	4	14-Jul-99	Bottle (empty)	Plastic	35	0.35	5390-02
06-06-AGC	Sm. Berry	6	01-Sep-99	Tygon tubing, sleeving, bottle (piece)	Plastic	90	0.90	Segregate
07-05A-AGC	Berry	7	24-Aug-99	Bag	Plastic	100	1.00	5390-01
07-06-AGC	Sm. Berry	7	16-Jul-99	Lids	Plastic	50	0.50	5390-01
07-09-AGC	Sm. Berry	7	19-Jul-99	Bottle (empty)	Plastic	20	0.20	5390-02
07-11-AGC	Sm. Berry	7	19-Jul-99	Bottle (empty), bag	Plastic	33	0.33	5390-02
07-12-AGC	Sm. Berry	7	19-Jul-99	Styrofoam cups	Plastic	50	0.50	5390-01
07-13-AGC	Sm. Berry	7	19-Jul-99	Styrofoam cups	Plastic	50	0.50	5390-01
07-14-AGC	Sm. Berry	7	19-Jul-99	Styrofoam cup	Plastic	20	0.20	5390-02
07-15-AGC	Sm. Berry	7	19-Jul-99	Sleeving	Plastic	100	1.00	5390-01
07-16-AGC	Sm. Berry	7	19-Jul-99	Styrofoam cup	Plastic	25	0.25	5390-02

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
07-16-AGC	Sm. Berry	7	19-Jul-99	Bottle pieces	Plastic	20	0.20	5390-02
07-17-AGC	Sm. Berry	7	19-Jul-99	Bottle pieces	Plastic	33	0.33	5390-01
07-18-AGC	Sm. Berry	7	19-Jul-99	Bottle pieces	Plastic	32	0.32	5390-02
07-19-AGC	Sm. Berry	7	20-Jul-99	Bag, styrofoam pieces	Plastic	25	0.25	5390-02
07-20-AGC	Sm. Berry	7	20-Jul-99	Bottle pieces, styrofoam pieces	Plastic	40	0.40	5390-01
07-21-AGC	Sm. Berry	7	20-Jul-99	Bottle pieces, styrofoam pieces	Plastic	40	0.40	5390-01
07-22-AGC	Sm. Berry	7	20-Jul-99	Bag, styrofoam cups, bottle pieces	Plastic	70	0.70	5390-01
07-23-AGC	Sm. Berry	7	20-Jul-99	Bottle pieces, styrofoam pieces, syringe, tygon tubing	Plastic	45	0.45	5390-01
07-24-AGC	Sm. Berry	7	20-Jul-99	Tygon tubing, syringe, bottle pieces, styrofoam pieces	Plastic	100	1.00	5390-01
07-25-AGC	Sm. Berry	7	20-Jul-99	Styrofoam pieces, bottle (empty), tygon	Plastic	45	0.45	5390-02
07-26-AGC	Sm. Berry	7	20-Jul-99	Styrofoam pieces, bottle pieces	Plastic	45	0.45	5390-02
07-27-AGC	Sm. Berry	7	20-Jul-99	Bag, bottle pieces, styrofoam pieces	Plastic	40	0.40	5390-01
07-28-AGC	Sm. Berry	7	21-Jul-99	Bottle pieces, styrofoam pieces	Plastic	50	0.50	5390-01
07-29-AGC	Sm. Berry	7	21-Jul-99	Bottle pieces, styrofoam, tygon	Plastic	55	0.55	5390-01
07-30-AGC	Sm. Berry	7	21-Jul-99	Bottle pieces, styrofoam pieces	Plastic	30	0.30	5390-02
07-31-AGC	Sm. Berry	7	21-Jul-99	Bottle pieces, styrofoam, tygon, syringe	Plastic	45	0.45	5390-02
07-32-AGC	Sm. Berry	7	21-Jul-99	Bottle pieces	Plastic	35	0.35	5390-02
07-33-AGC	Sm. Berry	7	21-Jul-99	Bag, styrofoam cups	Plastic	25	0.25	5390-02
07-34-AGC	Sm. Berry	7	21-Jul-99	Styrofoam cups, bottle pieces, tape	Plastic	100	1.00	5390-01
07-35-AGC	Sm. Berry	7	21-Jul-99	Styrofoam cups, bottle pieces, tape	Plastic	100	1.00	5390-01
07-36-AGC	Sm. Berry	7	21-Jul-99	Styrofoam cups, bottle pieces, tape	Plastic	100	1.00	5390-01
07-37-AGC	Sm. Berry	7	23-Jul-99	Styrofoam, tygon, bottle pieces, tape	Plastic	65	0.65	5390-02
07-38-AGC	Sm. Berry	7	23-Jul-99	Tape	Plastic	5	0.05	5390-02
07-39-AGC	Sm. Berry	7	23-Jul-99	Styrofoam cups, bottle pieces, tape	Plastic	65	0.65	5390-01
07-40-AGC	Sm. Berry	7	23-Jul-99	Styrofoam cups	Plastic	25	0.25	5390-02
07-41-AGC	Sm. Berry	7	23-Jul-99	Bottle, styrofoam cups	Plastic	35	0.35	5390-02
07-42-AGC	Sm. Berry	7	23-Jul-99	Bottle pieces, empty bottles (2)	Plastic	45	0.45	5390-02
07-43-AGC	Sm. Berry	7	23-Jul-99	Bottle pieces	Plastic	25	0.25	5390-02
07-44-AGC	Sm. Berry	7	23-Jul-99	Bottles pieces, styrofoam cups	Plastic	40	0.40	5390-02
07-45-AGC	Sm. Berry	7	26-Jul-99	Bottles pieces, styrofoam cups	Plastic	50	0.50	5390-01
07-46-AGC	Sm. Berry	7	26-Jul-99	Bottle pieces, styrofoam, bag	Plastic	45	0.45	5390-01
07-47-AGC	Sm. Berry	7	26-Jul-99	Vial, bags, bottle pieces, tygon	Plastic	90	0.90	5390-01
07-48-AGC	Berry	7	27-Jul-99	Tygon tubing	Plastic	65	0.65	5390-02

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
07-49-AGC	Berry	7	28-Jul-99	Tygon pieces, empty poly bottle	Plastic	100	1.00	5390-01
07-50-AGC	Sm. Berry	7	28-Jul-99	Bag, bottle, pieces, styrofoam,	Plastic	40	0.40	5390-02
07-51-AGC	Sm. Berry	7	27-Jul-99	Empty bottles, pieces, tygon, styrofoam	Plastic	45	0.45	5390-02
07-52-AGC	Sm. Berry	7	28-Jul-99	Empty bottles, bottle pieces, tygon	Plastic	100	1.00	5390-01
07-53-AGC	Sm. Berry	7	30-Jul-99	Tygon tubing, empty bottle, tape	Plastic	85	0.85	5390-01
07-54-AGC	Sm. Berry	7	03-Aug-99	Tygon tubing, bottle, pieces, tape	Plastic	55	0.55	5390-02
07-59-AGC	Sm. Berry	7	05-Aug-99	Bottle pieces	Plastic	30	0.30	5390-01
07-60-AGC	Sm. Berry	7	05-Aug-99	Bag, tygon tubing, bottle pieces	Plastic	40	0.40	5390-01
07-61-AGC	Sm. Berry	7	06-Aug-99	Tygon, bags, scale parts, bottle pieces	Plastic	65	0.65	5390-01
07-62-AGC	Sm. Berry	7	13-Aug-99	Bottle pieces	Plastic	34	0.34	5390-01
07-68-AGC	Berry	7	26-Aug-99	Bag	Plastic	5	0.05	5390-02
08-03-AGC	Sm. Berry	8	10-Aug-99	Arm bag	Plastic	100	1.00	5390-01
08-04-AGC	Sm. Berry	8	10-Aug-99	Arm bag	Plastic	100	1.00	5390-01
08-05-AGC	Sm. Berry	8	12-Aug-99	Arm bag, tygon, lid, vial	Plastic	40	0.40	5390-02
08-06-AGC	Sm. Berry	8	12-Aug-99	Tygon tubing	Plastic	10	0.10	5390-02
08-07-AGC	Sm. Berry	8	12-Aug-99	Bag, tubing, bottles	Plastic	90	0.90	5390-02
08-08-AGC	Sm. Berry	8	12-Aug-99	Plastic bottle tops	Plastic	100	1.00	5390-01
08-09-AGC	Sm. Berry	8	12-Aug-99	Plastic bottle	Plastic	50	0.50	5390-02
08-10-AGC	Sm. Berry	8	13-Aug-99	Bottle, bag	Plastic	20	0.20	5390-02
07-69-AGC	Overpack	7	31-Aug-99	Bottle w/ unknown liquid	Plastic/Liquid	100		Segregate
03-01-AGC	Berry	3	18-Jun-99	Gasket	Rubber	20	0.20	5390-02
04-05-AGC	Berry	4	06-Jul-99	Arm bag	Rubber	15	0.15	5390-01
04-06-AGC	Berry	4	07-Jul-99	Electric cord	Rubber	5	0.05	5390-02
07-33-AGC	Sm. Berry	7	21-Jul-99	Green rubber gloves	Rubber	25	0.25	5390-02
07-50-AGC	Sm. Berry	7	28-Jul-99	Green rubber gloves	Rubber	20	0.20	5390-02
07-60-AGC	Sm. Berry	7	05-Aug-99	Rubber stoppers	Rubber	10	0.10	5390-01
08-01-AGC	Sm. Berry	8	09-Aug-99	Rubber glovebag end, foam padding	Rubber	80	0.80	5390-01
08-02-AGC	Sm. Berry	8	09-Aug-99	Foam padding	Rubber	60	0.60	5390-02
07-57-AGC	Sm. Berry	7	05-Aug-99	Elec. Cords	Rubber/Copper	80	0.80	5390-01
07-59-AGC	Sm. Berry	7	05-Aug-99	Elec. Cords	Rubber/Copper	30	0.30	5390-01
07-09-AGC	Sm. Berry	7	19-Jul-99	Soil	Soil	20	0.20	Segregate
07-10-AGC	Sm. Berry	7	19-Jul-99	Soil	Soil	25	0.25	Segregate
07-11-AGC	Sm. Berry	7	19-Jul-99	Soil	Soil	32	0.32	Segregate
07-14-AGC	Sm. Berry	7	19-Jul-99	Soil	Soil	25	0.25	Segregate
07-16-AGC	Sm. Berry	7	19-Jul-99	Soil	Soil	20	0.20	Segregate

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
07-17-AGC	Sm. Berry	7	19-Jul-99	Soil	Soil	34	0.34	Segregate
07-18-AGC	Sm. Berry	7	19-Jul-99	Soil	Soil	32	0.32	Segregate
07-19-AGC	Sm. Berry	7	20-Jul-99	Soil	Soil	25	0.25	Segregate
07-20-AGC	Sm. Berry	7	20-Jul-99	Soil	Soil	20	0.20	Segregate
07-21-AGC	Sm. Berry	7	20-Jul-99	Soil	Soil	20	0.20	Segregate
07-23-AGC	Sm. Berry	7	20-Jul-99	Soil	Soil	25	0.25	Segregate
07-25-AGC	Sm. Berry	7	20-Jul-99	Soil	Soil	25	0.25	Segregate
07-26-AGC	Sm. Berry	7	20-Jul-99	Soil	Soil	25	0.25	Segregate
07-27-AGC	Sm. Berry	7	20-Jul-99	Soil	Soil	20	0.20	Segregate
07-28-AGC	Sm. Berry	7	21-Jul-99	Soil	Soil	25	0.25	Segregate
07-29-AGC	Sm. Berry	7	21-Jul-99	Soil	Soil	20	0.20	Segregate
07-30-AGC	Sm. Berry	7	21-Jul-99	Soil	Soil	15	0.15	Segregate
07-31-AGC	Sm. Berry	7	21-Jul-99	Soil	Soil	15	0.15	Segregate
07-40-AGC	Sm. Berry	7	23-Jul-99	Soil	Soil	25	0.25	Segregate
07-41-AGC	Sm. Berry	7	23-Jul-99	Soil	Soil	33	0.33	Segregate
07-43-AGC	Sm. Berry	7	23-Jul-99	Soil	Soil	25	0.25	Segregate
07-44-AGC	Sm. Berry	7	23-Jul-99	Soil	Soil	20	0.20	Segregate
07-45-AGC	Sm. Berry	7	26-Jul-99	Soil	Soil	25	0.25	Segregate
07-46-AGC	Sm. Berry	7	26-Jul-99	Soil	Soil	25	0.25	Segregate
07-51-AGC	Sm. Berry	7	27-Jul-99	Soil	Soil	20	0.20	Segregate
07-61-AGC	Sm. Berry	7	06-Aug-99	Soil	Soil	30	0.30	Segregate
07-62-AGC	Sm. Berry	7	13-Aug-99	Soil	Soil	33	0.33	Segregate
07-01-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	100	1.00	3150-01
07-02-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	100	1.00	3150-01
07-03-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	100	1.00	3150-01
07-04-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	100	1.00	3150-01
07-05-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	100	1.00	3150-01
07-06-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	50	0.50	3150-01
07-07-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	100	1.00	3150-01
07-08-AGC	Sm. Berry	7	16-Jul-99	Burn up slugs	Solidified Liquids	100	1.00	3150-01
07-09-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	20	0.20	3150-01
07-10-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	25	0.25	3150-01
07-11-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	32	0.32	3150-01
07-12-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	50	0.50	3150-01
07-13-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	50	0.50	3150-01

Appendix D

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
07-14-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	25	0.25	3150-01
07-16-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	25	0.25	3150-01
07-17-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	33	0.33	3150-01
07-18-AGC	Sm. Berry	7	19-Jul-99	Burn up slugs	Solidified Liquids	32	0.32	3150-01
07-19-AGC	Sm. Berry	7	20-Jul-99	Burn up slugs	Solidified Liquids	25	0.25	3150-01
07-20-AGC	Sm. Berry	7	20-Jul-99	Burn up slugs	Solidified Liquids	20	0.20	3150-01
07-21-AGC	Sm. Berry	7	20-Jul-99	Burn up slugs	Solidified Liquids	20	0.20	3150-01
07-22-AGC	Sm. Berry	7	20-Jul-99	Burn up slugs	Solidified Liquids	30	0.30	3150-01
07-23-AGC	Sm. Berry	7	20-Jul-99	Burn up slugs	Solidified Liquids	25	0.25	3150-01
07-30-AGC	Sm. Berry	7	21-Jul-99	Burn up slugs	Solidified Liquids	20	0.20	3150-01
07-42-AGC	Sm. Berry	7	23-Jul-99	Burn up slugs	Solidified Liquids	20	0.20	3150-01
07-54-AGC	Sm. Berry	7	03-Aug-99	Burn up slugs	Solidified Liquids	25	0.25	3150-01
07-48-AGC	Berry	7	27-Jul-99	Sweepings	Sweepings	30	0.30	5390-02
03-03-AGC	Sm. Berry	3	07-Jul-99	Bottle of abraisive powder	UNK	25	0.25	Segregate
C4-1	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-10	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-11	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-12	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-13	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-14	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-15	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-16	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-17	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-18	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-19	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-2	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-20	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-21	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-22	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-23	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-24	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-25	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-26	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-27	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-28	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
C4-29	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-3	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-30	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-31	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-32	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-33	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-34	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-35	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-36	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-4	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-5	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-6	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-7	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-8	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
C4-9	Berry	4	30-Jun-99	Legacy Waste	UNK	100	1.00	
05-01-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-02-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-03-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-04-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-05-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-06-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-07-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-08-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-09-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-10-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-11-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-12-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-13-AGC		5		In SDSBC 1935(LLW), thought LLW	UNK	100		Segregate
05-14-AGC		5		In SDSBC 1935(LLW), thought LLW	UNK	100		Segregate
05-15-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-16-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-17-AGC		5		In SDSBC 1935(LLW), thought LLW	UNK	100		Segregate
05-18-AGC		5		In SDSBC 1935(LLW), thought LLW	UNK	100		Segregate
05-19-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-20-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate

Appendix D

Alpha/Gamma Cells Berry Can Repackaging Inventory

Original Can No.	Can Type	Cell No.	Pack Date	Original Contents	Materials	Percent	Comp. Vol. (gal.)	Waste Stream
05-21-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-22-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-23-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
05-BAG1-AGC		5		In SDSBC 1934(LLW), thought LLW	UNK	100		Segregate
06-01-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-02-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-03-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-04-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-05-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-07-AGC		6		In SDSBC 1935(LLW)	UNK	100		Segregate
06-08-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-09-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-10-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate
06-11-AGC		6		In SDSBC 1935(LLW)	UNK	100		Segregate
06-12-AGC		6		In SDSBC 1934(LLW)	UNK	100		Segregate

Technical Basis Document

Acceptable Knowledge Process Description

TRU Waste Laundry Decontamination

April 2000

TCP-98-03.1.3

UNCONTROLLED COPY

Prepared for:

Battelle Columbus Laboratories
Decommissioning Project (BCLDP)
Columbus, Ohio

Prepared by:

WASTREN, Inc.
1333 W. 120th Avenue, Suite 300
Westminster, Colorado 80234

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REVISION RECORD INDICATING LATEST DOCUMENT REVISION

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for Kevin Peters

K. Peters (Signed Copy on file) — Date: 5-23-2000

WASTREN, Inc.

This report, ***TCP-98-03.1.3, Acceptable Knowledge Process Description – TRU Waste Laundry Decontamination***, has been reviewed and approved by the following.

Approved By:

J. Eide — Date: May 23, 2000

TRU Waste Site Project Manager

1.0 INTRODUCTION

This Technical Basis Document describes the TRU waste laundry decontamination operation performed by the Battelle Columbus Laboratories Decommissioning Project (BCLDP) Transuranic Waste Certification Program (TRU WCP). Specifically, this document describes the process implemented to decontaminate TRU level cotton rags and mop heads to be disposed of as low level waste or reused in the BCLDP decontamination operations.

As described in TCP-98-03.1.2, *Repackaging of Building JN-1 Clean-Up Waste Containers,*[4] certain wastes generated during the decontamination of JN-1 hot cells will be segregated for decontamination. Rags and mop heads generated during both historical and current clean-up operations will be decontaminated using the Donini laundry unit located in the JN-1 Pump Room. The purpose of this process is to reduce the contamination of these materials allowing for low level waste disposal or reuse of the rags and mop heads for during the continuing decontamination of the JN-1 hot cells.

This report provides an auditable record that serves as a road map to the sources of acceptable knowledge (AK) used to describe the process and characterize each TRU waste stream in accordance with TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation*[1]. The purpose of this document is to identify the historical origin of the waste materials, describe the TRU waste process, and characterize the TRU waste streams that will be generated by this process as required by TCP-98-02, *Transuranic Waste Characterization Quality Assurance Project Plan (QAPjP) for the BCLDP TRU WCP*[2]. The TRU waste stream characterization is based primarily on the review of the Building JN-1 historical operations and waste inventories described in TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document,*[3] and TCP-98-03.1.2, *Repackaging of Building JN-1 Clean-Up Waste Containers,*[4] respectively.

2.0 PROCESS DESCRIPTION

Rags and mop heads generated during the clean-up operations in Building JN-1 will be transferred to the JN-1 Pump Room to be decontaminated by a Donini laundry system.[P051] Waste materials to be processed also include cotton rags, towels, and mop heads generated during repackaging of historical waste containers performed in the MTC, HEC, and LLC in Building JN-1. Figure 2-1 illustrates the TRU waste laundry decontamination process.[(4) P028]

Bags of rags and mop heads identified for decontamination will be opened and inspected on the downdraft table in the Pump Room. The rags are then pretreated by saturating them with either Spray Nine[P025] or De-Solve It[P025] and allowing the materials to soak overnight (at least 12 hours). Rags already saturated with cleaning fluids from current clean-up activities do not require pretreatment. The items are then placed in the laundry unit with 5 ounces of Trans-10 (a defoaming agent)[P025] and washed with water in cycles lasting from 99 minutes to 306 minutes depending upon the levels of contamination observed. The system uses water from two tanks that recirculates no more than 45 gallons of water through polypropylene sock filters. The wash water is recirculated and is not released as a waste stream. After the drum has been drained, the items are partially dried by a spin/dry cycle lasting 59 minutes. After the items have cooled they are removed from the system, placed on the downdraft table, and allowed to completely dry.[C028,P050]

To determine if the items are below the TRU limit, the laundered mop heads and rags are surveyed and sampled in accordance with DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis,*[(7)] and WA-OP-33, *Sampling of Waste Materials for Chemical and/or Radiological Characterization,*[(10)] respectively. If the materials are below TRU levels, they are either bagged for disposal in accordance with WA-OP-20, *Identification, Segregation, Separation and Documentation of Low Level Waste,*[(9)] or returned for reuse in decontamination operations. If the rags and mop heads have not been successfully decontaminated, the items will either be washed again or returned to the Repackaging Process (TCP-03.1.2) to be disposed of as TRU waste stream 5390-02, Hazardous Organic Debris.[(4) C028, P050]

Other wastes generated by this process include the plastic bags used to transfer the contaminated materials into the Pump Room, polypropylene sock filters, cotton lint from the lint trap, sludge from still box, and wipes used during maintenance of the system. The sock filters and lint will be packaged together with Radsorb in plastic radioactive bags. Laundry sludge from the still box is raked into plastic radioactive bags with Radsorb. Used plastic bags and wipes will be disposed of as low level waste in accordance with WA-OP-20[(9)]. The bags containing the

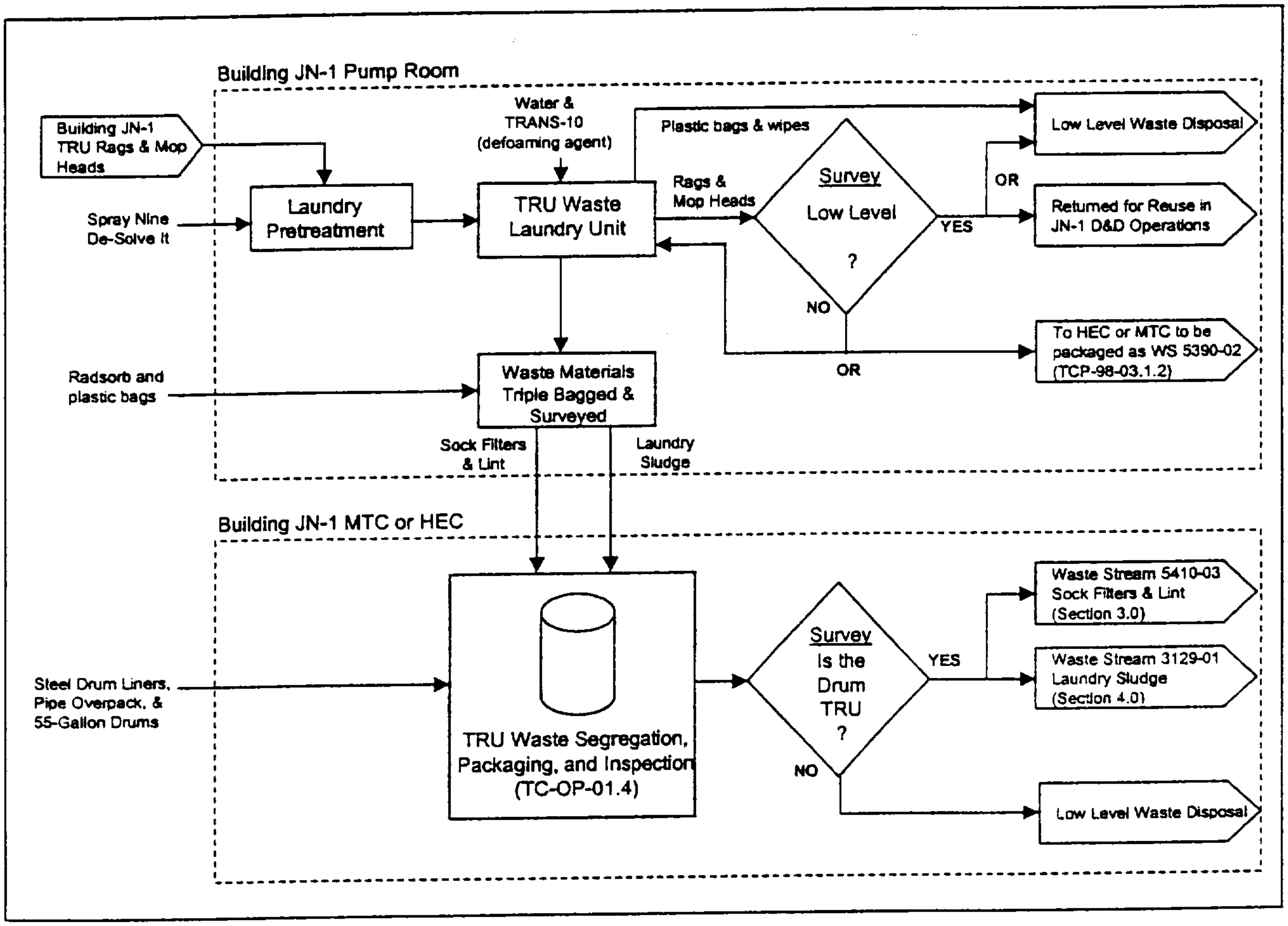

Figure 2.1. TRU Waste Laundry Decontamination Operation.

sludge and filters/lint are transferred to the MTC or HEC to be segregated into waste streams 5410-03, Sock Filters and Lint (Section 3.0) and 3129-01, Laundry Sludge (Section 4.0).[C028, P050]

During packaging the bags will be opened and the contents inspected in accordance with TC-OP-01.4, *Segregation and Packaging of TRU Waste,*[(5)] to verify AK and absence of prohibited items (e.g., free liquid). The waste will either be packaged into steel drum liners or pipe overpack containers to be placed into 55-gallon drums. No other confinement layers shall be used in the packaging of these waste streams.

As the liners are placed in 55-gallon drums, each drum will be surveyed to determine if the package is TRU in accordance with DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis.* [(7)] In addition, samples from each package within each drum will be taken and composited in accordance with WA-OP-33, *Sampling of Waste Materials for Chemical and/or Radiological Characterization.*[(10)] The samples will be analyzed to verify the

TRU content of every container. The containers determined to be low level will be managed in accordance with BCLDP-90-1, *The BCLDP Low-Level Waste Certification Plan.*[6]

3.0 LAUNDRY SOCK FILTERS AND LINT

Waste Stream ID:	5410-03
Generation Building:	Building JN-1; Pump Room[C028]
Waste Stream Volume (Projected):	3.9 m^3 [C028]
Generation Dates (Projected):	February 2000 – February 2003[C028]
EPA Hazardous Waste Numbers:	D005, D007, D008, D009, D011, F001, F002, F003, F005[3,4]
Radionuclides:	JN-1 Standard Isotopic Mix[7]
TRUCON Content Codes:	SQ121 (CH-TRU), BC321 (RH-TRU)[5]
Summary Category:	S5000[8]
Waste Matrix Code:	S5410[8]
Waste Matrix Code Group:	Filters

3.1 Waste Stream Description

Sock filters and lint are generated during the operation of the BCLDP TRU waste laundry decontamination system in the JN-1 Pump Room. This stream includes Rosedale polypropylene high-efficiency liquid filter bags and cotton lint from laundered mop heads and rags. Table 3-1 presents the waste matrix code and estimated waste material parameters for this waste stream.[C028,P049,P050]

Table 3-1. Sock Filters and Lint Waste Matrix.[C028]

Waste Stream	Waste Matrix Code	Waste Material Parameters	Weight %
5410-03, Sock Filters and Lint	S5410, Composite Filter Debris	Cellulosics (cotton lint)	40-50%
		Plastics (sock filter matrix)	20-30%
		Organic matrix (Radsorb)	10-20%
		Other Inorganic Materials	10-20%
		Iron-based Metals/Alloys	<5%

Waste Stream 5410-03, Sock Filters and Lint: This waste consists of sock filters and lint generated during the laundering of mop heads and rags. The sock filters are made of a polypropylene material supported by a carbon steel ring. The filters will collect inorganic dirt and debris contained in the mop heads and rags in addition to cotton lint originating from these materials. This stream will also contain lint collected by the lint trap during drying cycles of the laundry unit. The waste matrix will also include Radsorb (10-20% by weight) added to each liner to absorb any water from condensation or dewatering .[C028,P049,P050]

3.2 Characterization Rationale

The sock filters and lint are characterized based on the characterization of the mop heads and rags being laundered by this process (see waste stream 5390-02). This section provides a RCRA hazardous and TSCA waste determination for this waste stream.[4]

3.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40 CFR 261.23), or toxicity for organics (40 CFR 261.24), but may exhibit the characteristic of toxicity for metals originally contained in the mop heads and rags laundered by this operation.

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, any free liquid would be water and absorbents have been added to the filters to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable wastes (D001).[3,4]

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to the filters to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).[3,4]

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).[3,4]

Toxicity: The materials in this waste stream may meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. This waste stream may exhibit the characteristic of toxicity for barium, chromium, lead, mercury, and silver.[3,4]

Barium sulfate, chromic acid, potassium dichromate, mercury, and silver nitrate were used in various processes in Building JN-1. The inputs to this process (mop heads and rags) are potentially contaminated with these materials; and therefore, these metals may be concentrated in the filters. Therefore, waste stream 5410-03 is assigned EPA Hazardous Waste Numbers D005, D007, D008, D009, and D011. [3,4]

Benzene, carbon tetrachloride, methyl ethyl ketone, and trichloroethylene were used in Building JN-1. These compounds were typically used as solvents and may have contaminated the rags and mop heads. Therefore the filters will be regulated as a listed hazardous waste and not a characteristic waste since these compounds are specifically addressed in the treatment standards for listed hazardous waste. [3,4]

3.2.2 Listed Hazardous Waste

This waste stream is characterized as a listed hazardous waste because it may have been mixed with materials contaminated with spent solvents listed in 40 CFR 261, Subpart D. Based on acceptable knowledge documentation reviewed, the material is not, or was not mixed with, a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33). [3,4]

Carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, acetone, methanol, benzene, and methyl ethyl ketone were used in laboratory operations for cleaning and degreasing. The process inputs are potentially contaminated with these spent solvents. Therefore waste stream 5410-03 is assigned EPA Hazardous waste numbers F001, F002, F003, and F005.[3,4]

3.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 5410-03, is not a TSCA regulated waste.[3,4]

4.0 LAUNDRY SLUDGE

Waste Stream ID:	3129-01
Generation Building:	Building JN-1; Pump Room[C028]
Waste Stream Volume (Projected):	0.16 m^3 [C028]
Generation Dates (Projected):	February 2000 – February 2003[C028]
EPA Hazardous Waste Numbers:	D005, D007, D008, D009, D011, F001, F002, F003, F005[3,4]
Radionuclides:	JN-1 Standard Isotopic Mix[7]
TRUCON Content Codes:	SQ121 (CH-TRU), BC321 (RH-TRU)[5]
Summary Category:	S3000[8]
Waste Matrix Code:	S3129[8]
Waste Matrix Code Group:	Solidified Inorganics

4.1 Waste Stream Description

Laundry sludge is generated during the operation of the BCLDP TRU waste laundry decontamination system in the JN-1 Pump Room. Table 4-1 presents the waste matrix code and estimated waste material parameters for this waste stream.[C028,P049,P050]

Table 4-1. Laundry Sludge Waste Matrix.[C028]

Waste Stream	Waste Matrix Code	Waste Material Parameters	Weight %
3129-01, Laundry Sludge	S3129, Other Inorganic Sludges	Cellulosics (cotton lint)	10-20%
		Organic matrix (Radsorb)	10-20%
		Other Inorganic Materials	60-80%

Waste Stream 3129-01, Laundry Sludge: This waste consists of a particulate sludge (dirt, debris, and lint) generated when the laundry system still box requires cleaning, the box is heated to boil off the water contained in the particulate material. The resulting sludge is raked into plastic radioactive bags with Radsorb (10-20% by weight) added to each liner to absorb any water from condensation or dewatering .[C028,P049,P050]

4.2 Characterization Rationale

The laundry sludge is characterized based on the characterization of the mop heads and rags being laundered by this process (see waste stream 5390-02). This section provides a RCRA hazardous and TSCA waste determination for this waste stream.[4]

4.2.1 Characteristic Waste

Based on the acceptable knowledge documentation reviewed, the materials do not exhibit the characteristics of ignitability (40 CFR 261.21), corrosivity (40 CFR 261.22), reactivity (40

CFR 261.23), or toxicity for organics (40 CFR 261.24), but may exhibit the characteristic of toxicity for metals originally contained in the mop heads and rags laundered by this operation.

Ignitability: The materials in this waste stream do not meet the definition of ignitability as defined in 40 CFR 261.21. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, any free liquid would be water and absorbents have been added to the sludge to absorb any liquids that may be generated due to condensation or dewatering. This material will not cause fire through friction, absorption of moisture, or spontaneous chemical changes. This material is not a compressed gas as defined in 49 CFR 173.151. This material is not an oxidizer as defined in 49 CFR 173.300. The materials in this waste stream are therefore not ignitable wastes (D001).[3,4]

Corrosivity: The materials in this waste stream do not meet the definition of corrosivity as defined in 40 CFR 261.22. The materials are not liquid and visual examination is performed to ensure free liquids are not added to containers during repackaging. In addition, absorbents have been added to the sludge to absorb any liquids that may be generated due to condensation or dewatering. The materials in this waste stream are therefore not corrosive wastes (D002).[3,4]

Reactivity: The materials in this waste stream do not meet the definition of reactivity as defined in 40 CFR 261.23. The materials are stable and will not undergo violent chemical change. The materials will not react violently with water, form potentially explosive mixtures with water, or generate toxic gases, vapors, or fumes when mixed with water. The materials do not contain cyanides or sulfides, and are not capable of detonation or explosive reaction. The materials in this waste stream are therefore not reactive wastes (D003).[3,4]

Toxicity: The materials in this waste stream may meet the definition of toxicity as defined in 40 CFR 261.24. The toxicity characteristic contaminants fall into one of two categories: metals and organics. Organic compounds include halogenated and nonhalogenated solvents, pesticides, herbicides, and other toxic compounds. This waste stream may exhibit the characteristic of toxicity for barium, chromium, lead, mercury, and silver.[3,4]

Barium sulfate, chromic acid, potassium dichromate, mercury, and silver nitrate were used in various processes in Building JN-1. The inputs to this process (mop heads and rags) are potentially contaminated with these materials; and therefore, these metals may be concentrated in the sludge. Therefore, waste stream 5410-03 is assigned EPA Hazardous Waste Numbers D005, D007, D008, D009, and D011.[3,4]

Benzene, carbon tetrachloride, methyl ethyl ketone, and trichloroethylene were used in Building JN-1. These compounds were typically used as solvents and may have contaminated the rags and mop heads. Therefore the sludge will be regulated as a listed hazardous waste and not a characteristic waste since these compounds are specifically addressed in the treatment standards for listed hazardous waste.[3,4]

4.2.2 Listed Hazardous Waste

This waste stream is characterized as a listed hazardous waste because it may have been mixed with materials contaminated with spent solvents listed in 40 CFR 261, Subpart D. Based on acceptable knowledge documentation reviewed, the material is not, or was not mixed with, a hazardous waste from specific sources (40 CFR 261.32), or as a discarded commercial chemical product, an off-specification species, a container residue, or a spill residue thereof (40 CFR 261.33).[3,4]

Carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, acetone, methanol, benzene, and methyl ethyl ketone were used in laboratory operations for cleaning and degreasing. The process inputs are potentially contaminated with these spent solvents. Therefore waste stream 3129-01 is assigned EPA Hazardous waste numbers F001, F002, F003, and F005.[3,4]

4.2.3 TSCA Waste Determination

The material in this waste stream is not TSCA regulated waste as defined in 40 CFR 761. Review of AK identified no possible source of PCB contamination of this waste. Therefore, waste stream 3129-01, is not a TSCA regulated waste.[3,4]

5.0 REFERENCES AND AK SOURCES

1. TC-AP-03.1, *Collection, Review, and Management of Acceptable Knowledge Documentation.*

2. TCP-98-02, *Transuranic Waste Characterization Quality Assurance Project Plan for the BCLDP TRU Waste Certification Program.*

3. TCP-98-03, *Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document.*

4. TCP-98-03.1.2, *Acceptable Knowledge Process Description, Repackaging of Building JN-1 Clean-Up Waste Containers.*

5. TC-OP-01.4, *Segregation and Packaging of TRU Waste.*

6. BCLDP-90-1, *The BCLDP Low-Level Waste Certification Plan.*

7. DD-98-04, *Waste Characterization, Classification, and Shipping Support Technical Basis.*

8. DOE 1995. *DOE Waste Treatability Group Guidance.* DOE/LLW-217.

9. WA-OP-20, *Identification, Segregation, Separation and Documentation of Low Level Waste.*

10. WA-OP-33, *Sampling of Waste Materials for Chemical and/or Radiological Characterization.*

TABLE 5-1. Acceptable Knowledge Source Documents

Ref No.	Title/Author	Summary	Date
C028	Interview Record of Peter Erickson, BCL, conducted by Kevin Peters. WASTREN, Inc.	This information supplied by Peter Erickson describes the operation of the BCLDP laundry decontamination unit for TRU mop heads and rags, including the process inputs and process outputs. The composition and volume of the TRU waste streams is estimated.	2000. April 10.
P025	Miscellaneous Materials Safety Data Sheets (MSDSs). Authored by Manufacturers.	Miscellaneous MSDS sheets collected from numerous sources collected during AK research at the West Jefferson site.	Various.
P049	Rosedale High-Efficiency Liquid Filter Bag Information Sheet.	Manufacturer's information identifying the filter media of the Rosedale POMF filter used by the BCLDP laundry operatoin as polypropylene. This filter will be contained in Waste Stream 5410-03.	Undated
P050	Operation of the TRU Level Mop Head Decontamination Unit. Battelle Columbus Laboratories.	Procedure describing the methodology used to operate and maintain the Donini TRU mop head decontamination unit. Procedure describes the process inputs and management of the outputs generated by this operation.	2000. February. Revision 0
P051	Computest Instruction Manual. Donini International.	Manufacturers instructions for operating the Donini Computest 2000 laundry systems. Includes sytem drawings and schematics. Manual describes solvent dry cleaning operation of the unit. BCLDP utilizes water washing system in accorance with TC-OP-01.6 (P050).	1995.

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TC-OP-01.4
Revision 1

TRANSURANIC (TRU) WASTE CERTIFICATION PROGRAM

WASTE MANAGEMENT AND TRANSPORTATION OPERATING PROCEDURE

SEGREGATION AND PACKAGING OF TRU WASTE

UNCONTROLLED COPY

BATTELLE
505 King Avenue
Columbus, Ohio 43201

Procedure Status:

[X] Non Critical Procedure
[ ] Critical Procedure – Procedure Qualification Packet (PQP) Required

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APPROVAL FORM PROCEDURE CHANGE

Requester Peter J. Erickson Waste Certification Official
(Print name & title)

This is an approved change by one of the following methods:

☑ **Field Change** **Effective until** Next Revision

☐ **Waiver** **Effective until** ________________

NOTE: *Waivers may not be used on any documents involved with the TRU Waste Program.*

THIS CHANGE APPLIES TO:

☑ Procedure/Plan	☐ Work Instruction
No. TC-OP-01.4 Rev. No. 1 Approvals:	No. ________ Rev. No. ____ Approvals:
PJ Weaver / [signature] / 8/29/00 Print or Type Sign Date Functional Manager	____ / ____ / ____ Print or Type Sign Date W. I. Originator (Technical Rep.)
[signature] 8/29/00 M.E. Jackson, RC&ESHO Manager Date	____ / ____ / ____ Print or Type Sign Date W. I. Originator (Health Physics Rep.)
[signature] 8/29/00 G.H. Eriksen, Quality Manager Date	____ / ____ / ____ Print or Type Sign Date Waste Representative
[signature] 8/29/00 A.C. Chance, Radiological Technical Support Manager Date	____ / ____ / ____ Print or Type Sign Date Safety Officer
	____ / ____ / ____ Print or Type Sign Date Functional Manager
	____ / ____ A. C. Chance, Radiological Technical Support Manager Date

11 Field Change to p. 16

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REVISION RECORD INDICATING LATEST DOCUMENT REVISION

Title Segregation and Packaging of TRU Waste

No. TC-OP-01.4
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REVISION RECORD	
Rev. No.	Date

REVISION RECORD	
Rev. No.	1
Issue Date	6/02/00
Issued By	RB

PROCEDURE APPROVAL PAGE

Prepared By:

P. Erickson — 5-23-2000 (Date)
Waste Certification Official

This procedure, ***TC-OP-01.4, Segregation and Packaging of TRU Waste***, has been reviewed and approved by the following.

Approved By:

J. Eide — 5/23/2000 (Date)
TRU Waste Site Project Manager

M. Jackson — 5/24/00 (Date)
Manager, Regulatory Compliance & Environment, Safety, and Health Oversight

P. Weaver — 5/24/00 (Date)
Manager, Field Operations

G. Eriksen — 5/23/00 (Date)
Manager, Quality

SEGREGATION AND PACKAGING OF TRU WASTE

1.0 Scope

This procedure applies to the Battelle Columbus Laboratories Decommissioning Project (BCLDP), and covers waste stream segregation, waste item inspection, and payload container packaging activities for transuranic (TRU) wastes.

2.0 Purpose

The purpose of this procedure is to specify how to visually examine, segregate, package, and provide initial waste certification of TRU waste. This waste will be certified and disposed of in accordance with the TRU Waste Certification Plan for the BCLDP TRU Waste Certification Program (TCP-98-01).

3.0 References and Definitions

3.1 References

3.1.1 40 CFR 260-265, Protection of Environment

3.1.2 40 CFR 761, Polychlorinated Biphenyl's (PCBs) Manufacturing, Processing, Distribution in Commerce and Use Prohibitions

3.1.3 49 CFR 100-185, Transportation

3.1.4 10 CFR 835, Occupational Radiation Protection

3.1.5 DD-98-04, Waste Characterization, Classification and Shipping Support Technical Basis Document

3.1.6 DD-MN-01, Quality Manual, D&D Operations

3.1.7 This reference removed

3.1.8 HP-AP-01.0, Issue and Use of Radiation Work Permits

3.1.9 HP-OP-019, Radiation and Contamination Survey Techniques

3.1.10 HS-OP-001, Completion of the Industrial Safety Check List

3.1.11 PR-AP-17.1, Operation of the Project Records Management System

3.1.12 QD-AP-05.2, Work Instructions

3.1.13 TC-AP-01.1, TRU Waste Data Package Generation

3.1.14 TC-AP-01.1.1, Completion of the TRU Waste Stream Profile Form

3.1.15 TC-AP-01.2, Calculations Using Radioassay Data

3.1.16 TC-OP-01.1, Acceptance Criteria for Sonatol Treatment

3.1.17 TC-AP-03.1, Collection, Review, and Management of Acceptable Knowledge Documentation

3.1.18 TC-OP-01.3, Operation, Maintenance, and Calibration of the SCS-300 TRU Waste Decontamination Unit

3.1.19 TC-OP-01.5, Packaging Video Documentation

3.1.20 TCP-98-01, TRU Waste Certification Plan for the BCLDP TRU WCP

3.1.21 TCP-98-01.2, TRU Waste Authorized Methods for Payload Control for the BCLDP TRU WCP

3.1.22 TCP-98-03, Building JN-1 Hot Cell Laboratory Acceptable Knowledge Document

3.1.23 TCP-98-03.1, TRU Waste Process Descriptions

3.1.24 TCP-98-04, Mobile Vendor Interface Plan For The BCLDP

3.1.25 WA-OP-006, Procurement and Inspection of Packagings for Hazardous Materials Shipments

3.1.26 WA-OP-020, Identification, Segregation, Separation and Documentation of Low Level Waste

3.1.27 WA-OP-022, Radioactive Hazardous Waste Packaging, Storage and Transfer

3.1.28 WA-OP-029, Radioactive Waste and Radioactive Mixed Waste Absorption

3.1.29 WA-OP-030, Packaging, Marking and Labeling of Radioactive Waste and Radioactive Mixed Waste (RMW)

3.1.30 WIPP/DOE-069, Waste Acceptance Criteria for the Waste Isolation Pilot Plant

3.2 Definitions

3.2.1 Content Code – A uniform system applied to waste forms to group those with similar characteristics for purposes of shipment. An approved content code describes how a particular waste complies with authorized methods for payload control as specified in TCP-98-01.2. Approved content codes are catalogued in the TRUPACT-II Content Codes document (for contact-handled [CH-] TRU waste) and the Remote-Handled TRU Waste Content Codes document (for remote-handled [RH-] TRU waste). BCLDP waste streams are assigned to content codes under TCP-98-03.1.

3.2.2 Compressed Gas – Compressed gases are those materials defined as such by 49 CFR 173.300.

3.2.3 Corrosive – Corrosive material is that material defined as such by 40 CFR 261.22, *Characteristics of Corrosivity.*

3.2.4 Explosive – Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion (i.e., with substantial instantaneous release of gas and heat). Examples of explosives are ammunition, dynamite, black powder, detonators, nitroglycerin, urea nitrate, and picric acid.

3.2.5 Filter Vent – A payload container filter vent with filter media manufactured of carbon composite, Kevlar, stainless steel, or any material that enables the filter to meet the minimum performance specifications of TCP-98-01.

3.2.6 Free Liquid – Liquid that is not sorbed on or in a host material such that it could spill or drain from its container.

3.2.7 Low-Level Waste – Waste that contains radioactivity and is not classified as high-level waste, TRU waste, spent nuclear fuel. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste (LLW), provided the concentration of transuranics is less than or equal to 99 nanocuries per gram (nCi/g).

3.2.8 Mixed TRU Waste – TRU waste that is co-contaminated with hazardous, dangerous, or toxic constituents as defined in 40 CFR 261 and 761.

3.2.9 Payload Container – A 55-gallon drum, pipe overpack, or RH-TRU canister meeting the requirements of TCP-98-01.2 and inspected and approved in accordance with WA-OP-006.

3.2.10 Pressurized Vessels – Containers such as aerosol cans, which may hold compressed gas.

3.2.11 Pyrophoric –Materials which may ignite spontaneously or which emit sparks when scratched or struck especially with materials such as steel.

3.2.12 RCRA – Resource Conservation and Recovery Act.

3.2.13 Segregation – The act of sorting different types of items or material according to physical or chemical characteristics.

3.2.14 Separation – For the purpose of this procedure, the process of designating waste as either TRU waste or low-level Waste.

3.2.15 Transuranic (TRU) Waste – Waste contaminated with alpha-emitting radionuclides of atomic number greater than 92 (e.g., the radioactive isotopes of plutonium) with half-lives greater than 20 years and present in concentrations greater than or equal to 100 nCi/g of waste. Waste packaged under this procedure is identified as TRU waste under DD-98-04.

3.2.16 TSCA – Toxic Substances Control Act.

4.0 General

4.1 Safety

Specific safety concerns shall be reviewed/addressed by Industrial Safety and Health prior to the performance of this procedure. Requirements shall be delineated on the work instruction or addressed in a job-specific briefing. Health Physics survey and job coverage requirements shall be delineated in the radiation work permit and shall be performed by the Health Physics technician assigned to the work. All personnel are responsible for safe work practices with regard to radiation and industrial safety concerns.

4.2 **Equipment**

Note: The following list is an example of equipment that may be used. It is not all-inclusive nor should the assumption be made that all equipment on this list shall be used during each work segregation or packaging job.

4.2.1 Payload container as specified in TCP-98-01.2 and approved in accordance with WA-OP-006 (a rigid liner may be included in 55-gallon drums).

4.2.2 Calibrated scale

4.2.3 Approved absorbent material

4.2.4 Blocking or restraining material

4.2.5 Approved void space fill material

4.2.6 Cloth reinforced duct tape

4.2.7 Barrel wrench

4.2.8 Stencils or adhesive labels for marking

4.2.9 Applicable forms and writing utensils.

4.3 **Precautions**

4.3.1 Packaging of TRU waste as defined in this procedure may be carried out over an extended period, therefore, only certain sections of this procedure may be activated during a particular stage of the operation. For example, wastes may be packaged in accordance with the applicable sections of this procedure and put into storage until scheduled for shipment.

4.3.2 Radioactively contaminated equipment and materials should be decontaminated if possible. The TRU Waste Site project Manager/designee will provide assistance with these evaluations when necessary and should always be consulted in cases involving large or heavy equipment/materials.

4.4 **Limitations**

4.4.1 Only containers that meet the WIPP WAC requirements and have been inspected and approved in accordance with WA-OP-006 shall be used.

4.4.2 Only wastes that are adequately identified, segregated, and separated in accordance with DD-98-04, WA-OP-020 and WA-OP-022 may be packaged.

4.4.3 Project Managers shall ensure that all work instructions, or other activities that generate waste, have been reviewed by Waste Management Operations, and that the Waste Management Checklist (DDO-164) has been completed and approved as required per WA-OP-020. Additionally, Waste Management Operations shall be notified of any changes affecting the waste estimates or instructions that were originally listed/issued on the Checklist. (This will require generation and review of a new or amended Checklist.)

5.0 **Responsibilities**

Responsibilities and authority of staff members involved in the segregation, inspection, and packaging of TRU waste are summarized below.

5.1 TRU Waste Site Project manager (SPM), or designee, is responsible for oversight of all activities that generate or process TRU waste. The SPM shall provide input to Project Managers during the planning stages of those activities, ensuring that regulatory and procedural requirements for segregating, inspecting, and packaging TRU waste are met. The SPM shall ensure that all TRU waste documentation of work activities is generated and forwarded to Project Records.

5.2 Manager, Quality, is responsible for facilitating implementation of quality requirements and practices into TRU waste certification and transportation related activities and for verifying these operations are being performed effectively and in accordance with all requirements.

5.3 Manager, Training, is responsible for arranging the training of staff segregating, inspecting, and packaging waste and for recording worker training in the worker training and qualification system.

5.4 Project Manager or designee is responsible for ensuring the coordination of tasks with other ongoing facility activities and for ensuring safety for all present at the facility. Responsibilities specific to this procedure include the following:

- Ensure that Industrial Safety Checklists (HS-OP-001, Form DDO-195), have been prepared, approved and issued by Safety;
- Ensure that work instructions (QD-AP-05.2, Form DDO-104) and have been prepared, approved, and issued;
- Obtain the services of Health Physics (HP) to support the packaging of TRU wastes;
- Required documentation is completed and included in the work instruction package and the work instruction package is closed when the activity is completed and submitted to project records.

5.5 The Waste Certification Official (WCO) is responsible for the following activities:

- Performing independent inspections of waste container and contents;
- Ensure that all personnel assigned have been trained in this procedure and that their qualifications have been documented;
- Control records as specified in DD-MN-01 and applicable procedures;
- Oversee the packaging of TRU waste ensuring compliance with all applicable TRU plans and procedures;
- Answer questions concerning the disposition of TRU waste.

5.6 Visual Examination Expert will document packaging activities as specified in TC-OP-01.5, Packaging Video Documentation, using both audio and visual documentation. The Visual Examination Expert will operate under the supervision of the WCO. The Visual Examination Expert is responsible for the following:

- Process descriptions are followed;
- Able to identify prohibited items;
- Document and verify TRU waste packaging as specified in this procedure.

5.7 Waste Management D&D Technicians are responsible for packaging TRU Waste in accordance with this procedure as well as the applicable process description.

5.8 HP Technicians are responsible for all radiological survey and documentation, including routine surveillance and job coverage, and for ensuring that personnel comply with all applicable HP procedures. The

HP Technicians are responsible for ensuring that Radiation Work Permits (HP-AP-01.0, Form DDO-105) have been prepared, approved and issued by HP at the direction of the Project/ Building Manager. HP Technicians shall complete any documentation necessary to take and ship the samples.

6.0 **Procedure**

6.1 Review and Documentation of Activities

The TRU Waste Site Project Manager or designee shall review all work instructions related to TRU waste packaging activities.

BCLDP personnel shall report all work activities and results associated with packaging operations on the Summary and/or Special Report Form (DDO-103). BCLDP personnel shall assemble a complete data package including but not limited to all forms, records, and health physics survey numbers related to the activity. A copy of the completed data package shall be sent to Project Records on a monthly basis, or when the applicable work instruction has been closed out. The data collected under this procedure shall be reviewed by the TRU Waste Site Project Manager, or designee, for compliance with TCP-98-01, during the completion of the waste certification documents as described in TC-AP-01.1.

6.2 Waste Segregation

6.2.1 TRU Waste Determination

BCLDP personnel shall segregate TRU waste from other wastes (e.g., LLW) as described in WA-OP-020 and/or work instructions, which implement the methodology presented in DD-98-04.

6.2.2 RCRA Waste Stream Determination

BCLDP personnel shall segregate TRU RCRA mixed waste from other non-mixed TRU waste using WA-OP-020 and TCP-98-03.1. TRU RCRA mixed waste will be staged in a Satellite Accumulation Area meeting the requirements of WA-OP-022. After 55 gallons of TRU RCRA mixed waste is packaged it shall be stored in accordance the 90 day storage area requirements set forth WA-OP-022.

6.2.3 Asbestos

Upon discovery of TRU asbestos waste, the Visual Examination Expert shall contact the Waste Certification Official. The Waste

Certification Official shall evaluate the asbestos to determine its appropriate waste stream. When the asbestos is packaged, the Waste Certification Official shall draft a letter describing the characterization used to determine the correct waste stream. The WCO shall notify the TRU Waste Site Project Manager who will issue a letter to the CAO Waste Certification Manager that includes a list of waste streams containing asbestos and request guidance for those waste streams.

6.2.4 Polychlorinated Biphenyl Concentration

As specified in the WIPP WAC, PCBs must be in concentrations less than 50 ppm. The BCLDP TRU WCP shall use AK documentation and/or sampling and analysis to confirm the absence of PCBs in concentrations exceeding this acceptance criterion.

6.2.5 Non-mixed TRU waste shall be considered for Sonatol treatment in accordance with the acceptance criteria of TC-OP-01.1. Non-mixed TRU waste meeting the acceptance criteria may undergo Sonatol treatment in accordance with TC-OP-01.3.

6.2.6 Non-mixed TRU waste that does not meet the acceptance criteria for Sonatol treatment or that fails to be decontaminated to LLW by Sonatol treatment, and all mixed TRU waste, shall be segregated into a waste stream defined in TCP-98-03.1. TCP-98-03.1 defines specific waste streams, which may be grouped under the following comprehensive waste categories (parenthetical text indicates the content codes associated with each category):

- Solidified Organics (SQ 112 [CH-TRU] and BC 312 or BC314 [RH-TRU])
- Solid Organics (SQ 121 [CH-TRU] and BC 321 [RH-TRU])
- Solid Inorganics (SQ 122 [CH-TRU] and BC 322 [RH-TRU]).

For example, the characterized waste stream for pool filters falls under the solid organic waste category. Each content code may represent more than one waste stream (e.g., both mixed and non-mixed solid organic TRU waste streams are assigned to SQ 121 [CH-TRU]). Exhibit 8.2.1 **(on page 20)** provides examples of TRU waste items that may be included in the above categories.

Under TCP-98-03.1, each waste stream is designated as "mixed" or "non-mixed."

U.S. Environmental Protection Agency (EPA) Hazardous Waste Codes are assigned to each mixed waste stream under TCP-98-03.1. These assignments are based on the acceptable knowledge (AK) presented in TCP-98-03. In accordance with TCP-98-03, Section 6.3.1, describes the verification activities to be performed during segregation prior to the assignment of EPA Hazardous Waste Codes. The EPA Hazardous Waste Codes are recorded for each mixed waste stream in Waste Stream Profile Forms, which are prepared as described in TC-AP-01.1.1.

6.3 Waste Inspection

Prior to the inspection and packaging of any waste item, the TRU Waste Site Project Manager, or designee, shall review all documentation generated during the segregation and characterization process. Compliance with the following inspection parameters shall be determined during the segregation of waste items and their placement into the payload container. Visual examination, including video/audio documentation in accordance with TC-OP-01.5, shall be used to verify and document the physical content of each payload container.

6.3.1 Verification of Acceptable Knowledge

In accordance with TCP-98-03, the waste items identified in Exhibit 8.2.2 must be visually examined to ensure that no visible residue (e.g., sludge or encrusted material) is present. This verification will ensure the correct application of AK information in the assignment of EPA Hazardous Waste Codes to the mixed waste streams under TCP-98-03.1. In addition, inner containers (e.g., plastic bags or plastic, glass, or metal containers) must be visually examined to ensure the inner container is empty per the criteria set forth in 40 CFR 261.7.

BCLDP personnel shall visually examine each waste item assigned to a non-mixed waste stream to ensure that no residue is present and to ensure that any inner container is empty per the criteria set forth in 40 CFR 261.7. If residue is identified within a waste item, the waste item shall be tagged and segregated and shall not be shipped to the WIPP. If visual examination indicates that the waste does not match a waste description in TCP-98-03.1 based on AK characterization, a report must be completed in accordance with TC-AP-03.1, and the waste shall be set aside until a new or revised process description can be generated for the waste stream in accordance with TCP-98-03.1.

6.3.2 Prohibited Items

The following prohibited items shall be removed prior to packaging the waste. BCLDP personnel shall visually examine the waste to restrict the presence of the following prohibited items:

- Liquids. The BCLDP TRU WCP will use acceptable knowledge (AK) and/or visual examination (VE) to verify that the liquid content of the payload container complies with the WIPP WAC requirements (<1 volume % of external container and/or <1 inch or 2.5cm in bottom of internal containers).

  Packaging personnel shall restrict the presence of free liquids to the extent that is reasonably achievable by pouring, pumping, or aspirating. Free liquids encountered during packaging shall be absorbed per WA-OP-029. Any liquid in nontransparent inner containers including pumps or mechanical equipment that may contain an oil reservoir that is not solidified, will be handled by assuming that the container is filled with liquid and this volume will be added to the total liquid documented for the payload container.

- Pyrophoric Materials. Nonradioactive pyrophorics (e.g., organic peroxides, sodium metal, and chlorates) shall be segregated and shall not be shipped to the WIPP. Radioactive pyrophorics (e.g., metallic plutonium and americium) are allowed in quantities <1% (weight) of the payload container. Note that the radioactive pyrophoric content of the waste is expected to be well below 1% .

- Explosives, Corrosives and Compressed Gases. Explosives (e.g., ammunition, dynamite, black powder, detonators, nitroglycerin, urea nitrate, and picric acid), corrosives, and compressed gases (e.g., aerosol cans) shall be segregated and shall not be shipped to the WIPP.

- EPA Characteristic Waste. Wastes exhibiting the characteristics off ignitability, corrosivity, or reactivity (EPA Hazardous Waste Numbers D001, D002, or D003) will be segregated and not shipped to the WIPP.

- Physical and Chemical Form of the Waste. In accordance with work instructions, BCLDP personnel shall ensure that the physical and chemical form of the waste is consistent with the characterized waste stream as described in TCP-98-03.1.

- Sealed Containers. In accordance with the WIPP WAC, sealed containers greater than 4 liters, except for those packaging Waste Material Type II.2 (solid inorganic materials in metal cans) shall not be packaged.

6.4 Waste Packaging

The characterized waste stream as described in TCP-98-03.1 dictates compliance with the following parameters.

6.4.1 Payload Container Issuance

The BCLDP TRU waste shall be packaged in 55-gallon drums as the outer packaging. For RH-TRU waste, the 55-gallon drums shall be over-packed into an RH-TRU canister prior to transport to the WIPP. This packaging process, along with the RH-TRU canister specific requirements (e.g., marking and labeling), is described in TCP-98-04 and is performed by subcontracted TRU waste services.

Following receipt inspections, and filter installation, payload containers are issued under WA-OP-006 to BCLDP personnel. Upon issuance of the container, BCLDP personnel will re-verify that the conditions have not changed from the initial inspection of the container and that the correct number and type of filter vent is installed.

6.4.2 *Payload Container Marking and Labeling*-Each Marking and Labeling must be applied in 3 locations of the package about 120^0 apart. The barcode Code 39 symbology for these numbers must be at least 1 inch high with alphanumeric characters at least ½ inch high. The numbers must also be medium to low density. All marking and labeling instructions will be given on the Marking and Labeling Instructions form (DDO-168).

6.4.2.1 All waste containers shall be marked with "Caution Radioactive Material" using a yellow and magenta label as specified in 10 CFR 835.

6.4.2.2 Each Payload Container must be marked with a Content Code. The Content Code for each type of packaging is found in the TRU Waste Process Descriptions (TCP-98-

03.1) and its Acceptable Knowledge sub- documents. The Content Code will begin with the letters "BC" for RH-TRU or "SQ" for CH-TRU followed by a four-digit alphanumeric number with a letter at the end designating the type of packaging being used.

6.4.2.3 Each Payload Container must have a unique container identification number. This number should consist of the site identification as well as the container identification. Waste Management shall assign this number on the Waste Container Issuance Request form (DDO-167).

6.4.2.4 Each CH-TRU Payload Container must have a Shipping Category Assignment. This 10-digit shipping category number is determined in accordance with TCP-98-01.2

6.4.2.5 For TRU-RCRA mixed waste, each container must have a hazardous waste label affixed. See WA-OP-030 to label mixed waste containers in accordance with 40 CFR 262.31 and 49 CFR 172 Subpart E. **Note:** These labels need only be applied one per container in a visible location.

6.4.2.6 If an empty container is issued to fill void space in an TRUPACT-II per TCP-98-01.2, the container must be labeled "EMPTY" in addition to the unique identification number. Empty containers (dunnage) shall have open vent ports (i.e., not filtered or plugged).

6.4.3 Completion of Form DDO-438

BCLDP personnel shall load waste materials into the payload container and record entries on Form DDO-438 (attached) as follows:

6.4.3.1 Enter the BCLDP Waste Management issued package identification number (PIN).

6.4.3.2 Enter the package type, such as "55-gallon drum." Record payload container model/serial number.

6.4.3.3 Legibly print the name(s) of the staff loading the waste.

6.4.3.4 Sequentially number each entry.

6.4.3.5 Using as many lines as needed, enter a detailed item description for all materials added to the payload container. List a physical description and record the environmental laboratory sample number (EL#), if sample(s) are taken (for example: wood, concrete, metal or soil, EL#-96-0000).

NOTE: Absorbent/void filling material added to the waste package must be recorded on the form as well as waste items.

NOTE: Use of the word "miscellaneous" is not acceptable for describing waste materials.

6.4.3.6 Enter the source location (hot cell, pool, etc.) for each waste item.

6.4.3.7 Through visual examination, enter the type of material and estimate the percent of each material in the item. For example, "90 percent slate, 10 percent wood." Examples of other acceptable material type entries include, but are not limited to, plastic, paper, cloth, rubber, concrete, steel, aluminum, metal, and glass.

6.4.3.8 Enter "Y" (yes) or "N" (no) to indicate if a smear sample has been collected for the waste item with acceptable analysis results. As stated in Section 6.4.2.5, the EL# shall be recorded for the waste item if a smear sample has been collected. Smear samples shall be collected in accordance with HP-OP-019. Each sample shall be sent to the RAL for radionuclide analysis as described in the Work Instructions.

6.4.3.9 Enter the dose rate of the item, if a dose measurement has been made on the individual item. Dose rates shall be taken in accordance with HP-OP-019. **Note: If it is not feasible to take the dose measurement, place an "N/A" in the block.**

6.4.3.10 Enter the weight estimate of the item in pounds, if the individual item weight has been determined. **Note: If it is not feasible to take the weight of an item, place an "N/A" in the block.**

6.4.3.11 Enter the loading date.

6.4.3.12 Enter the initials of the loader.

6.4.3.13 Enter any additional information in the Summary/Comments column such as additional tape numbers or condition of item.

6.4.3.14 Enter the number of the videotapes, and counter numbers, that are recording the individual payload container loading activities as per Procedure TC-OP-01.5.

6.4.3.15 Continue adding waste and repeat steps 6.4.3.5 through 6.4.3.14 as directed by Work Instruction(s) or the Waste Certification Official.

6.4.3.16 A Waste Certification Official shall verify that each payload container contents or waste records are correct and sign off on the DDO-438.

6.4.4 Inner packaging that consists of bags may be closed by one of the following methods:

6.4.4.1 Twist-and-tape closure
6.4.4.2 Fold-and-tape closure
6.4.4.3 Heat seal closure with vented bag – Heat sealed unvented bags are prohibited.

6.4.5 Confinement Layers

BCLDP personnel shall ensure that the configuration of the payload container inner packaging complies with that defined by the appropriate content code. This includes the closure of the inner packaging. BCLDP personnel shall ensure that any inner containers greater than 4 liters in size (e.g., metal cans) are not sealed or are installed with at least one filter vent meeting the specifications of TCP-98-01.2. Sharp or heavy items shall be "blocked" or otherwise restrained in payload containers to prevent shifting during handling and transportation that could result in damage to the payload container.

6.4.6 Shipping Category

For CH-TRU payload containers, BCLDP personnel shall determine the shipping category in accordance with TCP-98-01.2, Field Change

which describes the packaging configuration of each payload container. The loaded payload container shall be evaluated for compliance with the shipping category and content code. The CH-TRU payload container shall be labeled with the shipping category assignment as described in 6.4.2.4 of this procedure.

6.4.7 Closure of 55-Gallon Drums

6.4.7.1 Inspect the lid seal gasket for damage and ensure correct placement.

6.4.7.2 Place the lid and lid ring on the 55-gallon drum and tighten the draw bolt and jam nut assembly to manufacturer specifications. During tightening, strike the drum ring with a rubber mallet (or equivalent) and tighten the jam nut. Repeat this process until all slack has been eliminated in the draw bolt/jam nut assembly and ensure that the lid is properly seated.

6.4.7.3 Following closure, the loaded payload container shall be weighed. Record the weight on DDO-438.

6.4.8 Radiation Surveys

BCLDP HP Technicians in accordance with HP-OP-019, or subcontracted services, shall measure the following parameters for each loaded payload container following its closure:

- Removable surface contamination
- Contact dose rate.

6.4.9 Verification of DDO-438

6.4.9.1 Verify that DDO-438 has been completed.

6.4.9.2 Transfer the completed DDO-438 to the Waste Certification Official for review. Forward the completed DDO-438 to the TRU Waste Site Project Manager, or designee, for approval and filing. Report the payload container loading activity summary into the appropriate work instruction data package via Form DDO-103. ~~(Completed DDO-438 forms shall be sent to Project Records on a monthly basis as well as with the shipment records for the waste/package.)~~

F.C.
PJE
8-28-00

6.5 Post-Packaging Determinations

BCLDP personnel shall use the data presented in the completed DDO-438 as required for the determination of radioassay properties under the methodology described in DD-98-04 and to determine required payload container parameters as described in TC-AP-01.2. In addition, all loaded payload containers shall be included in a sampling program conducted by subcontracted services to determine total volatile organic compound (VOC) concentrations, flammable VOC concentrations, and polychlorinated biphenyl concentrations.

NOTE: The TRU Waste Site Project Manager, or designee, shall review all payload container data for compliance with the TCP-98-01 during the completion of the waste certification documents as described in TC-AP-01.1.

7.0 Records

The following documents will be submitted to Project Records with the applicable Work Instruction in accordance with PR-AP-17.1.

7.1 All reports generated by this procedure, including but not limited to the following:

- Completed work instructions.
- Completed summary and/or special report forms.
- Completed radiological work permits
- Completed DDO-438.

8.0 Forms and Exhibits

8.1 Forms

8.1.1 DDO-164, Waste Management Checklist (see Reference 3.1.24)
8.1.2 DDO-103, Summary and/or Special Report Form (see Reference 3.1.11)
8.1.3 DDO-104, Work Instruction (see Reference 3.1.11)
8.1.4 DDO-105, Radiation Work Permit (see Reference 3.1.7)
8.1.5 DDO-438, TRU Waste Package Loading Record
8.1.6 DDO-195, Industrial Safety Checklist (see Reference 3.1.9)
8.1.7 DDO-168, Marking and Labeling Instructions (see Reference 3.1.27)
8.1.8 DDO-167, Waste Container Issuance Request (see Reference 3.1.23)

8.2 **Exhibits**

8.2.1 Example TRU Waste Items by Category

8.2.2 Wastes to be Visually Inspected to Ensure Absence of Residue

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TRU Waste Package Loading Record
Loading - Itemized Data

Payload Container Identification No:	Package Type/Model:
Loading Personnel (print name[s]):	

Item No.	Item Description	Source Location	Material		Smear Sample Collected (Y / N)	Dose Rate[a] (mrem/hr)	Weight[b] (lbs.)	Loading Date	Loader Initials	Tape No./ Counter No.	Summary/ Comments
			Type	%							

Loaded Package Measured Radiation Dose Rate (mrem/hr)		Accumulation Date (Mixed Waste Only)	
Loaded Package Final Measured Gross Weight[b] (lbs.)		Authorized Review and Approval	
Contains No Suspect Hazardous Materials	Initial: Date:	(signature)	(date)
Contains Hazardous Materials	Initial: Date:		

[a] Record dose rate of item, if a dose rate measurement has been made on the individual item (not required). Only a single measurement of the loaded package radiation dose rate is required.

[b] Record weight of item, if the weight of the individual item has been determined (not required). Total payload container weight may be determined by (1) summing individual items plus error if each item has been weighed, or (2) single measurement of a total payload container plus error.

Exhibit 8.2.1
Example TRU Waste Items by Category

Category	Content Codes	Example	
Solidified Organics	SQ 112 BC 312 BC 314	Solidified Liquids	Organic liquids, acidic wastewater's, etc., that are absorbed or solidified prior to packaging
Solid Organics	SQ 121 BC 321	Organic Solids	Organic resins and absorbed oils
		Combustible wastes	Plastic/rubber (e.g., shoes, gloves, strips, belts, bags, sheeting, herculite, bubblehoods, bottles, PVC pipe), paper/cloth (e.g., towels, rags, clothing, masslinn, cardboard, sheet/sheaf), and wood (e.g., plywood, pallets)
		Heterogeneous Debris	Composite filter debris, electronic equipment, and other contaminated fixtures and equipment
		Leaded Rubber/Plastic	Leaded rubber gloves and aprons, and lead acid battery casings that have been drained of their electrolyte
Solid Inorganics	SQ 122 BC 322	Glass Waste	Leaded glass windows, laboratory glassware, and light bulbs
		Inorganic Solids	Concrete, ceramic/brick items, insulation, activated carbon, stabilized particulate materials, and filters from Sonatol treatment operations
		Metal Wastes	Metal debris (e.g., equipment, cans, etc., and elemental lead, cadmium

Exhibit 8.2.2
Wastes to be Visually Inspected to Ensure Absence of Residue

Plastic/Rubber Debris	
Sheeting	Respirators
Rope	Gloves
Tape	Boots
Booties	Rain Suits
Hose/Tubing	O-Rings
Spray Can Lids	Electrical cords
Packing Material	Safety Glasses
Glass Debris	
Broken Laboratory Glassware	Windows (not leaded glass)
Various Apparatus	
Filters Debris	
Roughing Filters	HEPA Filters
Cartridge Filters	
Concrete Debris	
Concrete Blocks	
Insulation	
Pipe Insulation	
Metal Debris	
Cable	Foil
Wire	Sheeting
Planchets	Fixtures
Signs	Ballasts
Respirator Filters	Pumps
Valves	Motors
Piping	Hardware
Strapping	Fuel Rod Cladding
Tools	Metmounts

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TC-AP-01.1
Revision 1

TRANSURANIC (TRU) WASTE CERTIFICATION PROGRAM

WASTE MANAGEMENT AND TRANSPORTATION
ADMINISTRATIVE PROCEDURE

TRU WASTE DATA PACKAGE GENERATION

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BATTELLE
505 King Avenue
Columbus, Ohio 43201

Procedure Status:

[X] Non Critical Procedure
[ ] Critical Procedure – Procedure Qualification Packet (PQP) Required

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REVISION RECORD INDICATING LATEST DOCUMENT REVISION

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No. TC-AP-01.1

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PROCEDURE APPROVAL PAGE

Prepared By:

P. Erickson
Waste Certification Official

6-23-2000
Date

This procedure, ***TC-AP-01.1, TRU Waste Data Package Generation***, has been reviewed and approved by the following.

Approved By:

J. Eide, Site Project Manager,
Tru Waste Certification Program

6-26-00
Date

N. J. Gantos, Program Manager
Decontamination & Decommissioning Operations

6/27/2000
Date

M. Jackson, Manager
Regulatory Compliance & Environment,
Safety, and Health Oversight

6/23/00
Date

P. Weaver, Manager,
Field Operations

6/23/00
Date

G. Eriksen Manager,
Quality

6/23/00
Date

TRU WASTE DATA PACKAGE GENERATION

1.0 Scope

This procedure covers data package generation required for compliance with the Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (WAC) (WIPP/DOE-069).

2.0 Purpose

The purpose of this procedure is to define the completion of the data package generated for each contact-handled (CH-) TRU and remote-handled (RH-) TRU payload container under the Battelle Columbus Laboratories Decommissioning Project (BCLDP) TRU Waste Certification Program (WCP). The proper implementation of this procedure will ensure that all required certification, characterization, and transportation data are completed and compiled in a data package during the certification process for each payload container and payload assembly.

3.0 References and Definitions

3.1 References

The current revision of each reference shall be used.

3.1.1 HP-OP-019, Radiation and Contamination Survey Techniques

3.1.2 PR-AP-17.1, Operation of the Project Records Management System

3.1.3 QD-AP-04.1, Documentation and Control of Purchased Items and Services

3.1.4 TC-AP-01.1.1, Completion of TRU Waste Stream Profile Form

3.1.5 TC-AP-01.2, Calculations Using Radioassay Data

3.1.6 TC-AP-01.4, TRU Waste Data Transmittal by WIPP Waste Information System

3.1.7 TC-OP-01.4, Segregation and Packaging of TRU Waste

3.1.8 TCP-98-01.2, TRU Waste Authorized Methods for Payload Control for the BCLDP TRU WCP

3.1.9 TCP-98-02, TRU Waste Characterization Quality Assurance Project Plan for the BCLDP TRU WCP

3.1.10 TCP-98-03.1, TRU Waste Process Descriptions

3.1.11 TCP-98-04, Mobile Vendor Interface Plan for the BCLDP TRU WCP

3.1.12 TR-OP-003, Shipping and Receiving Radioactive Materials

3.1.13 TR-OP-007, Completion of Uniform Hazardous Waste Manifest and LDR Notification Forms

3.1.14 WA-OP-006, Procurement and Inspection of Packagings for Hazardous Materials Shipments

3.1.15 DOE/WIPP-069, Waste Acceptance Criteria for the Waste Isolation Pilot Plant

3.1.16 DD-98-04, Waste Characterization, Classification And Shipping Support Technical Basis Document

3.2 Definitions

3.2.1 Contact-Handled Transuranic (CH-TRU) Waste – TRU waste with contact dose rates less than or equal to 200 milliroentgen equivalent man per hour (mrem/hr).

3.2.2 Mixed TRU Waste – Transuranic Waste that contains hazardous constituents listed in 40 CFR 261, subpart D (Lists of Hazardous Waste) or that exhibits any of the hazardous waste characteristics identified in 40 CFR 261, subpart C (Characteristics of Hazardous Waste).

3.2.3 Payload Container – Containers meeting the requirements of TCP-98-01.2.

3.2.4 Remote-Handled Transuranic (RH-TRU) Waste – TRU waste with contact dose rates greater than 200 mrem/hr.

3.2.5 Transuranic (TRU) Waste – Waste contaminated with alpha-emitting radionuclides of atomic number greater than 92 with half-lives greater than 20 years and present in concentrations greater than or equal to 100 nanocuries per gram (nCi/g) of waste.

4.0 Responsibilities

Responsibilities and authority of staff members involved in the generation of data packages are summarized in the following sections.

4.1 TRU Waste Site Project Manager (SPM), or designee, is responsible for ensuring that personnel involved in the generation of data packages comply with the requirements of this procedure. The SPM shall verify that the criteria set forth in TCP-98-02 are addressed.

4.2 TRU Waste Site Quality Assurance Officer, is responsible for facilitating implementation of quality requirements and practices into TRU waste certification-related activities and for verifying these operations are being performed effectively and in accordance with requirements.

4.3 Manager, Training, is responsible for arranging for training of staff performing TRU waste data package generation and for recording worker training in the worker training and qualification system.

4.4 TRU Waste Transportation Certification Official, or designee, is responsible for ensuring that all documentation required for TRU waste transportation activities is completed in a timely manner.

4.5 TRU Waste Certification Official, or designee, is responsible for ensuring that all documentation required for TRU waste certification activities is completed in a timely manner.

5.0 Procedure

Payload container certification data shall be compiled and maintained by BCLDP TRU WCP personnel in the data package during the certification process. As specific payload container data are generated, the information shall be recorded, as applicable, in the data package. Supporting data shall be filed in the BCLDP TRU WCP project files and correlated to the appropriate payload container by payload container identification number. The complete data package shall consist of data organized by the following WIPP certification criteria (DOE/WIPP-069):

- Identification Information
- Payload Container Description
- Payload Container Weight and Center of Gravity
- Removable Surface Contamination
- Payload Container Identification/Marking

- Dunnage
- Filter Vents
- Radionuclide Composition
- Fissile Material Quantity
- TRU Alpha Activity
- Pu-239 Equivalent Activity
- Radiation Dose Rate
- Liquids
- Sealed Containers
- Pyrophoric Materials
- Hazardous Waste
- Chemical Compatibility
- Explosives, Corrosives, and Compressed Gases
- Headspace Gas Volatile Organic Compound (VOC) Concentrations
- Polychlorinated Biphenyl (PCB) Concentration
- Asbestos
- Payload Shipping Category
- Decay Heat
- Test Category Waste
- Flammable VOCs
- Venting and Aspiration
- Characterization and Certification Data
- Shipping Data.

Completion of records supporting the above certification criteria is detailed in Sections 5.1 through 5.28. These records form the data package.

As described in Attachments 7.2.1, 7.2.2, and 7.2.3, BCLDP TRU WCP personnel shall review the data package(s) for each payload container or payload assembly to verify compliance with the CH- or RH-TRU transportation requirements of TCP-98-01.2. For CH-TRU waste, an individual payload container shall be qualified for transport in a Transuranic Package Transporter-II (TRUPACT-II) by verifying that it meets the parameter requirements/limits listed in the Payload Container Transportation Certification Document (PCTCD) (Attachment 7.2.1). Individual CH-TRU payload containers that have been qualified for transport shall be assembled as a TRUPACT-II payload in accordance with TCP-98-01.2. A CH-TRU payload shall be qualified for TRUPACT-II shipment by verifying compliance with the parameter requirements/limits listed in the Attachment 7.2.2, Completion of CH-TRU Payload Assembly Transportation Certification Document (CH-TRU PATCD). Note that this differs from Attachment 7.2.3, Completion of RH-TRU Payload Assembly Transportation Certification Document (RH-TRU PATCD) which shall be used to qualify each RH-TRU canister for transport in the 72-B Cask.

As described in Attachment 7.2.4, Completion of TRU Waste Certification Documents. BCLDP TRU WCP personnel shall review the data package(s), including the appropriate transportation certification documents, for each payload container and payload assembly to verify that it is complete during the preparation of the TRU Waste Certification Documents. BCLDP TRU WCP personnel shall prepare a TRU Waste Certification Document for each CH-TRU or RH-TRU payload container and payload assembly as described in the following sections and Attachment 7.2.4. The TRU Waste Certification Documents are completed as data are accumulated. The approved (signed and dated) TRU Waste Certification Documents complete the final data package.

BCLDP TRU WCP personnel shall use the final data package as the source for compiling the WIPP Waste Information System (WWIS) data in accordance with TC-AP-01.4, TRU Waste Data Transmittal by WIPP Waste Information System. The required WWIS data will be submitted to the WIPP Managing and Operating contractor for approval prior to shipping waste to the WIPP. Alternatively, as described in TCP-98-04, the WWIS data may be transmitted by subcontracted TRU waste services in accordance with their procedures.

5.1 Identification Information

5.1.1 Payload Container Identification Number

Payload container identification numbers shall be assigned per the labeling instructions of TC-OP-01.4. The payload container identification number shall be recorded on the appropriate TRU Waste Certification Document.

5.1.2 Date of Payload Container Closure

The date of payload container closure as determined under TC-OP-01.4 shall be recorded on the appropriate TRU Waste Certification Document.

5.1.3 Date of Payload Container Certification

The date of the approval signature for the TRU Waste Certification Document that is completed for the payload container is the certification date.

5.1.4 WIPP WAC Exception Number

The WIPP WAC exception number is a number granted to the shipper for an exception to the WIPP WAC. The number consists of a 2-character site code (e.g., BC) plus the last two numbers of the year the request was made plus a sequential number beginning with "1" each year. If applicable, this number shall be recorded on the appropriate TRU Waste Certification Document.

5.1.5 Waste Stream Profile Form Number

As described in Section 5.27, BCLDP TRU WCP shall complete a Waste Stream Profile Form (WSPF) for each characterized waste stream in accordance with TC-AP-01.1.1. The number of the WSPF approved by the WIPP for the waste stream packaged by a specific payload container must be recorded on the appropriate TRU Waste Certification Document.

5.2 Payload Container Description

The payload container will be one of the following types:

- 55-Gallon Drum
- Pipe Overpack
- RH-TRU Canister.

The records generated by the payload container inspections of QD-AP-04.1, WA-OP-006, and TC-OP-01.4 shall be included in the data package.

In addition, any payload container inspection records generated by the subcontracted services shall be included in the data package. The BCLDP receipt of such documents is dictated by TCP-98-04. The payload container type shall be recorded on the appropriate TRU Waste Certification Document.

5.3 Container Weight and Center of Gravity

The payload container weight shall be determined under TC-OP-01.4 or by subcontracted services. Any records generated under TC-OP-01.4 shall be included in the data package. Subcontracted services shall provide the required data to the BCLDP TRU WCP in accordance with TCP-98-04. The total measured or calculated weight shall be recorded on the appropriate TRU Waste Certification Document.

5.4 Removable Surface Contamination

The removable surface contamination shall be measured under HP-OP-019 or by subcontracted services. Any records generated under HP-OP-019 shall be included in the data package. Subcontracted services shall provide the required data to the BCLDP TRU WCP in accordance with

TCP-98-04. The survey results shall be recorded on the appropriate TRU Waste Certification Document.

5.5 **Container Identification/Marking**

The payload container identification number and the shipping category, if applicable (see Section 5.22, Payload Shipping Category), shall be recorded on the appropriate TRU Waste Certification Document. The records generated under TC-OP-01.4 documenting the identification number and shipping category assignment shall be included in the payload container data package.

5.6 **Dunnage**

If dunnage is used to complete a CH-TRU payload assembly, a CH-TRU Dunnage Certification Document (DDO-452-W) shall be completed. The dunnage container identification number, if applicable, and associated data shall be recorded. The records generated under TC-OP-01.4 documenting the identification number shall be included in the payload container data package. The TRU Waste Certification Document need not be completed for dunnage containers.

5.7 **Filter Vents**

Records generated by the filter vent inspections under QD-AP-04.1, WA-OP-006, and TC-OP-01.4 shall be included in the data package. In addition, any payload container inspection records generated by the subcontracted services received in accordance with TCP-98-04 shall be included in the data package. Compliance with the filter vent specifications shall be recorded on the appropriate TRU Waste Certification Document.

5.8 **Radionuclide Composition**

The records generated under the Waste Characterization, Classification, And Shipping Support Technical Basis Document (DD-98-04), during the determination of the radionuclide composition of RH-TRU waste shall be included in the data package. As applicable, records generated for CH-TRU waste by any subcontracted services shall be included in the data package. The BCLDP receipt of such records is dictated by TCP-98-04. The quantities of Am-241, Pu-238, Pu-239, Pu-240, Pu-242, U-233, U-234, U-238, Sr-90, and Cs-137 shall be recorded on the appropriate TRU Waste Certification Document.

5.9 **Fissile Material Quantity**

The records generated under TC-AP-01.2 documenting the calculation of Fissile Gram Equivalent (FGE) for each payload container shall be included in the data package. The calculated FGE value, which includes two standard deviations, shall be recorded on the appropriate TRU Waste Certification Document.

5.10 **TRU Alpha Activity Concentration**

The records generated under TC-AP-01.2 documenting the calculation of TRU alpha activity concentration for each payload container shall be included in the data package. The calculated TRU alpha activity concentration value shall be recorded on the appropriate TRU Waste Certification Document.

5.11 **Pu-239 Equivalent Activity (PE-Ci)**

The records generated under TC-AP-01.2 documenting the calculation of plutonium equivalent curies (PE-Ci) for each payload container shall be included in the data package. The calculated PE-Ci value shall be recorded on the appropriate TRU Waste Certification Document.

5.12 **Radiation Dose Rate**

The radiation dose rate shall be measured under HP-OP-019 or by subcontracted services. Any records generated under HP-OP-019 shall be included in the data package. Subcontracted services shall provide the required data to the BCLDP TRU WCP in accordance with TCP-98-04. The survey results shall be recorded on the appropriate TRU Waste Certification Document.

Prior to shipment, WIPP approval is required if the measured radiation dose rate for an RH-TRU canister is greater than 100 roentgen equivalent man per hour (rem/hr). If required, the receipt of preapproval shall be indicated in the appropriate space on the appropriate TRU Waste Certification Document.

5.13 **Liquids**

The records generated under TCP-98-03.1 documenting acceptable knowledge (AK) supporting the absence of free liquids (<1% volume) shall be included in the data package. The records generated under TC-OP-01.4 documenting the inspection of payload container contents for free liquids during packaging shall be included in the data package.

Compliance with the restriction on free liquids shall be recorded on the appropriate TRU Waste Certification Document.

5.14 **Sealed Containers**

The records generated under TCP-98-03.1 documenting AK supporting the absence of sealed containers shall be included in the data package. The records generated under TC-OP-01.4 documenting the inspection of payload container contents for sealed containers during packaging shall be included in the data package. Compliance with the restriction on sealed containers shall be recorded on the appropriate TRU Waste Certification Document.

5.15 **Pyrophoric Materials**

The records generated under TCP-98-03.1 documenting AK supporting the absence of nonradionuclide pyrophorics and no significant quantities of radionuclide pyrophorics (i.e., <1% weight) shall be included in the data package. The records generated under TC-OP-01.4 documenting the inspection of payload container contents for pyrophoric materials during packaging shall be included in the data package. Compliance with the restriction on pyrophoric materials shall be recorded on the appropriate TRU Waste Certification Document.

5.16 **Hazardous Waste**

The records generated under TC-OP-01.4 documenting the WSPF assignment shall be included in the data package. Recording the WSPF number on the appropriate TRU Waste Certification Document and attaching the supporting data satisfies the hazardous waste data requirements.

5.17 **Chemical Compatibility**

The records generated under TCP-98-03.1 documenting chemical composition based on AK information shall be included in the data package. The records generated under TC-OP-01.4 documenting the evaluation of chemical compatibility also shall be included in the data package. Compliance with the chemical compatibility requirements shall be recorded on the appropriate TRU Waste Certification Document.

5.18 **Explosives, Corrosives, and Compressed Gases**

The records generated under TCP-98-03.1 documenting AK supporting the absence of explosives, corrosives, and compressed gases shall be included in the data package. The records generated under TC-OP-01.4 documenting the inspection of payload container contents for prohibited items during packaging shall be included in the data package. Compliance with the restriction on explosives, corrosives, and compressed gases shall be recorded on the appropriate TRU Waste Certification Document.

5.19 **Head Space Gas VOC Concentrations**

Subcontracted services shall provide headspace gas sampling and analysis results for each payload container in accordance with TCP-98-04. The headspace gas sampling and analysis results for total VOC concentration shall be recorded on the appropriate TRU Waste Certification Document.

5.20 **PCB Concentration**

The records generated under TC-OP-01.4 documenting the WSPF assignment shall be included in the data package. Recording the WSPF number on the appropriate TRU Waste Certification Document and attaching the supporting data satisfies the PCB concentration data requirements.

5.21 **Asbestos**

For waste streams containing asbestos, the SPM shall prepare and issue a letter to the CAO Waste Certification Manager that includes a description of the waste stream and requests guidance for those waste streams. For such a waste stream, any associated data shall be included in the payload container data package. The presence of asbestos in a payload container shall be indicated on the appropriate TRU Waste Certification Document. This parameter is not applicable to payload containers that do not contain asbestos.

5.22 **Payload Shipping Category**

The records generated under TC-OP-01.4 supporting the content code and shipping category (CH-TRU only) assignments shall be included in the data package. CH-TRU payload containers shall be labeled with the assigned shipping category under TC-OP-01.4. The content code and shipping category, if applicable, for the payload container shall be recorded on the appropriate TRU Waste Certification Document.

The records generated under TC-OP-01.4 supporting the packaging configuration (i.e., number and type of confinement layers used to package the payload container contents) described by the assigned content code and shipping category shall be included in the data package.

Recording the assigned content code and shipping category for the payload container on the appropriate TRU Waste Certification Document and attaching the verification data satisfies the confinement layers data requirement.

5.23 **Decay Heat**

The records generated under TC-AP-01.2 documenting the calculation of decay heat for each payload container shall be included in the data package. The calculated decay heat value shall be recorded on the appropriate TRU Waste Certification Document.

5.24 **Test Category Waste**

If applicable, subcontracted services shall provide gas generation test results for test category payload containers results in accordance with TCP-98-01.2 and TCP-98-04. The gas generation test results shall be recorded on the appropriate TRU Waste Certification Document.

5.25 **Flammable VOCs**

Subcontracted services shall provide headspace gas sampling and analysis results for each payload container in accordance with TCP-98-04. The headspace gas sampling and analysis results for flammable VOCs shall be recorded on the appropriate TRU Waste Certification Document.

5.26 **Venting and Aspiration**

All payload containers shall be vented during packaging in accordance with TC-OP-01.4. As stated in TCP-98-01, aspiration for hydrogen will not be needed because all waste will be vented at the time of generation.

5.27 **Characterization and Certification Data**

Based on the characterization of a BCLDP TRU waste stream as defined in TCP-98-02 and TCP-98-03.1, BCLDP TRU WCP personnel shall complete a WSPF in accordance with TC-AP-01.1.1. The WSPF is the tool that the BCLDP uses to notify the WIPP that the waste stream has been characterized. The BCLDP shall transmit the WSPF to the WIPP for review and approval. Following WIPP approval of a WSPF, the BCLDP may certify payload containers under the approved waste stream profile. Therefore, the approved WSPF number associated with a payload container must be recorded on the appropriate TRU Waste Certification Document.

During segregation and packaging activities under TC-OP-01.4, BCLDP TRU WCP personnel shall identify which waste stream is packaged into each payload container. The records generated under TC-OP-01.4 correlating payload container contents to a waste stream during packaging shall be included in the data package.

Completing the WSPF, recording its number on the appropriate TRU Waste Certification Document, and attaching the WSPF and supporting data satisfies the data requirement for characterization documentation.

As described in Attachment 7.2.4, BCLDP TRU WCP personnel shall prepare a TRU Waste Certification Document indicating the approval of a payload container or payload assembly for WIPP disposal. The acceptance of the TRU Waste Certification Document is supported by the data package(s) compiled as described in this document.

5.28 **Shipping Data**

BCLDP TRU WCP personnel shall prepare the following transportation certification documents, as applicable:

- PCTCD for each CH-TRU payload container (Attachment 7.2.1)
- CH-TRU PATCD for each CH-TRU payload assembly (Attachment 7.2.2)
- RH-TRU PATCD for each RH-TRU canister. (Attachment 7.2.3)

The completion of the PCTCD and CH-TRU PATCD or RH-TRU PATCD is a requirement of TCP-98-01.2 and is detailed in Attachments 7.2.1, 7.2.2, and 7.2.3. The completed transportation certification documents qualify individual payload containers and payload assemblies for transport to the WIPP by verifying compliance with the payload requirements of the TRUPACT-II Safety Analysis Report (SAR) and the 72-B Cask SAR.

For mixed TRU shipments, records generated under TR-OP-007 during the completion of the Uniform Hazardous Waste Manifest according to 40 CFR 262.23 and Land Disposal Restriction notification, according to 40 CFR 268 shall be included in the data package. For nonmixed TRU shipments, records generated under TR-OP-003 during the completion of the Bill of Lading according to 49 CFR 172, Subpart C, shall be included in the data package.

Completing the PCTCD and/or PATCD, the Uniform Hazardous Waste Manifest and Land Disposal Restriction notification or the Bill of Lading, and attaching supporting documentation satisfies the data requirement for shipping documentation.

6.0 **Records**

The following records will be maintained as permanent quality records in accordance with PR-AP-17.1.

6.1 All reports generated by this procedure, including the following:

- Completed PCTCD (CH-TRU)
- Completed CH-TRU PATCD
- Completed RH-TRU PATCD
- Completed TRU Waste Certification Documents.

7.0 **Forms and Attachments**

7.1 **Forms**

7.1.1 DDO-445-W, Analytical CH-TRU Payload Shipping Category

7.1.2 DDO-446-W, Test CH-TRU Payload Shipping Category

7.1.3 DDO-447-W, CH-TRU Payload Assembly Transportation Certification

7.1.4 DDO-448-W, RH-TRU Payload Assembly Transportation Certification Document

7.1.5 DDO-449-W, CH-TRU Payload Container TRU Waste Certification Document

7.1.6 DDO-450-W, RH-TRU Canister TRU Waste Certification Document

7.1.7 DDO-451-W, CH-TRU Payload Assembly TRU Waste Certification Document

7.1.8 DDO-452-W, CH-TRU Waste Dunnage Certification Document

7.1.9 DDO-453-W, RH-TRU Payload Assembly TRU Waste Certification Document

7.2 Attachments

7.2.1 Attachment 1, Completion of Payload Container Transportation Certification Document (CH-TRU)

7.2.2 Attachment 2, Completion of CH-TRU Payload Assembly Transportation Certification Document

7.2.3 Attachment 3, Completion of Payload Assembly Transportation Certification Document (RH-TRU)

7.2.4 Attachment 4, Completion of TRU Waste Certification Documents

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Analytical CH-TRU Payload Shipping Category

Payload Container Transportation Certification Document (PCTCD)

IDENTIFICATION PARAMETERS

Container ID #:____________________ Container Bar Code #: ____________________

Shipping Category:____ _______ _______ Content Code: ____________________

Payload Container Type: ☐ 55-Gallon Drum ☐ Pipe Overpack

Certification Site: BCLDP

CH-TRAMPAC TRANSPORTATION PARAMETERS

Parameter	Initials	Filter(s) Identification[a]
Free liquids are < 1% of payload container volume	______	1. ______ 2. ______
Nonradioactive pyrophorics are not present	______	
Radioactive pyrophorics are < 1% (weight)	______	3. ______ 4. ______
Explosives are not present	______	
Corrosives are not present	______	5. ______ 6. ______
Pressurized containers are not present	______	
Sealed containers >4 liters are not present[b]	______	7. ______ 8. ______
55-Gallon drum liner (if present) is punctured/vented	______	
Flammable VOCs are ≤ 500 ppm	______	9. ______ 10. ______
Radiation dose rate is ≤ 200 mrem/hour	______	

MEASURED PARAMETERS

Container Parameter	Value	Error	Value + 1x Error	Value + 2x Error	Limit
Weight (lbs.)					
Decay Heat (watts)					
Fissile Mass (FGE)					

[a]See TCP-98-01.2 for the number of filters required for each container type.
[b]This requirement does not apply to Waste Material Type II.2 packaged in metal containers.

I certify that the above container meets all the requirements for shipment as stated in TCP-98-01.2, current revision. The container is approved for shipment.

Transportation Certification Official (Print Name)	Signature	Date

Test CH-TRU Payload Shipping Category

Payload Container Transportation Certification Document (PCTCD)

IDENTIFICATION PARAMETERS

Container ID #:______________________ Container Bar Code #: ________________________

Shipping Category:____ _______ _______ Content Code: ________________________________

Payload Container Type: Γ 55-Gallon Drum Γ Pipe Overpack

Certification Site: BCLDP

CH-TRAMPAC TRANSPORTATION PARAMETERS

Parameter	Initials	Filter(s) Identification[a]
Free liquids are < 1% of payload container volume	________	1. ________ 2. ________
Nonradioactive pyrophorics are not present	________	
Radioactive pyrophorics are < 1% (weight)	________	3. ________ 4. ________
Explosives are not present	________	
Corrosives are not present	________	5. ________ 6. ________
Pressurized containers are not present	________	
Sealed containers >4 liters are not present	________	7. ________ 8. ________
55-Gallon drum liner (if present) is punctured/vented	________	
Radiation dose rate is ≤ 200 mrem/hour	________	
	________	9. ________ 10. ________

MEASURED PARAMETERS

Container Parameter	Value	Error	Value + 1x Error	Value + 2x Error	Limit
Weight (lbs.)					
Decay Heat (watts)					
Fissile Mass (FGE)					

TEST CRITERIA[b]

Container Parameter	Limit	Measurement
Total Gas Release Rate (mol/s)[c]		
H_2 Gas Generation Rate (mol/s)		
Flammable VOC Concentration (ppm)	500	

Date Test Completed:______________________

[a] See TCP-98-01.2 for the number of filters required for each container type.
[b] Test category criteria and data must be entered from the associated data sheet (see TRAMPAC).
[c] Required only for containers of Waste Type III in payloads over 7 watts per TRUPACT-II and all of Waste Type IV.

I certify that the above container meets all the requirements for shipment as stated in TCP-98-01.2, current revision. The container is approved for shipment.

Transportation Certification Official (Print Name)	Signature	Date

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CH-TRU Payload Assembly Transportation Certification

IDENTIFICATION PARAMETERS

Shipment #: ____________ Packaging OCA Body/Lid #: ______________ / ______________

Governing Payload Shipping Category: _____ ________ ________

Governing Payload Shipping Category Decay Heat Limit: ______________________________ watts

Type of Payload: ☐ 55-Gallon Drums ☐ Pipe Overpacks

Date ICV Closed: ________________________

BOTTOM PAYLOAD ASSEMBLY COMPOSITION

Container ID Number	Weight[a] (lbs.)	Error[a] (lbs.)	Decay Heat (watts)	Error (watts)	Fissile Mass (FGE)	2x Error (FGE)
Subtotal (A)						
Subtotal RMS Error (C)						

TOP PAYLOAD ASSEMBLY COMPOSITION

Container ID Number	Weight[a] (lbs.)	Error[a] (lbs.)	Decay Heat (watts)	Error (watts)	Fissile Mass (FGE)	2x Error (FGE)
Subtotal (B)						
Subtotal RMS Error[b] (D)						

TOTAL PAYLOAD ASSEMBLY COMPOSITION

Total[c] RMS Error[b]						

PAYLOAD TOTALS

Weight of Pallets, Reinforcing Plates, Slip Sheets, Guide Tubes, Adjustable Slings, etc.[d] (E) ______________________ lbs.

Total (A+B+E) Weight: ______________	lbs.	Total RMS Weight Error: ______________	lbs.
Total (A+B) Decay Heat: ______________	watts	Total RMS Decay Heat Error: ______________	watts
Total (A+B) Fissile Mass: ______________	FGE	Total RMS Fissile Mass Error: ______________	FGE

PAYLOAD CERTIFICATION PARAMETERS

Bottom Assembly Weight plus Subtotal RMS Error (A+C) (lbs.): ______________
Top Assembly Weight plus Subtotal RMS Error (B+D) (lbs.): ______________
Total Weight plus RMS Error[a] (lbs): ____________ Total Fissile Mass plus Total RMS Error (FGE): _______
Total Decay Heat plus RMS Error (watts): ______________
Package Radiation Dose Rates (mrem/hr): contact ________ @ 2 meters ________ in Cab __________

	Initials
Bottom Weight ≥ Top Weight	_______
Total Weight plus RMS Error ≤ __________ lbs.[e]	_______
Decay Heat plus RMS Error ≤ ______________ watts[f]	_______
Fissile Mass (Pu-239 FGE) plus RMS Error ≤ __________ FGE[g]	_______
Package Radiation Dose Rates ≤ Limits[h]	_______

[a] Total weight may be determined by one of the following methods: (1) sum of individual payload containers plus error; (2) sum of seven-pack(s) plus error; or (3) single measurement of a total payload of drums plus error.

[b] RMS Error = root mean square error (square root of the sum of the squares of the individual errors).

[c] Total RMS error for the entire payload (Top and Bottom).

[d] Weight of Pallets, Reinforcing Plates, Slip Sheets, Guide Tubes, Adjustable Slings, etc. can be estimated as 265 lbs. for the TRUPACT-II.

[e] TRUPACT-II total payload weight plus RMS error ≤ 7,265 lbs. Total weight plus error shall include weight of all payload containers plus weight of pallets, reinforcing plates, slip sheets, guide tubes, adjustable slings, etc.

[f] TRUPACT-II packaging decay heat limit plus RMS error ≤ 40 watts.

[g] If the payload is composed of only pipe overpacks, the total Pu-239 FGE limit is 2,800 grams/TRUPACT-II. The total Pu-239 FGE limit for all other payloads is 325 grams/TRUPACT-II.

[h] Package Radiation Dose Limits: Contact ≤ 200 mrem/hr; @ 2 meters ≤ 10 mrem/hr; in cab ≤ 2 mrem/hr.

I certify that the above payload assembly meets all the requirements for shipment as stated in TCP-98-01.2, current revision. The payload assembly is approved for shipment.

Transportation Certification Official (Print Name)	Signature	Date

RH-TRU Payload Assembly Transportation Certification Document (RH-TRU PATCD)

Canister ID #: ______________________

Certification Site: BCLDP

Payload Content Code: ______________________

Payload Container Type*: __________

Canister Filtered: ______________________

Filter Model: ______________________

Inner Containers Overpacked in Canister

Drums: ______________________

Number of Drums: __________

Other: ______________________

Number: __________

Inner Containers Filtered: ______________________

Filter Model: ______________________

Canister Weight __________ + Error __________ = __________

Canister Fissile Mass __________ + Error __________ = __________ *(if applicable)*

Gas Generation and Hydrogen Concentration Limits (Complete Option 1 or Option 2)

OPTION 1:

Limit for Hydrogen Generation Rate: ______________________

Determined Hydrogen Generation Rate: ______________________

OPTION 2:

Decay Heat Limit for Content Code: ______________________

Calculated Decay Heat: ______________________

Payload Assembly

72-B Cask ID#: ______________________

Shipment No.: ______________________

Radiation Dose Rate: At surface $\leq$ 200 mrem/hour __________

At 2 meters $\leq$ 10 mrem/hour __________

Approved for Shipment

I certify that the above canister meets the requirements for shipment in the 72-B Cask.

____
Transportation Certification Official

____
Date

CH-TRU Payload Container
TRU Waste Certification Statement

Identification Information:
Payload Container Identification No: ____________________
Date of Payload Container Closure: ____________________
Date of Payload Container Certification: ____________________
WIPP WAC Exception No. (if applicable): ____________________
Waste Stream Profile Form No: ____________________

Initials indicate compliance with payload container requirements based on the review of supporting data attached).

Criteria	Limits	Supporting Data (attached)	Initials
Payload Container Description	• DOT Type A payload containers	• PCTCD • Records generated by QD-AP-04.1, WA-OP-006, and TC-OP-01.4, and by subcontracted services, if applicable	
Payload Container Weight	• ≤1,000 lbs. per 55-gallon drum (or pipe overpack)	• PCTCD • Records generated by TC-OP-01.4, and by subcontracted services, if applicable	
Removable Surface Contamination	• ≤20 dpm/100 cm^2 alpha • ≤200 dpm/100 cm^2 beta-gamma(1)	• Records generated by HP-OP-019, and by subcontracted services, if applicable	
Payload Container Marking	• Bar code • Shipping category	• PCTCD • Records generated by WA-OP-030	
Filter Vents	• Payload containers vented	• PCTCD • Records generated by QD-AP-04.1, WA-OP-006, and TC-OP-01.4, and by subcontracted services, if applicable	
Liquids	• No liquid wastes • <2 L total residual liquid per 55-gallon drum • <1 in. (2.5 cm) in the bottom of any container	• PCTCD • Records generated by TCP-98-03.1 and TC-OP-01.4	
Nuclear Criticality (Pu-239 FGE)	• <200 g per 55-gallon drum (or pipe overpack)	• PCTCD • Records generated by TC-AP-01.2	
Pu-239 Equivalent Activity (PE-Ci)	Untreated Waste • ≤80 PE-Ci per 55-gallon drum Solidified/Vitrified Waste • ≤1,800 PE-Ci per 55-gallon drum	• Records generated by TC-AP-01.2	

Criteria	Limits	Supporting Data (attached)	Initials
Radiation Dose Rate	• ≤200 mrem/hr contact dose rate per payload container	• PCTCD • Records generated by HP-OP-019 and by subcontracted services, if applicable	
Thermal Power	• Report if >0.1 watt/ft^3	• Records generated by TC-AP-01.2	
TRU Alpha Activity	• >100 nCi/g of waste matrix	• Records generated by TC-AP-01.2	
Pyrophoric Materials	• No nonradionuclide pyrophorics • <1 wt. % radionuclide pyrophorics per payload container	• PCTCD • Records generated by TCP-98-03.1 and TC-OP-01.4	
Mixed Waste	• Characterization per QAPP • Limited to EPA Waste Codes listed in WIPP WAC	• Records generated by TCP-98-03.1 and TC-OP-01.4 • WSPF	
Chemical Compatibility	• All chemicals must be allowable per the TRUPACT-II SAR	• PCTCD • Records generated by TCP-98-03.1 and TC-OP-01.4	
Hazardous Constituents	• Target analytes and TICs to be reported per the QAPP	• Records generated by TCP-98-03.1 and TC-OP-01.4 • WSPF	
Explosives, Corrosives and Compressed Gases	• None present	• PCTCD • Records generated by TCP-98-03.1 and TC-OP-01.4	
PCB Concentration	• <50 ppm	• Records generated by TCP-98-03.1 • WSPF	
Decay Heat	• ≤ Wattages listed in TRUPACT-II SAR	• PCTCD • Records generated by TC-AP-01.2	
Flammable VOCs	• ≤500 ppm in payload container headspace	• PCTCD • Records generated by subcontracted services	
VOC Concentration	• ≤ Limits specified in WIPP WAC	• Records generated by subcontracted services	
Aspiration	• ≥ Times specified in TRUPACT-II SAR	• NA	NA(2)
Shipping Category	• Content codes listed in TRUCON	• PCTCD • Records generated by WA-OP-030 and TC-OP-01.4	
Confinement Layers	• Liner punctured/vented • Number of layers known • Bags closed by approved methods specified in the TRUPACT-II SAR • Sealed container >4 L prohibited (except for Waste Material Type II.2)	• PCTCD • Records generated by TC-OP-01.4	

Criteria	Limits	Supporting Data (attached)	Initials
Acceptance Data	• Auditable package of data with signed TRU Waste Certification Statement on file	• Signed TRU Waste Certification Statement (this document)	
RCRA Data	• WSPF	• Records generated by TCP-98-03.1 and TC-OP-01.4 • WSPF	
Shipping Data	• PCTCD Records	• PCTCD	

NOTES: (1) May be 1,000 dpm/100 cm^2 for certain isotopes as specified in the WIPP WAC.
(2) Aspiration requirements are not applicable because all BCLDP TRU waste is newly generated.

I hereby certify that I have reviewed the data for this waste container and that it is complete and accurate to the best of my knowledge. I have determined that it meets the requirements stated in the current revision of the WIPP Waste Acceptance Criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Waste Certification Official (Print Name)	Signature Date

RH-TRU Canister
TRU Waste Certification Document

Identification Information:
RH-TRU Canister Identification No: ____________________
Date of RH-TRU Canister Closure: ____________________
Date of RH-TRU Canister Certification: ____________________
WIPP WAC Exception No. (if applicable): ____________________
Waste Stream Profile Form No: ____________________

Initials indicate compliance with payload container requirements based on the review of supporting data (attached).

Criteria	Limits	Supporting Data (attached)	Initials
Payload Container Description	• DOT Type A RH-TRU canister	• RH-PATCD • Records generated by QD-AP-04.1, WA-OP-006, and TC-OP-01.4, and by subcontracted services, if applicable	
Container Weight and Center of Gravity	• #8,000 lbs. per RH-TRU canister	• RH-PATCD • Records generated by TC-OP-01.4, and by subcontracted services, if applicable	
Removable Surface Contamination	• #20 dpm/100 cm^2 alpha • #200 dpm/100 cm^2 beta-gamma(1)	• Records generated by HP-OP-019, and by subcontracted services, if applicable	
Container Identification/ Marking	• Canister ID	• RH-PATCD • Records generated by TC-OP-01.4	
Dunnage	• Limited to inside RH-TRU canister	• RH-PATCD	
Filter Vents	• RH-TRU canister vented	• RH-PATCD • Records generated by QD-AP-04.1, WA-OP-006, and TC-OP-01.4, and by subcontracted services, if applicable	
Radionuclide Composition	• Assay measurements • Quantification of Am-241, Pu-238, Pu-239, Pu-240, Pu-242, U-233, U-234, U-238, Sr-90, Cs-137	• Records generated by DD-98-04, and by subcontracted services, if applicable	
Fissile Material Quantity (Pu-239 FGE)	• <325 g per RH-TRU canister	• RH-PATCD • Records generated by DD-98-04 and TC-AP-01.2	

Criteria	Limits	Supporting Data (attached)	Initials
TRU Alpha Activity Concentration	• >100 nCi/g of waste matrix • <23 Ci/L	• Records generated by DD-98-04 and TC-AP-01.2	
Pu-239 Equivalent Activity (PE-Ci)	• #1,000 PE-Ci per RH-TRU canister	• Records generated by DD-98-04 and TC-AP-01.2	
Radiation Dose Rate	• #1,000 rem/hr per RH-TRU canister • Preapproval received for >100 rem/hr per RH-TRU canister	• RH-PATCD • Records generated by HP-OP-019 and by subcontracted services, if applicable	
Liquids	• No liquid wastes • <6 L total residual liquid per RH-TRU canister • <1 in. (2.5 cm) in the bottom of any container	• RH-PATCD • Records generated by TCP-98-03.1, TC-OP-01.4, and WA-OP-029	
Sealed Containers	• No sealed containers greater than 4 liters	• RH-PATCD • Records generated by TC-98-03.1 and TC-OP-01.4	
Pyrophoric Materials	• No nonradionuclide pyrophorics • <1 wt. % radionuclide pyrophorics	• RH-PATCD • Records generated by TCP-98-03.1 and TC-OP-01.4	
Hazardous Waste	• Characterization per QAPP • Limited to EPA Waste Codes listed in WIPP WAC • Target analytes and TICs to be reported per the QAPP	• Records generated by TCP-98-03.1, TC-OP-01.4, and TC-AP-01.1.1	
Chemical Compatibility	• All chemicals must be allowable per the 72-B Cask SAR	• RH-PATCD • Records generated by TCP-98-03.1 and TC-OP-01.4	
Explosives, Corrosives and Compressed Gases	• None present	• RH-PATCD • Records generated by TCP-98-03.1 and TC-OP-01.4	
Headspace Gas VOC Concentration	• Every container will be headspace gas sampled • ≤Limits in the WIPP WAC	• Records generated by subcontracted services	
PCB Concentration	• <50 ppm	• Records generated by TCP-98-03.1 and TC-AP-01.1.1	
Asbestos	• Sites shall identify wastes containing asbestos	• Records generated by TCP-98-03.1 • Contact DOE-CAO Waste Certification Manager for guidance	
Content Code	• Approved content codes	• RH-PATCD • Records generated by TC-OP-01.4 and TCP-98-03.1	

Criteria	Limits	Supporting Data (attached)	Initials
Decay Heat	• #Decay heat limits listed in 72-B Cask SAR	• RH-PATCD • Records generated by DD-98-04 and TC-AP-01.2	
Test Category Waste	• Steady-state hydrogen gas generation release rate ≤ rate specified in 72-B Cask SAR	• Records of gas generation testing/sampling (Mobile Vendor Interface Plan, BCLDP TRAMPAC, or QAPjP)	
Flammable VOCs	• #500 ppm in payload container headspace	• RH-PATCD • Records generated by subcontracted services	
Venting and Aspiration	• None currently identified	• Not applicable	
Characterization and Certification Data	• WSPF and accompanying characterization data summary reports	• Records generated by TC-AP-01.1.1 • Signed TRU Waste Certification Document (this document)	
Shipping Data	• Uniform Hazardous Waste Manifest or Bill of Lading • Land Disposal Restriction Notification • Transportation Certification Documents	• RH-PATCD • Signed TRU Waste Certification Document (this document) • Records generated by TR-OP-003 or TR-OP-007	

NOTES: (1) May be 1,000 dpm/100 cm^2 for certain isotopes as specified in the WIPP WAC.

I hereby certify that I have reviewed the data for this waste container and that it is complete and accurate to the best of my knowledge. I have determined that it meets the requirements stated in the current revision of the WIPP Waste Acceptance Criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Waste Certification Official (Print Name)	Signature Date

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CH-TRU Payload Assembly
TRU Waste Certification Document

Identification Information:
Shipment No: ____________________
Date of Shipment: ____________________
TRUPACT-II No: ____________________
Date of TRUPACT-II Closure: ____________________
WIPP WAC Exception No. (if applicable): ____________________

Initials indicate compliance with payload container requirements based on the review of supporting data (attached).

Criteria	Limits	Supporting Data (attached)	Initials
Payload Container Description	• DOT Type A payload containers	• CH-PATCD • Records generated by QD-AP-04.1, WA-OP-006, and TC-OP-01.4, and by subcontracted services, if applicable	
Container Weight and Center of Gravity	• DOT Type A or equivalent limits • TRAMPAC limits	• CH-PATCD • Records generated by TC-OP-01.4, and by subcontracted services, if applicable	
Removable Surface Contamination	• #20 dpm/100 cm^2 alpha • #200 dpm/100 cm^2 beta-gamma(1)	• Records generated by HP-OP-019, and by subcontracted services, if applicable	
Dunnage	• Empty 55-gallon drums	• CH-PATCD • Records generated by TC-OP-01.4	
Fissile Material Quantity (Pu-239 FGE)	• ≤325 g per TRUPACT-II • ≤2,800 g per TRUPACT-II (payload of 14 pipe overpacks)	• CH-PATCD • Records generated by TC-AP-01.2, and by subcontracted services	
Radiation Dose Rate	• ≤200 mrem/hr contact dose rate per loaded TRUPACT-II • ≤10 mrem/hr per loaded TRUPACT-II at 2 meters distance	• CH-PATCD • Records generated by HP-OP-019 and by subcontracted services, if applicable	
Payload Shipping Category	• Approved content codes • Same or equivalent shipping category per TRUPACT-II	• CH-PATCD • Records generated by TC-OP-01.4 and TCP-98-03.1	

Criteria	Limits	Supporting Data (attached)	Initials
Decay heat	• #40 watts per TRUPACT-II	• CH-PATCD • Records generated by TC-AP-01.2 and by subcontracted services	
Characterization and Certification Data	• WSPF and accompanying data summary report	• Records generated by TC-AP-01.1.1 • Signed TRU Waste Certification Document (this document)	
Shipping Data	• Uniform Hazardous Waste Manifest or Bill of Lading • Land Disposal Restriction Notification • Transportation Certification Documentation	• CH-PATCD • Signed TRU Waste Certification Document (this document) • Records generated by TR-OP-003 or TR-OP-007	

I hereby certify that I have reviewed the data for this payload assembly and that it is complete and accurate to the best of my knowledge. I have determined that it meets the requirements stated in the current revision of the WIPP Waste Acceptance Criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Waste Certification Official (Print Name)	Signature Date

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CH-TRU Waste Dunnage Certification Document

Dunnage Container Identification No: ______________________

Criteria	Limits	Initials
Dunnage Container Type	• Empty 55-gallon drum	
Dunnage Container Weight	• <60 lbs. per 55-gallon drum	
Removable Surface Contamination	• ≤20 dpm/100 cm^2 alpha • ≤200 dpm/100 cm^2 beta-gamma	
Dunnage Container Marking	• Bar code, if applicable • "EMPTY" or "DUNNAGE"	
Filter Vents	• Dunnage container open or vented	
Liquids	• Dry	
Fissile Material Quantity (Pu-239 FGE)	• 0	
Comments:		

I hereby certify that I have reviewed the data for this assembly dunnage and have determined that it meets the requirements stated in the current revision of the WIPP Waste Acceptance Criteria.

Waste Certification Official (Print Name)	Signature Date

RH-TRU Payload Assembly
TRU Waste Certification Document

Identification Information:

RH-TRU Canister Identification No: ______________________
Date of RH-TRU Canister Closure: ______________________
Date of RH-TRU Canister Certification: ______________________
WIPP WAC Exception No. (if applicable): ______________________

Initials indicate compliance with payload container requirements based on the review of supporting data (attached).

Criteria	Limits	Supporting Data (attached)	Initials
Weight	• Limits from Appendix 1.3.7 of 72-B Cask SAR	• RH-PATCD • Records generated by TC-OP-01.4, and by subcontracted services, if applicable	
Removable Surface Contamination	• 20 dpm/100 cm^2 alpha • 200 dpm/100 cm^2 beta-gamma	• Records generated by HP-OP-019, and by subcontracted services, if applicable	
Fissile Material Quantity (Pu-239 FGE)	• <325 g per 72-B Cask	• RH-PATCD • Records generated by DD-98-04 and TC-AP-01.2	
Radiation Dose Rate	• 200 mrem/hr contact dose rate per loaded 72-B Cask • 10 mrem/hr per loaded 72-B Cask at 2 meters distance	• RH-PATCD • Records generated by HP-OP-019 and by subcontracted services, if applicable	
Decay heat	• 300 watts per 72-B Cask	• RH-PATCD • Records generated by DD-98-04 and TC-AP-01.2	
Characterization and Certification Data	• WSPF and accompanying data summary report	• Records generated by TC-AP-01.1.1 • Signed TRU Waste Certification Document (this document)	
Shipping Data	• Uniform Hazardous Waste Manifest or Bill of Lading • Land Disposal Restriction Notification • Transportation Certification Documentation	• CH-PATCD • Signed TRU Waste Certification Document (this document) • Records generated by TR-OP-003 or TR-OP-007	

I hereby certify that I have reviewed the data for this payload assembly and that it is complete and accurate to the best of my knowledge. I have determined that it meets the requirements stated in the current revision of the WIPP Waste Acceptance Criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Waste Certification Official (Print Name)	Signature Date

Attachment 1

Completion of Payload Container Transportation Certification Document (CH-TRU)

Procedure for Qualifying Individual Payload Containers for Transportation (Analytical Category)

The BCLDP TRU WCP shall qualify an individual CH-TRU payload container for transport in a Transuranic Package Transporter-II (TRUPACT-II) under the analytical category as described in TCP-98-01.2. Transportation qualification is accomplished by verifying that the payload container meets the parameter requirements/limits listed in the Payload Container Transportation Certification Document (PCTCD), Analytical Category (DDO-445-W). Form DDO-445-W (the PCTCD, Analytical Category) shall be completed for each payload container to be directly loaded into the inner containment vessel (ICV). Form DDO-445-W shall be completed as follows:

Identification Parameters

- Container ID #/Container Bar Code #: The payload container identification (ID) number is unique to each payload container of waste and provides a means for tracking process data records and package history (i.e., the data package). The payload container ID number shall be assigned prior to waste packaging in accordance with the labeling instructions of WA-OP-030. Information necessary for transporting payload containers is entered into the data package under this ID number.

- Shipping Category: The proper shipping category shall be assigned to the payload container by consulting the appropriate approved content code in the TRUPACT-II Content Codes document (TRUCON). If the assigned shipping category does not match any of the shipping categories contained in the TRUCON for the content code, the payload container is not eligible for shipment.

- Content Code: The content code assigned to the payload container shall be approved as part of the TRUCON. If the content code is not listed in the TRUCON, it is not eligible for shipment. The content code describes its physical and chemical form of the waste.

- Container Type: The payload container shall be one of the approved types in one of the following authorized configurations:

- **55-Gallon Drum**: Waste directly loaded into one 55-gallon drum. Complete Form DDO-445-W for the 55-gallon drum.

- **Pipe Overpack**: Waste packaged in one pipe component overpacked in one 55-gallon drum. Note that the pipe component is only authorized for use in this configuration. Complete Form DDO-445-W for the pipe overpack.

- Certification Site: The certification site shall be recorded as the location at which transportation certification occurs. Certification of BCLDP TRU waste will occur at the BCLDP as all waste will be newly generated.

TRAMPAC Transportation Parameters

Compliance information for the TRAMPAC transportation parameters shall be obtained from the data package for the payload container. The Transportation Certification Official (TCO) shall indicate compliance with each requirement by initials in the space provided. The following criteria shall be met:

- Free liquids <1 percent of payload container volume.

- Non-radioactive pyrophorics are not present.

- Radioactive pyrophorics <1 percent (weight).

- Explosives are not present.

- Corrosives are not present.

- Pressurized containers are not present.

- Sealed containers >4 liters are not present, except for Waste Material Type II.2 packaged in metal cans.

- 55-gallon drum liner (if present) is punctured/vented.

- Flammable volatile organic compounds (VOC) ≤500 parts per million (ppm).

- Radiation dose rate is ≤200 millirem per hour (mrem/hr) at surface of payload container.

- Filter(s) Identification. The filter information listed shall be for a single payload container unless Form DDO-445-W is being completed for a pipe overpack as defined above. For a pipe overpack, filter information shall be listed for the filter installed in the 55-gallon drum and for the filter installed in the pipe component. Identification (i.e., identification of the supplier and date of manufacture, lot number, or unique serial number) shall be listed for the type and appropriate number of filters as determined by payload container type. See TCP-98-01.2 for the number of filters required for each container type.

Measured Parameters

- Weight: The maximum allowable weight limit for the appropriate payload container type shall be recorded.

  The measured weight of the payload container may be obtained from its data package. The measured payload container weight plus the measurement error shall be compared to the maximum allowable weight limit for the appropriate payload container type.

- Decay Heat: The maximum allowable decay heat limit per payload container for the applicable payload shipping category shall be recorded from the appropriate content code. The decay heat for the payload container shall be calculated in accordance with TC-AP-01.2. The calculated decay heat value, which includes the error, shall be compared to the maximum allowable decay heat limit per payload container for the appropriate shipping category.

- Fissile Mass (fissile gram equivalent [FGE]): The maximum allowable fissile mass limit for the appropriate payload container type shall be recorded. The fissile mass for the payload container shall be calculated in accordance with TC-AP-01.2. The calculated fissile mass, which includes two times the error, shall be compared to the maximum allowable fissile mass limit per payload container for the appropriate payload container type.

Transportation Certification Official

The TCO shall verify that all of the requirements for the above transportation parameters are met as stated in TCP-98-01.2. The TCO shall sign and date the PCTCD upon completion, thereby authorizing the payload container for transport in the TRUPACT-II. If the requirements are not met, the payload container is rejected and not qualified for shipment.

7.2.1.2 Procedure for Certification of Individual Payload Containers (Test Category)

The BCLDP TRU WCP shall qualify an individual CH-TRU payload container for transport in a TRUPACT-II under the test category as defined by TCP-98-01.2 by verifying that the container meets the parameter requirements/limits listed in the PCTCD, Test Category (Form DDO-446-W).

Form DDO-446-W (the PCTCD, Test Category) shall be completed for each payload container to be directly loaded into the ICV. Data on the parameters for specific payloads shall be obtained by the methods outlined in TCP-98-01.2 and shall be consistent with the information for each parameter provided in the appropriate content code. Form DDO-446-W shall be completed as follows:

Identification Parameters, TRAMPAC Transportation Parameters, Measured Parameters

Complete items described for Form DDO-445-W as directed in Section 7.3.1.1 above.

Test Criteria

The test criteria data are obtained as described in TCP-98-01.2 based on the completion of the test procedure for each payload container.

- Limit/Measurement for Total Gas Generation Rate: Record the limit as defined for the appropriate shipping category in the TRUPACT-II Authorized Methods for Payload Control (TRAMPAC) (Appendix 1.3.7 of the TRUPACT-II Safety Analysis Report). Record the measured value under the measurement column. This value shall be less than the limit to be approved for shipment.

- Limit/Measurement for Hydrogen Gas Generation Rate: Record the limit as defined for each shipping category in the TRAMPAC. Record the measured value under the measurement column. This value shall be less than the limit to be approved for shipment.

- Limit/Measurement for Potentially Flammable VOCs: Record the measured value under the measurement column. This value shall be less than or equal to the 500-ppm limit to be approved for shipment.

- Date Test Completed: This shall be the date the test is terminated as outlined in the TRAMPAC.

Attachment 2

Completion of Payload Assembly Transportation Certification Document (CH-TRU)

The BCLDP TRU WCP shall qualify a payload for transport in a Transuranic Package Transporter-II (TRUPACT-II) by verifying that the payload meets the parameter requirements/limits listed in the CH-TRU Payload Assembly Transportation Certification Document (CH-TRU PATCD) (Form DDO-447-W). Form DDO-447-W shall be completed as follows:

Identification Parameters

- Shipment #: The Transportation Certification Official (TCO) shall record the shipment number of the trailer of TRUPACT-IIs.

- Packaging Outer Containment Assembly (OCA) Body/Lid #: The identification numbers on the TRUPACT-II OCA body and lid shall be recorded.

- Governing Payload Shipping Category: The shipping category of the payload shall be recorded.

  The waste type and payload container type shall be the same for all payload containers making up a payload. If containers with different shipping categories are included in the same payload, the governing payload shipping category is the same as the shipping category for the container with the lowest decay heat limit.

- Governing Payload Shipping Category Decay Heat Limit: The maximum allowable decay heat per payload container for the governing payload shipping category shall be recorded from the appropriate content code. Note: The "Governing Payload Shipping Category Decay Heat Limit" is the most conservative limit listed in the Payload Container Transportation Certification Document (PCTCD) (Attachment 7.2.1).

- Type of Payload: The payload configuration shall consist of an approved type of payload container.

- Date ICV Closed: The date that the inner containment vessel (ICV) is closed shall be recorded.

Bottom Payload Assembly Composition, Top Payload Assembly Composition

The following data shall be recorded from the PCTCD (Attachment 7.2.1) for each payload container comprising the payload. Only the "Container ID Number," "Weight," and weight measurement "Error" need to be completed for dunnage.

- Payload container identification (ID) number or "DUNNAGE" or "EMPTY"
- Measured weight and measurement error
- Measured decay heat and measurement error
- Measured fissile mass and two times the measurement error.

The weight, decay heat, and fissile mass values of all containers are summed for both the bottom and top layers, and the RMS error for each parameter shall be calculated as the square root of the sum of the squares of the individually listed errors (indicated in the PCTCD, Attachment 7.2.1). If the weight is determined through a single measurement of the payload assembly, the associated error is simply the error for that one measurement.

Payload Totals

- Weight of Pallets, Reinforcing Plates, Slip Sheets, Guide Tubes, Adjustable Slings, etc.: The total measured weight of the pallets, reinforcing plates, slip sheets, guide tubes, etc., (or 265 pounds [lbs.] for TRUPACT-II payloads) is recorded.

- Total Weight/Total RMS Weight Error: The sum of the subtotal weights plus the weight of the pallets, reinforcing plates, slip sheets, guide tubes, etc., (or 265 lbs.) and the RMS weight error shall be recorded. If the weight is determined through a single measurement of the payload assembly, the associated error is simply the error for that one measurement.

- Total Decay Heat/Total RMS Decay Heat Error: The sum of the subtotal decay heats and the total RMS error shall be recorded.

- Total Fissile Mass/Total RMS Fissile Mass Error: The sum of the subtotal fissile masses and the total RMS error shall be recorded.

Payload Certification Parameters

- Bottom Assembly Weight plus Subtotal RMS Error (A+C) (lbs.): The subtotal weight plus the subtotal RMS error for the bottom layer of seven 55-gallon drums or seven pipe overpacks shall be recorded.

- Top Assembly Weight plus Subtotal RMS Error (B+D) (lbs.): The subtotal weight plus the subtotal RMS error for the top layer of seven 55-gallon drums or seven pipe overpacks shall be recorded.

- Total Weight plus RMS Error: The sum of the subtotal weights plus the weight of the pallets, reinforcing plates, slip sheets, guide tubes, adjustable slings, etc., plus the total RMS weight error shall be recorded.

- Total Fissile Mass (fissile gram equivalent [FGE]) plus RMS Error: The sum of the subtotal fissile mass values plus the total RMS fissile mass error shall be recorded. The total RMS fissile mass error includes two times the individual error measurements for fissile mass (previously calculated in PCTCD, Attachment 7.2.1).

- Total Decay Heat plus RMS Error (watts): The sum of the subtotal decay heat values plus the total RMS decay heat error shall be recorded.

- Package Radiation Dose Rates (mrem/hr): The measured contact radiation dose rate, and the radiation dose rates measured at 2 meters and in the cab shall be recorded. The measured dose rates for the package shall be compared to the limits of 200 millirem per hour (mrem/hr) at the surface, 10 mrem/hr at 2 meters, and 2 mrem/hr in the cab.

- Bottom Weight Greater Than or Equal to Top Weight: The subtotal weight plus subtotal RMS weight error of the bottom layer of seven 55-gallon drums or seven pipe overpacks shall be greater than or equal to that of the top layer.

- Total Weight plus RMS Error Less Than or Equal to Packaging Limit: The total measured payload weight plus the weight of the pallets, reinforcing plates, etc., plus the total RMS weight error shall be less than or equal to 7,265 lbs. for TRUPACT-II payloads. NOTE: Actual payload assembly maximum allowable weights are limited by the maximum allowable loaded package weights as well as the "as-built" TRUPACT-II weights and U.S. Department of Transportation requirements for a loaded tractor/trailer.

- Decay Heat plus RMS Error Less Than or Equal to Packaging Decay Heat Limit: The total measured decay heat value plus the total RMS decay heat error shall be less than or equal to the design limit for the packaging. The design limit for the TRUPACT-II is 40 watts.

- Fissile Mass (Pu-239 FGE) plus RMS Error Less Than or Equal to Payload Limit: The total measured fissile mass (Pu-239 FGE) plus the total RMS fissile mass error shall be less than or equal to the maximum allowable fissile mass limit established for the payload configuration. If the payload is composed of only pipe overpacks, the total Pu-239 FGE limit is

2,800 grams/TRUPACT-II. The total Pu-239 FGE limit for all other payloads is 325 grams/TRUPACT-II.

- Package Radiation Dose Rates Less Than or Equal to Limits: The measured radiation dose rates shall be less than the following limits: 200 mrem/hr at the surface of the package, 10 mrem/hr at 2 meters, and 2 mrem/hr in the cab.

- Transportation Certification Official: The TCO shall sign and date the CH-TRU PATCD upon verifying that the transportation requirements of TCP-98-01.2 are met and the payload is qualified for transport.

Attachment 3

Completion of Payload Assembly Transportation Certification Document (RH-TRU)

The BCLDP TRU WCP shall qualify a payload for transport in the 72-B Cask by verifying that the canister meets the parameter requirements/limits listed in the RH-TRU PATCD (Form DDO-448-W). Form DDO-448-W shall be completed as follows:

- Canister ID #: The RH-TRU canister identification (ID) number is unique to each canister of waste and provides a means for tracking process data records and package history (i.e., the data package). The RH-TRU canister ID number shall be raised or indented into the surface of the RH-TRU canister prior to packaging. Information necessary for transporting canisters is entered into the data package under this ID number.

- Certification Site: The certification site shall be recorded as the location at which transportation certification occurs. Certification of BCLDP TRU waste will occur at the BCLDP as all waste will be newly generated.

- Payload Content Code: The Transportation Certification Official (TCO) shall ensure that the proper content code is assigned to the RH-TRU waste canister. The content code shall be approved as part of the RH-TRUCON document. If the content code is not listed in the RH-TRUCON document, it is not eligible for transport in the 72-B Cask.

- Payload Container Type: The payload container shall be an approved type. Currently, the only allowable payload container for the 72-B Cask is the RH-TRU waste canister.

- Canister Filtered: It shall be verified and recorded that the canister is filtered with the appropriate number of filters (i.e., one).

- Filter Model: The TCO shall ensure that the proper filter model is installed in the canister, so that the specifications listed in TCP-98-01.2 are met.

- Inner Containers Overpacked in Canister: This section shall identify any inner containers overpacked in the canister, for example, three 55-gallon drums, or other inner containers.

- Inner Containers Filtered: The appropriate number and identification shall be listed as determined by inner waste container type.

- Canister Weight + Error: The loaded weight of each canister is obtained from its data package. The canister weight, plus the measurement error if applicable, shall be compared to the maximum canister weight limit of 8,000 pounds.

- Fissile Mass + Error: The FGE for the canister shall be calculated in accordance with TC-AP-01.2. The calculated FGE value, which includes two times the error, shall be recorded for each canister. The TCO shall ensure that the calculated fissile mass + error is less than the transport limit of 325 grams. If it can be demonstrated using methods described in TCP-98-01.2 that the fissile content of the canister is below 10% of the FGE limit, the FGE value shall be reported as "less than 32.5 grams." No error needs to be assigned. This information shall be obtained from the data package by the TCO.

- Gas Generation and Hydrogen Concentration Limits: The 5% limit on hydrogen concentration shall be complied with by one of two options:

    1. The hydrogen generation rate for the content code shall be determined according to the procedures described in the Remote-Handled Transuranic Waste Authorized Methods for Payload Control (RH-TRAMPAC) (Appendix 1.3.7 of the 72-B Cask Safety Analysis Report) (DOE, 1996) and recorded on the datasheet. The TCO shall ensure that this rate is less than the allowable limit set in the RH-TRUCON for the appropriate content code.

    2. The decay heat limit for the canister shall be determined as per the procedures described in the RH-TRAMPAC. The TCO shall ensure that the calculated wattage is less than the allowable limit set in the RH-TRUCON for the appropriate content code.

Payload Assembly

- 72-B Cask: The ID number on the 72-B Cask outer containment body shall be recorded.

- Shipment No.: The TCO shall record the shipment number of the trailer of the 72-B Cask.

- Radiation Dose Rate On The Outside of the 72-B Cask: The TCO shall be responsible for ensuring that the dose rates measured for the package do not exceed the limits defined in the RH-TRAMPAC.

- Approved for Transport: The TCO shall ensure that all of the requirements for the above transportation parameters are met as stated in the RH-TRAMPAC. If the requirements are not met the canister is rejected and not qualified for shipment.

- Transportation Certification Official: The TCO shall sign and date this document upon completion, thereby authorizing the payload container for transport in the 72-B Cask.

Attachment 4

Completion of TRU Waste Certification Documents

A TRU Waste Certification Document shall be completed for each CH-TRU payload container or RH-TRU canister, and each CH-TRU or RH-TRU payload assembly. If dunnage is used to complete a CH-TRU payload assembly, a CH-TRU Dunnage Certification Document shall be completed.

The TRU Waste Certification Documents shall be completed as data is accumulated. Some transportation and certification criteria are the same. Therefore, certain certification criteria are verified and documented during the qualification of a payload container or payload assembly for transportation. The approved PCTCD (Attachment 7.2.1), CH-PATCD (Attachment 7.2.2), or RH-PATCD (Attachment 7.2.3) shall be used as the compliance documentation for the parameters listing "PCTCD", "CH-PATCD", or "RH-PATCD" under the Supporting Data column.

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TC-AP-01.2
Revision 2

TRANSURANIC (TRU) WASTE CERTIFICATION PROGRAM

WASTE MANAGEMENT AND TRANSPORTATION
ADMINISTRATIVE PROCEDURE

CALCULATIONS USING RADIOASSAY DATA

UNCONTROLLED
COPY

BATTELLE
505 King Avenue
Columbus, Ohio 43201

Procedure Status:

[X] Non Critical Procedure
[ ] Critical Procedure – Procedure Qualification Packet (PQP) Required

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REVISION RECORD INDICATING LATEST DOCUMENT REVISION

Title Calculations Using Radioassay Data

No. TC-AP-01.2

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PROCEDURE APPROVAL PAGE

Prepared By:

P. Erickson
TRU Waste Certification Official

10/24/2000
Date

This procedure, ***TC-AP-01.2, Calculations Using Radioassay Data***, has been reviewed and approved by the following.

Approved By:

P. Weaver, Manager
Field Operations

10/24/00
Date

N.J. Gantos, DDO
Program Manager

10/25/2000
Date

J. Eide, Site Project Manager
TRU Waste Certification Program

10/24/2000
Date

M. Jackson
Manager, Regulatory Compliance & Environment, Safety, and Health Oversight

10/24/00
Date

G. Eriksen
Manager, Quality

10/24/00
Date

CALCULATIONS USING RADIOASSAY DATA

1.0 Scope

This procedure summarizes the methods used to determine required remote-handled (RH)- transuranic (TRU) waste payload container certification compliance for the following parameters:

- TRU alpha activity concentration
- Fissile gram equivalent (FGE)
- Plutonium (Pu)-239 equivalent activity
- Decay heat.

For RH-TRU payload containers, radioassay data for these parameters shall be determined based on the methodology defined in DD-98-04, Waste Characterization, Classification and Shipping Support, Technical Basis Document.

Section 7.8 of this procedure may be used to direct the calculations using radioassay data required for determining the compliance of contact-handled (CH) TRU payload containers. For CH-TRU payload containers, radioassay data for these parameters shall be provided by subcontracted TRU waste services as described in TCP-98-04.

2.0 Purpose

The purpose of this procedure is to identify the methods used to determine required payload container certification data for the parameters listed in Section 1.0. Implementation of this procedure will ensure that the calculations used to generate data demonstrating compliance with the requirements associated with the parameters are performed as specified by TCP-98-01 and TCP-98-01.2 .

3.0 References and Definitions

3.1 References

The current revision of each reference shall be used.

3.1.1 DD-98-04, Waste Characterization, Classification and Shipping Support, Technical Basis Document

3.1.2 DD-MN-01, Quality Manual, D&D Operations

3.1.3 HP-OP-019, Radiation and Contamination Survey Techniques

3.1.4 HS-OP-001, Completion of the Industrial Safety Check List

3.1.5 PR-AP-17.1, Operation of the Project Records Management System

3.1.6 QD-AP-05.2, Work Instructions

3.1.7 TC-AP-01.5, Software Management for the BCLDP TRU WCP

3.1.8 TC-OP-01.4, Segregation and Packaging of TRU Waste

3.1.9 TCP-98-01, TRU Waste Certification Plan for the BCLDP TRU WCP

3.1.10 TCP-98-01.2, TRU Waste Authorized Methods for Payload Control for the BCLDP TRU WCP

3.1.11 TCP-98-03.1, TRU Waste Process Descriptions

3.1.12 TCP-98-04, Mobile Vendor Interface Plan for the BCLDP TRU WCP

3.1.13 WA-OP-006, Procurement and Inspection of Packagings for Hazardous Materials Shipments

3.1.14 WA-OP-020, Identification, Segregation, Separation and Documentation of Low Level Waste

3.1.15 WA-OP-022, Radioactive Hazardous Waste Packaging, Storage and Transfer

3.2 Definitions

3.2.1 **Contact-Handled Transuranic (CH-TRU) Waste** – TRU waste with contact dose rates less than or equal to 200-milliroentgen equivalent man per hour (mrem/hr).

3.2.2 **Fissile Gram Equivalent (FGE)** – An isotopic mass of radionuclide normalized to Pu-239.

3.2.3 **MCNP** - Monte Carlo N-Particle (MCNP) computer code is based on a statistical (Monte Carlo) radiation transport solver methodology to track neutron and gamma-ray penetration through various materials and configurations. The DD-98-04 methodology for determining the radioassay properties of RH-TRU waste uses MCNP as an independent verification of the criticality factor, dose rates, and the shielding requirements generated by the QAD-CGGP-A computer code (see Section 3.2.6).

3.2.4 **ORIGEN2** – Oak Ridge Isotope Generation and Depletion (ORIGEN-2) is a fission reactor modeling code for predicting the isotopes generated and depleted during the processes of fissioning of uranium, activation of non-fuel materials, and decay of spent fuel. The DD-98-04 methodology for determining the radioassay properties of RH-TRU waste uses ORIGEN-2 to generate the basic distribution of significant isotopes from PWR fuel that was the typical waste source for the West Jefferson North-1 (JN-1) facility.

3.2.5 **Payload Container** – Containers meeting the requirements of TCP-98-01.2.

3.2.6 **QAD-CGGP-A** – The QAD Combinatorial Geometry/Geometric Progression (QAD-CGGP-A) computer code is based on a point-kernel calculation methodology and relies on ray-tracing to calculate neutron and gamma-ray penetration through various shield configurations. The DD-98-04 methodology for determining the radioassay properties of RH-TRU waste uses QAD-CGGP-A to determine the dose rates and the shielding requirements associated with PWR fuel that was the typical waste source for the JN-1 facility.

3.2.7 **Remote-Handled Transuranic (RH-TRU) Waste** – TRU waste with contact dose rates greater than 200 mrem/hr.

3.2.8 **Transuranic (TRU) Waste** – Waste contaminated with alpha-emitting radionuclides of atomic number greater than 92 (e.g., the radioactive isotopes of plutonium) with half-lives greater than 20 years and present in cumulative concentrations greater than or equal to 100 nanocuries per gram (nCi/g) of waste.

4.0 Responsibilities

Responsibilities and authority of staff members involved in the determination of required payload container certification data for the parameters listed in Section 1.0 are summarized below.

4.1 **Manager, Field Operations**, or designee, is responsible for oversight of all activities that generate or process waste, providing input to the Waste Management staff and to Building Management during the planning stages of those activities, and ensuring that all Waste Management documentation of work activities is generated and forwarded to Project Records.

4.2 **Site Project Manager, TRU Waste Certification Program,** oversees all daily components of the TRU waste characterization, certification, and transportation activities under the BCLDP TRU WCP.

4.3 **Manager, Quality**, is responsible for facilitating implementation of quality requirements and practices into TRU waste certification- and transportation-related activities and for verifying that these operations are being performed effectively and in accordance with all requirements. Responsibilities specific to this procedure include ensuring that all computer codes comply with the applicable software quality assurance requirements as defined in TC-AP-01.5.

4.4 **Manager, Training** is responsible for arranging for training of staff performing work under this procedure and for recording worker training in the worker training and qualification system.

4.5 **TRU Waste Certification Official**, or designee, is responsible for the implementation and supervision of specific tasks under the direction of the Manager, Field Operations. Responsibilities specific to this procedure include the following:

- Determine payload container certification compliance for the following parameters as described by this procedure: TRU alpha activity concentration, FGE, Pu-239 equivalent activity, and decay heat.
- Ensure the coordination of tasks with other ongoing facility activities and ensure safety for all present at the facility.
- Ensure that all personnel assigned have been trained in this procedure and that their qualifications have been documented.
- Ensure that work is performed in accordance with this procedure.

- Provide direction and assistance to staff members in the determination of payload container certification data.
- Ensure that Industrial Safety Checklists (HS-OP-001, Form DDO-195) have been prepared, approved and issued by Safety.
- Ensure that Work Instructions (QD-AP-05.2, Form DDO-104) and safety checklists have been prepared, approved and issued at the direction of the Manager, Field Operations, and submitted to Project Records.
- Obtain the services of Health Physics (HP) to determine the radiation level of the TRU wastes as specified in this procedure.
- Control records as specified in DD-MN-01 and applicable procedures.

4.6 **Waste Management D&D Technician Supervisor**, or designee, will assign personnel to perform the tasks. The Waste Management D&D Technician Supervisor will assume the position of observer and will ensure the following:

- Procedures are followed.
- Safety checklists are followed.
- Work Instructions are followed.
- Work activities are coordinated with the assigned HP Technicians and that the instructions of HP Technicians are followed.

4.7 **Waste Management D&D Technicians** are responsible for the correct performance of procedure tasks as directed by the Waste Management D&D Technician Supervisor, and for ensuring that safe work practices are used.

4.8 **HP Technicians** are responsible for all radiological survey and documentation, including routine surveillance and job coverage, and for ensuring that personnel comply with all applicable HP procedures. The HP Technicians are responsible for ensuring that Radiation Work Permits (HP-OP-019, Form DDO-105) have been prepared, approved and issued by HP at the direction of the Project/Building Manager. HP Technicians shall complete any documentation necessary to take and ship the samples.

5.0 Methodology for RH-TRU Waste Radioassay Determinations

The overall methodology for the determination of radioassay properties is shown in Figure 1. The isotopic content for an identified TRU waste stream is determined as per DD-98-04 by a "non-destructive assay (NDA)-based, dose/weight-to-curie evaluation." The isotopic content for a waste stream is determined by combining the measured isotopic distribution (gamma emitters) with the conservative application of ORIGEN2 computer code values to account for all isotopes. This calculated isotopic distribution is verified by sample submission to the BCLDP Radioanalytical Laboratory for gamma and/or alpha spectroscopy when requested by the TRU Waste Program Technical Advisor. Based on the calculated isotopic distribution, external dose rates for 1 millicurie of isotopic mix are modeled for different packaging configurations. TRU/low-level waste field sort charts are generated for use in determining the quantity of radionuclides in each waste package based on its measured weight and dose rate. For wastes determined to be TRU, the inventory of gamma emitting isotopes (predominately CS-137) is determined for each 55-gallon drum based on an external radiation field measurement using standard dose rate instrumentation. This gamma ray dose rate is used as an indicator of the TRU content of the drum based on the ratio of radionuclides.

The assumptions of the DD-98-04 methodology ensure a conservative estimate and bound any error in the isotopic composition. The results of the implementation of the NDA-based, dose/weight-to-curie evaluation provide the data inputs to the computer program (spreadsheet) used by the TRU Waste Certification Official (WCO) to determine the parameters of interest for each payload container (i.e., TRU alpha activity concentration, FGE, Pu-239 equivalent activity, and decay heat). Verification and validation of the computer programs used in the DD-98-04 methodology are performed per TC-AP-01.5, which requires structured programming techniques, internal reviews, and checks to validate the use of the programs.

Isotopic Composition

- ORIGEN2 output
- Smear samples - alpha and gamma spectroscopic analysis
- Determines Isotopic Mix

↓

Dose Estimates for 1 mCi of Mix

- Waste configuration (trash bags, B-25 boxes, 55-gallon drums, D-boxes, misc. metal objects)
- QAD-CGGP-A run to determine dose for 1 mCi
- Isotopes with activities >1.0E-5 mCi
- Matrix used - water (bags and D-boxes with plastics, wood, clothes, etc.); iron (B-25 boxes with dense materials including concrete)

↓

Isotopic Quantity Estimates for Items

- Derive equations and graphs for dose rate as a function of weight
- Sort criteria in graphs determine split between TRU and LLW
- Net weight and dose rate entered in a spreadsheet determine isotopic quantity

↓

Determination of Cs-137

- External radiation field measurement
- Cs-137 content indicates TRU content based on radionuclide ratio

↓

Determination of Transportation Parameters

- Isotopic quantity and composition yield FGE, decay heat, TRU alpha activity and PE-curies

Figure 1
BCLDP Methodology for Determination of Radioassay Properties for RH-TRU Waste

6.0 Limitations

6.1 BCLDP personnel shall segregate TRU waste from other wastes (e.g., low-level waste) as described in WA-OP-020 and/or WA-OP-022 and Work Instructions, which implement the segregation methodology and sort criteria (i.e., series of field ready charts) presented in DD-98-04.

6.2 BCLDP personnel shall package TRU waste as described in TC-OP-01.4. During waste packaging, BCLDP personnel shall inventory the waste items loaded into each payload container by completing Form DDO-438 as described in TC-OP-01.4. An "Item Number" lists each waste item. This form provides a correlation of waste item/package numbers to payload container identification number.

6.3 Form DDO-438 requires the documentation of the source location (hot cell, pool, etc.) for each waste item, this inventory will be used to select the proper isotopic mix for the waste items from DD-98-04. Only waste items from the same source location will be packaged together to ensure the correct assignment of isotopic mix to each loaded payload container.

If an isotopic mix for a specific source location is not established in DD-98-04, the document will be amended to incorporate the appropriate source terms, spreadsheets, and any other tools needed to facilitate assessment of the quantities and nature of the isotopes involved.

7.0 Procedure

During the completion of this procedure, BCLDP personnel shall complete Form DDO-439 (attached) by evaluating each RH-TRU canister for all parameters. The 55-gallon drum data shall be used to arrive at the RH-TRU canister properties (values may be summed with the root mean square of the individual errors added, except for radiation dose rate, which must be measured for the RH-TRU canister).

7.1 BCLDP personnel shall record the payload container identification number on Form DDO-439.

7.2 Following payload container loading and closure under TC-OP-01.4, HP Technicians shall measure the radiation dose rate of each payload container and record the measurement on Form DDO-439.

7.3 BCLDP personnel shall record the total weight of the loaded payload container on Form DDO-439. This weight may be taken from Form DDO-438 as it is previously determined and recorded under TC-OP-01.4.

7.4 BCLDP personnel shall determine whether the waste conforms to the JN-1 standard mix by taking periodic samples as directed by the TRU Waste Program Technical Advisor.

7.5 BCLDP personnel shall indicate whether or not (yes/no) a smear sample has been taken for the payload container contents and if acceptable analyses results have been obtained. This data shall be taken from Form DDO-438 as it is previously determined and recorded under TC-OP-01.4.

NOTE: If smear sample analyses have been performed, the results shall be evaluated for consistency with the DD-98-04 model. If the sampling results contribute to a pattern of significant deviation from the associated mix, the Waste Management Specialist shall document and justify the use of a specific isotopic mix in accordance with DD-98-04.

7.6 Using the source location determination, the Waste Management Specialist, or designee, shall use the DD-98-04 methodology summarized in Section 5.0 to assign an isotopic mix number to each payload container. The isotopic mix number assignment shall be recorded on Form DDO-439.

NOTE: If smear sample analyses have been performed, the Waste Management Specialist shall assign the isotopic mix number following the evaluation of the sampling results and/or revision of DD-98-04.

7.7 Using the assigned isotopic mix number, the WCO, or designee, shall select the appropriate DD-98-04 spreadsheet. Form DDO-439 completed to this point shall be the source of inputs to the DD-98-04 spreadsheet.

7.8 For RH-TRU waste, the results of the implementation of the DD-98-04 methodology will provide an isotopic inventory (list of radionuclides and curies of each) for the drum. With the isotopic inventory, the WCO shall use the spreadsheet to calculate (1) TRU alpha activity concentration, (2) FGE, (3) Pu-239 equivalent activity, and (4) decay heat. (Note: This section may be used to direct similar calculations using radioassay data required for determining the compliance of CH-TRU waste containers. TCP-98-01 and TCP-98-01.2 define the applicable TRU alpha activity concentration, FGE, Pu-239 equivalent activity, and decay heat limits for CH-TRU waste.)

7.8.1 TRU alpha activity concentration. The spreadsheet will calculate TRU alpha activity as nCi/g. The WCO shall record the calculated value on Form DDO-439 and verify that the value is greater than or equal to 100 nCi/g. If the value is less than 100 nCi/g, the payload container shall be segregated from the TRU payload containers and handled as LLW.

If the contents of an RH-TRU canister exceed 23 curies/liter of waste matrix, the waste will be segregated from the RH-TRU canisters and will not be shipped to the Waste Isolation Pilot Plant.

7.8.2 FGE. The spreadsheet will calculate Pu-239 FGE as grams based on the list of radionuclides and associated curie content. The WCO shall record the calculated value on Form DDO-439 and verify that the value complies with the 325 g per RH-TRU canister limit.

7.8.3 Pu-239 Equivalent Activity. The spreadsheet calculates Pu-239 equivalent activity as Pu-equivalent curies (PE-Ci) based on the list of radionuclides and associated curie content. The WCO shall record the calculated value on Form DDO-439 and verify that the value complies with the 1,000 PE-Ci per RH-TRU canister limit.

7.8.4 Decay Heat. The spreadsheet calculates decay heat and associate error as watts based on the list of radionuclides and associated curie content. The WCO shall record the calculated value and error on Form DDO-439 and verify that it meets the decay heat limits specified by the content code assigned to the payload container under TCP-98-03.1 (verified under TC-OP-01.4).

7.9 The WCO shall attach a hard copy printout of the spreadsheet to Form DDO-439. The WCO shall approve Form DDO-439 by signature and date.

8.0 Records

The following records will be maintained as permanent quality records in accordance with PR-AP-17.1.

8.1 All records generated by this procedure, including the following:

- Completed Work Instructions
- Completed Summary and/or Special Report Forms
- Completed Radiological Work Permits

- Completed Form TRU Waste Payload Container Nuclear Properties Data

9.0 Forms

9.1 Forms

9.1.1 DDO-104, Work Instruction (see Reference 3.1.6)

9.1.2 DDO-105, Radiation Work Permit (see Reference 3.1.3)

9.1.3 DDO-195, Industrial Safety Checklist (see Reference 3.1.4)

9.1.4 DDO-438, Waste Package Loading Record

9.1.5 DDO-439, TRU Waste Payload Container Nuclear Properties Data

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TRU Waste Package Loading Record
Loading - Itemized Data

Payload Container Identification No:	**Package Type/Model:**
Loading Personnel (print name[s]):	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]		[illegible]	
[illegible]		[illegible]	
[illegible]	Initial: Date:	[illegible]	[illegible]
[illegible]	Initial: Date:		

[a] Record dose rate of item, if a dose rate measurement has been made on the individual item (not required). Only a single measurement of the loaded package radiation dose rate is required.
[b] Record weight of item, if the weight of the individual item has been determined (not required). Total payload container weight may be determined by (1) summing individual items plus error if each item has been weighed, or (2) single measurement of a total payload container plus error.

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TRU Waste Package Loading Record
Loading - Itemized Data

Payload Container Identification No: | **Package Type/Model:**

Loading Personnel (print name[s]):

Item No.	Item Description	Source Location	Material Type	Material %	Smear Sample Collected (Y / N)	Dose Rate[a] (mrem/hr)	Weight[b] (lbs.)	Loading Date	Loader Initials	Tape No./ Counter No.	Summary/ Comments

Loaded Package Measured Radiation Dose Rate (mrem/hr)		Accumulation Date (Mixed Waste Only)	
Loaded Package Final Measured Gross Weight[b] (lbs.)		Authorized Review and Approval	
Contains No Suspect Hazardous Materials	Initial: Date:	(signature)	(date)
Contains Hazardous Materials	Initial: Date:		

[a] Record dose rate of item, if a dose rate measurement has been made on the individual item (not required). Only a single measurement of the loaded package radiation dose rate is required.

[b] Record weight of item, if the weight of the individual item has been determined (not required). Total payload container weight may be determined by (1) summing individual items plus error if each item has been weighed, or (2) single measurement of a total payload container plus error.

TRU Waste Payload Container Nuclear Properties Data

Parameters	Value	Initials
Payload Container Identification No.		
Payload Container Radiation Dose Rate (mrem/hr)		
Payload Container Weight (lbs.)		
Sample Results (Y / N)		
Isotopic Mix		
Spreadsheet Values:		
TRU Alpha Activity (nCi/g)		
TRU Alpha Activity (Ci/L) (RH-TRU waste only)		
FGE (g)		
Pu-239 Equivalent Activity (PE-Ci)		
Decay Heat/Thermal Power (W)		

I hereby certify that I have reviewed the data for this payload container and that it is complete and accurate to the best of my knowledge. I have determined that it meets the requirements stated in the current revision of TC-AP-01.2.

____________________ Waste Management Specialist/ Waste Certification Official Signature	__________ Date	__________ Initials

DD-98-04

WASTE CHARACTERIZATION, CLASSIFICATION AND SHIPPING SUPPORT TECHNICAL BASIS DOCUMENT

for

Battelle Columbus Laboratories Decommissioning Project (BCLDP)
West Jefferson North Facility

Battelle
505 King Avenue
Columbus, Ohio 43201

DD-98-04
Revision 3

WASTE CHARACTERIZATION, CLASSIFICATION, AND SHIPPING SUPPORT TECHNICAL BASIS DOCUMENT

for

Battelle Columbus Laboratories Decommissioning Project (BCLDP)
West Jefferson North Facility

March 2000

BATTELLE
505 King Avenue
Columbus, Ohio 43201

Issued by:

Craig Jensen — 16 March 2000

C. E. Jensen — Date

TRU Waste Programs Technical Advisor

Concurred with:

James H. Eide — 17 March 2000

J. H. Eide — Date

Site Project Manager, TRU Waste Certification Program

Issued on 3-23-00
Ruth Baruth
Document Control Manager

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ACRONYMS

AEC/DOE	Atomic Energy Commission/Department of Energy
ALARA	As low as reasonably achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BCLDP	Battelle Columbus Laboratories Decommissioning Project
BMI	Battelle Memorial Institute
CEMP	Columbus Environmental Management Project
CH-TRU	Contact-handled TRU
CZT	Cadmium-zinc-telluride
DOE	Department of Energy
DOE-CEMP	DOE – Columbus Environmental Management Project
DQO	Data Quality Objectives
HPGe	High purity germanium
JN	Battelle's West Jefferson North
LLW	Low-level waste
NaI	Sodium iodide
ORIGEN2	Oak Ridge Isotope Generation and Depletion Code
QAO	Quality Assurance Objective
RAL	Radioanalytical Laboratory
RH-TRU	Remote-handled TRU
SWAC	Hanford Site Solid Waste Acceptance Criteria
TRU	Transuranic
WCP	Waste Certification Program
WIPP	Waste Isolation Pilot Plant

EXECUTIVE SUMMARY

This technical basis document presents the reasoned and defensible technical bases for characterizing the radioactive materials at the Battelle Memorial Institute's West Jefferson North Site (JN). This characterization function is to identify and quantify the isotopes of interest present in the JN facilities to the extent necessary for transportation and disposal at one of several facilities.

This document is logically divided into two parts in keeping with the two major waste classifications of radioactive waste to be generated: low level waste (LLW) and the transuranic (TRU) evaluation stream. The common subjects are contained in the LLW sections. In addition, this document may be used to present the technical bases to regulatory authorities that have jurisdiction over any aspect of the process, from characterization through disposal.

1.0 INTRODUCTION

1.1 OVERVIEW

This document describes a method for determining the quantity of isotopes in radioactive waste generated under the Battelle Columbus Laboratories Decommissioning Project (BCLDP) at Battelle's West Jefferson North (JN) site, the former Nuclear Sciences Area. It also describes reasoned and defensible methods for characterizing the radioactive materials at the JN site, chiefly in Building JN-1. The method will assure that the radioactive materials at this JN site are ultimately sorted into the general categories of low-level waste (LLW) and transuranic waste (TRU). The LLW will be shipped from the site, thus freeing facilities for decommissioning. Any contact-handled TRU (CH-TRU) waste will also be shipped as specified in TCP-98-01, TRU Waste Certification Plan for the BCLDP TRU Waste Certification Program, CH-TRU waste generated by the BCLDP will undergo radioassay by sub-contracted mobile vendor services in accordance with the requirements of Appendix A of the WIPP Waste Acceptance Criteria (DOE/WIPP-069). Current planning requires that the remote-handled TRU (RH-TRU) waste be stored in an onsite interim facility to await shipment authorization. The RH-TRU waste radionuclide content will be determined and documented in accordance with the methodology described in this document. Subsequently, the RH-TRU waste will be shipped and the interim storage facility decommissioned.

This document describes the sources of contamination at JN, the procedures for modeling these sources, and the steps used to determine the correlation between waste package activity and external gamma measurements. Waste package models described include individual field sort waste bags, standard B-25 boxes, IP-2 147 ft^3 boxes, standard D boxes, 55-gallon drums, and miscellaneous metal objects.

1.2 BACKGROUND

JN has had an active and varied history of radioactive material usage since the mid-1950s. Atomic Energy Commission/Department of Energy (AEC/DOE) defense program work on military fuels (e.g.: high-enrichment navy fuels) development and performance testing was conducted in Buildings JN-1, -2, and –3. Plutonium work was conducted in Buildings JN-2, and JN-4. Light water reactor research was conducted in the JN-3 reactor facility. A wide range of nuclear fuel studies was conducted in Building JN-1's test and hot cells and support areas. Before the facility was shut down, the majority of the research was conducted on commercial nuclear fuels (irradiated and decayed). No concerted effort was made to isolate waste types or to return operational areas to unconditional release levels (with the exception of the JN-4 building); therefore commercial nuclear contaminated materials co-mingled with the earlier defense program materials and cannot be effectively segregated from them.

1.3 ORGANIZATION OF REPORT

Section 2 discusses the sources of contamination at Battelle's West Jefferson North (JN) site and the methods used to make this determination. Section 3 describes the approach for determining low-level waste package activity using several different waste package models. Section 4 describes the methodology used to quantify the radionuclide content of remote-handled transuranic waste packages. Section 5 contains a list of references. The appendices present the results of QAD calculations, the physical description of the waste models, data plots, sort criteria, shipping support spreadsheets, and several photographs of actual waste packages.

2.0 SOURCES OF CONTAMINATION

2.1 GENERAL DISCUSSION

The JN standard isotopic mixture is representative of the composition of the majority of radioactive waste generated in all areas of the facility except the pool. Waste from the pool will be shipped as characterized based on sample results. Pool wastes were individually characterized due to solubility differences between various nuclides in the mix. Cesium, upon which this modeling methodology depends, is highly soluble while the transuranic isotopes and others tend to be largely insoluble. This inconsistency rendered the cesium-based modeling unsuitable for any waste stream in which solubility is a major concern. Therefore, all pool related wastes are to be characterized individually.

In addition to the waste from the pool, other waste streams may be encountered which do not match the JN standard isotopic mix. In such cases, this document will be amended to incorporate these additional waste streams or these newly characterized wastes may be shipped based on specific analytical results.

2.2 WASTE STREAM MODELING

Since the gamma rays emitted by radionuclides can be readily detected and quantified by common measurement techniques, emitted gamma rays are used to model the quantity of isotopes present in a standard waste stream. Verifying samples are analyzed for both gamma and alpha emitters. Because isotopes other than gamma emitters are known to be present at JN, laboratory measurements of the isotopic distribution are combined with a computer-generated distribution to account for all isotopes. The measured isotopic distribution is based on laboratory analysis (alpha and gamma spectroscopy) of air, smear and material samples taken from throughout the accessible work areas of Building JN-1. Using the measured distribution as a base, the remaining isotopes are scaled according to the distribution generated by the Oak Ridge Isotope Generation and Depletion (ORIGEN2)[1] computer code, which models the production and decay of fission and activation products of commercial nuclear power plant fuel.

A given quantity of the combined distribution is then used as the radioactive material source with the QAD[2] computer shielding code to generate external gamma ray interaction rates for various package and form weights. These interaction rates are used to generate interaction rates-to-weight conversion equations for each package and waste form. The equations are incorporated into software so that activity content, in millicuries, for individual packages and waste forms can be calculated. Spreadsheets are also used to calculate TRU and/or LLW interaction rates levels, and plots of these values as a function of net container weight are provided for each container type to simplify field sorting and packaging.

2.3 JN STANDARD ISOTOPIC DISTRIBUTION

Characterization of the JN Standard Isotopic Distribution depended upon whether available data existed to permit estimation of the normalized activity ratio (to Cs-137 activity) for the isotopes of interest. Where data were available, a lognormal fit was used on the available data. Where no data were available, the results of a series of ORIGEN2 software analyses were employed.

For Am-241, Cm-244, Co-60, Cs-134, Eu-154, Np-237, Pu-238, Pu-239/240, Sb-125, Sr-90, U-234, and U-238 as many as 69 samples[1] from the anticipated waste stream were available. A two-parameter (μ, σ) lognormal distribution—which fit the data reasonably and is often applied to activity data in the general scientific literature—was fitted to these data. Table 1 below presents the estimated parameters of the lognormal distribution fitted to each isotope's data. The mean parameter (μ) estimated for each studied isotope represented its assumed normalized activity ratio (to Cs-137) in the standard isotopic distribution. The estimated spread parameter (σ) was used in considering the total uncertainty associated with the waste characterization outlined in this report (see Sections 3.8 and 4.3.3).

Table 1. Parameters of Fitted Lognormal Distribution for Those Isotopes with Available Data

Transuranic Isotope	**Parameters of Lognormal Distribution**	
	μ	σ
Am-241	3.237E-02	2.5482
Cm-244	2.552E-02	2.6051
Co-60	3.421E-02	8.1581
Cs-134	3.294E-03	1.9466
Eu-154	1.317E-02	1.7570
Np-237	2.522E-05	2.5395
Pu-238	3.723E-02	2.0573
Pu-239/240	1.190E-02	2.2132
Sb-125	4.739E-03	6.1094
Sr-90	4.047E-01	2.0785
U-234	6.812E-05	4.4847
U-238	3.331E-05	6.8078

For the isotopes of interest the computer code ORIGEN2 was used to estimate their normalized activity ratio (to Cs-137). Specifically, values were assumed for enrichment, burn-up, and decay consistent with the process used to generate the waste stream being classified. These values were then applied as parameters within the ORIGEN2 software, producing estimates of the activities of the various isotopes of interest.

1 For some of the 69 samples identified as relevant, the activity of some of the targeted isotopes was either not measured or was below the instrument's level of detection. Since the basis for any missing data was in question, those samples with missing values for the isotope in question were discarded when fitting the lognormal distribution.

Consensus center, low, and high values were identified for each of these three parameters: enrichment, decay, and burn-up. Taken together, these three values were meant to represent the central tendency and distribution (i.e., practical range) of the enrichment, burn-up, and decay of potential waste stream. These values are reported in Table 2 below.

Table 2. Consensus Low, Center, and High Values for ORIGEN2 Parameters

ORIGEN2 Parameter	Range of Values		
	Low	Center	High
Enrichment (% U235 by WT.)	2.0	2.8	4.0
Burn-Up (MWD / MTU)	15K	33K	45K
Decay (years)	13	17	30

Twenty-seven iterations of ORIGEN2 software code would be required to consider each combination of these three values for each of three parameters (i.e., $3^3 = 27$). Additional code runs would be necessary, moreover, to provide some measure of the uncertainty associated with the application of ORIGEN2 in estimating the normalized activity ratios of the remaining isotopes of interest. Latin Hypercube sampling(3) is an alternative approach, allowing effective interrogation of computer code but with fewer runs. In order to apply these values in the context of a Latin Hypercube design, an assumed distribution is required for each parameter considered in the design. Since the low and high values for each parameter were not symmetric in relation to the center value, a skewed distribution was selected. The lognormal represents a skewed distribution that can be readily applied without additional mathematical complication. The log-transformed center value was assumed to represent the distribution's log mean and its log standard deviation was derived by averaging the deviations of the log-transformed low and high values from the log mean. Specifically, the average deviation was assumed to represent 1.645 (i.e., the 0.95 quantile of a standard Normal distribution) times the log-standard deviation. Doing so is equivalent to assuming the low and high values represent, on average, a range from the 5th to the 95th percentile of the distribution.

In using the ORIGEN2 software code to characterize the normalized activity ratios for the isotopes without available data, the appropriate Latin Hypercube design to employ depends upon how the software and associated parameters values are perceived. If assumed values for enrichment, burn-up and decay equate to sample data, and the ORIGEN2 code is merely a deterministic translation of the values into activities, then a single replicate 20-point design should be applied. Using this approach, the mean and variance in each isotope's normalized (to Cs-137) activity calculated across the code runs are considered. If, instead, the assumed values and software together represent a 'black-box' estimation of normalized activity ratios, a series of replicate designs should be applied. In this approach, the mean result from each replicate design is considered when estimating the mean and variance in normalized activity. The application of the ORIGEN2 code in this circumstance was deemed most consistent with the second approach.

Four replicates of a five-sample Latin hypercube design were developed—using a S-Plus© version 4.5 program written for this purpose and based on the procedure outlined in the referenced paper—thereby providing 20 analysis runs. The distribution of each parameter (Table 2) was divided into five partitions of equal probability. Latin hypercube sampling, then, ensures a random value of each partition is included in each of the five replicated designs, while minimizing the total number of required analysis runs. The resulting 20 (5 samples x 4 replicates) analysis runs are presented in Table 3 below.

Table 3. Experimental Design Parameter Values Used in ORIGEN2 Analysis Runs

Run No.	Enrichment	Burn-Up	Decay
1	2.29	33.83	21.31
2	3.49	32.32	35.08
3	2.41	28.70	15.25
4	2.47	42.53	9.70
5	3.84	30.66	12.98
6	4.51	26.62	13.37
7	2.09	26.30	23.71
8	2.83	36.94	23.25
9	2.88	37.98	18.50
10	2.63	19.91	14.19
11	3.42	23.33	16.08
12	3.09	57.25	17.87
13	2.24	24.62	19.86
14	3.01	40.46	11.28
15	2.67	50.19	19.13
16	3.24	29.73	14.42
17	2.52	44.14	17.04
18	3.22	53.81	16.69
19	2.74	35.43	15.55
20	1.81	18.15	20.84

The mean result across the 20 ORIGEN2 runs (or equivalently, the mean of the mean results determined for the four replicated designs) estimated for each studied isotope represents its assumed normalized activity ratio (to Cs-137) in the standard isotopic distribution. Though ORIGEN2 reports activities for all the isotopes of interest, only the results for those isotopes without sufficient available sample data were retained. Fortunately, the ORIGEN2 results and those based on available data are remarkably comparable. Table 4 presents, by isotope, the estimated normalized activity ratio derived from the ORIGEN2 analyses. The estimated variance in mean result across the four replicate designs—a measure of the uncertainty associated with using the ORIGEN2 software to characterize isotope activity—is used in considering the total uncertainty associated with the waste characterization outlined in this report (see Sections 3.8 and 4.3.3).

Table 4. ORIGEN2 Output for Selected Isotopes of Interest

Activity Normalized to Cs-137

Run ID	AM241	PU238	PU239	PU240	PU242	Summed PU239/0	U233	U234	U235	U236	U238	SR 90	NP237	SB125	CS134	EU154	PU241	CM244	CO 60
1	4.56E-02	3.68E-02	4.86E-03	8.55E-03	3.19E-05	1.34E-02	6.54E-10	1.75E-05	2.106E-07	3.684E-06	4.90E-06	6.62E-01	5.10E-06	1.26E-03	1.97E-03	3.17E-02	7.51E-01	1.93E-02	1.24E-03
2	6.95E-02	3.72E-02	6.87E-03	1.11E-02	3.20E-05	1.80E-02	1.39E-09	3.27E-05	4.672E-07	6.029E-06	7.04E-06	7.09E-01	7.24E-06	5.02E-05	2.33E-05	1.24E-02	4.74E-01	7.72E-03	2.47E-04
3	3.64E-02	3.02E-02	4.94E-03	8.11E-03	2.89E-05	1.30E-02	4.29E-10	1.47E-05	2.027E-07	3.047E-06	5.04E-06	6.48E-01	4.09E-06	5.37E-03	1.21E-02	4.32E-02	9.71E-01	1.87E-02	2.63E-03
4	2.11E-02	4.15E-02	3.02E-03	6.04E-03	3.47E-05	9.06E-03	2.58E-10	7.50E-06	5.718E-08	2.032E-06	2.97E-06	5.88E-01	3.69E-06	1.88E-02	9.63E-02	7.67E-02	1.01E+00	6.90E-02	4.26E-03
5	2.28E-02	2.23E-02	4.27E-03	6.40E-03	1.51E-05	1.07E-02	4.43E-10	2.17E-05	3.821E-07	3.961E-06	4.45E-06	7.51E-01	3.94E-06	7.23E-03	2.14E-02	3.90E-02	7.52E-01	6.29E-03	2.53E-03
6	1.86E-02	1.45E-02	4.64E-03	5.70E-03	8.49E-06	1.03E-02	4.77E-10	3.20E-05	6.979E-07	4.624E-06	5.15E-06	8.05E-01	3.50E-06	5.95E-03	1.47E-02	2.82E-02	5.89E-01	1.80E-03	2.11E-03
7	6.20E-02	3.32E-02	6.52E-03	1.03E-02	3.76E-05	1.69E-02	6.78E-10	1.79E-05	2.410E-07	3.473E-06	6.70E-06	6.25E-01	4.94E-06	8.26E-04	8.30E-04	2.64E-02	8.58E-01	1.67E-02	1.12E-03
8	4.99E-02	4.28E-02	4.70E-03	8.74E-03	3.75E-05	1.34E-02	7.16E-10	1.63E-05	1.626E-07	3.550E-06	4.68E-06	6.40E-01	5.45E-06	8.25E-04	1.16E-03	3.05E-02	7.16E-01	2.70E-02	1.02E-03
9	3.91E-02	4.08E-02	4.10E-03	7.70E-03	3.39E-05	1.18E-02	5.43E-10	1.39E-05	1.386E-07	3.164E-06	4.08E-06	6.41E-01	4.86E-06	2.41E-03	5.19E-03	4.06E-02	7.98E-01	3.07E-02	1.69E-03
10	3.20E-02	1.66E-02	6.42E-03	7.84E-03	1.57E-05	1.43E-02	4.36E-10	2.47E-05	5.132E-07	3.788E-06	7.06E-06	7.23E-01	3.56E-06	6.84E-03	1.27E-02	3.10E-02	9.56E-01	3.89E-03	2.91E-03
11	3.05E-02	1.70E-02	5.75E-03	7.11E-03	1.31E-05	1.29E-02	5.25E-10	2.91E-05	6.047E-07	4.417E-06	6.31E-06	7.60E-01	3.84E-06	3.70E-03	6.54E-03	2.66E-02	7.51E-01	2.94E-03	1.94E-03
12	3.14E-02	5.94E-02	2.71E-03	5.90E-03	4.31E-05	8.61E-03	4.84E-10	9.09E-06	3.459E-08	2.278E-06	2.65E-06	5.77E-01	4.87E-06	2.68E-03	8.40E-03	5.00E-02	6.75E-01	1.02E-01	1.59E-03
13	5.16E-02	2.78E-02	6.29E-03	9.34E-03	2.98E-05	1.56E-02	5.67E-10	1.87E-05	2.901E-07	3.494E-06	6.55E-06	6.53E-01	4.45E-06	1.92E-03	2.56E-03	3.01E-02	9.40E-01	1.21E-02	1.66E-03
14	2.35E-02	3.86E-02	3.27E-03	6.26E-03	2.92E-05	9.52E-03	3.34E-10	1.06E-05	1.052E-07	2.655E-06	3.24E-06	6.43E-01	4.14E-06	1.22E-02	5.14E-02	6.27E-02	9.32E-01	3.84E-02	3.61E-03
15	3.73E-02	5.48E-02	3.19E-03	6.77E-03	4.53E-05	9.96E-03	5.04E-10	9.61E-06	4.489E-08	2.324E-06	3.12E-06	5.70E-01	4.78E-06	2.14E-03	5.44E-03	4.64E-02	7.24E-01	8.56E-02	1.48E-03
16	2.89E-02	2.56E-02	4.60E-03	7.18E-03	1.99E-05	1.18E-02	4.57E-10	1.92E-05	3.100E-07	3.693E-06	4.76E-06	7.14E-01	4.11E-06	5.69E-03	1.45E-02	3.94E-02	8.31E-01	9.64E-03	2.43E-03
17	3.57E-02	4.79E-02	3.44E-03	7.03E-03	4.15E-05	1.05E-02	4.43E-10	9.64E-06	6.181E-08	2.373E-06	3.39E-06	5.82E-01	4.48E-06	3.53E-03	9.85E-03	5.08E-02	8.22E-01	6.67E-02	1.91E-03
18	3.04E-02	5.56E-02	2.81E-03	5.95E-03	3.96E-05	8.75E-03	4.71E-10	9.66E-06	4.840E-08	2.479E-06	2.75E-06	6.00E-01	4.88E-06	3.48E-03	1.17E-02	5.24E-02	7.19E-01	7.98E-02	1.78E-03
19	3.39E-02	3.68E-02	4.09E-03	7.47E-03	3.12E-05	1.16E-02	4.44E-10	1.31E-05	1.447E-07	2.975E-06	4.09E-06	6.43E-01	4.40E-06	4.80E-03	1.26E-02	4.69E-02	8.85E-01	2.84E-02	2.38E-03
20	6.06E-02	2.13E-02	8.37E-03	1.07E-02	2.76E-05	1.90E-02	5.69E-10	2.17E-05	4.046E-07	3.524E-06	9.06E-06	6.48E-01	4.21E-06	1.77E-03	1.69E-03	2.45E-02	1.04E+00	6.78E-03	1.73E-03
	AM241	PU238	PU239	PU240	PU242	PU239/0	U233	U234	U235	U236	U238	SR 90	NP237	SB125	CS134	EU154	PU241	CM244	CO 60
Mean	3.80E-02	3.50E-02	4.74E-03	7.71E-03	2.98E-05	1.25E-02	5.41E-10	1.75E-05	2.56E-07	3.38E-06	4.90E-06	6.59E-01	4.53E-06	4.58E-03	1.46E-02	3.95E-02	8.10E-01	3.16E-02	2.01E-03
Median	3.48E-02	3.68E-02	4.62E-03	7.33E-03	3.15E-05	1.18E-02	4.80E-10	1.69E-05	2.07E-07	3.48E-06	4.72E-06	6.46E-01	4.43E-06	3.50E-03	9.13E-03	3.92E-02	8.10E-01	1.90E-02	1.84E-03
Std. Deviation	1.43E-02	1.33E-02	1.55E-03	1.64E-03	1.04E-05	3.06E-03	2.26E-10	7.64E-06	1.98E-07	9.52E-07	1.74E-06	6.53E-02	8.35E-07	4.41E-03	2.23E-02	1.48E-02	1.44E-01	3.12E-02	9.11E-04
Meas. Mean	3.27E-02	3.72E-02				1.19E-02		6.81E-05			3.33E-05	4.05E-01	2.52E-05	4.74E-03	3.29E-03	1.32E-02		2.55E-02	3.42E-02
LHC/ Meas.	116.29%	94.11%				104.67%		25.62%			14.71%	162.85%	17.95%	96.54%	441.93%	299.70%		124.12%	5.88%
Results/sample	69/69	69/69				69/69		24/69			14/69	13/69	5/69	8/69	50/69	54/69		69/69	63/69

2.4 ANALYSIS

The analysis of samples from JN-1 (Table 1) reveals the presence of Co-60, Cs-134, Cs-137, Eu-154, Am-241, Cm-244, Pu-238, Pu-239/240, U-234, U-238, Np-237, Sb-125 and Sr-90 in measurable quantities in at least one sample, with Cs-137 being dominant. The sample analyses were performed at the BCLDP Radioanalytical Laboratory (RAL). The quality control/assurance used at the RAL is discussed in section 4.3. Since Cs-137 is also the dominant isotope in the ORIGEN2 output, it is used as the basis for the standard mix specification. Ratios for all isotopes not identified in the smear samples are based on the ORIGEN2 calculations (daughter isotopes are routinely assumed to be in equilibrium with the parent and are not listed separately) and are then normalized to Cs-137.

Because of the extensive modeling capabilities of the ORIGEN2 code, the output contains many isotopes that are present in only trace quantities. QAD and the prepared spreadsheets used to perform package activity calculations consider only those isotopes with activities that comprise the upper 95% of the total activity and/or are required by DOE, DOT, or one of the waste burial sites. H-3 and Kr-85 were removed from the ORIGEN2 output since the fuel was unsealed and the tritium and krypton, which routinely off-gas, and are therefore no longer present.

For the other radionuclides, the theoretical analysis of radionuclide content described above is used to relate radionuclide content to Cs-137 content. For the isotopes listed in Table 1, it is possible to make a direct comparison between measured activities from the West Jefferson database and theoretical results from the ORIGEN2 analyses. This comparison is provided at the bottom of Table 4. Four of the isotopes, Am-241, Pu-238, Pu-239/40, and Cm-244 were detected in every sample and show excellent agreement with the ORIGEN2 values. Two isotopes, Eu-154 and Cs-134, were detected in most samples, but have short half lives which make them unsuitable for comparison since a conservative assumption was used for the age of the ORIGEN2 generated material. All other isotopes were only detected in less than half of the samples and comparisons to ORIGEN2 values are of minimal value. Co-60 is a special case discussed in the following paragraph. Considering the fact that the history of the types of fuel characteristics could only be approximately reconstructed to support the series of ORIGEN2 analyses, the agreement is excellent. There is an apparent tendency for the ORIGEN2 results to be slightly higher than the empirical values by approximately 20%. Because the Cs-137 activity is proportional to the total number of fissions, whereas the actinide activities are proportional to the total number of captures in U-238, this bias could be the result of a slight under-estimation of the average enrichment of U-235 in the ORIGEN2 analyses. This could also be a result of the conservative estimation of the age of the material.

Most samples included measurable quantities of Co-60, but because Co-60 is an activation product rather than a fission product, its quantity can not intrinsically be correlated from the quantity of Cs-137. In addition, ORIGEN2 is not expected to produce a very good estimate of the Co-60 activity, since it is an input parameter and varies depending upon operations conducted.

In the database, there are a few outlier values of total curie content that are approximately a factor of two higher than the other values measured. It is quite possible that there is a unique character to these samples, such that they don't truly belong to the general distribution. However, because there are a small number of these outliers, their effect on the estimated radioactivity content of a specific container is minor.

Table 4 provides the mean values for the other reportable radionuclides as developed in a series of ORIGEN2 analyses. The relative activities of these radionuclides are very small in comparison with the inventories of Cs-137 and Co-60, which are measured directly, and with the inventories of the transuranic radionuclides tabulated in Table 1. The combination of empirically derived values and ORIGEN2 values that will be used for the JN Standard Isotope Mix is shown in Table 5.

Table 5. JN Standard Mix with Mean Values

Isotope	Normalized To Cs-137	1mCi
Cs-137	1	0.383
Am-241	0.032	0.012
Pu-238	0.037	0.014
Pu-239/40	0.012	0.005
Cm-244	0.026	0.010
Co-60	0.034	0.013
Pu-241	0.81	0.310
Sr-90	0.659	0.252
Pu-242	2.98E-05	1.14E-05
U-233	5.41E-10	2.07E-10
U-234	1.75E-05	6.70E-06
U-235	2.56E-07	9.8E-08
U-236	3.38E-06	1.30E-06
U-238	4.90E-06	1.88E-06
Total	2.610	1.000
TRU sum		3.10E+04 nCi

2.5 TECHNICAL REQUIREMENTS AND ISSUES

2.5.1 Requirements

As Hanford is the disposal option for the BCLDP low-level waste, this document is subject to the requirements of Hanford Solid Waste Acceptance Criteria (SWAC)[(4)], the current revision, and DOE Order 5820.2A[(5)]. DOE Order 435.1 "Radioactive Waste Management"[(6)] has superceded 5820.2A and this document will be updated to that reference in accordance with the project implementation schedule when 435.1 becomes a contractual commitment. The TRU Waste Characterization methodology put forth in this document is subject to the requirements of DOE Carlsbad Area Office and the QAPD (CAO-94-1012)[(7)].

2.5.2 Decay Correction

The Hanford SWAC requires periodic decay corrections on the activity of radioactive materials that comprise the JN-1 standard isotope distribution. The ratio of the isotopes present in the JN-1 standard isotope distribution changes as the shorter half-lived isotopes decay (principally activation products). Further, the change in the ratio of the isotopes that are gamma emitters has a significant effect on the modeling since it affects the base gamma interaction rate used to ratio the actual gamma interaction rate.

The process of decay correction is based on (1) correcting each of the actual isotope activities for the elapsed time and replacing the isotope values with new, current sample activities, or (2) using the ORIGEN2 code generated activities, decay correct the individual isotopes by means of computer output. In either case, the standard decay equation is used, which is:

$$A = A_0 e^{-\lambda t} \qquad \text{(Eq. 1)}$$

Where,

A_0 equals the starting number of atoms of the isotope

λ equals decay constant, $\frac{\ln 2}{t_{1/2}}$

$t_{1/2}$ equals the isotopic half-life

t equals the time elapsed from A_0 to A

The revised Hanford SWAC, requires periodically recertifying as a result of radiological decay. This is a prudent and reasonable practice since it is based on the ratios of easily detected gamma emitters to other, less easily detected components, e.g., alpha emitters.

A significant gamma emitter is Co-60, which loses over 10 percent of its activity in one year. The predominant gamma emitter, Cs-137, has a half-life of 30.17 years and loses over 10 percent of its activity due to decay in five years.

The frequency at which the model will be corrected is based upon a graded approach, as required in the SWAC, and is either data or document driven. If periodic sampling consistently and significantly deviates from the JN standard isotope distribution, the distribution is adjusted or reconstructed as appropriate. If the distribution does not require adjustment for four years, decay correction is required due to Cs-137 decay.

An isotope of Plutonium, Pu-241, is predicted in relatively high concentrations by the ORIGEN2 computer model. As this isotope decays, with a short half-life of 14.4 years, it produces an increasing concentration of Am-241.

Table 6. Am-241 Ingrowth from Pu-241 – Case: 3.2% Enriched 33 KMWD / MTU

	15yr	20yr	25yr	30yr	35yr	40yr	45yr	50yr
Pu-241	60500	47600	37400	29400	23100	18200	14300	11200
Am-241	2210	2621	2938	3180	3363	3500	3601	3674
Am. decay		2192	2175	2157	2140	2123	2106	2089
Am. Ingrowth		429	763	1023	1223	1377	1495	1585
Ingrowth %		16.4%	26.0%	32.2%	36.4%	39.3%	41.5%	43.1%

Note: All numeric values are Ci/MTU unless otherwise labeled.

Table 6 represents total Am-241 concentration as a function of natural decay and the ingrowth from Pu-241 for several post-irradiation fuel ages of standard enrichment and burn-up values for commercial reactor fuel. Ingrowth percentage shown at the bottom of this table represents the percentage of total Am-241 present due to ingrowth post 15 years.

Table 7. Pu-241 Decay and Am-241 Ingrowth – Post Sampling

	15yr		20yr		25yr	30yr
Pu-241	60500		47600		37400	29400
Am-241	2210		2621		2938	3180
	15+4yr	15+2yr	20+4yr	20+2yr	25+4yr	30+4yr
Pu-241	49904	54947	39263	43231	30850	24251
Am-241	2548	2388	2881	2758	3137	3331
Am decay	2196	2203	2604	2613	2919	3160
Am Ingrowth	352	185	277	145	218	171
Ingrowth %	16.03%	8.40%	10.64%	5.55%	7.47%	5.41%

Note: All numeric values are Ci/MTU unless otherwise labeled.

Table 7 illustrates worst case error encountered when Am-241 ingrowth from Pu-241, after a sample is analyzed, is not accounted for in a waste model. Calculations were performed for selected timeframes and fuel ages at the time of analysis. The ingrowth percentage is shown for the selected cases. The worst case, fifteen year-old fuel, would result in sixteen percent ingrowth in a four year span and only eight percent in two years.

Only five data points (of the current waste model comprised of sixty-nine samples) exceed two years post analysis. The fuel age represented in each individual sample is not known and an aggregate fuel age is estimated at twenty-five years, however a value of seventeen years is used for conservatism. The error introduced by ignoring ingrowth after sample analysis for this case would be less than eleven percent. The measurement uncertainty shown for many actual Am-241 sample results is approximately ten percent. This small additional error contributed from just a few samples will have negligible effect on the overall uncertainty across the waste matrix. Am-241 values will be decay corrected when entire model revision is required as discussed above.

2.5.3 Activity Distribution - Verification and Validation

Waste streams that in process are sampled periodically. Activity data is compared and validated against the current distribution values to verify continuing applicability of the waste model. Additionally, direct sampling data are compared to the indirect distribution from ORIGEN2 code. Results are discussed below.

2.5.4 Indirect Method Evaluation

The Hanford SWAC requires that if indirect methods are used, they are to be conservative. The method used in this document minimizes the use of indirect methods, that is the ORIGEN2 computer code, by using direct sample data to the extent reasonable.

The ORIGEN2 data are set up to be conservative by deliberately choosing a less decayed spent fuel activity than is present. This conclusion is repeatedly demonstrated in the comparison of actual sample data to ORIGEN2 generated activities. For many of the isotopes of interest, direct analysis methods are available, thus reducing the overall reliance on indirect methods.

Finally, independent vendors conduct verification assays of waste containers in some cases and their results are compared with internally prepared model-generated data.

2.5.5 Waste Profile Sheets

The Hanford SWAC requires the use of waste profile sheets and an annual review, including radiological characteristics of the waste.

2.5.6 Choice of Waste Matrix

Waste stream matrices are modeled as either cellulose or iron. Similar modeling was previously employed in the 1993 U.S. Ecology Report, "Waste Characterization and Shipping Curie Conversions - Battelle, Columbus West Jefferson Facility"[8]. The cellulose matrix represents the varied composition of the bag and D-box models, which are composed of plastics, wood, cloth, etc. and are similar to cellulose in their electronic configuration. The iron matrix is used for the B-25 box models, which include a range of more dense materials, including concrete. Cellulose and iron are desirable waste configuration models because their physical properties relative to radiological parameters are very well characterized.

3.0 LOW-LEVEL WASTE SORTING

3.1 WASTE PACKAGE MODELS

3.1.1 General Approach

The general approach used for determining waste package activity is to correlate measured external package radiation levels with the quantity of radionuclides within the package. This approach is useful when the package contains gamma emitting radionuclides in sufficient quantities to cause measurable external dose rates, and when non-gamma-emitting radionuclides are present in known, calculated proportions.

To determine the correlation between waste package activity and external dose rate, a model of the package is constructed with a radiation shielding design computer program, QAD. Required QAD inputs include source and package dimensions, dimensions of any shielding materials, and quantities of individual isotopes that make up the source –the JN standard isotope mixture. The quantity used in these calculations was 1 millicurie of the JN standard isotope mixture presented in Table 5, Column 3, unless otherwise noted.

QAD calculations are performed for a range of representative weights for each package. The outputs for each package and form are subjected to regression analysis to obtain an equation describing the dose rate as a function of weight. These equations are incorporated, along with the established JN Standard Isotope Mixture, into computer software for each package and form to facilitate the calculation of the quantity of each isotope present for shippable forms and a graphical representation delineating field use waste sorting criteria. Shippable forms use a factor of 1.67 below the TRU level (100 nCi/g) based on the 30.8% calculated uncertainty plus a 10% allowance to insure conservatism. Non-shippable forms use a factor of 3.4 below the TRU level based on the approximate 290% uncertainty for a single item plus a 15% allowance.

3.1.2 Specific Package Models

Various field sort waste bags, metal cases, IP-2 147 ft^3 boxes, standard D box, 55-gallon drum, and standard B-25 box models are described below.

3.2 INDIVIDUAL FIELD SORT WASTE BAG CASES

3.2.1 Package Model

Two sizes of full individual field sort waste bags were considered: a small bag 12 inches in diameter and 15 inches high, and a tall bag 18 inches in diameter and 27 inches high. Cases were calculated for full small bags at incremental weights of 1, 4, 8, 12, 16, 20, 24, 26, 28, and 30 pounds; and for full tall bags so modeled at incremental weights of 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 pounds. In all cases, the source material was modeled as cellulose because the bags generally contain light materials (e.g., paper products, latex gloves, and various cloth items). Additionally the dose point was set at two inches from the surface at the centerline (i.e. mid-plane) of the bag to represent the distance from the outside of a bag to the center of the detector.

3.2.2 Individual Field Sort Waste Bag Results

Complete results of QAD calculations for individual trash bag cases are presented in Appendix A. Curve-fitting techniques applied to these results were used to determine equations to describe external dose rates as a function of bag weight. For full small bags and full tall bags the equations are presented in the data plot for the applicable model.

The regression correlation coefficients are shown on the data plot as well. Both coefficients indicate a good fit between the data and respective equations. Plots representing the field use waste sort criteria are presented in Appendix A.

3.3 B-25 BOX CASES

3.3.1 Package Model

B-25 boxes are rectangular sheet metal bins generally used for packaging irregularly shaped or bulky materials for shipment and/or disposal. The inner dimensions of a standard B-25 box are 6 feet wide by 3 feet 11 inches tall, by 3 feet 9 inches deep for a total actual volume of 88 cubic feet.

Box walls were modeled as being 0.105 inches thick. Dose rate calculations were performed for contact radiation level measurements taken halfway up at the midpoint of the long side of the box. The model also included a 2-inch air gap between the side of the box and the dose point since the distance from the outside of a box to the centerline of the ion chamber used is 2 inches.

The density of the waste material contained within the box is derived from the box volume and net weight. For the JN site, a typical box weighs are around 4,500 lbs. Therefore, cases were run ranging from 1,000 pounds to 7,000 pounds. Because objects placed in B-25 boxes are often metal, the material chosen for the waste matrix was iron.

Several cases were also run to evaluate the effect of changes in waste material composition on exterior B-25 box dose rates. Previous modeling demonstrated that changing the waste material to concrete from iron resulted in a change in external package dose rates of approximately 8 percent. This effect is sufficiently small that the model may be considered valid for B-25 boxes containing metal, scrap, concrete debris, or a combination of these materials.

B-25 boxes present a special case in that they must be foam-filled to eliminate void space. To preclude the possibility that a full box will exceed applicable activity limits, and to ensure that a box will not have to be re-packaged to meet these limits, QAD calculations were made for 1/4, 1/2, 3/4, and full B-25 boxes. These incremental calculations were performed with the corresponding 1/4, 1/2, 3/4, and 1 millicurie contents to ensure uniformity of the model. The results of these calculations and the corresponding spreadsheets and plots are used to assess the activity of the contents of the B-25 boxes in several steps as they are filled.

3.3.2 B-25 Box Results

Complete results of individual B-25 box case runs are presented in Appendix B. Cases run with varying densities (i.e., from 1,000 pounds to 7,000 pounds) indicated some variation in expected contact dose rate with weight.

Copies of the data plot / regression analysis output for the four B-25 box cases are presented in Appendix B. The relationship between net B-25 box weight and expected external dose rate for the four B-25 box configurations was best estimated by the equations shown on the data plots in Appendix B. The regression analysis indicates a high degree of correlation for all four of these configurations. This indicates an excellent fit between the data and the equations.

Plots presenting the field use waste sort criteria for the four B-25 box configurations are presented in Appendix B along with a sample activity calculation worksheet.

3.4 D BOX CASES

3.4.1 Package Model

D boxes are rectangular, thin walled steel bins generally used for packaging dry active waste (e.g., plastic, paper, or cloth) for super compactor processing. The box dimensions are 3 feet 6 inches by 3 feet 10 inches by 2 feet 9 inches for a total volume of about 36.9 cubic feet.

Box walls were modeled at 0.048 inches thick. Dose rate calculations were performed for contact radiation level measurements taken halfway up (i.e. mid-plane) at the midpoint of the long side of the box. The models also included a 2-inch air gap between the side of the box and the dose point to compensate for the distance between a surface and the centerline position of an ion chamber radiation detector.

The density of the waste material contained within the box is derived from the box volume and net weight. For the JN site, a typical net box weighs are about 500 pounds; however, some are much lighter due to the difficulty in compressing light materials such as plastic. Therefore, cases were run with net weights ranging from 100 pounds to 1,000 pounds. Because the objects placed in D boxes are compactible and relatively light, the material chosen to represent the waste matrix is cellulose.

3.4.2 D Box Results

Complete results of individual D box case runs are presented in Appendix C. Cases run with varying net weights (100 to 1000 pounds) indicated some variation in expected contact dose rate with weight.

A copy of the data plot/regression analysis output for the D box case is presented in Appendix C. The relationship between net D box weight and expected external dose rate was best estimated by the equation shown on the data plot in Appendix C. The regression analysis indicates a high degree of correlation with this equation over the range of the data. This indicates a good fit between the data and the equation developed.

Plots presenting the field use waste sort criteria derived from the spreadsheets for the D box are presented in the appendix along with a sample activity calculation worksheet.

3.5 IP-2 147 ft^3 BOX

3.5.1 Package Model

IP-2 147 ft^3 boxes are rectangular, thin walled steel bins generally used for overpacking B-25 boxes. The box dimensions are 6 feet 10 inches by 4 feet 7 inches by 4 feet 8.5 inches (I.D.) for a total volume of about 147 cubic feet.

Box walls were modeled at 0.1046 inches thick. Dose rate calculations were performed for contact radiation level measurements taken halfway up (i.e. mid-plane) at the midpoint of the long side of the box. The models also included a 2-inch air gap between the side of the box and the dose point to compensate for the distance between a surface and the centerline position of an ion chamber radiation detector.

The density of the waste material contained within the box is derived from the box volume and net weight. For the JN site, a typical net box weighs are about 5000 lbs. if used as a B-25 overpack; however, some are much lighter due to use for other contents. Therefore, cases were run with net weights ranging from 2000 pounds to 12,000 pounds. Because the objects placed in IP-2 147 ft^3 boxes will vary greatly, both iron and cellulose were modeled, the material chosen to represent the waste matrix is cellulose which had the lower dose for a given source and weight.

3.5.2 IP-2 147 ft^3 Box Results

Complete results of individual IP-2 147 ft^3 case runs are presented in Appendix D. Cases run with varying net weights (2000 to 12000 pounds) indicated some variation in expected contact dose rate with weight.

A copy of the data plot/regression analysis output for the IP-2 147-ft3 case is presented in Appendix D. The relationship between net IP-2 147-ft3 box weight and expected external dose rate was best estimated by the equation shown on the data plot.

The regression analysis indicates a high degree of correlation with this equation over the range of the data. This indicates a good fit between the data and the equation developed.

Plots representing the field use waste sort criteria derived from the spreadsheets for the IP-2 147 ft^3 box are also presented in Appendix D along with a sample activity calculation worksheet.

3.6 55-GALLON DRUM CASES

3.6.1 Package Model

The 55-gallon drum waste container is a cylinder with inner dimensions approximately 33 inches tall and 22.6 inches in diameter, resulting in a total volume of about 7.6 cubic feet. Drums are used for packaging compactible and non-compactible waste for shipping and/or disposal.

The 55-gallon drum wall was modeled at 0.048 inches thick. Dose rate calculations were performed for contact radiation level measurements taken halfway up the side of the drum. The models also included a 2-inch air gap between the side of the drum and the dose point to compensate for the distance between a surface and the centerline position of an ion chamber radiation detector.

The density of the waste material contained within the box is derived from the calculated drum volume and net weight. For this project, cases were run utilizing net drum weights from 50 pounds to 500 pounds. Because the material placed in 55-gallon drums may vary from lab trash to construction debris, the material chosen for the waste matrix was iron.

3.6.2 55-Gallon Drum Results

Complete results of individual 55-gallon drum case runs are presented in Appendix E. Cases run with varying densities (i.e., net weights from 50 pounds to 500 pounds) indicated some variation in expected contact dose rate with weight.

A copy of the data plot/regression analysis output for the 55-gallon drum case is presented in Appendix E. The relationship between 55-gallon drum weight and expected external dose rate is described by the equation on the data plot in Appendix A.

The regression analysis indicates a high degree of correlation with this equation over the range of the data. This indicates a good fit between the data and the equation developed.
Field waste sorting criteria levels derived from the spreadsheets for the 55-gallon drum is presented in the appendix also. A sample activity calculation worksheet for the 55-gallon drum is presented as well.

3.7 MISCELLANEOUS METAL CASES

The activity content of a number of waste components cannot be adequately estimated by the use of the models described previously. Among these waste components are ventilation ducts, pumps, valves, and motors. To better estimate the activity content of items such as these, two general models and spreadsheets were developed. The models developed are small and large metal (iron) cylinders, which are discussed below in detail. Both models are fixed in size, but cover a range of weights, and therefore densities, to provide a means to estimate activities contained in a broad range of real objects.

3.7.1 Small Metal Form Cases

The small metal form model is a right circular cylinder 6 inches in radius and 15 inches high. The dose measuring point is separated from the source by a 2-inch air gap, which simulates the centerline of the indicated ion chamber detector.

QAD calculations were performed for this model with net weights of 5, 10, 15, 20, 25, 30, 40, 50, and 60 pounds. The radiation source for these calculations was 1 millicurie of the JN standard isotopic mixture. The dose point was located at the vertical centerline of the cylinder.

A regression analysis / data plot performed on the QAD output yields the equation shown on the data plot for this form in Appendix F. The regression correlation coefficient for this equation shows a high degree of correlation, which indicates good agreement between the equation and the QAD output. The data plot/regression analysis output for the small metals forms is presented in Appendix F. Plots representing the field use waste sort criteria derived from the spreadsheets for the small metal forms are in this appendix as well.

3.7.2 Cylindrical Form Cases

The cylindrical form model is a right circular cylinder 12 inches in diameter by 36 inches high. The dose measuring point is separated from the source by a 2-inch air gap, which simulates the measuring point of the radiation survey instrument.

QAD calculations were performed for this model with net weights from 10 pounds to 100 pounds in 10-pound increments. The radiation source for these calculations was 1 millicurie of the JN standard isotopic mixture. The dose point was located at the vertical centerline of the cylinder.

A regression analysis performed on the QAD output yields the equation shown on the data plot for this form in Appendix F. The regression correlation coefficient for this equation shows a high degree of correlation, which indicates good agreement between the equation and the QAD output. The data plot/regression analysis results for the cylindrical form is presented in Appendix F. Plots representing the field use waste sort criteria derived from the spreadsheets for the cylindrical forms are also presented in this appendix.

3.8 TREATMENT OF UNCERTAINTIES

Estimation of the uncertainty associated with the characterization of low-level waste has four components:

- Uncertainty in measuring dose at the center line of the container being characterized;
- Uncertainty in the weight of the container being characterized;
- Uncertainty in the assumed JN Standard Isotopic Distribution used to estimate the limiting (consistent with low-level waste) dose emanating from the container; and,
- Uncertainty in the dosage predicted (as a function of container configuration and weight) by the QAD software calculations.

Available data suggests a ±10 percent uncertainty associated with measuring dose using a standard ion chamber. For purposes of estimating total uncertainty, ion chamber measurement error was assumed to have a Normal distribution with mean zero and standard deviation, 6.1 (=10/1.645). Doing so equates to assuming the −10% and +10% limits represent the 5^{th} and 95^{th} quantiles, respectively, of the assumed Normal distribution in error. In contrast, testing showed the effect on estimated exposure of error in measurement of the container weight was negligible, primarily because the accuracy of the measurement method (±2 lbs.). Uncertainty in the weight of the container, therefore, was not considered further.

As noted earlier (Section 2.2), the normalized (to Cs-137) activity of some isotopes was estimated using available data, while for others the estimation depended upon the ORIGEN2 software and assumed values for enrichment, decay, and burn-up. As such, the uncertainty associated with the JN

Standard Isotopic Distribution depends upon how the normalized activity assumed for each isotope was estimated.

For Am-241, Cm-244, Co-60, Pu-238, and Pu-239/240, Lognormal distributions were fitted to available data for ratioed activity (to Cs-137 activity). The resulting estimated distribution reflects uncertainty due to variability in the true ratioed activity and due to measurement error in the available data. This estimated uncertainty is dampened, however, because the aggregate dose emanating from the collection of items in the container is the parameter actually being characterized. Statistical theory indicates an isotope's aggregate dose has variance equal to the variance in that isotope's ratioed activity of any given item divided by the number of items being aggregated (i.e., in the container). An estimate of the latter variance can be derived from the σ term estimated (see Section 2.3) when fitting a Lognormal distribution to the available data. Based on operator experience to date, the number of items in a container can be conservatively assumed equal to 100. For each isotope with available data, then, the uncertainty in normalized activity of a 100-item container can be estimated and is reported in Table 8.

Table 8. Estimated Uncertainty in Aggregate Ratioed Activity of 100-Item Container as Estimated Using Available Data

Transuranic Isotope	Estimated Uncertainty in Ratioed Activity
Am-241	5.93E-03
Cm-244	4.95E-03
Co-60	2.79E-01
Pu-238	3.99E-03
Pu-239/240	1.53E-03

For Sr-90, Pu-241, Pu-242, U-233, U-234, and U-238, the ORIGEN2 software was used in combination with assumed parameter values for enrichment, decay, and burn-up to estimate ratioed activity. As when data were available, the relevant uncertainty is that associated with the mean ratioed activity representing the aggregate exposure from a container of items. As detailed in Section 2.3, four replicates of a five-run Latin Hypercube design were applied within the ORIGEN2 software in order to estimate for each isotope the mean ratioed activity and the uncertainty in that estimated mean. Table 9 below reports, for each considered isotope, the uncertainty in mean ratioed activity as estimated by calculating the standard deviation in mean ratioed activity observed (in the ORIGEN2 output) across the four replicates.

Table 9. Estimated Uncertainty in Mean Ratioed Activity
as Estimated Using ORIGEN2

Transuranic Isotope	Estimated Uncertainty in Ratioed Activity
Pu-241	8.11E-02
Pu-242	3.62E-06
Sr-90	2.81E-02
U-233	6.97E-11
U-234	2.85E-06
U-235	7.43E-08
U-236	3.20E-07
U-238	2.83E-07

The isotopes in Tables 8 and 9 together represent the JN Standard Isotopic Distribution. Summing the isotopes estimated ratioed activities and then normalizing to the resulting total estimates the percentage contribution of each isotope to 1.0 mCi of activity. Table 10 below reports by isotope the resulting normalized activity ratios and their associated uncertainty, correctly scaled from that reported in Tables 8 and 9.

Table 10. Estimated Uncertainty in Mean Normalized Activity as Estimated Using Available Data and ORIGEN2

Transuranic Isotope	Basis	Ratios Normalized to 1 mCi	
		Mean	Uncertainty
Cs-137	Samples	3.83E-01	0.00E+00
Am-241	Samples	1.24E-02	2.27E-03
Pu-238	Samples	1.43E-02	1.53E-03
Pu-239/40	Samples	4.56E-03	5.86E-04
Cm-244	Samples	9.78E-03	1.89E-03
Co-60	Samples	1.31E-02	1.07E-01
Pu-241	ORIGEN2	3.10E-01	3.11E-02
Sr-90	ORIGEN2	2.52E-01	1.08E-02
Pu-242	ORIGEN2	1.14E-05	1.39E-06
U-233	ORIGEN2	2.07E-10	2.67E-11
U-234	ORIGEN2	6.70E-06	1.09E-06
U-235	ORIGEN2	9.81E-08	2.85E-08
U-236	ORIGEN2	1.29E-06	1.23E-07
U-238	ORIGEN2	1.88E-06	1.08E-07

For a given container configuration and weight, p, the measured dose (in mR per hour) predicted by the QAD software can be approximated as:

$$D_{QAD}(p) \cong .383 \cdot T_{Cs-137}(p) + .383 \cdot f_{Co-60} \cdot T_{Co-60}(p), \qquad \text{(Eq. 2)}$$

where,

$T_{Cs-137}(p)$, $T_{Co-60}(p)$ are transfer functions reflecting the assumed material composition;

f_{Co-60} is the normalized activity ratio for Co-60; and

.383 is the percentile of 1 mCi activity deriving from Cs-137.

Uncertainty in the normalized activity ratio for Co-60 (f_{Co-60}) is reported in Table 10. Uncertainty in the transfer functions ($T_{Cs-137}(p)$, $T_{Co-60}(p)$) can be derived from contrasting the QAD calculations assuming a cellulose composition to the container contents with those assuming an iron composition. While the resulting analysis indicated that uncertainty in the QAD-predicted dose varied significantly as a function of container weight and container configuration, the uncertainty ratioed to the predicted dose (i.e., the coefficient of variation in statistical terminology) was reasonably constant. Therefore, a value for the uncertainty ratioed to the predicted dose (which is unitless) of 1.257 was calculated and used.

The three components of uncertainty (recall that container weight uncertainty was found to have negligible effect) can now be combined to estimate the uncertainty in characterizing low-level waste as detailed in this report. Integrating the three components begins by recognizing the characterization of low-level waste is fundamentally a comparison between the measured dose emanating from the container and the limiting dose for such a container consistent with low-level waste. The total inventory of transuranics (Am-241, Pu-238, Pu-239/240, and Pu-242) which will be compared to the 100 nCi per gram limit for low-level waste can be written as,

$$\frac{D_{measured} \cdot .383}{D_{QAD}(p) \cdot Weight} \cdot \sum_{i=1}^{4} f_i \,, \qquad \text{(Eq. 3)}$$

where,

$D_{measured}$ is the ion chamber measured dose (in mR per hour);

$D_{QAD}(p)$ is the QAD-predicted dose (in mR per hour);

f_i are the normalized activity ratios for Am-241, Pu-238, Pu-239/240, and Pu-242;

$Weight$ is the container weight (in grams); and

.383 is the percentile of 1 mCi activity deriving from Cs-137.

An asymptotic approximation to the uncertainty in the estimated total transuranic inventory was derived using this expression and assuming the three sources of uncertainty were statistically independent. The categorization of low-level waste, then, was estimated to have an uncertainty of 51 percent among non-shippable forms and of 37.8 percent among shippable forms.

4.0 TRANSURANIC (TRU) ANALYSIS

4.1 SUMMARY

This section provides guidance to determine the quantities of isotopes present in transuranic (TRU) waste generated under the Battelle Columbus Laboratories Decommissioning Project (BCLDP) TRU Waste Certification Program (WCP). Based on dose rate measurements, the TRU waste is sorted as contact-handled (CH-) TRU waste or remote-handled (RH-) TRU waste. The methodology described in this section is used to quantify the radionuclide content of RH-TRU waste packages. The BCLDP methodology provides a conservative estimate of the radionuclide content of RH-TRU wastes for use in the determination of compliance with the Waste Isolation Pilot Plant (WIPP) TRU waste disposal requirements in accordance with TCP-98-01, TRU Waste Certification Plan for the BCLDP TRU Waste Certification Program.

4.2 SOURCES OF CONTAMINATION

4.2.1 General Discussion

As discussed, in Section 2, the JN-1 standard isotope mixture is the waste stream applied to the general contamination at the JN-1 facility. Because it encompasses a broad spectrum of contamination sources within the JN-1 facility, the JN-1 standard isotope mixture has been selected as the initial TRU waste stream model. Details of the JN-1 standard isotope mixture analysis are discussed in Section 2.3.

4.3 WASTE STREAM MODELING

The primary contributors to the gamma field external to a shipping container containing the TRU waste expected to be generated during Battelle West Jefferson decontamination and decommissioning (D&D) operations are the decay of Cs-137 and Co-60. The estimation of the TRU waste isotopic content relies on the measurement of this gamma field. The inventories of Cs-137 and Co-60 are based on the direct measurement of the gamma field. The estimation of inventories of key transuranic isotopes is determined from empirically determined ratios between each isotope and the activity of Cs-137. As discussed in Section 2.4, Co-60 has a much higher uncertainty based on sample result variability, and ORIGEN2 is not expected to produce a very good estimate of the Co-60 concentration. Thus, the quantity of Co-60 in each container is measured directly, rather than using a ratio to Cs-137 activity. Other reportable radionuclide inventories are based on computer-generated correlations that were developed from ORIGEN2 analyses and/or sample results.

A database of West Jefferson waste samples has been collected, as discussed in Section 2.3. The BCLDP Radioanalytical Laboratory (RAL) performed alpha and gamma spectroscopy on these samples. The RAL operates under the *Radioanalytical Laboratory Quality Assurance Program Plan*,[9] which is consistent with the quality assurance requirements of the DOE Order 414.1[10] and the American National Standards Institute/American Society of Mechanical Engineers Nuclear Quality Assurance-1.[11] In addition, an internal RAL quality control program ensures that the analytical results are reliable and that data integrity is maintained throughout the measurement system. If gamma and/or alpha spectroscopy results for periodic samples indicate the presence of isotopic distributions other than those initially determined for an identified waste stream, the model is amended to incorporate the appropriate waste streams.

The analysis approach is divided into two parts. The first part of the analysis is an assessment of the Cs-137 and Co-60 contents of a shipping container based on radiation measurements. The second part of the analysis is the estimation of radionuclide content of transuranic isotopes based on the known content of Cs-137.

4.3.1 Estimation of Cs-137 and Co-60 Content

By definition, the remotely handled (RH) transuranic (TRU) waste will have exposure rates in excess of 200 mR/hr. It is expected that these exposure rates will exceed 100 R/hr for some of the waste containers. The following section describes the approach to estimating Cs-137 content of a container. Co-60 content is determined in an identical manner. In order to determine the TRU contents of the drum, a methodology has been developed which uses a common gamma-ray emitting fission product (Cs-137) as an indicator of the TRU. The 662 keV photon emitted upon the decay of the Cs-137 daughter Ba-137m is easily distinguished from other photon energies. A typical gamma energy spectrum from the waste is shown in Figure 1. In this figure the photopeak from Cs-137 at 662 keV is dominant. Photopeaks from other radioisotopes including Co-60 (1.1

and 1.3 MeV) are clearly discernable.

It is desirable to use an energy discriminating detector to selectively measure the 662 keV photons. Scattering of higher energy photons (Compton continuum) causes other photons to be present under the 662 keV photopeak. A multi-channel detection system will be used to subtract the Compton background from the 662 keV photopeak, thus yielding those photons from the decay of Cs-137 that have not undergone scatter or absorption. This uncollided photon flux can be used to determine the amount of Cs-137 in the waste container.

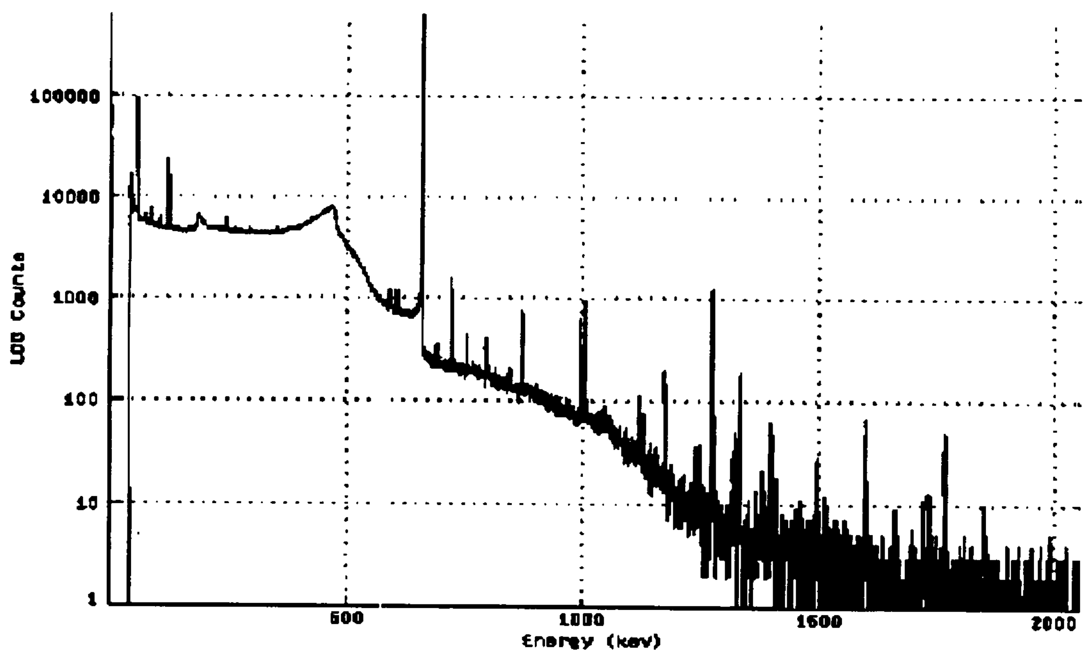

Figure 1. Gamma Spectra from Typical Waste Sample

The type of detector proposed for use will have energy discrimination capability. Detectors such as high purity germanium (HPGe), sodium iodide (NaI), and cadmium-zinc-telluride (CZT) are among those detectors, which have desirable energy discrimination capabilities. The spectrum above was produced using a HPGe detector. This detector is capable of clearly resolving the 662 keV photopeak from other photon energies.

The CZT detector also has relatively high resolution, but decreased sensitivity for gamma energies above 100 keV. Because of the predominance of the Cs-137 in the waste, there are ample 662 keV photons, which can be seen easily, even at lower detection efficiencies. In fact, the lower detection efficiency is advantageous because of the high exposure rates, including contributions from the greater than 1 MeV photons from Co-60. The lower efficiency of the CZT for higher energies will result in a reduced tendency of the detector to saturate. Another advantage of the CZT detector is that the higher resolution is obtained without the need for cryogenic cooling.

The NaI detector is also capable of detecting the 662 keV photopeak, but has lower resolution and could include contributions from other photopeaks that cannot be discriminated out. The NaI detector is very efficient, but can be saturated if the gamma exposure rates exceed several mR/hr.

Due to the high exposure rates, the waste container will be placed in a shield with a thin slit to minimize the gamma flux at the detector. It has been reported the waste containers can have surface exposure rates of tens of R/hr. It is desirable to reduce the exposure rate at the detector to around 1 mR/hr. The overall source/detector geometry to accomplish this reduction is shown in Figure 2. The cylindrical waste container (either a steel liner or a 55-gallon drum and the liner) is placed upon a turntable inside a shield. The shield is sufficiently tall and thick to reduce the exposure rate outside the shield for personnel radiation protection and to reduce the overall radiation background at the detector. The shield will have a thin (nominally 3 mm) slit, which runs along the axial dimension of the waste container. The slit is oriented such that it is facing the detector and is collinear with the waste container axis and the detector. The collimating / shielding material around the detector is sufficiently thick to minimize any background interference from any other sources located in the vicinity.

The cylindrical waste container will be rotated during the measurement to allow the detector to receive a gamma ray contribution from waste throughout the drum. This rotation of the drum tends to cause the individual sources to effectively become annular sources. The presence of numerous sources presents the appearance of many annular rings. The thin slit reduces the total gamma contribution to the detector and reduces the overall exposure rate to personnel. The detector "sees" the waste container as a thin source. The height of the waste container is small relative to the distance to the detector. The radioactive source may therefore be treated as a thin slab with a width of 3 mm and a thickness equivalent to the diameter of the waste container. The height of the slab is the same as the waste container. It is assumed that the detector is centered at the mid-plane of the waste container. Mathematically the gamma flux at the detector may be expressed as:

$$\phi(\rho) := \frac{2 \cdot S_v \cdot \Delta y}{4 \cdot \pi} \cdot \int_0^{\frac{h}{2}} \int_0^{d} \frac{e^{-\left(\mu_1(\rho)+\mu_2 \cdot \frac{t}{x}\right) \cdot \sqrt{\left(\frac{x \cdot z}{P+t+x}\right)^2 + x^2}}}{z^2 + (P+t+x)^2} \, dx \, dz \qquad \text{(Eq. 4)}$$

Where,

ϕ = Uncollided flux of Cs-137 [γ-photons-cm^{-2}–sec^{-1}]

d = diameter of the waste container [cm]

h = height of the waste container [cm]

S_v = Inventory of Cs-137 [γ-photons/cm^{-3}-sec^{-1}]

ρ = density of waste matrix, determined from weight of container and fill height [g cm^{-3}]

μ = linear attenuation coefficient for gamma rays in the radioactive source material, μ_1, and wall of the container, μ_2 [cm^{-1}]

t = thickness of the container wall [cm]

Δy = width of the slit in the shield around the waste container [cm]

P = distance from the detector to the waste container.

For the typical waste container, used as a liner in a 55-gallon drum, the expected uncollided gamma flux per millicurie of Cs-137 at a detector 25 feet from the waste container is shown in Figure 3. The gamma flux is shown as a function of the density of the waste matrix material.

From the measured dose rate obtained for a window around the Cs-137 photopeak (and appropriately corrected for Compton background), the above equation is used to determine the Cs-137 source strength of the cask. Similarly, a second measurement is made of one of the Co-60 photopeaks and the Co-60 inventory of the cask is determined.

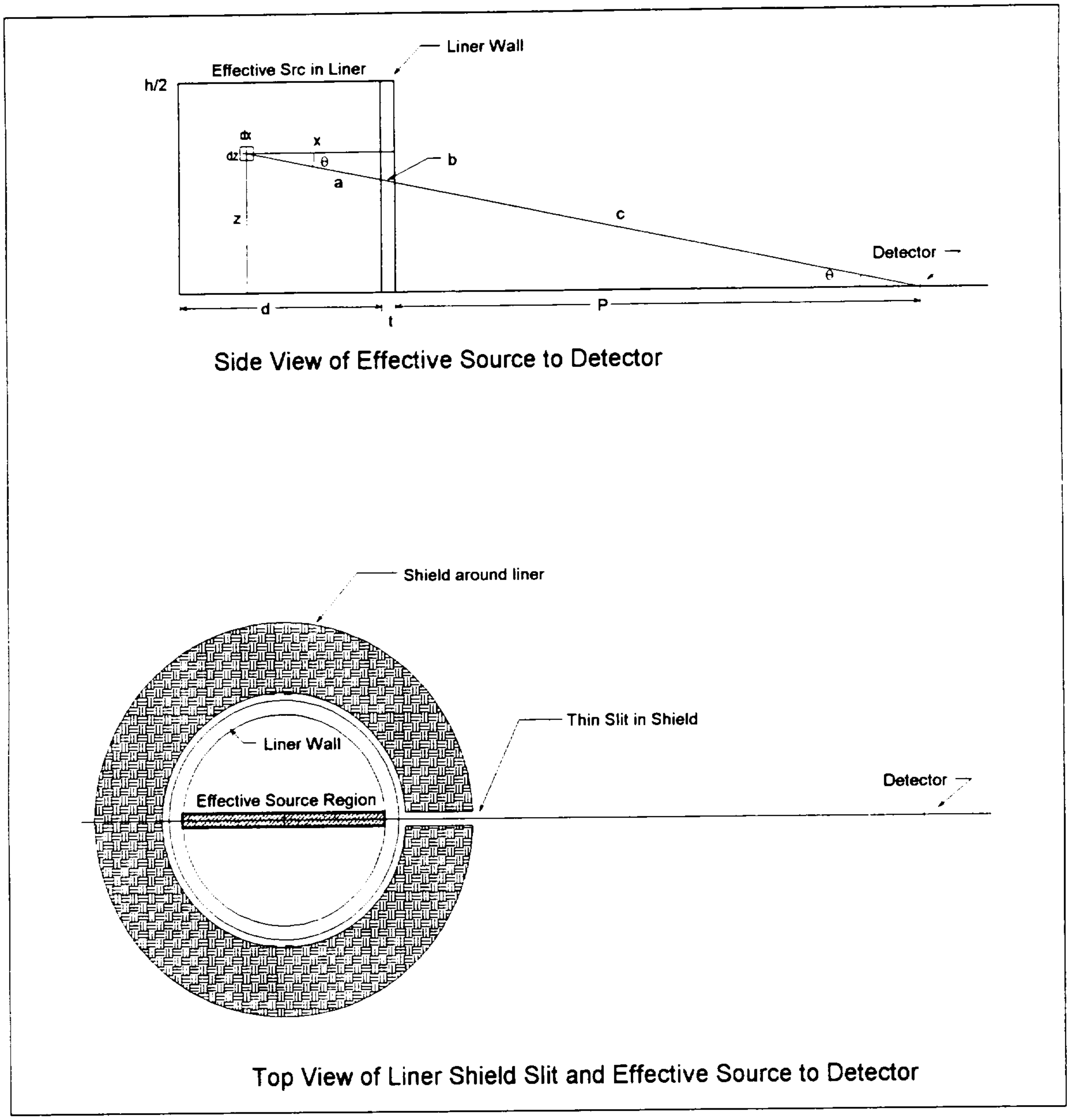

Figure 2. Source/Detector Arrangement

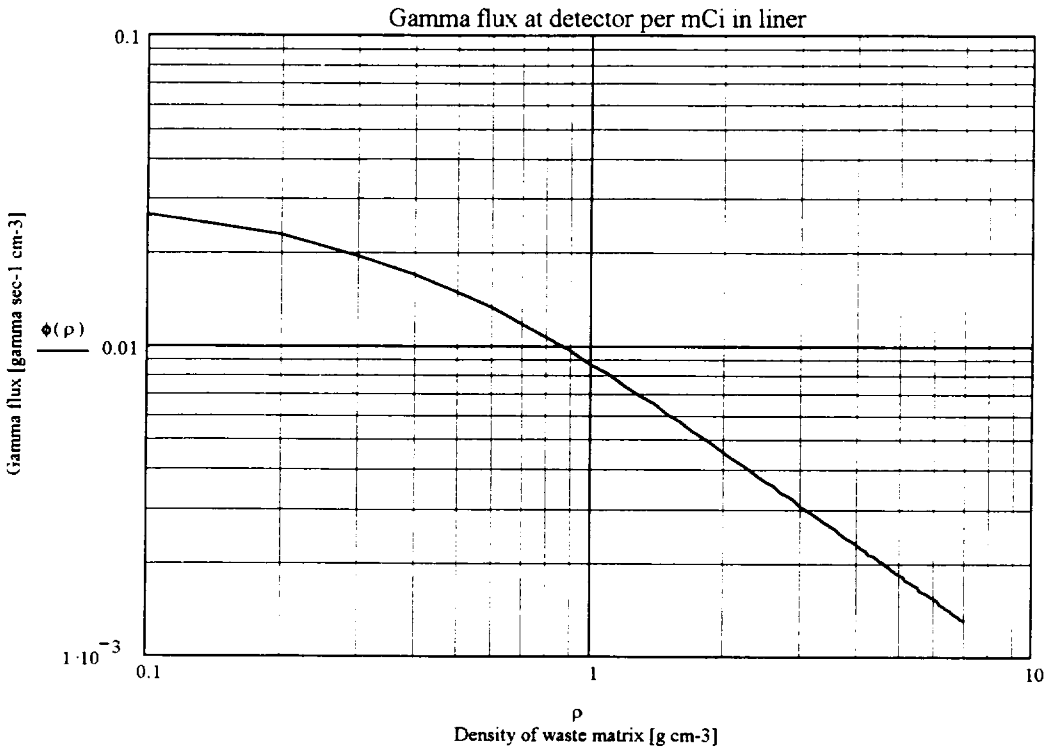

Figure 3. Uncollided Gamma Flux at Detector per mCi Cs-137 in Waste Container

4.3.2 Calculation of Transuranic Content based on Cs-137 Content

There is variability in the ratios of fission products and transuranic isotopes that arise from differences in irradiation conditions (such as burnup, fuel enrichment, cycle characteristics, and decay time). A database of waste samples from West Jefferson operations has been assembled to characterize the transuranic waste at the site. The methodology primarily accounts for uncertainties associated with this variability by means of a statistical analysis of data collected from the waste samples. For the other reportable isotopes, where there is not a sufficient set of measurements, the basis is provided by computer code prediction. Validation of the computer code analysis is provided by comparison between theory and experiment for the radionuclides in the database for which measurements exist.

After the Cs-137 content of a container has been determined (as in Section 4.3.1), the waste sample database is used to estimate the curie content of the container for the most important transuranic radionuclides of the BCLDP inventory: Pu-238, Pu-239/240, and Am-241. As indicated in Table 5, there are a number of additional transuranic and other radionuclides that are also to be reported for the shipping package. Because the curie content of many of these other radionuclides is small, the quantities of these radionuclides were typically below the minimum level of detectability in the waste sample database. For this reason, a number of calculations were performed with the computer code ORIGEN2 to develop an analytical basis for estimating the curie content of these less significant radionuclides. These analyses are described in Section 2.

The variance of the measured distribution of waste samples includes variation in the fuel histories for the experiments that occurred at the West Jefferson site, as well as the contribution from measurement uncertainty. The probability distribution for waste samples is not the same as the distribution of the curie content in the waste containers. The variance of the distribution of curie content in a waste container is substantially smaller. Under the assumption that waste containers are loaded in a random manner, the distribution for containers is characterized by the standard deviation of the mean of the loading of containers, rather than by the standard deviation of the waste sample distribution. For example, if each drum is loaded with a large number of waste samples that have been randomly selected, the standard deviation of the distribution of the radionuclide to Cs-137 fraction of the drum inventory will be reduced by the square root of the number of samples in the drum relative to the population from which the samples are being drawn (for 100 samples in each drum, the distribution is narrower by a factor of ten). A review of the experience at West Jefferson in the loading process indicates that 300 is a typical number of items in a container and that 100 items is a conservative lower bound for statistical purposes. Appendix G contains three pictures that illustrate typical item size and loading.

4.3.3 Treatment of Uncertainties

An upper-bounding uncertainty has been established for the methodology. Estimated uncertainties have been factored into the upper bounds. Many factors contribute to the overall uncertainty of the estimated TRU content of the waste containers from the decontamination and decommissioning of the Battelle West Jefferson facilities. One of the chief factors is the widely varying research that has occurred during facility's operation. These diverse operations are described elsewhere such the Acceptable Knowledge Document [12].

In order to predict the degree of variation in specific radionuclide populations, i.e. TRU and fission products, a number of calculations were performed using the ORIGEN2 computer code. ORIGEN2 calculates isotope depletion and generation for specified conditions. In the vast majority of cases at West Jefferson, the fuel that contributes to the waste was from light water moderated reactors. As described in Section 2.3, a series of calculational parameters were selected based upon the best understanding of the range of conditions of fuel enrichment, exposure, and decay. The ORIGEN2 calculations predict core average conditions. In reality, particular fuel rods or segments of fuel will come from areas of a particular reactor core that may vary from the average conditions in that reactor.

As the waste is an amalgam of isotopes from many differing sources, the variations are expected to average out. This assumption has been confirmed in the examination of a set of sixty-nine samples that provide the best picture of the distribution of specific isotopes. The samples were of non-fixed contamination on the surface of waste, equipment, and facilities being decontaminated. The Cs-137 fission product dominated the gamma activity. From radiochemistry techniques using alpha spectroscopy, activities of TRU (Am-241, Pu-238, Pu-239/240) and other isotopes were measured.

As summarized in Table 4, there was very good agreement between the sample data and the ORIGEN2 based calculations for those isotopes. As described in Section 2.3, where no measured data exist, the values from ORIGEN2 were used. All isotopic values are normalized to the respective Cs-137 activity as the Cs-137 gamma energy is easily measured and serves as an indicator of the amount of TRU present.

The distribution of waste in the waste containers contributes to uncertainty by two means. First, via variation in the distribution of solid material, which acts as an absorber of gamma rays from the Cs-137. A non-uniform distribution of solid material will cause uneven attenuation of the 662 keV gamma rays from Cs-137 and will affect the prediction of the TRU content. Second, the amount of radioactive material in the waste container is likely to be non-uniformly distributed. The various regions of source will have to travel through differing thickness of absorber material and through differing distances to the detector.

The counting of gamma rays from the Cs-137 will also contribute to measurement uncertainty. Radioactive decay is a statistical process and this directly translates to the detection probability. In the proposed measurement scheme, an energy discriminating detector will be used with a multichannel analyzer. In the region about the 662 keV photopeak, there will exist gamma photons from the decay of Cs-137 and scatter of other higher energy emitting isotopes. This Compton background will be subtracted from the total area under the 662 keV photopeak, yielding the amount of photons from Cs-137 that has not undergone an interaction. Other sources of background radiation may also result in a contribution to the uncertainty of the measurement.

Estimation of the uncertainty associated with the characterization of TRU-level waste, therefore, has three components:

- Uncertainty in measuring the Cs-137 activity in the container based on the measurement of decay gammas emanating from the container;
- Uncertainty in the weight of the container being characterized; and,
- Uncertainty in estimating the inventories of other radionuclides and total transuranics based on their measured or predicted ratios to Cs-137 activity.

Testing showed the effect on estimated exposure of error in measurement of the container weight was negligible, primarily because the accuracy of the measurement method (±2 lbs.). Uncertainty in the weight of the container, therefore, was not considered further. In addition, though the apparatus for measuring Cs-137 and Co-60 activity has not yet been assembled, consensus opinion suggested a 20 percent uncertainty (i.e., the measurement distribution will have a standard deviation of 20 percent). A more detailed analysis of this uncertainty will be performed for the actual system after it has been assembled.

Section 3.8 details the uncertainty in estimated normalized (to Cs-137) activity of each of the targeted isotopes including the transuranics, Am-241, Pu-238, and Pu-239/240. The uncertainty in the total normalized transuranic activity is estimated to be 8.6 percent (i.e., .086 pCi per pCi Cs-137 activity).

Estimation of the total transuranic activity emanating from the container is calculated as the product of the measured Cs-137 activity and the estimated total normalized activity ratio. The uncertainty associated with this product can be approximated using a first-order Taylor series representation of the product and assuming the two values are statistically independent. Specifically, the uncertainty in total activity estimated for a container is approximately,

$$\sqrt{\mu_Y^2 \cdot VarX + \mu_X^2 \cdot VarY}\ , \qquad \text{(Eq. 5)}$$

where,

μ_X equals the total normalized activity of the targeted isotopes;

μ_Y equals the apparatus-measured Cs-137 activity;

$VarX$ equals the squared uncertainty in total (across isotopes) normalized activity, 8.6^2=74; and,

$VarY$ equals the squared uncertainty in measured Cs-137 activity, 20^2=400.

Finally, it is important to stress that there are steps that can be taken to reduce the various sources of uncertainty. These steps are best considered as procedural recommendations for the completion of the packaging of the waste and preparation for shipment to a repository. Specifically,

- Historical practices and practical considerations have led to cutting waste materials into small, typically less than 12 inch, pieces for easy placement into inter-Hot Cell transfer and storage containers locally called "berry cans". The berry cans are slightly larger than 1 gallon paint cans. The material from the berry cans is sorted into material types and the berry cans are crushed into a metals container. The result is components in a waste container that are somewhat uniform in size but likely randomly distributed in location. Compaction of the waste further reduces void spaces and evens out the attenuation of the gamma rays for equivalent shield distance. This uniform packing of the waste is illustrated in the photographs in Appendix G taken of actual waste containers.

- Because of the high exposure rates expected from the waste containers, the measurement apparatus (discussed in Section 4.3.2) will involve use of shielding for personnel radiation protection and to avoid saturating the radiation detector. The rotation of the drum during measurement of the Cs-137 gamma rays will prompt an averaging effect of the distributed radiation sources. The use of a thin slit in the shield will allow for counting of thin slices of waste in the container. Both the detector and the waste container will be shielded, with the detector highly collimated to reduce background effects. It is recommended that the alignment of the detector and slit be precise and reproducible. Use of tools such as lasers can assist in achieving this precise repeatable alignment.

- The radiation measurement technique lends itself to computerization for the identification of the 662 keV photopeak and Compton background, the subtraction operation to obtain the uncollided gamma flux from Cs-137, and performance of the mathematical evaluations to obtain the estimate of the TRU content in the waste container. Automating these steps will reduce the likelihood of transcription errors and provide a record for each measurement.

- Each waste container is uniquely identified, as required by CAO, to more easily enable association with a measurement and predicted TRU and other isotopic inventory.

4.3.4 Software Quality Assurance

The use of software packages (i.e., ORIGEN2, QAD-CGGP-A, MCNP, Excel) in the methodology has been determined under TC-AP-01.5, *Software Management for the BCLDP TRU WCP*[13], to be compliant with the quality assurance requirements of the *Quality Assurance Program Document* (CAO-94-1012). All BCLDP TRU WCP software packages are used and maintained in accordance with TC-AP-01.5.

4.3.5 Technical Requirements and Issues

Section 4 has been developed in accordance with the requirements of the BCLDP TRU WCP, which implements the U.S. Department of Energy-Carlsbad Area Office requirements of the Waste Isolation Pilot Plant TRU WCP for the BCLDP.

The BCLDP approach for RH-TRU waste characterization is consistent with the current DOE draft guidance[14]. The draft guidance states the guiding principles for designing radioassay methods for RH-TRU waste as follows:

- Must provide the data needed to ensure the QAOs are met
- Must be practical for the generator site to apply
- Must be consistent with worker safety (ALARA) principles.

The proposed quality assurance objectives interpret limit compliance as "measured value plus the uncertainty." This provides sites with "the flexibility to weigh the cost versus the benefit of developing higher precision and accuracy analytical methods and optimize for their particular situation.... Small quantity sites may find it more efficient to use less expensive, less precise measurement methods...." This proposal is key to the BCLDP method, for which the accuracy is periodically verified. The BCLDP TRU WCP methodology for the determination of radioassay properties for RH-TRU waste meets the above principles and has been specifically designed for implementation by the BCLDP, as a small quantity site.

Based on the current DOE draft guidance, the proposed BCLDP TRU WCP methodology for determining radioassay properties for RH-TRU wastes is conservative.

4.3.6 Summary

The determination of the radionuclide content of a TRU waste container involves the following steps:

- Using the measurement configuration illustrated in Figure 2, the count rates for the photopeaks of Cs-137 and Co-60 are measured (appropriately corrected for the Compton background).

- The Cs-137 dose rate, Co-60 dose rate, detector efficiency, waste type (steel, concrete, or organic), total drum weight, and total waste height within the container are provided as input to the analysis.

- The density of the waste is calculated.

- The total Cs-137 curie content and total Co-60 curie content of the container are determined using Equation 4.

- The total curie content of the other reported radionuclides are determined using either empirical ratios to Cs-137 content or ORIGEN2-based values, Table 5.

- The mean value and a conservatively estimated value (characterized by the mean plus one standard deviation) of the curie content for each of the reportable radionuclides is provided for documenting the inventory of the container.

REFERENCES

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DD-98-04 Rev. 3

APPENDIX A

Individual Field Sort Waste Bags

Contents:

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Trash Bag, 1 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                              body data
 rcc    1  .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
           .1524000D+02
 rpp    2  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   12

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                              input zone data
 src    0     1     0     0     0     0     0     0     0     0  z  1
 air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
comp/mat     h           c           o
    1     1.0000E-03  7.2000E-03  8.1000E-03
    2     0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.5945	0.15-1.50	3.6239E+03	1.0145E+00	4.2188E+00	4.2800E+00
1	.0300	0.025-0.035	1.9765E+02	1.0972E+00	5.8702E-02	6.4407E-02
2	.0400	0.035-0.045	4.6673E+01	1.1009E+00	8.2611E-03	9.0946E-03
3	.0600	0.055-0.070	3.8263E+01	1.0892E+00	4.5533E-03	4.9594E-03
4	.6000	0.550-0.700	3.1059E+03	1.0137E+00	3.6339E+00	3.6836E+00
5	1.0000	0.900-1.250	1.1757E+02	1.0101E+00	2.1634E-01	2.1851E-01
6	1.5000	1.250-1.750	1.1787E+02	1.0079E+00	2.9703E-01	2.9939E-01

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

Small Trash Bag, 4 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                  body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
              .1524000D+02
  rpp     2  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03    12

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                  input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat       h            c            o
     1      4.0000E-03   2.9000E-02   3.2300E-02
     2      0.0000E+00   0.0000E+00   0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.5915	0.15-1.50	3.4241E+03	1.0622E+00	4.0130E+00	4.2624E+00
1	.0300	0.025-0.035	1.6736E+02	1.3275E+00	4.9704E-02	6.5984E-02
2	.0400	0.035-0.045	4.1042E+01	1.3903E+00	7.2645E-03	1.0099E-02
3	.0600	0.055-0.070	3.4410E+01	1.3955E+00	4.0947E-03	5.7143E-03
4	.6000	0.550-0.700	2.9542E+03	1.0608E+00	3.4564E+00	3.6667E+00
5	1.0000	0.900-1.250	1.1300E+02	1.0430E+00	2.0792E-01	2.1687E-01
6	1.5000	1.250-1.750	1.1411E+02	1.0330E+00	2.8756E-01	2.9706E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Trash Bag, 8 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rcc    1  .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
            .1524000D+02
  rpp    2  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   12

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                      input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h           c           o
     1       8.1000E-03  5.7900E-02  6.4500E-02
     2       0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.5911	0.15-1.50	3.1868E+03	1.1273E+00	3.7623E+00	4.2412E+00
1	.0300	0.025-0.035	1.3673E+02	1.5540E+00	4.0610E-02	6.3109E-02
2	.0400	0.035-0.045	3.4984E+01	1.7335E+00	6.1922E-03	1.0734E-02
3	.0600	0.055-0.070	3.0106E+01	1.8202E+00	3.5826E-03	6.5211E-03
4	.6000	0.550-0.700	2.7683E+03	1.1275E+00	3.2389E+00	3.6519E+00
5	1.0000	0.900-1.250	1.0730E+02	1.0884E+00	1.9742E-01	2.1487E-01
6	1.5000	1.250-1.750	1.0937E+02	1.0668E+00	2.7562E-01	2.9402E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
Small Trash Bag, 12 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                          body data
 rcc     1   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.3810000D+02    3
             .1524000D+02
 rpp     2  -.2000000D+03    .2000000D+03   -.2000000D+03    .2000000D+03   -.2000000D+03
.2000000D+03   12

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                          input zone data
 src    0      1      0      0      0      0      0      0      0      0  z  1
 air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
comp/mat       h           c           o
     1      1.2100E-02  8.6900E-02  9.6700E-02
     2      0.0000E+00  0.0000E+00  0.0000E+00

grp      mean        energy        direct beam   mean buildup         dose rate
no      energy    group limits        flux          factors      direct beam   with buildup
         mev          mev         photons/cm**                           mrem/hr
                                  2/sec
total    .5924    0.15-1.50       2.9770E+03    1.1924E+00       3.5356E+00    4.2159E+00

 1       .0300    0.025-0.035     1.1402E+02    1.7188E+00       3.3865E-02    5.8207E-02
 2       .0400    0.035-0.045     3.0195E+01    2.0283E+00       5.3446E-03    1.0840E-02
 3       .0600    0.055-0.070     2.6571E+01    2.2372E+00       3.1619E-03    7.0737E-03
 4       .6000    0.550-0.700     2.5992E+03    1.1956E+00       3.0411E+00    3.6361E+00
 5      1.0000    0.900-1.250     1.0201E+02    1.1339E+00       1.8770E-01    2.1283E-01
 6      1.5000    1.250-1.750     1.0492E+02    1.1002E+00       2.6440E-01    2.9089E-01
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

Small Trash Bag, 16 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc    1  .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
            .1524000D+02
  rpp    2  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   12

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o
     1      1.6100E-02  1.1590E-01  1.2890E-01
     2      0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.5944	0.15-1.50	2.7898E+03	1.2569E+00	3.3295E+00	4.1850E+00
1	.0300	0.025-0.035	9.6822E+01	1.8401E+00	2.8756E-02	5.2914E-02
2	.0400	0.035-0.045	2.6361E+01	2.2785E+00	4.6658E-03	1.0631E-02
3	.0600	0.055-0.070	2.3637E+01	2.6343E+00	2.8128E-03	7.4099E-03
4	.6000	0.550-0.700	2.4451E+03	1.2639E+00	2.8608E+00	3.6158E+00
5	1.0000	0.900-1.250	9.7097E+01	1.1791E+00	1.7866E-01	2.1066E-01
6	1.5000	1.250-1.750	1.0073E+02	1.1332E+00	2.5384E-01	2.8764E-01

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            Small Trash Bag, 20 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                          body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
             .1524000D+02
  rpp    2  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   12

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                          input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     h           c           o
     1      2.0100E-02  1.4490E-01  1.6120E-01
     2      0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.5967	0.15-1.50	2.6214E+03	1.3205E+00	3.1414E+00	4.1482E+00
1	.0300	0.025-0.035	8.3521E+01	1.9301E+00	2.4806E-02	4.7878E-02
2	.0400	0.035-0.045	2.3250E+01	2.4891E+00	4.1152E-03	1.0243E-02
3	.0600	0.055-0.070	2.1182E+01	3.0056E+00	2.5207E-03	7.5760E-03
4	.6000	0.550-0.700	2.3042E+03	1.3316E+00	2.6959E+00	3.5899E+00
5	1.0000	0.900-1.250	9.2524E+01	1.2237E+00	1.7024E-01	2.0832E-01
6	1.5000	1.250-1.750	9.6773E+01	1.1655E+00	2.4387E-01	2.8424E-01

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

Small Trash Bag, 24 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rcc     1   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.3810000D+02     3
              .1524000D+02
  rpp     2  -.2000000D+03    .2000000D+03  -.2000000D+03    .2000000D+03  -.2000000D+03
.2000000D+03    12

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
comp/mat       h          c          o
     1       2.4200E-02  1.7380E-01  1.9340E-01
     2       0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.5990	0.15-1.50	2.4694E+03	1.3827E+00	2.9695E+00	4.1059E+00
1	.0300	0.025-0.035	7.3075E+01	1.9972E+00	2.1703E-02	4.3345E-02
2	.0400	0.035-0.045	2.0704E+01	2.6647E+00	3.6647E-03	9.7652E-03
3	.0600	0.055-0.070	1.9114E+01	3.3467E+00	2.2746E-03	7.6125E-03
4	.6000	0.550-0.700	2.1752E+03	1.3983E+00	2.5450E+00	3.5586E+00
5	1.0000	0.900-1.250	8.8264E+01	1.2674E+00	1.6241E-01	2.0583E-01
6	1.5000	1.250-1.750	9.3047E+01	1.1971E+00	2.3448E-01	2.8070E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
Small Trash Bag, 26 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                       body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
            .1524000D+02
  rpp    2  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   12

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                       input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o
     1      2.6200E-02  1.8830E-01  2.0950E-01
     2      0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean       energy        direct beam   mean buildup          dose rate
 no     energy   group limits       flux          factors       direct beam  with buildup
         mev         mev         photons/cm**                          mrem/hr
                                 2/sec
 total   .6001    0.15-1.50      2.3989E+03    1.4131E+00      2.8891E+00   4.0827E+00

  1      .0300    0.025-0.035    6.8679E+01    2.0241E+00      2.0398E-02   4.1287E-02
  2      .0400    0.035-0.045    1.9603E+01    2.7411E+00      3.4697E-03   9.5108E-03
  3      .0600    0.055-0.070    1.8203E+01    3.5054E+00      2.1662E-03   7.5935E-03
  4      .6000    0.550-0.700    2.1149E+03    1.4310E+00      2.4744E+00   3.5409E+00
  5     1.0000    0.900-1.250    8.6250E+01    1.2888E+00      1.5870E-01   2.0453E-01
  6     1.5000    1.250-1.750    9.1263E+01    1.2127E+00      2.2998E-01   2.7889E-01
```

```
              qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Trash Bag, 28 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02     3
            .1524000D+02
  rpp     2  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   12

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o
    1       2.8200E-02  2.0280E-01  2.2570E-01
    2       0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6012	0.15-1.50	2.3315E+03	1.4432E+00	2.8120E+00	4.0583E+00
1	.0300	0.025-0.035	6.4717E+01	2.0476E+00	1.9221E-02	3.9356E-02
2	.0400	0.035-0.045	1.8595E+01	2.8108E+00	3.2913E-03	9.2512E-03
3	.0600	0.055-0.070	1.7360E+01	3.6567E+00	2.0658E-03	7.5542E-03
4	.6000	0.550-0.700	2.0570E+03	1.4634E+00	2.4067E+00	3.5219E+00
5	1.0000	0.900-1.250	8.4298E+01	1.3100E+00	1.5511E-01	2.0319E-01
6	1.5000	1.250-1.750	8.9529E+01	1.2280E+00	2.2561E-01	2.7705E-01

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            Small Trash Bag, 30 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc    1   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.3810000D+02     3
             .1524000D+02
  rpp    2  -.2000000D+03    .2000000D+03   -.2000000D+03    .2000000D+03   -.2000000D+03
.2000000D+03    12

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                         input zone data
  src     0      1      0      0      0      0      0      0      0      0  z  1
  air     0      2     -1      0      0      0      0      0      0      0  z  2

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o
      1       3.0200E-02  2.1730E-01  2.4180E-01
      2       0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean      energy         direct beam  mean buildup          dose rate
 no     energy   group limits        flux        factors       direct beam  with buildup
         mev        mev          photons/cm**                           mrem/hr
                                 2/sec
 total   .6022    0.15-1.50      2.2674E+03   1.4728E+00      2.7382E+00   4.0329E+00

  1      .0300    0.025-0.035    6.1158E+01   2.0679E+00      1.8164E-02   3.7562E-02
  2      .0400    0.035-0.045    1.7676E+01   2.8741E+00      3.1286E-03   8.9920E-03
  3      .0600    0.055-0.070    1.6582E+01   3.7999E+00      1.9733E-03   7.4982E-03
  4      .6000    0.550-0.700    2.0017E+03   1.4953E+00      2.3420E+00   3.5018E+00
  5     1.0000    0.900-1.250    8.2418E+01   1.3308E+00      1.5165E-01   2.0182E-01
  6     1.5000    1.250-1.750    8.7848E+01   1.2431E+00      2.2138E-01   2.7519E-01
```

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            Large Trash Bag, 5 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02    3
             .2286000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     h           c           o
     1      1.2000E-03  8.9000E-03  9.9000E-03
     2      0.0000E+00  0.0000E+00  0.0000E+00

grp     mean      energy        direct beam  mean buildup        dose rate
no      energy   group limits      flux        factors      direct beam  with buildup
        mev        mev         photons/cm**                        mrem/hr
                               2/sec
total   .5932    0.015-1.50    1.5795E+03   1.0295E+00      1.8429E+00   1.8973E+00

 1      .0300    0.025-0.035   8.3072E+01   1.1789E+00      2.4672E-02   2.9085E-02
 2      .0400    0.035-0.045   1.9854E+01   1.1965E+00      3.5141E-03   4.2047E-03
 3      .0600    0.055-0.070   1.6412E+01   1.1842E+00      1.9530E-03   2.3128E-03
 4      .6000    0.550-0.700   1.3568E+03   1.0283E+00      1.5875E+00   1.6323E+00
 5     1.0000    0.900-1.250   5.1536E+01   1.0204E+00      9.4825E-02   9.6758E-02
 6     1.5000    1.250-1.750   5.1786E+01   1.0159E+00      1.3050E-01   1.3257E-01
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Large Trash Bag, 10 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                body data
  rcc    1   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.6858000D+02    3
             .2286000D+02
  rcc    2   .0000000D+00    .0000000D+00   -.1000000D+02    .0000000D+00    .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                input zone data
  src    0      1     0     0     0     0     0     0     0     0  z  1
  air    0      2    -1     0     0     0     0     0     0     0  z  2

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat       h            c            o
     1       2.5000E-03   1.7900E-02   1.9900E-02
     2       0.0000E+00   0.0000E+00   0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.5915	0.015-1.50	1.5214E+03	1.0614E+00	1.7829E+00	1.8924E+00
1	.0300	0.025-0.035	7.4462E+01	1.3257E+00	2.2115E-02	2.9318E-02
2	.0400	0.035-0.045	1.8240E+01	1.3869E+00	3.2284E-03	4.4776E-03
3	.0600	0.055-0.070	1.5300E+01	1.3912E+00	1.8207E-03	2.5329E-03
4	.6000	0.550-0.700	1.3125E+03	1.0601E+00	1.5356E+00	1.6279E+00
5	1.0000	0.900-1.250	5.0197E+01	1.0425E+00	9.2363E-02	9.6289E-02
6	1.5000	1.250-1.750	5.0686E+01	1.0326E+00	1.2773E-01	1.3189E-01

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

Large Trash Bag, 15 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02    3
            .2286000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
            .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h            c            o
     1       3.7000E-03   2.6800E-02   2.9800E-02
     2       0.0000E+00   0.0000E+00   0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.5909	0.015-1.50	1.4679E+03	1.0933E+00	1.7268E+00	1.8880E+00
1	.0300	0.025-0.035	6.7214E+01	1.4478E+00	1.9962E-02	2.8901E-02
2	.0400	0.035-0.045	1.6833E+01	1.5629E+00	2.9795E-03	4.6566E-03
3	.0600	0.055-0.070	1.4312E+01	1.5998E+00	1.7031E-03	2.7246E-03
4	.6000	0.550-0.700	1.2710E+03	1.0925E+00	1.4871E+00	1.6246E+00
5	1.0000	0.900-1.250	4.8931E+01	1.0647E+00	9.0032E-02	9.5855E-02
6	1.5000	1.250-1.750	4.9637E+01	1.0492E+00	1.2509E-01	1.3124E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Large Trash Bag, 20 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                 body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02    3
             .2286000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                 input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      h            c            o
     1       5.0000E-03  3.5800E-02  3.9800E-02
     2       0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.5910	0.015-1.50	1.4168E+03	1.1260E+00	1.6725E+00	1.8832E+00
1	.0300	0.025-0.035	6.0884E+01	1.5536E+00	1.8083E-02	2.8093E-02
2	.0400	0.035-0.045	1.5561E+01	1.7301E+00	2.7544E-03	4.7653E-03
3	.0600	0.055-0.070	1.3399E+01	1.8134E+00	1.5944E-03	2.8914E-03
4	.6000	0.550-0.700	1.2306E+03	1.1262E+00	1.4398E+00	1.6215E+00
5	1.0000	0.900-1.250	4.7686E+01	1.0874E+00	8.7743E-02	9.5415E-02
6	1.5000	1.250-1.750	4.8600E+01	1.0661E+00	1.2247E-01	1.3056E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Large Trash Bag, 25 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                          body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02    3
            .2286000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
            .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                          input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h           c           o
     1      6.2000E-03  4.4700E-02  4.9700E-02
     2      0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.5915	0.015-1.50	1.3694E+03	1.1581E+00	1.6217E+00	1.8781E+00
1	.0300	0.025-0.035	5.5503E+01	1.6429E+00	1.6485E-02	2.7083E-02
2	.0400	0.035-0.045	1.4447E+01	1.8830E+00	2.5571E-03	4.8150E-03
3	.0600	0.055-0.070	1.2584E+01	2.0217E+00	1.4975E-03	3.0275E-03
4	.6000	0.550-0.700	1.1928E+03	1.1596E+00	1.3956E+00	1.6183E+00
5	1.0000	0.900-1.250	4.6509E+01	1.1099E+00	8.5577E-02	9.4979E-02
6	1.5000	1.250-1.750	4.7614E+01	1.0826E+00	1.1999E-01	1.2989E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Large Trash Bag, 30 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02    3
              .2286000D+02
  rcc     2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
              .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h          c          o
     1       7.5000E-03  5.3600E-02  5.9700E-02
     2       0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.5922	0.015-1.50	1.3242E+03	1.1906E+00	1.5725E+00	1.8723E+00
1	.0300	0.025-0.035	5.0778E+01	1.7206E+00	1.5081E-02	2.5948E-02
2	.0400	0.035-0.045	1.3438E+01	2.0266E+00	2.3785E-03	4.8203E-03
3	.0600	0.055-0.070	1.1832E+01	2.2298E+00	1.4080E-03	3.1395E-03
4	.6000	0.550-0.700	1.1561E+03	1.1937E+00	1.3527E+00	1.6146E+00
5	1.0000	0.900-1.250	4.5359E+01	1.1326E+00	8.3460E-02	9.4524E-02
6	1.5000	1.250-1.750	4.6641E+01	1.0992E+00	1.1754E-01	1.2920E-01

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

Large Trash Bag, 35 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                 body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02     3
              .2286000D+02
  rcc     2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03    12
              .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                 input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h            c            o
     1       8.7000E-03   6.2600E-02   6.9700E-02
     2       0.0000E+00   0.0000E+00   0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.5932	0.015-1.50	1.2816E+03	1.2228E+00	1.5259E+00	1.8659E+00
1	.0300	0.025-0.035	4.6670E+01	1.7873E+00	1.3861E-02	2.4773E-02
2	.0400	0.035-0.045	1.2536E+01	2.1589E+00	2.2189E-03	4.7904E-03
3	.0600	0.055-0.070	1.1149E+01	2.4325E+00	1.3268E-03	3.2273E-03
4	.6000	0.550-0.700	1.1213E+03	1.2277E+00	1.3119E+00	1.6106E+00
5	1.0000	0.900-1.250	4.4254E+01	1.1551E+00	8.1427E-02	9.4058E-02
6	1.5000	1.250-1.750	4.5703E+01	1.1157E+00	1.1517E-01	1.2849E-01

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            Large Trash Bag, 40 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rcc    1  .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02    3
            .2286000D+02
  rcc    2  .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
            .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o
     1       9.9000E-03  7.1500E-02  7.9600E-02
     2       0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean      energy        direct beam  mean buildup          dose rate
 no     energy   group limits       flux        factors      direct beam  with buildup
         mev         mev        photons/cm**                          mrem/hr
                                2/sec
 total   .5942   0.015-1.50     1.2416E+03   1.2546E+00     1.4817E+00   1.8590E+00

  1      .0300   0.025-0.035    4.3107E+01   1.8441E+00     1.2803E-02   2.3610E-02
  2      .0400   0.035-0.045    1.1734E+01   2.2796E+00     2.0769E-03   4.7345E-03
  3      .0600   0.055-0.070    1.0531E+01   2.6279E+00     1.2532E-03   3.2932E-03
  4      .6000   0.550-0.700    1.0882E+03   1.2614E+00     1.2732E+00   1.6060E+00
  5     1.0000   0.900-1.250    4.3197E+01   1.1774E+00     7.9483E-02   9.3581E-02
  6     1.5000   1.250-1.750    4.4798E+01   1.1319E+00     1.1289E-01   1.2778E-01
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

Large Trash Bag, 45 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rcc     1   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.6858000D+02    3
              .2286000D+02
  rcc     2   .0000000D+00    .0000000D+00   -.1000000D+02    .0000000D+00    .0000000D+00
.1000000D+03   12
              .1000000D+03

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                      input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      h            c            o
     1      1.1200E-02  8.0500E-02  8.9500E-02
     2      0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.5954	0.015-1.50	1.2031E+03	1.2866E+00	1.4389E+00	1.8513E+00
1	.0300	0.025-0.035	3.9939E+01	1.8937E+00	1.1862E-02	2.2463E-02
2	.0400	0.035-0.045	1.1002E+01	2.3919E+00	1.9474E-03	4.6579E-03
3	.0600	0.055-0.070	9.9573E+00	2.8197E+00	1.1849E-03	3.3411E-03
4	.6000	0.550-0.700	1.0562E+03	1.2954E+00	1.2357E+00	1.6007E+00
5	1.0000	0.900-1.250	4.2163E+01	1.1998E+00	7.7580E-02	9.3078E-02
6	1.5000	1.250-1.750	4.3908E+01	1.1482E+00	1.1065E-01	1.2704E-01

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            Large Trash Bag, 50 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.6858000D+02    3
              .2286000D+02
  rcc     2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
              .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h           c           o
     1       1.2400E-02  8.9400E-02  9.9500E-02
     2       0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean      energy        direct beam  mean buildup        dose rate
 no     energy   group limits       flux        factors     direct beam  with buildup
         mev         mev        photons/cm**                         mrem/hr
                                2/sec
 total   .5965   0.015-1.50     1.1669E+03   1.3180E+00     1.3984E+00   1.8431E+00

  1      .0300   0.025-0.035    3.7154E+01   1.9362E+00     1.1035E-02   2.1365E-02
  2      .0400   0.035-0.045    1.0345E+01   2.4942E+00     1.8311E-03   4.5671E-03
  3      .0600   0.055-0.070    9.4357E+00   3.0031E+00     1.1229E-03   3.3721E-03
  4      .6000   0.550-0.700    1.0258E+03   1.3290E+00     1.2002E+00   1.5950E+00
  5     1.0000   0.900-1.250    4.1174E+01   1.2218E+00     7.5761E-02   9.2562E-02
  6     1.5000   1.250-1.750    4.3053E+01   1.1641E+00     1.0849E-01   1.2629E-01
```

Description: Full Small Trash Bag 12" diam X 15" tall, 1 mCi JN Std

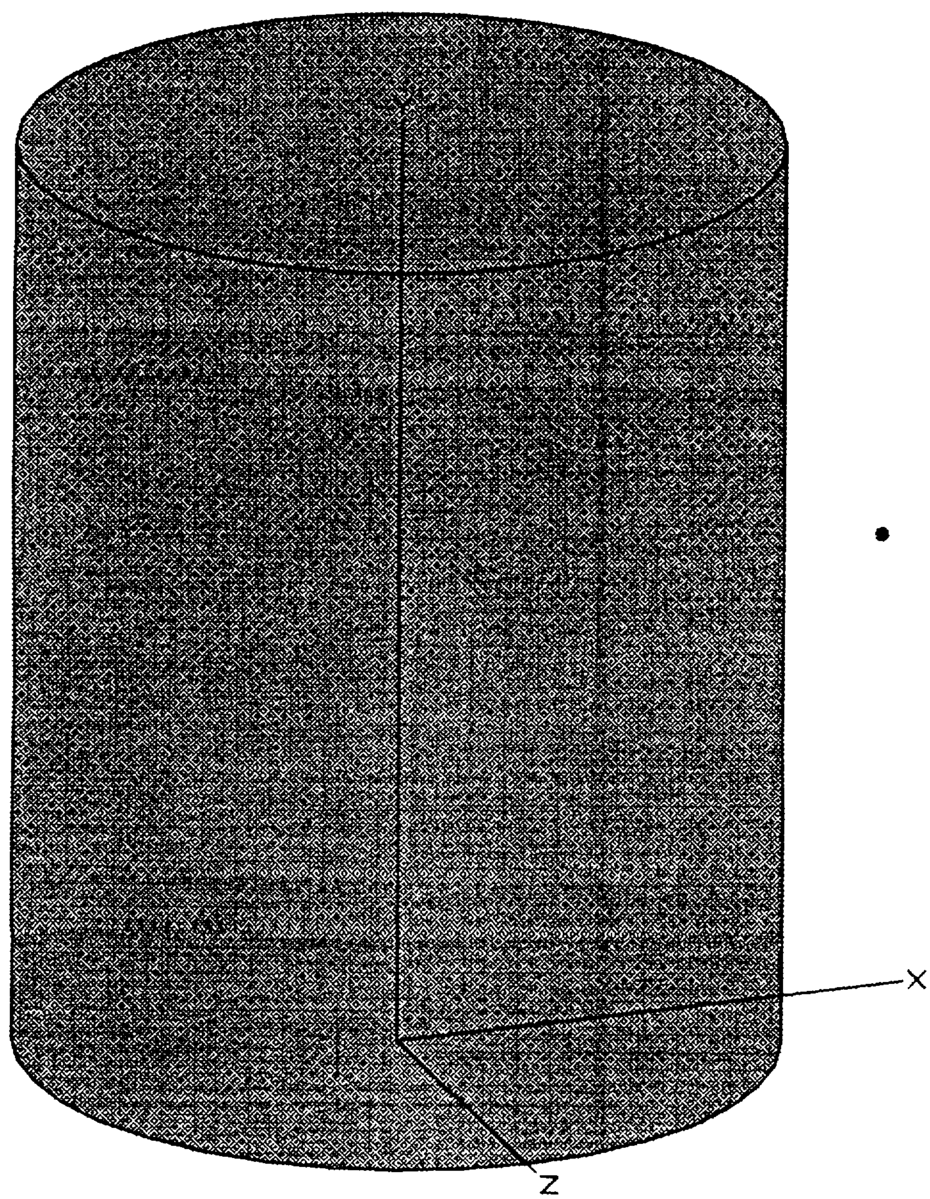
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	38.1 cm	1 ft 3.0 in
Radius	15.24 cm	6.0 in

Dose Points

	X	Y	Z
# 1	20.32 cm	19.05 cm	0 cm
	8.0 in	7.5 in	0.0 in



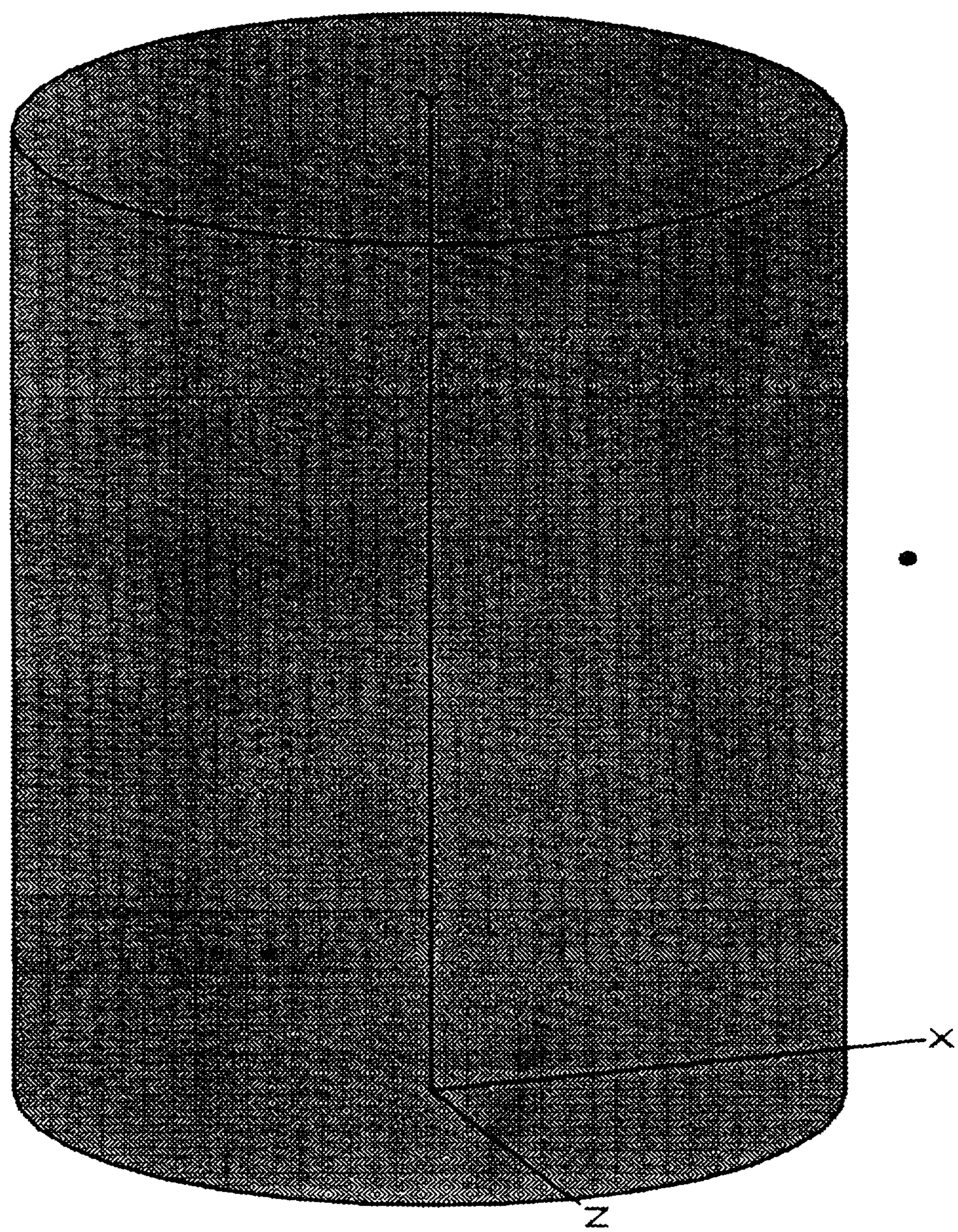
Description: Full Tall Trash Bag 18" diam X 27" tall, 1 mCi JN Std
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

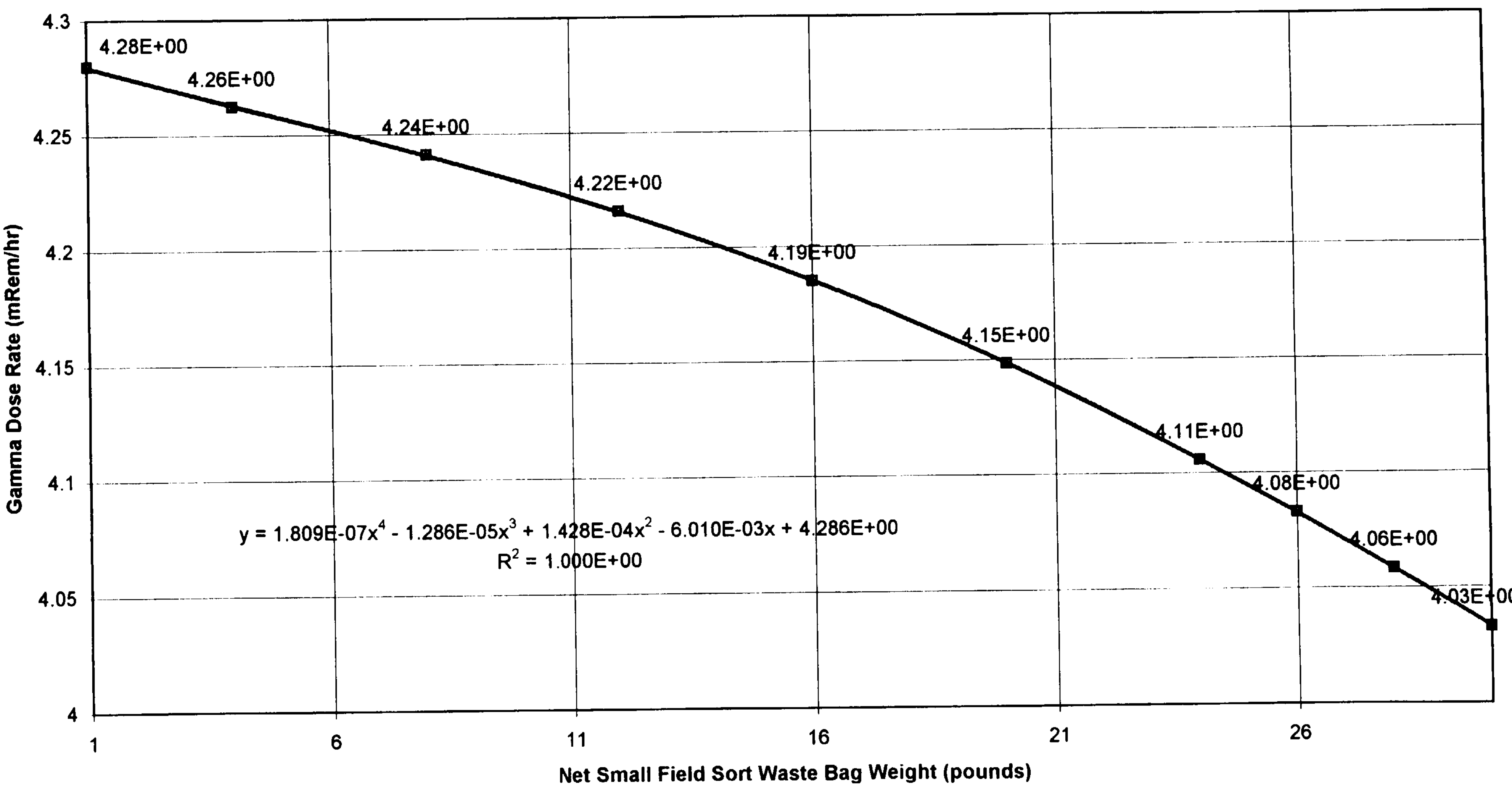
Height	68.58 cm	2 ft 3.0 in
Radius	22.86 cm	9.0 in

Dose Points

	X	Y	Z
# 1	27.94 cm	34.29 cm	0 cm
	11.0 in	1 ft 1.5 in	0.0 in

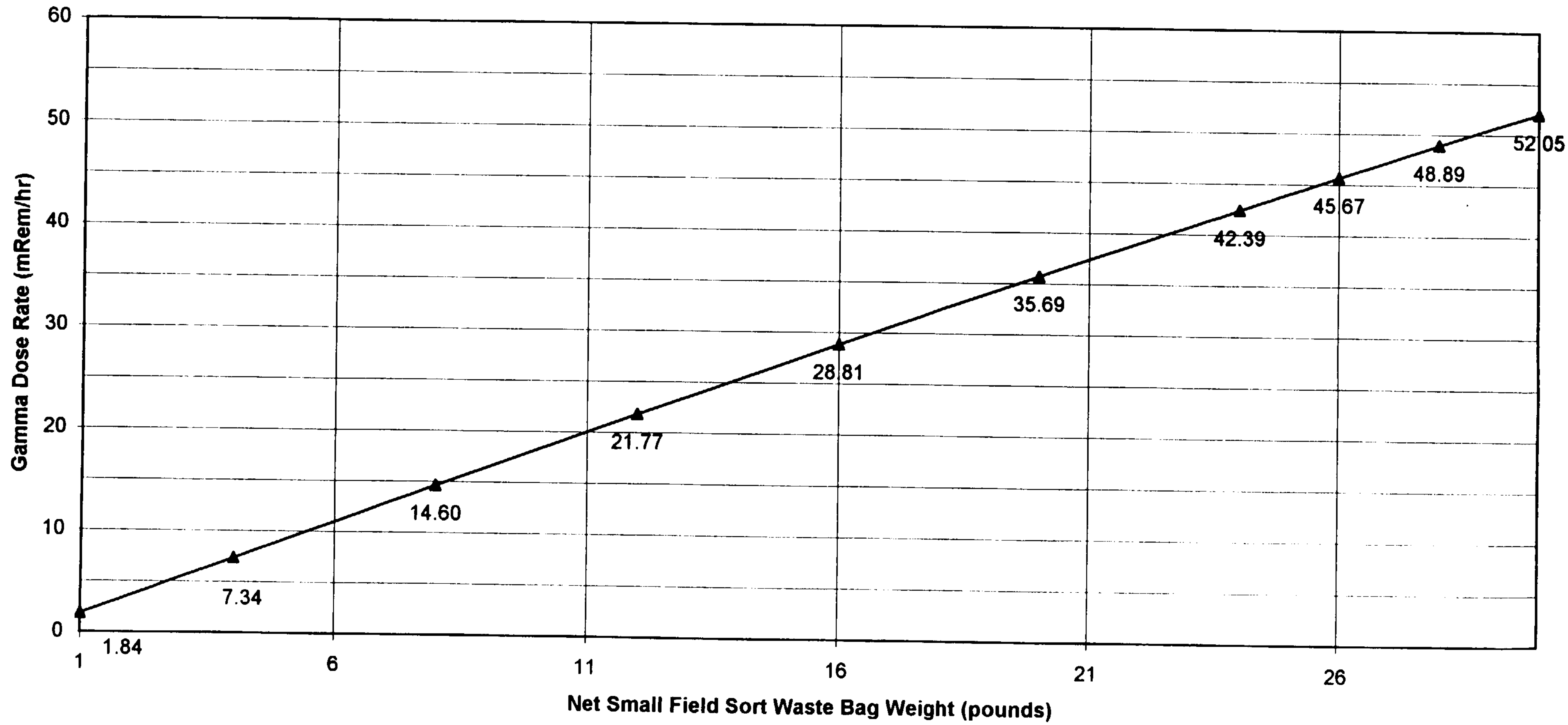


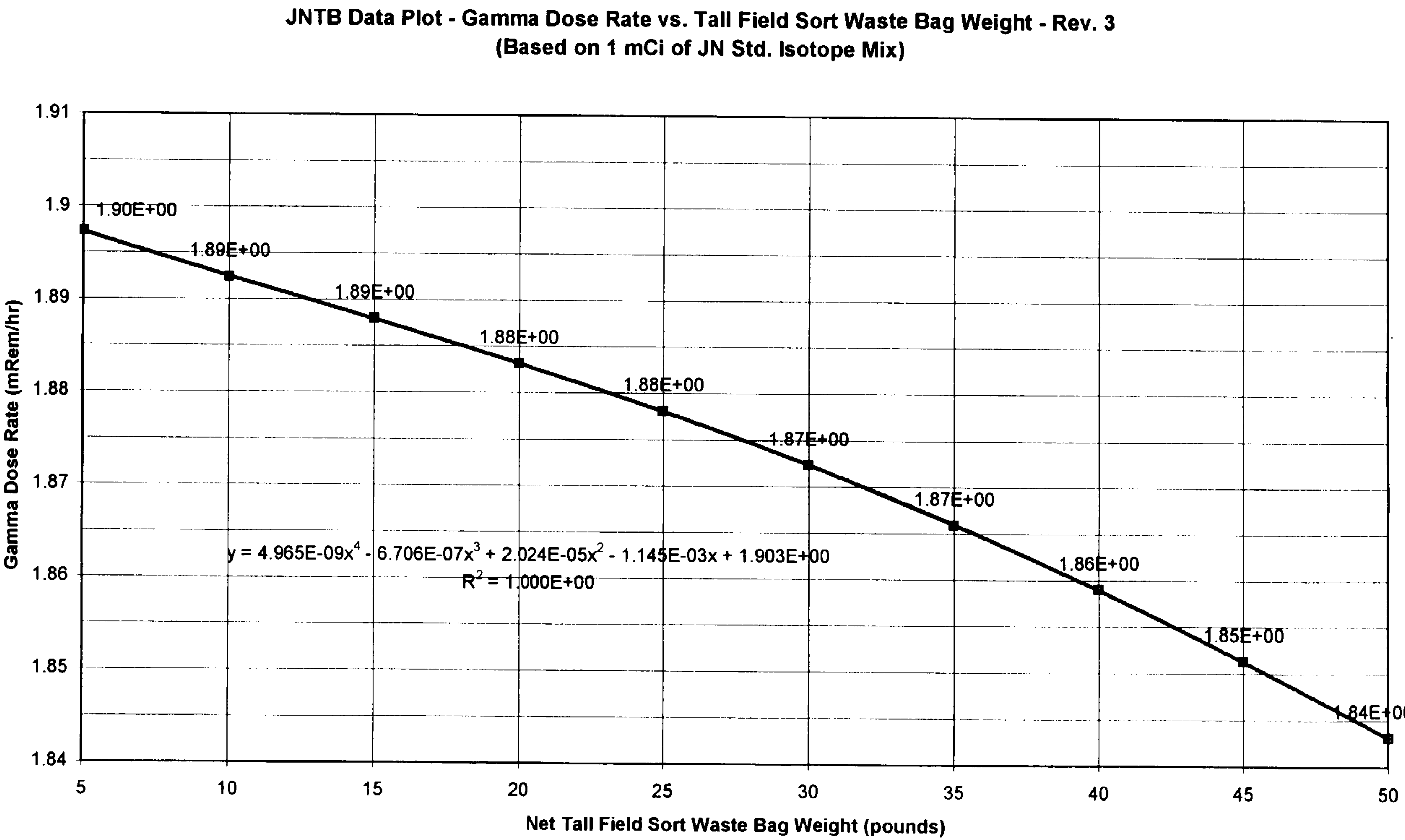
JNSB Data Plot - Gamma Dose Rate vs. Small Field Sort Waste Bag Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)

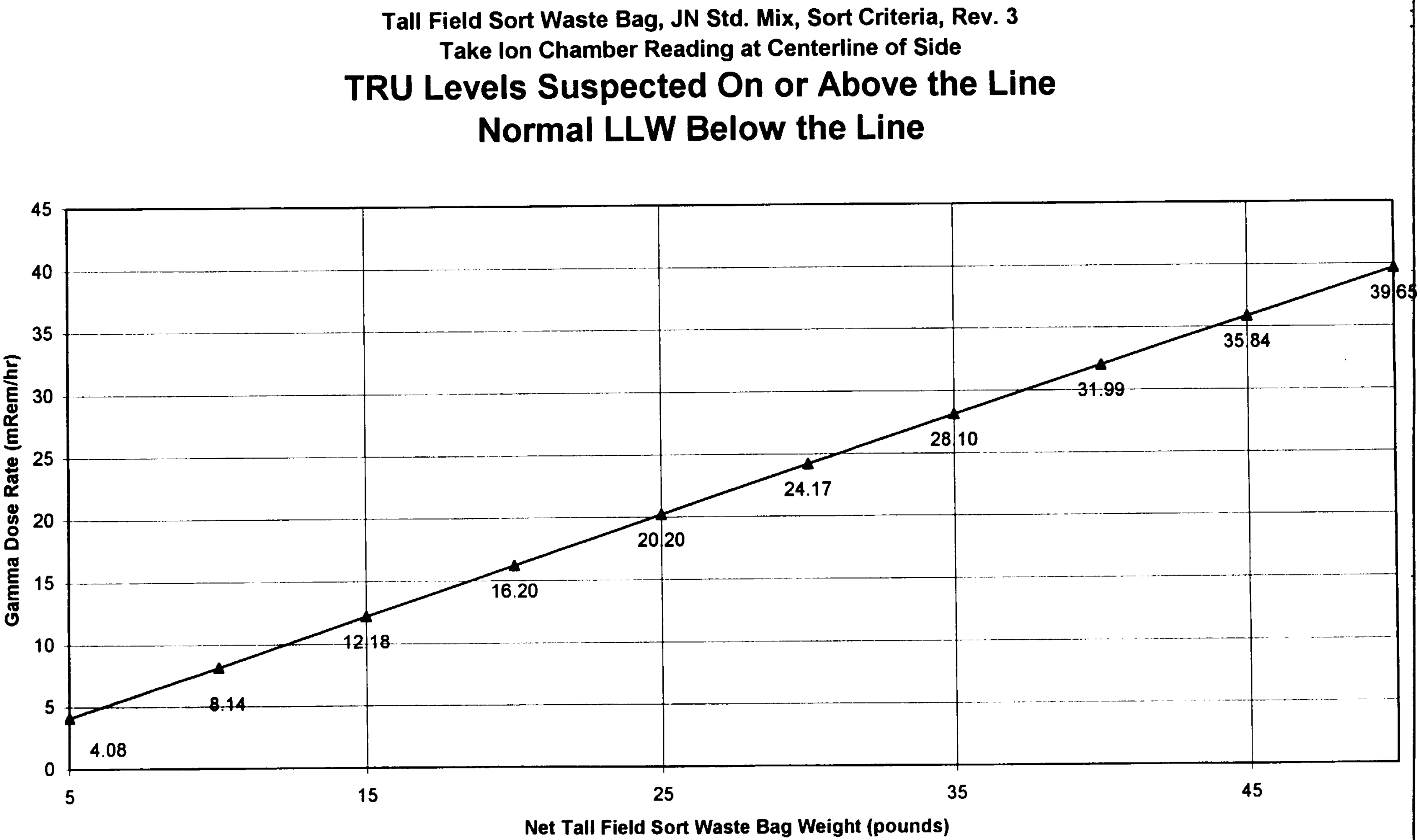


Small Field Sort Waste Bag, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Midpoint of Side

TRU Levels Suspected On or Above the Line
Normal LLW Below the Line




JNTB Data Plot - Gamma Dose Rate vs. Tall Field Sort Waste Bag Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)
Gamma Dose Rate (mRem/hr)
1.91
1.9
1.89
1.88
1.87
1.86
1.85
1.84
1.90E+00
1.89E+00
1.89E+00
1.88E+00
1.88E+00
1.87E+00
1.87E+00
1.86E+00
1.85E+00
1.84E+00
y = 4.965E-09x4 - 6.706E-07x3 + 2.024E-05x2 - 1.145E-03x + 1.903E+00
R2 = 1.000E+00
5
10
15
20
25
30
35
40
45
50
Net Tall Field Sort Waste Bag Weight (pounds)


Tall Field Sort Waste Bag, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line
Gamma Dose Rate (mRem/hr)
Net Tall Field Sort Waste Bag Weight (pounds)
0
5
10
15
20
25
30
35
40
45
5
15
25
35
45
4.08
8.14
12.18
16.20
20.20
24.17
28.10
31.99
35.84
39.65

DD-98-04 Rev. 3

APPENDIX B

B – 25 Box Cases

Contents:

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
              B-25 Box 1/4 full, 250 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                              body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                              input zone data
  src     0      1      0      0      0      0      0      0      0      0  z  1
  box     0      2     -1      0      0      0      0      0      0      0  z  2
  air     0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1       1.8170E-01
     2       7.8600E+00

 grp     mean      energy        direct beam  mean buildup         dose rate
 no     energy   group limits       flux        factors       direct beam  with buildup
         mev         mev        photons/cm**                          mrem/hr
                                2/sec
 total   .6482   0.015-1.75     3.3428E+01   1.6245E+00     4.2055E-02   6.8320E-02

  1      .0300   0.025-0.035    1.1606E-10   1.0783E+00     3.4468E-14   3.7169E-14
  2      .0400   0.035-0.045    2.1373E-06   1.1359E+00     3.7831E-10   4.2971E-10
  3      .0600   0.055-0.070    1.8056E-03   1.2909E+00     2.1487E-07   2.7738E-07
  4      .6000   0.550-0.700    3.0562E+01   1.6631E+00     3.5758E-02   5.9469E-02
  5     1.0000   0.900-1.250    1.3532E+00   1.4795E+00     2.4899E-03   3.6840E-03
  6     1.5000   1.250-1.750    1.5107E+00   1.3573E+00     3.8070E-03   5.1670E-03
```

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 375 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rpp    1  .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2  .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3 -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        2.7260E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6497	0.015-1.75	2.7424E+01	1.7581E+00	3.4610E-02	6.0849E-02
1	.0300	0.025-0.035	4.6891E-11	1.0792E+00	1.3926E-14	1.5029E-14
2	.0400	0.035-0.045	1.2540E-06	1.1369E+00	2.2196E-10	2.5235E-10
3	.0600	0.055-0.070	1.1811E-03	1.2920E+00	1.4055E-07	1.8159E-07
4	.6000	0.550-0.700	2.4977E+01	1.8050E+00	2.9223E-02	5.2749E-02
5	1.0000	0.900-1.250	1.1409E+00	1.5933E+00	2.0992E-03	3.3447E-03
6	1.5000	1.250-1.750	1.3044E+00	1.4465E+00	3.2871E-03	4.7547E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         3.6340E-01
     2         7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6511	0.015-1.75	2.3110E+01	1.8581E+00	2.9237E-02	5.4327E-02
1	.0300	0.025-0.035	1.9432E-11	1.0801E+00	5.7712E-15	6.2334E-15
2	.0400	0.035-0.045	7.9577E-07	1.1382E+00	1.4085E-10	1.6032E-10
3	.0600	0.055-0.070	8.6303E-04	1.2934E+00	1.0270E-07	1.3283E-07
4	.6000	0.550-0.700	2.0986E+01	1.9107E+00	2.4554E-02	4.6914E-02
5	1.0000	0.900-1.250	9.8080E-01	1.6832E+00	1.8047E-03	3.0376E-03
6	1.5000	1.250-1.750	1.1424E+00	1.5198E+00	2.8788E-03	4.3752E-03

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

B-25 Box 1/4 full, 625 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00    .1143000D+03    .0000000D+00    .1828800D+03    .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03    .1145660D+03    .0000000D+00    .1828800D+03    .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02    .1243000D+03   -.1000000D+02    .1928800D+03   -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1     0      0      0      0      0      0      0      0  z  1
  box    0      2    -1      0      0      0      0      0      0      0  z  2
  air    0      3    -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
      1        4.5420E-01
      2        7.8600E+00

 grp      mean        energy         direct beam   mean buildup          dose rate
 no      energy    group limits         flux         factors       direct beam  with buildup
          mev          mev          photons/cm**                            mrem/hr
                                    2/sec
 total    .6524    0.015-1.75       1.9894E+01    1.9340E+00       2.5216E-02    4.8768E-02

  1       .0300    0.025-0.035      8.0936E-12    1.0809E+00       2.4038E-15    2.5984E-15
  2       .0400    0.035-0.045      5.2120E-07    1.1397E+00       9.2253E-11    1.0514E-10
  3       .0600    0.055-0.070      6.6806E-04    1.2951E+00       7.9500E-08    1.0296E-07
  4       .6000    0.550-0.700      1.8023E+01    1.9902E+00       2.1087E-02    4.1969E-02
  5      1.0000    0.900-1.250      8.5691E-01    1.7544E+00       1.5767E-03    2.7662E-03
  6      1.5000    1.250-1.750      1.0128E+00    1.5800E+00       2.5522E-03    4.0323E-03
<np>
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 750 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                           body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                           input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        5.4510E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6535	0.015-1.75	1.7416E+01	1.9929E+00	2.2109E-02	4.4061E-02
1	.0300	0.025-0.035	3.3733E-12	1.0818E+00	1.0019E-15	1.0838E-15
2	.0400	0.035-0.045	3.4612E-07	1.1412E+00	6.1263E-11	6.9913E-11
3	.0600	0.055-0.070	5.3514E-04	1.2970E+00	6.3682E-08	8.2595E-08
4	.6000	0.550-0.700	1.5749E+01	2.0518E+00	1.8426E-02	3.7807E-02
5	1.0000	0.900-1.250	7.5879E-01	1.8113E+00	1.3962E-03	2.5289E-03
6	1.5000	1.250-1.750	9.0727E-01	1.6295E+00	2.2863E-03	3.7256E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 875 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        6.3590E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6544	0.015-1.75	1.5459E+01	2.0397E+00	1.9650E-02	4.0080E-02
1	.0300	0.025-0.035	1.4085E-12	1.0826E+00	4.1833E-16	4.5288E-16
2	.0400	0.035-0.045	2.3156E-07	1.1428E+00	4.0985E-11	4.6837E-11
3	.0600	0.055-0.070	4.3843E-04	1.2991E+00	5.2173E-08	6.7779E-08
4	.6000	0.550-0.700	1.3959E+01	2.1004E+00	1.6332E-02	3.4304E-02
5	1.0000	0.900-1.250	6.7962E-01	1.8575E+00	1.2505E-03	2.3228E-03
6	1.5000	1.250-1.750	8.2029E-01	1.6706E+00	2.0671E-03	3.4534E-03

```
               qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
               B-25 Box 1/4 full, 1000 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        7.2680E-01
     2        7.8600E+00

 grp     mean      energy         direct beam  mean buildup         dose rate
 no     energy   group limits        flux        factors       direct beam  with buildup
         mev         mev         photons/cm**                         mrem/hr
                                 2/sec
 total   .6552    0.015-1.75     1.3877E+01   2.0780E+00     1.7656E-02   3.6688E-02

  1      .0300    0.025-0.035    5.8801E-13   1.0834E+00     1.7464E-16   1.8919E-16
  2      .0400    0.035-0.045    1.5542E-07   1.1443E+00     2.7509E-11   3.1480E-11
  3      .0600    0.055-0.070    3.6461E-04   1.3014E+00     4.3388E-08   5.6466E-08
  4      .6000    0.550-0.700    1.2514E+01   2.1400E+00     1.4642E-02   3.1334E-02
  5     1.0000    0.900-1.250    6.1447E-01   1.8957E+00     1.1306E-03   2.1433E-03
  6     1.5000    1.250-1.750    7.4746E-01   1.7050E+00     1.8836E-03   3.2116E-03
```

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            B-25 Box 1/4 full, 1125 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp     1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02     3
  rpp     2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02    11
  rpp     3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02    19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src     0      1      0      0      0      0      0      0      0      0  z  1
  box     0      2     -1      0      0      0      0      0      0      0  z  2
  air     0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       8.1760E-01
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6559	0.015-1.75	1.2575E+01	2.1096E+00	1.6014E-02	3.3783E-02
1	.0300	0.025-0.035	2.4586E-13	1.0841E+00	7.3022E-17	7.9162E-17
2	.0400	0.035-0.045	1.0459E-07	1.1459E+00	1.8513E-11	2.1213E-11
3	.0600	0.055-0.070	3.0655E-04	1.3038E+00	3.6479E-08	4.7563E-08
4	.6000	0.550-0.700	1.1329E+01	2.1727E+00	1.3255E-02	2.8799E-02
5	1.0000	0.900-1.250	5.6014E-01	1.9276E+00	1.0307E-03	1.9867E-03
6	1.5000	1.250-1.750	6.8582E-01	1.7342E+00	1.7283E-03	2.9972E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 1250 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                  body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D-02
.3984500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                  input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
      1        9.0850E-01
      2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6565	0.015-1.75	1.1485E+01	2.1364E+00	1.4636E-02	3.1269E-02
1	.0300	0.025-0.035	1.0277E-13	1.0848E+00	3.0522E-17	3.3109E-17
2	.0400	0.035-0.045	7.0457E-08	1.1474E+00	1.2471E-11	1.4309E-11
3	.0600	0.055-0.070	2.5971E-04	1.3064E+00	3.0906E-08	4.0374E-08
4	.6000	0.550-0.700	1.0338E+01	2.2004E+00	1.2095E-02	2.6614E-02
5	1.0000	0.900-1.250	5.1414E-01	1.9547E+00	9.4602E-04	1.8492E-03
6	1.5000	1.250-1.750	6.3294E-01	1.7593E+00	1.5950E-03	2.8061E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 1375 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                       body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                       input zone data
  src    0      1     0     0     0     0     0     0     0     0  z  1
  box    0      2    -1     0     0     0     0     0     0     0  z  2
  air    0      3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        9.9930E-01
     2        7.8600E+00

 grp     mean       energy         direct beam  mean buildup          dose rate
 no     energy    group limits        flux        factors       direct beam  with buildup
          mev         mev         photons/cm**                          mrem/hr
                                  2/sec
 total    .6570    0.015-1.75     1.0561E+01    2.1595E+00      1.3467E-02    2.9082E-02

  1       .0300    0.025-0.035    4.3019E-14    1.0854E+00      1.2777E-17    1.3868E-17
  2       .0400    0.035-0.045    4.7535E-08    1.1489E+00      8.4137E-12    9.6668E-12
  3       .0600    0.055-0.070    2.2136E-04    1.3090E+00      2.6342E-08    3.4480E-08
  4       .6000    0.550-0.700    9.4987E+00    2.2242E+00      1.1113E-02    2.4718E-02
  5      1.0000    0.900-1.250    4.7486E-01    1.9780E+00      8.7374E-04    1.7282E-03
  6      1.5000    1.250-1.750    5.8725E-01    1.7810E+00      1.4799E-03    2.6357E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
B-25 Box 1/4 full, 1500 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rpp    1    .0000000D+00    .1143000D+03    .0000000D+00    .1828800D+03    .0000000D+00
.2984500D+02    3
  rpp    2    .1143000D+03    .1145660D+03    .0000000D+00    .1828800D+03    .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02    .1243000D+03  -.1000000D+02    .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         1.0902E+00
     2         7.8600E+00

grp     mean       energy          direct beam  mean buildup           dose rate
no      energy    group limits       flux        factors        direct beam  with buildup
         mev         mev          photons/cm**                          mrem/hr
                                  2/sec
total   .6574     0.015-1.75      9.7667E+00    2.1798E+00      1.2461E-02    2.7162E-02

 1       .0300    0.025-0.035     1.8000E-14    1.0861E+00      5.3460E-18    5.8060E-18
 2       .0400    0.035-0.045     3.2084E-08    1.1504E+00      5.6789E-12    6.5332E-12
 3       .0600    0.055-0.070     1.8948E-04    1.3116E+00      2.2548E-08    2.9574E-08
 4       .6000    0.550-0.700     8.7783E+00    2.2451E+00      1.0271E-02    2.3058E-02
 5      1.0000    0.900-1.250     4.4079E-01    1.9984E+00      8.1105E-04    1.6208E-03
 6      1.5000    1.250-1.750     5.4736E-01    1.8001E+00      1.3793E-03    2.4829E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 1625 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0      1     0      0      0      0      0      0      0      0  z  1
  box    0      2    -1      0      0      0      0      0      0      0  z  2
  air    0      3    -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
      1       1.1810E+00
      2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6578	0.015-1.75	9.0784E+00	2.1976E+00	1.1589E-02	2.5467E-02
1	.0300	0.025-0.035	7.5424E-15	1.0866E+00	2.2401E-18	2.4341E-18
2	.0400	0.035-0.045	2.1681E-08	1.1519E+00	3.8376E-12	4.4205E-12
3	.0600	0.055-0.070	1.6278E-04	1.3143E+00	1.9371E-08	2.5458E-08
4	.6000	0.550-0.700	8.1549E+00	2.2635E+00	9.5412E-03	2.1596E-02
5	1.0000	0.900-1.250	4.1107E-01	2.0164E+00	7.5637E-04	1.5251E-03
6	1.5000	1.250-1.750	5.1231E-01	1.8169E+00	1.2910E-03	2.3456E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/4 full, 1750 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.2984500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.3984500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.3984500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         1.2719E+00
     2         7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6582	0.015-1.75	8.4757E+00	2.2134E+00	1.0824E-02	2.3958E-02
1	.0300	0.025-0.035	3.1588E-15	1.0872E+00	9.3815E-19	1.0199E-18
2	.0400	0.035-0.045	1.4655E-08	1.1533E+00	2.5940E-12	2.9916E-12
3	.0600	0.055-0.070	1.4020E-04	1.3170E+00	1.6684E-08	2.1972E-08
4	.6000	0.550-0.700	7.6095E+00	2.2798E+00	8.9031E-03	2.0297E-02
5	1.0000	0.900-1.250	3.8488E-01	2.0325E+00	7.0819E-04	1.4394E-03
6	1.5000	1.250-1.750	4.8127E-01	1.8317E+00	1.2128E-03	2.2215E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/2 full, 500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rpp    1  .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2  .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3 -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        1.8170E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6490	0.015-1.75	4.4822E+01	1.7411E+00	5.6540E-02	9.8441E-02
1	.0300	0.025-0.035	1.1606E-10	1.0783E+00	3.4469E-14	3.7170E-14
2	.0400	0.035-0.045	2.1375E-06	1.1359E+00	3.7834E-10	4.2974E-10
3	.0600	0.055-0.070	1.8063E-03	1.2910E+00	2.1495E-07	2.7750E-07
4	.6000	0.550-0.700	4.0847E+01	1.7889E+00	4.7791E-02	8.5491E-02
5	1.0000	0.900-1.250	1.8587E+00	1.5696E+00	3.4200E-03	5.3678E-03
6	1.5000	1.250-1.750	2.1145E+00	1.4229E+00	5.3287E-03	7.5821E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
B-25 Box 1/2 full, 750 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0    1    0    0    0    0    0    0    0    0  z  1
  box    0    2   -1    0    0    0    0    0    0    0  z  2
  air    0    3   -2    0    0    0    0    0    0    0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        2.7260E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6510	0.015-1.75	3.5231E+01	1.9071E+00	4.4619E-02	8.5094E-02
1	.0300	0.025-0.035	4.6892E-11	1.0792E+00	1.3927E-14	1.5030E-14
2	.0400	0.035-0.045	1.2541E-06	1.1369E+00	2.2197E-10	2.5237E-10
3	.0600	0.055-0.070	1.1812E-03	1.2920E+00	1.4056E-07	1.8161E-07
4	.6000	0.550-0.700	3.1951E+01	1.9661E+00	3.7383E-02	7.3497E-02
5	1.0000	0.900-1.250	1.5100E+00	1.7122E+00	2.7784E-03	4.7571E-03
6	1.5000	1.250-1.750	1.7689E+00	1.5343E+00	4.4577E-03	6.8393E-03

```
             qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
             B-25 Box 1/2 full, 1000 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        3.6340E-01
     2        7.8600E+00

 grp      mean       energy          direct beam  mean buildup          dose rate
 no      energy    group limits         flux        factors       direct beam  with buildup
          mev          mev          photons/cm**                           mrem/hr
                                    2/sec
 total    .6529    0.015-1.75       2.8643E+01    2.0275E+00      3.6385E-02    7.3771E-02

  1       .0300    0.025-0.035      1.9432E-11    1.0801E+00      5.7714E-15    6.2335E-15
  2       .0400    0.035-0.045      7.9583E-07    1.1382E+00      1.4086E-10    1.6033E-10
  3       .0600    0.055-0.070      8.6312E-04    1.2934E+00      1.0271E-07    1.3285E-07
  4       .6000    0.550-0.700      2.5880E+01    2.0935E+00      3.0279E-02    6.3389E-02
  5      1.0000    0.900-1.250      1.2566E+00    1.8234E+00      2.3121E-03    4.2158E-03
  6      1.5000    1.250-1.750      1.5054E+00    1.6254E+00      3.7937E-03    6.1662E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/2 full, 1250 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1  .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2  .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3 -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        4.5420E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm** 2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6546	0.015-1.75	2.3932E+01	2.1139E+00	3.0470E-02	6.4411E-02
1	.0300	0.025-0.035	8.0938E-12	1.0809E+00	2.4039E-15	2.5984E-15
2	.0400	0.035-0.045	5.2124E-07	1.1397E+00	9.2260E-11	1.0515E-10
3	.0600	0.055-0.070	6.6813E-04	1.2951E+00	7.9507E-08	1.0297E-07
4	.6000	0.550-0.700	2.1563E+01	2.1837E+00	2.5229E-02	5.5093E-02
5	1.0000	0.900-1.250	1.0672E+00	1.9090E+00	1.9636E-03	3.7485E-03
6	1.5000	1.250-1.750	1.3007E+00	1.6990E+00	3.2778E-03	5.5690E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
B-25 Box 1/2 full, 1500 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       5.4510E-01
     2       7.8600E+00

 grp     mean       energy        direct beam  mean buildup          dose rate
 no     energy   group limits        flux         factors       direct beam  with buildup
         mev         mev         photons/cm**                          mrem/hr
                                 2/sec
 total   .6561   0.015-1.75      2.0441E+01   2.1760E+00       2.6070E-02   5.6727E-02

  1      .0300   0.025-0.035     3.3733E-12   1.0818E+00       1.0019E-15   1.0838E-15
  2      .0400   0.035-0.045     3.4614E-07   1.1412E+00       6.1267E-11   6.9919E-11
  3      .0600   0.055-0.070     5.3520E-04   1.2970E+00       6.3688E-08   8.2603E-08
  4      .6000   0.550-0.700     1.8379E+01   2.2476E+00       2.1504E-02   4.8332E-02
  5     1.0000   0.900-1.250     9.2214E-01   1.9743E+00       1.6967E-03   3.3499E-03
  6     1.5000   1.250-1.750     1.1387E+00   1.7582E+00       2.8696E-03   5.0451E-03
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

B-25 Box 1/2 full, 1750 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                       body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                       input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       6.3590E-01
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6572	0.015-1.75	1.7780E+01	2.2209E+00	2.2706E-02	5.0429E-02
1	.0300	0.025-0.035	1.4086E-12	1.0826E+00	4.1835E-16	4.5289E-16
2	.0400	0.035-0.045	2.3157E-07	1.1428E+00	4.0989E-11	4.6840E-11
3	.0600	0.055-0.070	4.3847E-04	1.2991E+00	5.2178E-08	6.7786E-08
4	.6000	0.550-0.700	1.5962E+01	2.2932E+00	1.8676E-02	4.2827E-02
5	1.0000	0.900-1.250	8.0880E-01	2.0240E+00	1.4882E-03	3.0121E-03
6	1.5000	1.250-1.750	1.0088E+00	1.8053E+00	2.5422E-03	4.5893E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/2 full, 2000 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                  body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                  input zone data
  src    0      1     0      0      0      0      0      0      0      0  z  1
  box    0      2    -1      0      0      0      0      0      0      0  z  2
  air    0      3    -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
      1        7.2680E-01
      2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6582	0.015-1.75	1.5694E+01	2.2539E+00	2.0062E-02	4.5218E-02
1	.0300	0.025-0.035	5.8802E-13	1.0834E+00	1.7464E-16	1.8920E-16
2	.0400	0.035-0.045	1.5543E-07	1.1443E+00	2.7512E-11	3.1482E-11
3	.0600	0.055-0.070	3.6464E-04	1.3014E+00	4.3392E-08	5.6472E-08
4	.6000	0.550-0.700	1.4073E+01	2.3261E+00	1.6465E-02	3.8300E-02
5	1.0000	0.900-1.250	7.1822E-01	2.0621E+00	1.3215E-03	2.7251E-03
6	1.5000	1.250-1.750	9.0273E-01	1.8430E+00	2.2749E-03	4.1927E-03

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
          B-25 Box 1/2 full, 2250 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                       body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                       input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        8.1760E-01
     2        7.8600E+00

grp      mean        energy         direct beam  mean buildup          dose rate
no      energy    group limits         flux        factors      direct beam  with buildup
         mev          mev         photons/cm**                          mrem/hr
                                  2/sec
total    .6590    0.015-1.75      1.4025E+01    2.2788E+00     1.7941E-02    4.0884E-02

 1       .0300    0.025-0.035     2.4587E-13    1.0841E+00     7.3024E-17    7.9164E-17
 2       .0400    0.035-0.045     1.0460E-07    1.1459E+00     1.8514E-11    2.1215E-11
 3       .0600    0.055-0.070     3.0658E-04    1.3038E+00     3.6483E-08    4.7568E-08
 4       .6000    0.550-0.700     1.2565E+01    2.3505E+00     1.4701E-02    3.4555E-02
 5      1.0000    0.900-1.250     6.4468E-01    2.0916E+00     1.1862E-03    2.4811E-03
 6      1.5000    1.250-1.750     8.1519E-01    1.8731E+00     2.0543E-03    3.8480E-03
```

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
          B-25 Box 1/2 full, 2500 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rpp     1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp     2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp     3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                      input zone data
  src     0      1      0      0      0      0      0      0      0      0  z  1
  box     0      2     -1      0      0      0      0      0      0      0  z  2
  air     0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       fe
     1          9.0850E-01
     2          7.8600E+00

 grp     mean       energy        direct beam  mean buildup          dose rate
 no      energy    group limits      flux        factors       direct beam  with buildup
         mev          mev         photons/cm**                         mrem/hr
                                  2/sec
 total    .6597    0.015-1.75     1.2660E+01   2.2976E+00     1.6205E-02    3.7234E-02

  1       .0300    0.025-0.035    1.0277E-13   1.0848E+00     3.0522E-17    3.3110E-17
  2       .0400    0.035-0.045    7.0463E-08   1.1474E+00     1.2472E-11    1.4311E-11
  3       .0600    0.055-0.070    2.5973E-04   1.3064E+00     3.0908E-08    4.0378E-08
  4       .6000    0.550-0.700    1.1334E+01   2.3689E+00     1.3261E-02    3.1414E-02
  5      1.0000    0.900-1.250    5.8390E-01   2.1146E+00     1.0744E-03    2.2719E-03
  6      1.5000    1.250-1.750    7.4182E-01   1.8975E+00     1.8694E-03    3.5472E-03
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

B-25 Box 1/2 full, 2250 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rpp     1   .0000000D+00    .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp     2   .1143000D+03    .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp     3  -.1000000D+02    .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                  input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
      1        8.1760E-01
      2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6590	0.015-1.75	1.4025E+01	2.2788E+00	1.7941E-02	4.0884E-02
1	.0300	0.025-0.035	2.4587E-13	1.0841E+00	7.3024E-17	7.9164E-17
2	.0400	0.035-0.045	1.0460E-07	1.1459E+00	1.8514E-11	2.1215E-11
3	.0600	0.055-0.070	3.0658E-04	1.3038E+00	3.6483E-08	4.7568E-08
4	.6000	0.550-0.700	1.2565E+01	2.3505E+00	1.4701E-02	3.4555E-02
5	1.0000	0.900-1.250	6.4468E-01	2.0916E+00	1.1862E-03	2.4811E-03
6	1.5000	1.250-1.750	8.1519E-01	1.8731E+00	2.0543E-03	3.8480E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/2 full, 3000 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                          body data
 rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
 rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
 rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                          input zone data
 src    0     1     0     0     0     0     0     0     0     0  z  1
 box    0     2    -1     0     0     0     0     0     0     0  z  2
 air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        1.0902E+00
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6607	0.015-1.75	1.0574E+01	2.3242E+00	1.3545E-02	3.1482E-02
1	.0300	0.025-0.035	1.8000E-14	1.0861E+00	5.3461E-18	5.8062E-18
2	.0400	0.035-0.045	3.2087E-08	1.1504E+00	5.6794E-12	6.5337E-12
3	.0600	0.055-0.070	1.8950E-04	1.3116E+00	2.2550E-08	2.9577E-08
4	.6000	0.550-0.700	9.4570E+00	2.3944E+00	1.1065E-02	2.6493E-02
5	1.0000	0.900-1.250	4.9000E-01	2.1469E+00	9.0161E-04	1.9356E-03
6	1.5000	1.250-1.750	6.2659E-01	1.9335E+00	1.5790E-03	3.0530E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/2 full, 3250 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         1.1810E+00
     2         7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6610	0.015-1.75	9.7599E+00	2.3339E+00	1.2506E-02	2.9189E-02
1	.0300	0.025-0.035	7.5426E-15	1.0866E+00	2.2401E-18	2.4342E-18
2	.0400	0.035-0.045	2.1683E-08	1.1519E+00	3.8379E-12	4.4208E-12
3	.0600	0.055-0.070	1.6279E-04	1.3143E+00	1.9372E-08	2.5461E-08
4	.6000	0.550-0.700	8.7259E+00	2.4038E+00	1.0209E-02	2.4541E-02
5	1.0000	0.900-1.250	4.5305E-01	2.1589E+00	8.3362E-04	1.7997E-03
6	1.5000	1.250-1.750	5.8075E-01	1.9467E+00	1.4635E-03	2.8490E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 1/2 full, 3500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.5969000D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.6969000D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.6969000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       fe
     1       1.2719E+00
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6613	0.015-1.75	9.0569E+00	2.3422E+00	1.1608E-02	2.7189E-02
1	.0300	0.025-0.035	3.1588E-15	1.0872E+00	9.3818E-19	1.0199E-18
2	.0400	0.035-0.045	1.4656E-08	1.1533E+00	2.5942E-12	2.9919E-12
3	.0600	0.055-0.070	1.4021E-04	1.3170E+00	1.6685E-08	2.1974E-08
4	.6000	0.550-0.700	8.0949E+00	2.4117E+00	9.4711E-03	2.2841E-02
5	1.0000	0.900-1.250	4.2102E-01	2.1686E+00	7.7467E-04	1.6800E-03
6	1.5000	1.250-1.750	5.4077E-01	1.9577E+00	1.3627E-03	2.6678E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
B-25 Box 3/4 full, 750 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       1.8170E-01
     2       7.8600E+00

 grp     mean       energy         direct beam  mean buildup           dose rate
 no     energy    group limits        flux        factors      direct beam  with buildup
          mev         mev         photons/cm**                          mrem/hr
                                  2/sec
 total   .6487    0.015-1.75      7.8253E+01   1.6914E+00      9.8598E-02   1.6677E-01

  1      .0300    0.025-0.035     2.3212E-10   1.0783E+00      6.8940E-14   7.4341E-14
  2      .0400    0.035-0.045     4.2750E-06   1.1359E+00      7.5668E-10   8.5948E-10
  3      .0600    0.055-0.070     3.6116E-03   1.2910E+00      4.2978E-07   5.5483E-07
  4      .6000    0.550-0.700     7.1412E+01   1.7350E+00      8.3552E-02   1.4497E-01
  5     1.0000    0.900-1.250     3.2120E+00   1.5316E+00      5.9101E-03   9.0521E-03
  6     1.5000    1.250-1.750     3.6254E+00   1.3956E+00      9.1359E-03   1.2750E-02
```

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            B-25 Box 3/4 full, 1125 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                  body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                  input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       2.7260E-01
     2       7.8600E+00

 grp      mean        energy        direct beam  mean buildup          dose rate
 no      energy    group limits        flux        factors       direct beam  with buildup
          mev          mev         photons/cm**                          mrem/hr
                                   2/sec
 total    .6505    0.015-1.75      6.2657E+01    1.8420E+00      7.9232E-02    1.4595E-01

  1       .0300    0.025-0.035     9.3786E-11    1.0792E+00      2.7854E-14    3.0060E-14
  2       .0400    0.035-0.045     2.5082E-06    1.1369E+00      4.4395E-10    5.0474E-10
  3       .0600    0.055-0.070     2.3620E-03    1.2920E+00      2.8108E-07    3.6316E-07
  4       .6000    0.550-0.700     5.6930E+01    1.8954E+00      6.6609E-02    1.2625E-01
  5      1.0000    0.900-1.250     2.6510E+00    1.6610E+00      4.8778E-03    8.1020E-03
  6      1.5000    1.250-1.750     3.0734E+00    1.4970E+00      7.7450E-03    1.1594E-02
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 1500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         3.6340E-01
     2         7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6522	0.015-1.75	5.1754E+01	1.9521E+00	6.5625E-02	1.2810E-01
1	.0300	0.025-0.035	3.8866E-11	1.0801E+00	1.1543E-14	1.2467E-14
2	.0400	0.035-0.045	1.5917E-06	1.1382E+00	2.8173E-10	3.2067E-10
3	.0600	0.055-0.070	1.7260E-03	1.2934E+00	2.0539E-07	2.6565E-07
4	.6000	0.550-0.700	4.6867E+01	2.0116E+00	5.4835E-02	1.1031E-01
5	1.0000	0.900-1.250	2.2374E+00	1.7619E+00	4.1169E-03	7.2536E-03
6	1.5000	1.250-1.750	2.6479E+00	1.5798E+00	6.6728E-03	1.0542E-02

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 1875 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                             body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                             input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1       4.5420E-01
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6536	0.015-1.75	4.3827E+01	2.0324E+00	5.5689E-02	1.1318E-01
1	.0300	0.025-0.035	1.6188E-11	1.0809E+00	4.8079E-15	5.1971E-15
2	.0400	0.035-0.045	1.0425E-06	1.1397E+00	1.8452E-10	2.1029E-10
3	.0600	0.055-0.070	1.3361E-03	1.2951E+00	1.5899E-07	2.0590E-07
4	.6000	0.550-0.700	3.9588E+01	2.0956E+00	4.6318E-02	9.7066E-02
5	1.0000	0.900-1.250	1.9242E+00	1.8401E+00	3.5405E-03	6.5150E-03
6	1.5000	1.250-1.750	2.3136E+00	1.6469E+00	5.8303E-03	9.6018E-03

```
             qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 2250 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       5.4510E-01
     2       7.8600E+00

grp      mean       energy          direct beam  mean buildup        dose rate
no      energy    group limits         flux        factors      direct beam  with buildup
         mev          mev          photons/cm**                        mrem/hr
                                   2/sec
total    .6549    0.015-1.75       3.7856E+01    2.0920E+00      4.8179E-02    1.0079E-01

 1       .0300    0.025-0.035      6.7470E-12    1.0818E+00      2.0039E-15    2.1677E-15
 2       .0400    0.035-0.045      6.9229E-07    1.1412E+00      1.2254E-10    1.3984E-10
 3       .0600    0.055-0.070      1.0702E-03    1.2970E+00      1.2736E-07    1.6518E-07
 4       .6000    0.550-0.700      3.4128E+01    2.1573E+00      3.9930E-02    8.6142E-02
 5      1.0000    0.900-1.250      1.6810E+00    1.9007E+00      3.0930E-03    5.8791E-03
 6      1.5000    1.250-1.750      2.0461E+00    1.7011E+00      5.1561E-03    8.7712E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 2625 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp     1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp     2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp     3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src     0      1      0      0      0      0      0      0      0      0  z  1
  box     0      2     -1      0      0      0      0      0      0      0  z  2
  air     0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        6.3590E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6560	0.015-1.75	3.3241E+01	2.1369E+00	4.2358E-02	9.0513E-02
1	.0300	0.025-0.035	2.8173E-12	1.0826E+00	8.3674E-16	9.0584E-16
2	.0400	0.035-0.045	4.6315E-07	1.1428E+00	8.1978E-11	9.3682E-11
3	.0600	0.055-0.070	8.7681E-04	1.2991E+00	1.0434E-07	1.3555E-07
4	.6000	0.550-0.700	2.9923E+01	2.2032E+00	3.5010E-02	7.7135E-02
5	1.0000	0.900-1.250	1.4885E+00	1.9480E+00	2.7388E-03	5.3352E-03
6	1.5000	1.250-1.750	1.8291E+00	1.7449E+00	4.6094E-03	8.0430E-03

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 3000 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02    19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        7.2680E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6569	0.015-1.75	2.9572E+01	2.1716E+00	3.7719E-02	8.1911E-02
1	.0300	0.025-0.035	1.1761E-12	1.0834E+00	3.4931E-16	3.7843E-16
2	.0400	0.035-0.045	3.1087E-07	1.1443E+00	5.5023E-11	6.2965E-11
3	.0600	0.055-0.070	7.2917E-04	1.3014E+00	8.6771E-08	1.1293E-07
4	.6000	0.550-0.700	2.6588E+01	2.2386E+00	3.1108E-02	6.9637E-02
5	1.0000	0.900-1.250	1.3328E+00	1.9854E+00	2.4523E-03	4.8686E-03
6	1.5000	1.250-1.750	1.6503E+00	1.7805E+00	4.1587E-03	7.4046E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 3375 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                 body data
  rpp    1  .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2  .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3 -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                 input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        8.1760E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6576	0.015-1.75	2.6601E+01	2.1990E+00	3.3956E-02	7.4670E-02
1	.0300	0.025-0.035	4.9179E-13	1.0841E+00	1.4606E-16	1.5834E-16
2	.0400	0.035-0.045	2.0920E-07	1.1459E+00	3.7028E-11	4.2431E-11
3	.0600	0.055-0.070	6.1306E-04	1.3038E+00	7.2954E-08	9.5121E-08
4	.6000	0.550-0.700	2.3895E+01	2.2662E+00	2.7957E-02	6.3357E-02
5	1.0000	0.900-1.250	1.2049E+00	2.0154E+00	2.2169E-03	4.4681E-03
6	1.5000	1.250-1.750	1.5011E+00	1.8096E+00	3.7827E-03	6.8454E-03

```
              qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
              B-25 Box 3/4 full, 3750 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         9.0850E-01
     2         7.8600E+00

 grp     mean       energy         direct beam  mean buildup          dose rate
 no      energy    group limits       flux        factors       direct beam   with buildup
          mev          mev         photons/cm**                         mrem/hr
                                   2/sec
 total    .6582    0.015-1.75      2.4146E+01   2.2212E+00      3.0842E-02    6.8506E-02

  1       .0300    0.025-0.035     2.0556E-13   1.0848E+00      6.1052E-17    6.6228E-17
  2       .0400    0.035-0.045     1.4093E-07   1.1474E+00      2.4944E-11    2.8621E-11
  3       .0600    0.055-0.070     5.1939E-04   1.3064E+00      6.1807E-08    8.0743E-08
  4       .6000    0.550-0.700     2.1673E+01   2.2885E+00      2.5357E-02    5.8031E-02
  5      1.0000    0.900-1.250     1.0981E+00   2.0398E+00      2.0205E-03    4.1213E-03
  6      1.5000    1.250-1.750     1.3748E+00   1.8339E+00      3.4646E-03    6.3536E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 4125 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1     0      0      0      0      0      0      0      0  z  1
  box    0      2    -1      0      0      0      0      0      0      0  z  2
  air    0      3    -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        9.9930E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6587	0.015-1.75	2.2090E+01	2.2395E+00	2.8231E-02	6.3223E-02
1	.0300	0.025-0.035	8.6052E-14	1.0854E+00	2.5558E-17	2.7741E-17
2	.0400	0.035-0.045	9.5078E-08	1.1489E+00	1.6829E-11	1.9335E-11
3	.0600	0.055-0.070	4.4269E-04	1.3090E+00	5.2680E-08	6.8956E-08
4	.6000	0.550-0.700	1.9815E+01	2.3069E+00	2.3184E-02	5.3482E-02
5	1.0000	0.900-1.250	1.0080E+00	2.0597E+00	1.8547E-03	3.8200E-03
6	1.5000	1.250-1.750	1.2671E+00	1.8541E+00	3.1930E-03	5.9203E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box 3/4 full, 4500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       1.0902E+00
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6592	0.015-1.75	2.0341E+01	2.2550E+00	2.6007E-02	5.8646E-02
1	.0300	0.025-0.035	3.6007E-14	1.0860E+00	1.0694E-17	1.1614E-17
2	.0400	0.035-0.045	6.4174E-08	1.1504E+00	1.1359E-11	1.3067E-11
3	.0600	0.055-0.070	3.7893E-04	1.3116E+00	4.5093E-08	5.9144E-08
4	.6000	0.550-0.700	1.8236E+01	2.3225E+00	2.1336E-02	4.9554E-02
5	1.0000	0.900-1.250	9.3083E-01	2.0767E+00	1.7127E-03	3.5567E-03
6	1.5000	1.250-1.750	1.1740E+00	1.8713E+00	2.9584E-03	5.5361E-03

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

B-25 Box 3/4 full, 4875 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        1.1810E+00
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6595	0.015-1.75	1.8839E+01	2.2684E+00	2.4096E-02	5.4659E-02
1	.0300	0.025-0.035	1.5088E-14	1.0866E+00	4.4812E-18	4.8694E-18
2	.0400	0.035-0.045	4.3367E-08	1.1519E+00	7.6759E-12	8.8417E-12
3	.0600	0.055-0.070	3.2554E-04	1.3143E+00	3.8739E-08	5.0913E-08
4	.6000	0.550-0.700	1.6881E+01	2.3360E+00	1.9751E-02	4.6139E-02
5	1.0000	0.900-1.250	8.6416E-01	2.0911E+00	1.5901E-03	3.3249E-03
6	1.5000	1.250-1.750	1.0931E+00	1.8858E+00	2.7546E-03	5.1945E-03

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
          B-25 Box 3/4 full, 5250 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                 body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.8953500D+02   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.9953500D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                 input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       1.2719E+00
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm** 2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6598	0.015-1.75	1.7534E+01	2.2800E+00	2.2434E-02	5.1149E-02
1	.0300	0.025-0.035	6.3193E-15	1.0872E+00	1.8768E-18	2.0404E-18
2	.0400	0.035-0.045	2.9313E-08	1.1533E+00	5.1884E-12	5.9838E-12
3	.0600	0.055-0.070	2.8038E-04	1.3170E+00	3.3365E-08	4.3941E-08
4	.6000	0.550-0.700	1.5705E+01	2.3477E+00	1.8375E-02	4.3140E-02
5	1.0000	0.900-1.250	8.0592E-01	2.1036E+00	1.4829E-03	3.1195E-03
6	1.5000	1.250-1.750	1.0220E+00	1.8985E+00	2.5755E-03	4.8898E-03

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

B-25 Box full, 1000 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                              body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                              input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         1.8170E-01
     2         7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6490	0.15-1.50	8.9647E+01	1.7411E+00	1.1308E-01	1.9689E-01
1	.0300	0.025-0.035	2.3165E-10	1.0784E+00	6.8800E-14	7.4191E-14
2	.0400	0.035-0.045	4.2750E-06	1.1359E+00	7.5667E-10	8.5947E-10
3	.0600	0.055-0.070	3.6126E-03	1.2910E+00	4.2991E-07	5.5500E-07
4	.6000	0.550-0.700	8.1696E+01	1.7889E+00	9.5585E-02	1.7099E-01
5	1.0000	0.900-1.250	3.7175E+00	1.5696E+00	6.8401E-03	1.0736E-02
6	1.5000	1.250-1.750	4.2292E+00	1.4229E+00	1.0658E-02	1.5165E-02

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            B-25 Box full, 1500 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        2.7260E-01
     2        7.8600E+00

 grp     mean       energy        direct beam  mean buildup          dose rate
 no     energy    group limits       flux        factors      direct beam  with buildup
         mev          mev        photons/cm**                          mrem/hr
                                 2/sec
 total   .6510    0.15-1.50      7.0463E+01   1.9071E+00     8.9239E-02   1.7019E-01

  1      .0300    0.025-0.035    9.3544E-11   1.0792E+00     2.7782E-14   2.9983E-14
  2      .0400    0.035-0.045    2.5081E-06   1.1369E+00     4.4394E-10   5.0472E-10
  3      .0600    0.055-0.070    2.3624E-03   1.2920E+00     2.8113E-07   3.6323E-07
  4      .6000    0.550-0.700    6.3903E+01   1.9661E+00     7.4767E-02   1.4700E-01
  5     1.0000    0.900-1.250    3.0201E+00   1.7122E+00     5.5570E-03   9.5145E-03
  6     1.5000    1.250-1.750    3.5380E+00   1.5343E+00     8.9156E-03   1.3679E-02
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box full, 2000 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                  body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                  input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        3.6340E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6529	0.15-1.50	5.7287E+01	2.0275E+00	7.2772E-02	1.4755E-01
1	.0300	0.025-0.035	3.8742E-11	1.0801E+00	1.1506E-14	1.2428E-14
2	.0400	0.035-0.045	1.5916E-06	1.1382E+00	2.8172E-10	3.2066E-10
3	.0600	0.055-0.070	1.7262E-03	1.2934E+00	2.0542E-07	2.6569E-07
4	.6000	0.550-0.700	5.1761E+01	2.0935E+00	6.0560E-02	1.2678E-01
5	1.0000	0.900-1.250	2.5132E+00	1.8234E+00	4.6242E-03	8.4319E-03
6	1.5000	1.250-1.750	3.0110E+00	1.6254E+00	7.5877E-03	1.2333E-02

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            B-25 Box full, 2500 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1       4.5420E-01
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6546	0.15-1.50	4.7864E+01	2.1139E+00	6.0941E-02	1.2883E-01
1	.0300	0.025-0.035	1.6126E-11	1.0810E+00	4.7893E-15	5.1771E-15
2	.0400	0.035-0.045	1.0424E-06	1.1397E+00	1.8451E-10	2.1028E-10
3	.0600	0.055-0.070	1.3363E-03	1.2951E+00	1.5902E-07	2.0594E-07
4	.6000	0.550-0.700	4.3127E+01	2.1838E+00	5.0458E-02	1.1019E-01
5	1.0000	0.900-1.250	2.1344E+00	1.9090E+00	3.9273E-03	7.4973E-03
6	1.5000	1.250-1.750	2.6015E+00	1.6990E+00	6.5558E-03	1.1138E-02

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            B-25 Box full, 3000 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        5.4510E-01
     2        7.8600E+00

 grp      mean        energy        direct beam  mean buildup        dose rate
 no      energy    group limits        flux        factors      direct beam  with buildup
          mev          mev         photons/cm**                        mrem/hr
                                   2/sec
 total    .6561    0.15-1.50       4.0882E+01   2.1760E+00      5.2141E-02   1.1346E-01

  1       .0300    0.025-0.035     6.7157E-12   1.0818E+00      1.9945E-15   2.1577E-15
  2       .0400    0.035-0.045     6.9225E-07   1.1412E+00      1.2253E-10   1.3983E-10
  3       .0600    0.055-0.070     1.0704E-03   1.2970E+00      1.2738E-07   1.6521E-07
  4       .6000    0.550-0.700     3.6759E+01   2.2477E+00      4.3008E-02   9.6666E-02
  5      1.0000    0.900-1.250     1.8443E+00   1.9743E+00      3.3936E-03   6.7000E-03
  6      1.5000    1.250-1.750     2.2775E+00   1.7582E+00      5.7393E-03   1.0091E-02
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box full, 3500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03    19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                       input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       6.3590E-01
     2       7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6572	0.15-1.50	3.5561E+01	2.2209E+00	4.5414E-02	1.0086E-01
1	.0300	0.025-0.035	2.8017E-12	1.0826E+00	8.3211E-16	9.0085E-16
2	.0400	0.035-0.045	4.6312E-07	1.1428E+00	8.1972E-11	9.3675E-11
3	.0600	0.055-0.070	8.7694E-04	1.2991E+00	1.0436E-07	1.3557E-07
4	.6000	0.550-0.700	3.1925E+01	2.2932E+00	3.7353E-02	8.5657E-02
5	1.0000	0.900-1.250	1.6176E+00	2.0240E+00	2.9765E-03	6.0244E-03
6	1.5000	1.250-1.750	2.0176E+00	1.8053E+00	5.0844E-03	9.1789E-03

```
               qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box full, 4000 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src     0      1      0      0      0      0      0      0      0      0  z  1
  box     0      2     -1      0      0      0      0      0      0      0  z  2
  air     0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        7.2680E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6582	0.15-1.50	3.1389E+01	2.2539E+00	4.0124E-02	9.0437E-02
1	.0300	0.025-0.035	1.1684E-12	1.0834E+00	3.4703E-16	3.7596E-16
2	.0400	0.035-0.045	3.1084E-07	1.1443E+00	5.5018E-11	6.2959E-11
3	.0600	0.055-0.070	7.2928E-04	1.3014E+00	8.6785E-08	1.1294E-07
4	.6000	0.550-0.700	2.8146E+01	2.3261E+00	3.2931E-02	7.6601E-02
5	1.0000	0.900-1.250	1.4365E+00	2.0621E+00	2.6431E-03	5.4505E-03
6	1.5000	1.250-1.750	1.8055E+00	1.8430E+00	4.5498E-03	8.3855E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box full, 4500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                           input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        8.1760E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6590	0.15-1.50	2.8050E+01	2.2788E+00	3.5883E-02	8.1770E-02
1	.0300	0.025-0.035	4.8802E-13	1.0841E+00	1.4494E-16	1.5713E-16
2	.0400	0.035-0.045	2.0918E-07	1.1459E+00	3.7024E-11	4.2426E-11
3	.0600	0.055-0.070	6.1316E-04	1.3038E+00	7.2966E-08	9.5136E-08
4	.6000	0.550-0.700	2.5130E+01	2.3506E+00	2.9402E-02	6.9111E-02
5	1.0000	0.900-1.250	1.2894E+00	2.0916E+00	2.3725E-03	4.9623E-03
6	1.5000	1.250-1.750	1.6304E+00	1.8731E+00	4.1087E-03	7.6961E-03

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            B-25 Box full, 5000 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                 body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                 input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         9.0850E-01
     2         7.8600E+00

 grp      mean       energy         direct beam  mean buildup         dose rate
 no      energy    group limits        flux        factors      direct beam  with buildup
          mev          mev          photons/cm**                        mrem/hr
                                    2/sec
 total    .6597    0.15-1.50        2.5321E+01   2.2977E+00     3.2411E-02   7.4469E-02

  1       .0300    0.025-0.035      2.0373E-13   1.0848E+00     6.0509E-17   6.5640E-17
  2       .0400    0.035-0.045      1.4091E-07   1.1474E+00     2.4941E-11   2.8618E-11
  3       .0600    0.055-0.070      5.1947E-04   1.3064E+00     6.1817E-08   8.0756E-08
  4       .6000    0.550-0.700      2.2669E+01   2.3689E+00     2.6523E-02   6.2830E-02
  5      1.0000    0.900-1.250      1.1678E+00   2.1146E+00     2.1488E-03   4.5439E-03
  6      1.5000    1.250-1.750      1.4837E+00   1.8975E+00     3.7389E-03   7.0946E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box full, 5500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rpp    1   .0000000D+00    .1143000D+03    .0000000D+00    .1828800D+03    .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03    .1145660D+03    .0000000D+00    .1828800D+03    .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02    .1243000D+03   -.1000000D+02    .1928800D+03   -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                      input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        9.9930E-01
     2        7.8600E+00

 grp      mean       energy        direct beam  mean buildup         dose rate
 no      energy    group limits       flux        factors      direct beam  with buildup
          mev          mev        photons/cm**                         mrem/hr
                                  2/sec
 total    .6602    0.15-1.50      2.3058E+01   2.3124E+00      2.9527E-02    6.8276E-02

  1       .0300    0.025-0.035    8.5169E-14   1.0855E+00      2.5295E-17    2.7457E-17
  2       .0400    0.035-0.045    9.5063E-08   1.1489E+00      1.6826E-11    1.9332E-11
  3       .0600    0.055-0.070    4.4276E-04   1.3090E+00      5.2688E-08    6.8967E-08
  4       .6000    0.550-0.700    2.0631E+01   2.3830E+00      2.4139E-02    5.7524E-02
  5      1.0000    0.900-1.250    1.0662E+00   2.1326E+00      1.9618E-03    4.1838E-03
  6      1.5000    1.250-1.750    1.3595E+00   1.9173E+00      3.4261E-03    6.5688E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

B-25 Box full, 6000 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                               body data
  rpp    1   .0000000D+00   .1143000D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03   .1145660D+03   .0000000D+00   .1828800D+03   .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02   .1243000D+03  -.1000000D+02   .1928800D+03  -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                              input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         1.0902E+00
     2         7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6607	0.15-1.50	2.1148E+01	2.3242E+00	2.7091E-02	6.2964E-02
1	.0300	0.025-0.035	3.5583E-14	1.0861E+00	1.0568E-17	1.1478E-17
2	.0400	0.035-0.045	6.4162E-08	1.1504E+00	1.1357E-11	1.3065E-11
3	.0600	0.055-0.070	3.7899E-04	1.3116E+00	4.5100E-08	5.9153E-08
4	.6000	0.550-0.700	1.8914E+01	2.3944E+00	2.2130E-02	5.2987E-02
5	1.0000	0.900-1.250	9.8003E-01	2.1468E+00	1.8032E-03	3.8713E-03
6	1.5000	1.250-1.750	1.2532E+00	1.9335E+00	3.1581E-03	6.1061E-03

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

B-25 Box full, 6500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                              body data
  rpp    1   .0000000D+00    .1143000D+03    .0000000D+00    .1828800D+03    .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03    .1145660D+03    .0000000D+00    .1828800D+03    .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02    .1243000D+03   -.1000000D+02    .1928800D+03   -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                              input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        1.1810E+00
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6610	0.15-1.50	1.9520E+01	2.3340E+00	2.5013E-02	5.8379E-02
1	.0300	0.025-0.035	1.4886E-14	1.0867E+00	4.4211E-18	4.8043E-18
2	.0400	0.035-0.045	4.3357E-08	1.1519E+00	7.6742E-12	8.8397E-12
3	.0600	0.055-0.070	3.2559E-04	1.3143E+00	3.8745E-08	5.0921E-08
4	.6000	0.550-0.700	1.7452E+01	2.4038E+00	2.0419E-02	4.9082E-02
5	1.0000	0.900-1.250	9.0612E-01	2.1589E+00	1.6673E-03	3.5994E-03
6	1.5000	1.250-1.750	1.1615E+00	1.9468E+00	2.9270E-03	5.6981E-03

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
B-25 Box full, 7000 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rpp    1   .0000000D+00    .1143000D+03    .0000000D+00    .1828800D+03    .0000000D+00
.1193800D+03    3
  rpp    2   .1143000D+03    .1145660D+03    .0000000D+00    .1828800D+03    .0000000D+00
.1193800D+03   11
  rpp    3  -.1000000D+02    .1243000D+03   -.1000000D+02    .1928800D+03   -.1000000D+02
.1293800D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                      input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       1.2719E+00
     2       7.8600E+00

 grp     mean        energy         direct beam  mean buildup          dose rate
 no     energy    group limits         flux        factors       direct beam  with buildup
         mev          mev         photons/cm**                          mrem/hr
                                  2/sec
 total   .6613    0.15-1.50       1.8114E+01    2.3422E+00       2.3217E-02    5.4379E-02

  1      .0300    0.025-0.035     6.2233E-15    1.0872E+00       1.8483E-18    2.0095E-18
  2      .0400    0.035-0.045     2.9305E-08    1.1533E+00       5.1870E-12    5.9822E-12
  3      .0600    0.055-0.070     2.8042E-04    1.3170E+00       3.3370E-08    4.3948E-08
  4      .6000    0.550-0.700     1.6190E+01    2.4117E+00       1.8942E-02    4.5683E-02
  5     1.0000    0.900-1.250     8.4205E-01    2.1686E+00       1.5494E-03    3.3600E-03
  6     1.5000    1.250-1.750     1.0815E+00    1.9578E+00       2.7255E-03    5.3359E-03
```

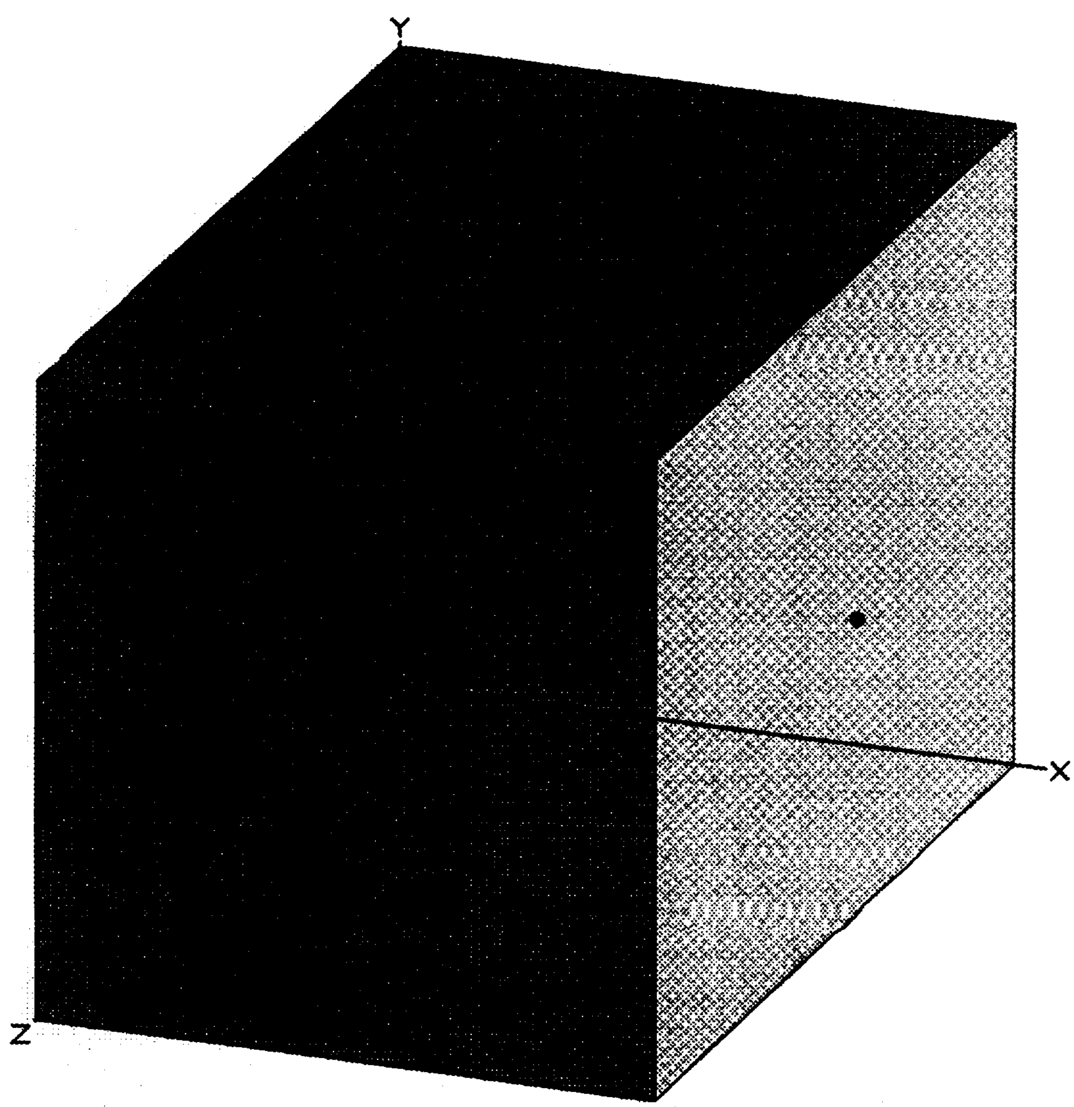
Description: Full B-25 Box 72" x 45" x 47" tall, 1 mCi JN Std
Geometry: 13 - Rectangular Volume

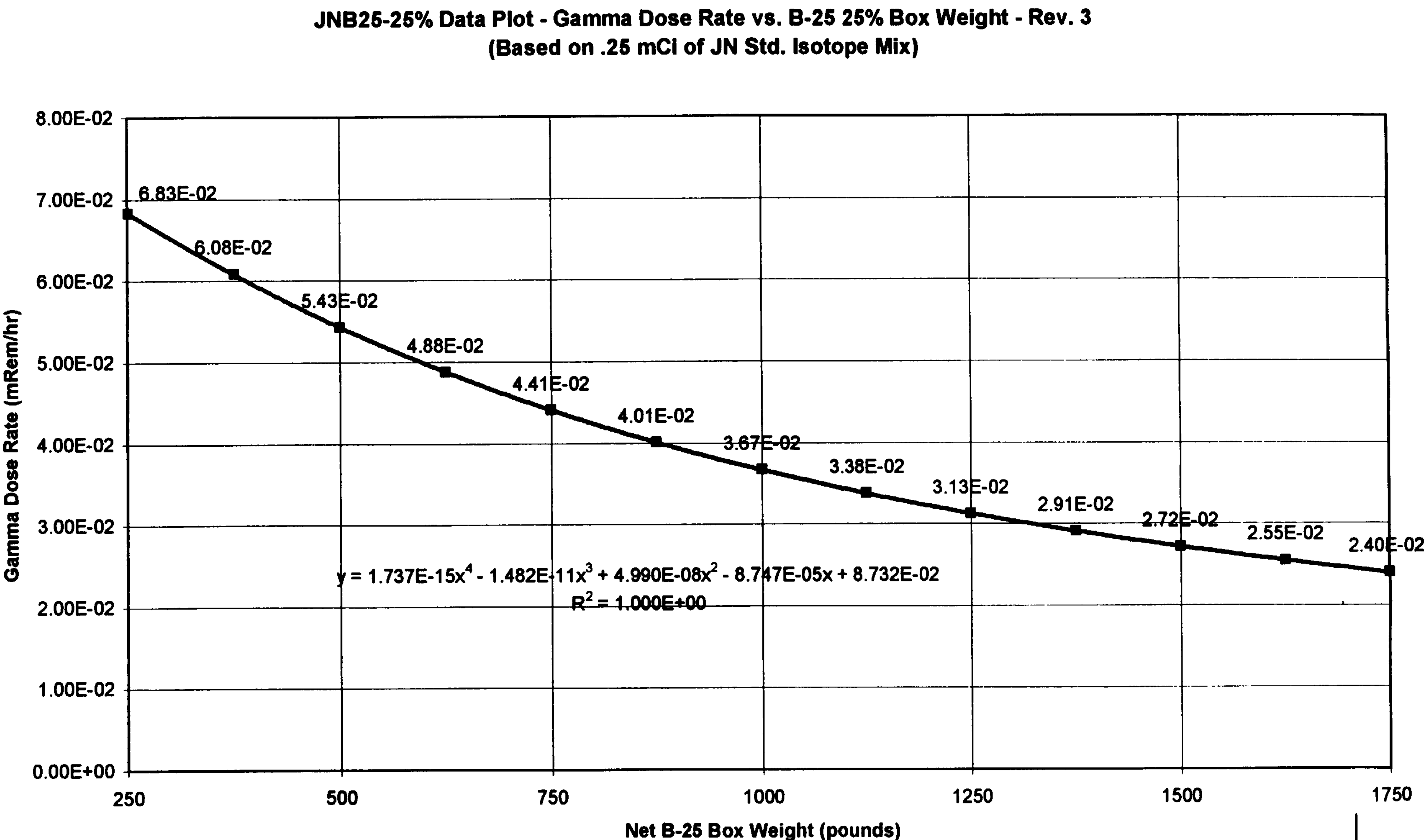
Source Dimensions

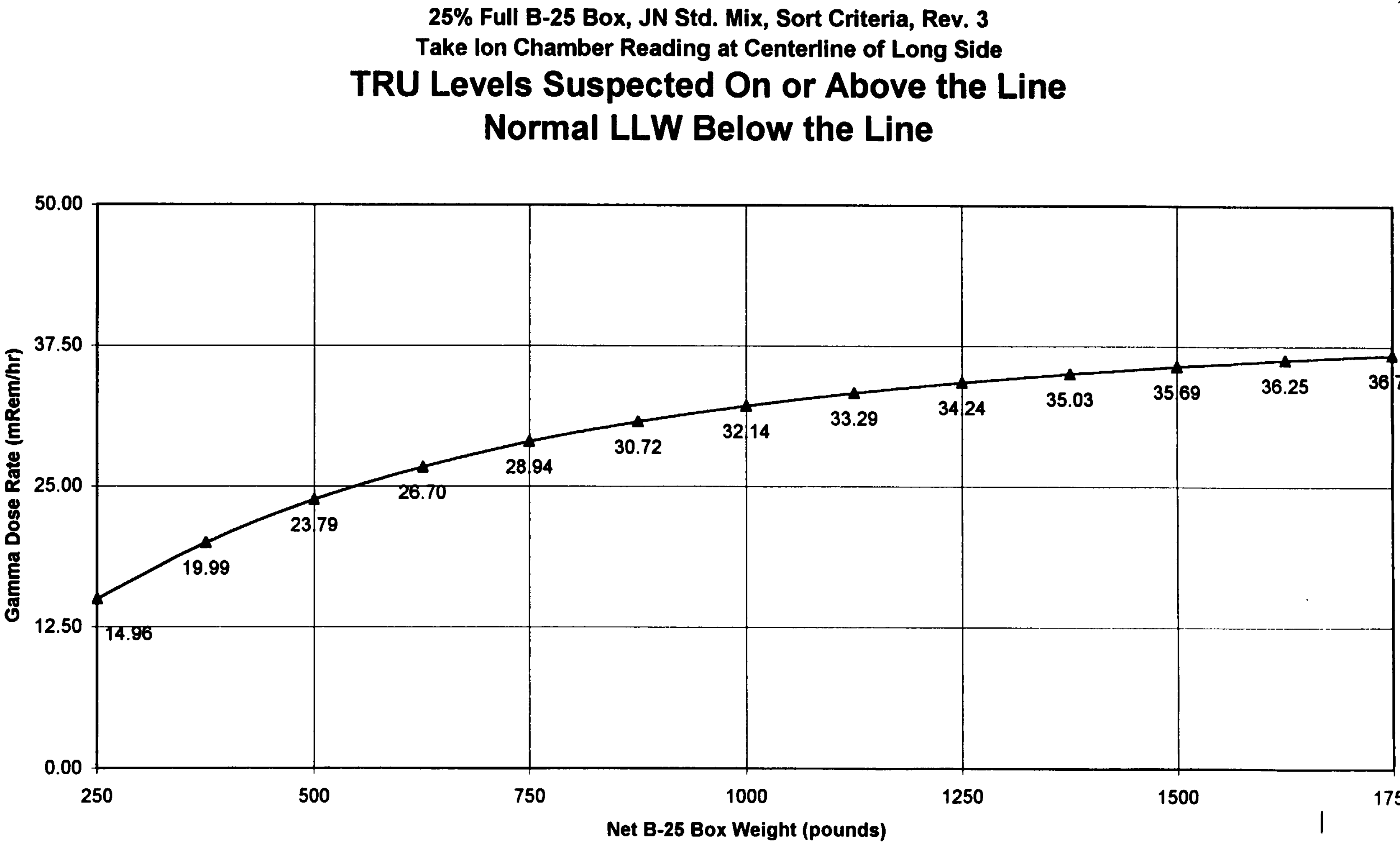
Length	114.3 cm	3 ft 9.0 in
Width	182.88 cm	6 ft
Height	119.38 cm	3 ft 11.0 in

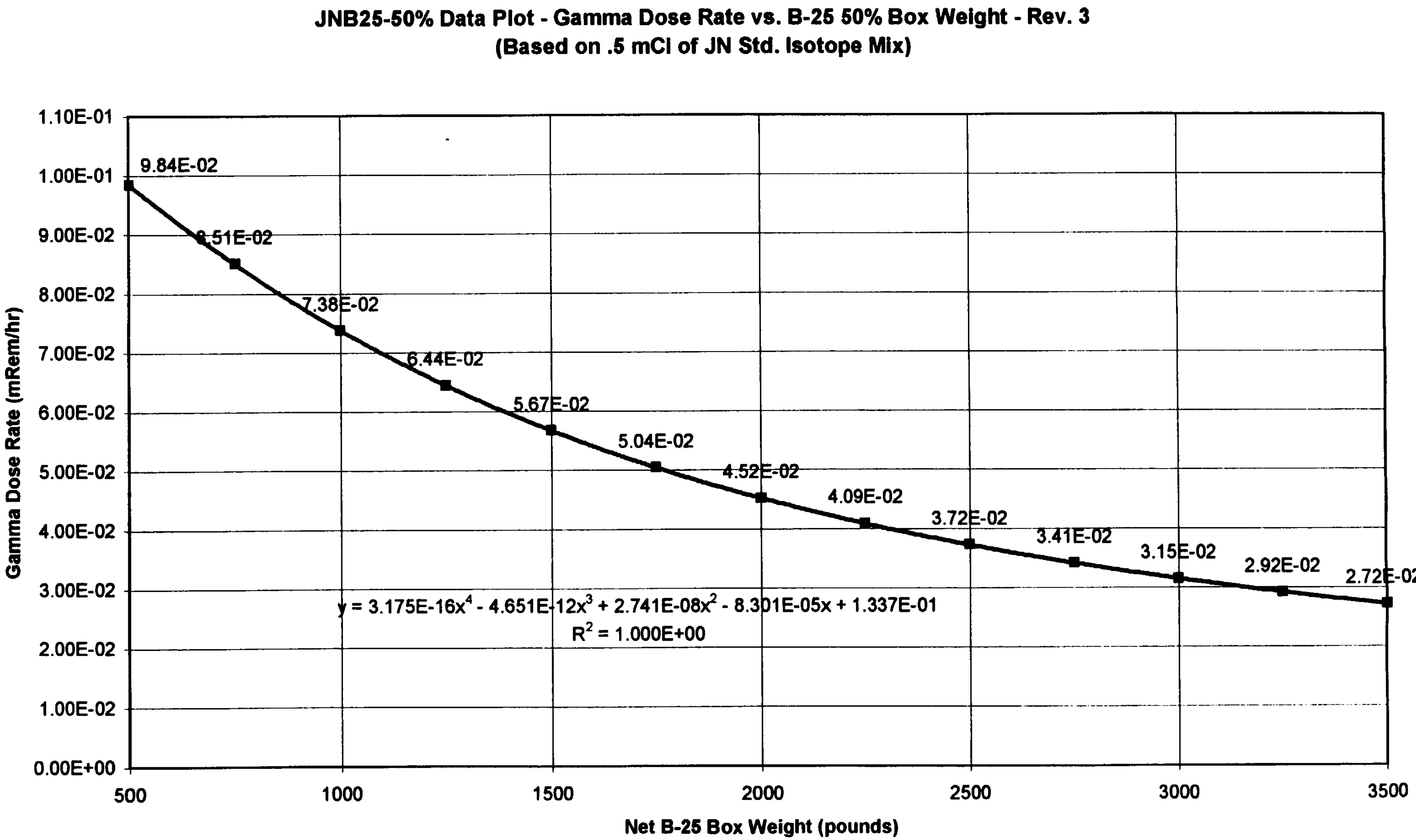
Dose Points

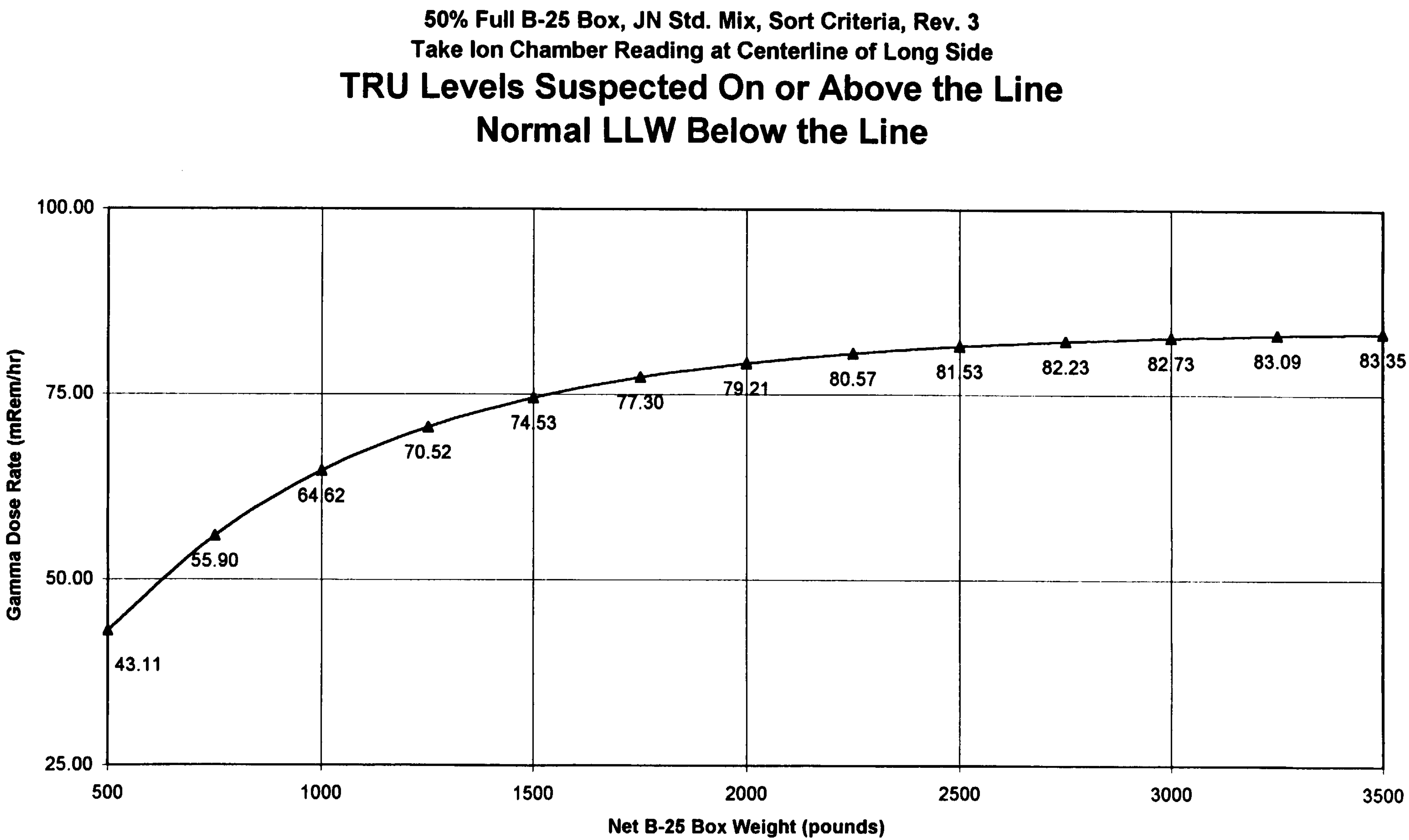
	X	Y	Z
# 1	1.20e+02 cm	59.69 cm	93.98 cm
	3 ft 11.1 in	1 ft 11.5 in	3 ft 1.0 in

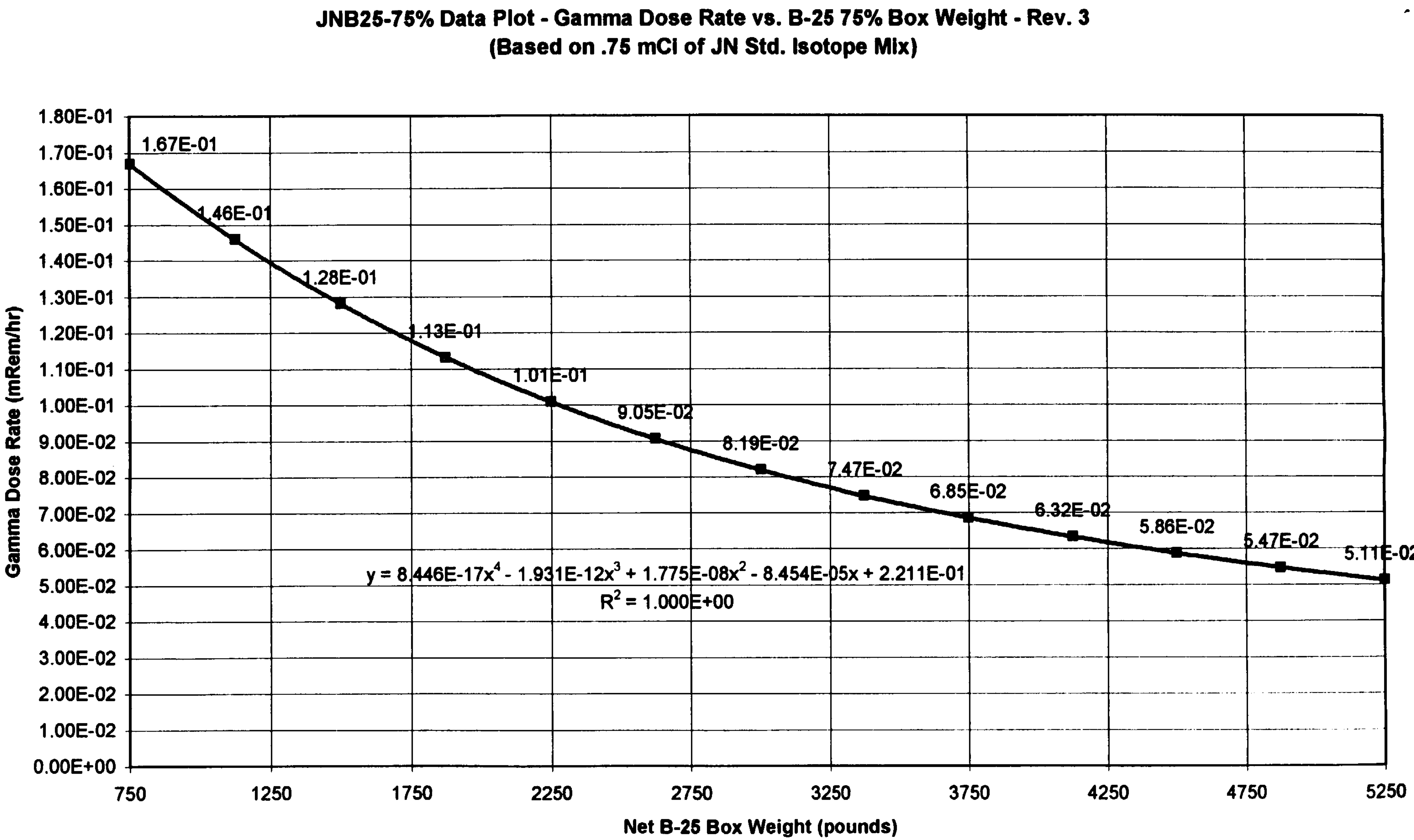



JNB25-25% Data Plot - Gamma Dose Rate vs. B-25 25% Box Weight - Rev. 3
(Based on .25 mCi of JN Std. Isotope Mix)
Gamma Dose Rate (mRem/hr)
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
6.83E-02
6.08E-02
5.43E-02
4.88E-02
4.41E-02
4.01E-02
3.67E-02
3.38E-02
3.13E-02
2.91E-02
2.72E-02
2.55E-02
2.40E-02
y = 1.737E-15x4 - 1.482E-11x3 + 4.990E-08x2 - 8.747E-05x + 8.732E-02
R2 = 1.000E+00
250
500
750
1000
1250
1500
1750
Net B-25 Box Weight (pounds)


25% Full B-25 Box, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Long Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line
Gamma Dose Rate (mRem/hr)
50.00
37.50
25.00
12.50
0.00
14.96
19.99
23.79
26.70
28.94
30.72
32.14
33.29
34.24
35.03
35.69
36.25
36.7
250
500
750
1000
1250
1500
175
Net B-25 Box Weight (pounds)

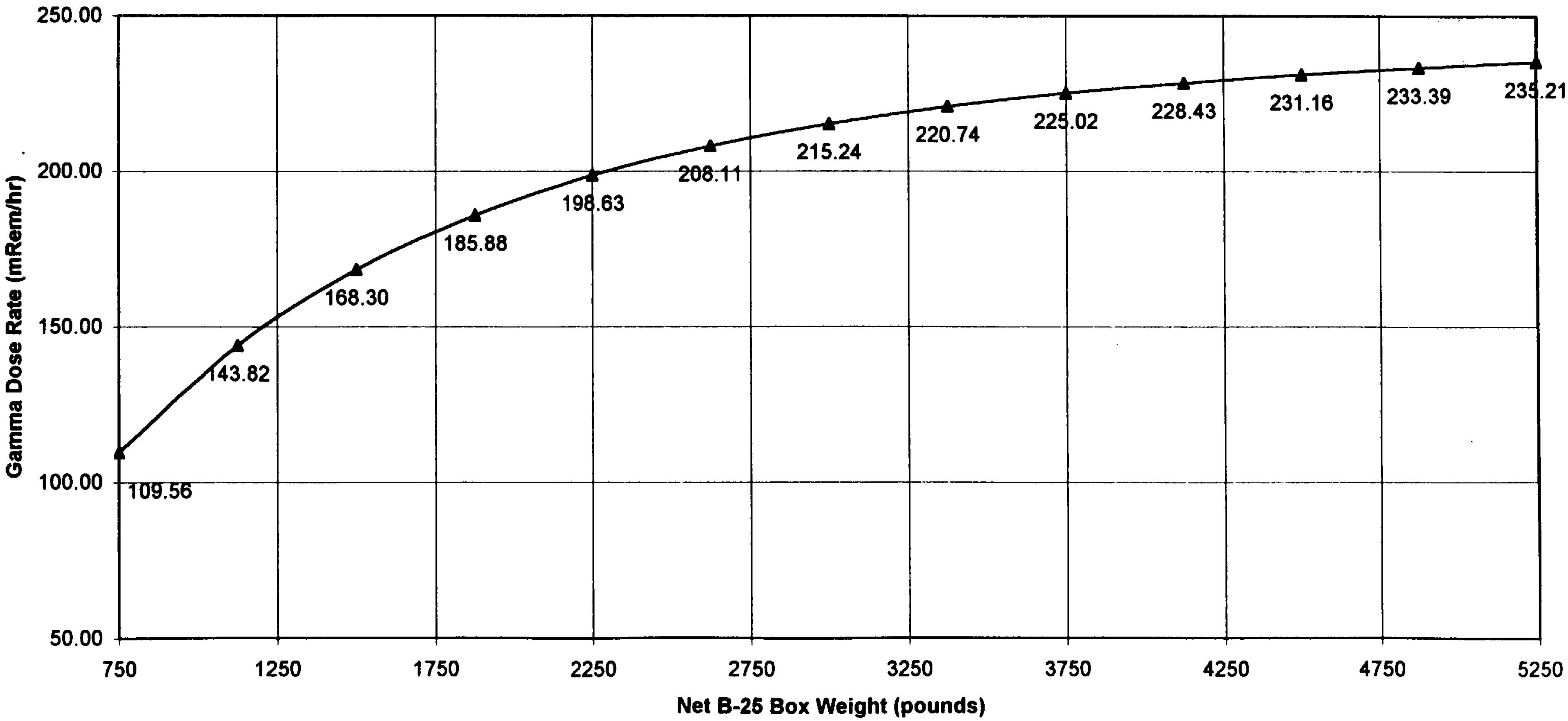

JNB25-50% Data Plot - Gamma Dose Rate vs. B-25 50% Box Weight - Rev. 3
(Based on .5 mCi of JN Std. Isotope Mix)
Gamma Dose Rate (mRem/hr)
1.10E-01
1.00E-01
9.00E-02
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
9.84E-02
8.51E-02
7.38E-02
6.44E-02
5.67E-02
5.04E-02
4.52E-02
4.09E-02
3.72E-02
3.41E-02
3.15E-02
2.92E-02
2.72E-02
y = 3.175E-16x4 - 4.651E-12x3 + 2.741E-08x2 - 8.301E-05x + 1.337E-01
R2 = 1.000E+00
500
1000
1500
2000
2500
3000
3500
Net B-25 Box Weight (pounds)


50% Full B-25 Box, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Long Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line
100.00
75.00
50.00
25.00
Gamma Dose Rate (mRem/hr)
43.11
55.90
64.62
70.52
74.53
77.30
79.21
80.57
81.53
82.23
82.73
83.09
83.35
500
1000
1500
2000
2500
3000
3500
Net B-25 Box Weight (pounds)

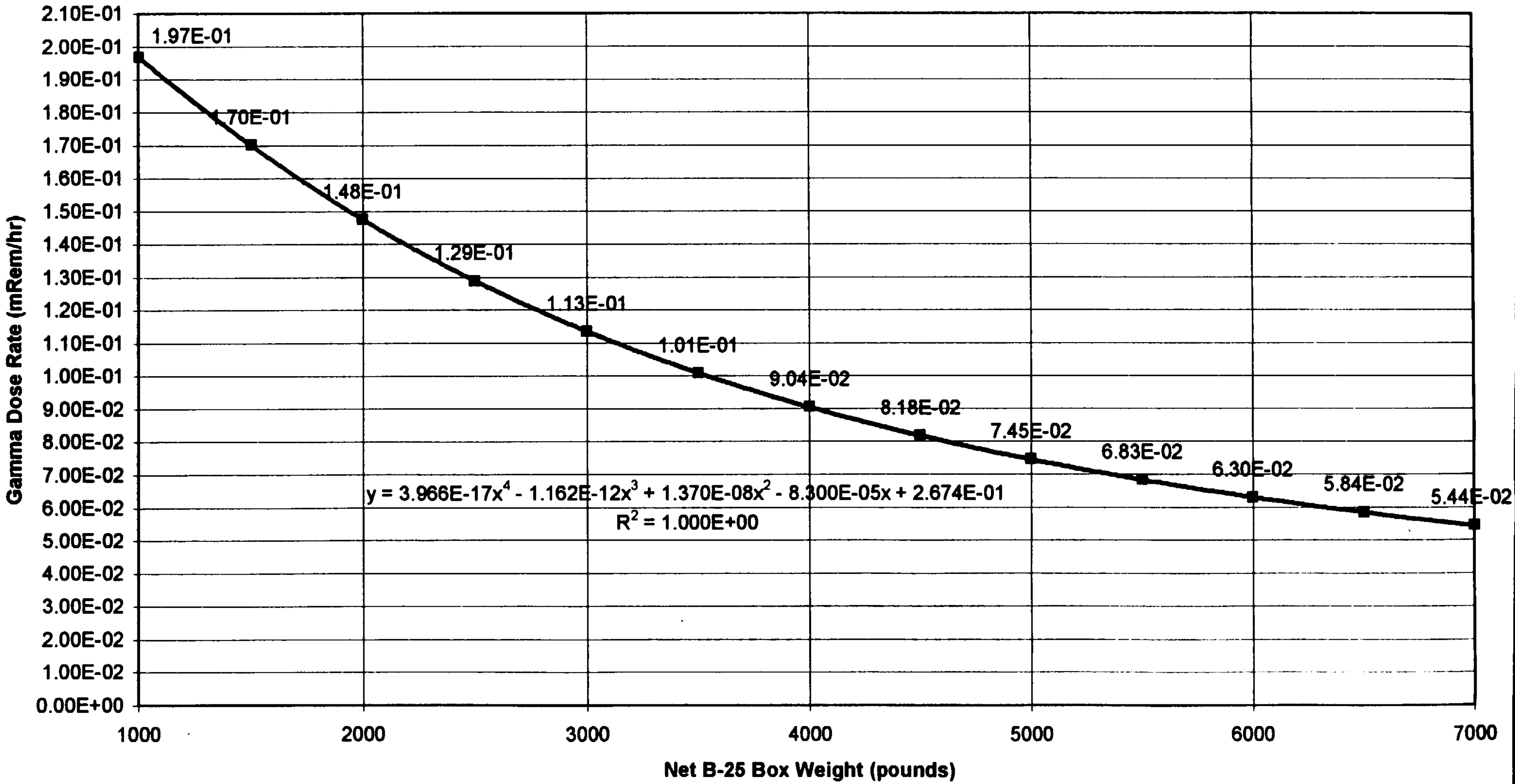

JNB25-75% Data Plot - Gamma Dose Rate vs. B-25 75% Box Weight - Rev. 3
(Based on .75 mCi of JN Std. Isotope Mix)
Gamma Dose Rate (mRem/hr)
Net B-25 Box Weight (pounds)
1.80E-01
1.70E-01
1.60E-01
1.50E-01
1.40E-01
1.30E-01
1.20E-01
1.10E-01
1.00E-01
9.00E-02
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
750
1250
1750
2250
2750
3250
3750
4250
4750
5250
1.67E-01
1.46E-01
1.28E-01
1.13E-01
1.01E-01
9.05E-02
8.19E-02
7.47E-02
6.85E-02
6.32E-02
5.86E-02
5.47E-02
5.11E-02
y = 8.446E-17x^4 - 1.931E-12x^3 + 1.775E-08x^2 - 8.454E-05x + 2.211E-01
R^2 = 1.000E+00

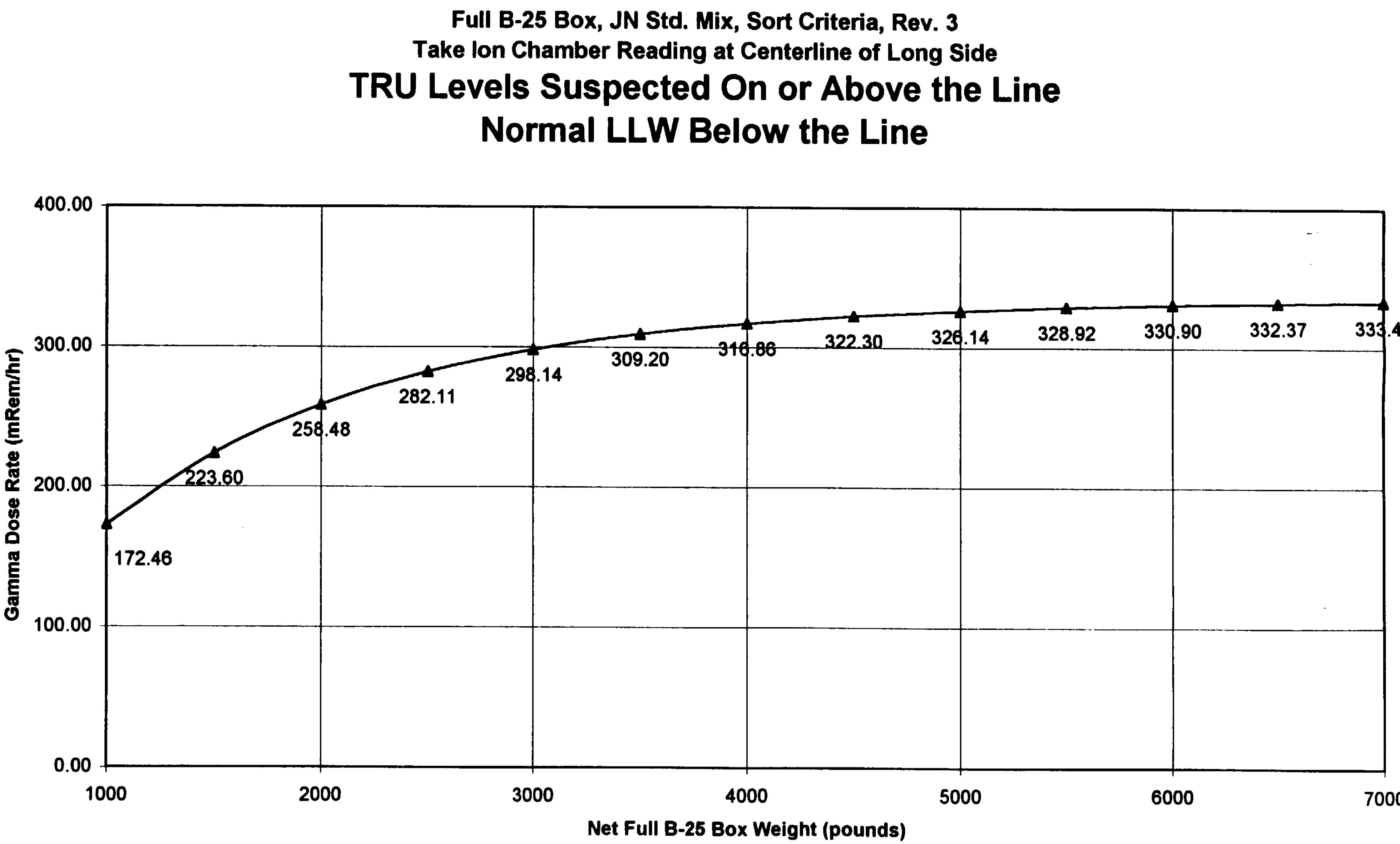
75% Full B-25 Box, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Long Side

TRU Levels Suspected On or Above the Line
Normal LLW Below the Line



JNB25-100 Data Plot - Gamma Dose Rate vs. B-25 Box Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)




Full B-25 Box, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Long Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line
400.00
300.00
200.00
100.00
0.00
Gamma Dose Rate (mRem/hr)
172.46
223.60
258.48
282.11
298.14
309.20
316.86
322.30
326.14
328.92
330.90
332.37
333.41
1000
2000
3000
4000
5000
6000
7000
Net Full B-25 Box Weight (pounds)

Full B-25 Box, JN Std. Mix, Corrected
REV 3

$$y = 3.966E\text{-}17x^4 - 1.162E\text{-}12x^3 + 1.370E\text{-}08x^2 - 8.300E\text{-}05x + 2.674E\text{-}01$$

Enter Container Number --------- -			1	2						
Enter Net Container Weight -----			1000	1000	0	0	0	0		
Enter Contact Dose Rate --------			85	288	0	0	0	0		
Dose Rate for 1mCi mix ---------			0.197	0.197	0.000	0.000	0.000	0.000		
MCi per container ----------------- -			431.52	1462.08	0.00	0.00	0.00	0.00		
									Uncertainty Range	
Isotope	dist/mCi		dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	Total mCi	-30.8%	+30.8%
Sr-90	2.52E-01		108.742	368.444	0.000	0.000	0.000	0.000	477.186	330.2129	624.1597
Cs-137	3.83E-01		165.271	559.977	0.000	0.000	0.000	0.000	725.247	501.8712	948.6237
U-234	6.70E-06		2.9E-03	9.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-02	0.008779	0.016595
U-235	9.80E-08		4.2E-05	1.4E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.9E-04	0.000128	0.000243
U-236	1.30E-06		5.6E-04	1.9E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.5E-03	0.001703	0.00322
U-238	1.88E-06		8.1E-04	2.7E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.6E-03	0.002463	0.004656
Pu-238	1.40E-02	1.40E-02	6.041	20.469	0.000	0.000	0.000	0.000	26.510	18.34516	34.67554
Pu-239/40	5.00E-03	5.00E-03	2.158	7.310	0.000	0.000	0.000	0.000	9.468	6.551844	12.38412
Pu-241	3.10E-01		133.770	453.245	0.000	0.000	0.000	0.000	587.015	406.2143	767.8155
Am-241	1.20E-02	1.20E-02	5.178	17.545	0.000	0.000	0.000	0.000	22.723	15.72443	29.72189
Cm-244	1.00E-02		4.315	14.621	0.000	0.000	0.000	0.000	18.936	13.10369	24.76824
Co-60	1.30E-02		5.610	19.007	0.000	0.000	0.000	0.000	24.617	17.03479	32.19872
U-233	2.07E-10		0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.71E-07	5.13E-07
Pu-242	1.14E-05	1.14E-05	0.005	0.017	0.000	0.000	0.000	0.000	0.022	0.014938	0.028236
	SUM	TRUSUM									
Total mCi	9.99E-01	3.101E-02	431.094	1460.649	0.000	0.000	0.000	0.000	1891.743	1309.086	2474.4
		TRUSUM	1.3E+01	4.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00			
		TRU nCi/g	29.502	99.958	0.000	0.000	0.000	0.000			

DD-98-04 Rev. 3

APPENDIX C

D Box Case

Contents:

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            D Box, 100 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                       body data
  rpp    1   .0000000D+00   .1066800D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02    3
  rpp    2   .1066800D+03   .1069460D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02   11
  rpp    3  -.1000000D+02   .1166800D+03  -.1000000D+02   .1281100D+03  -.1000000D+02
.9382000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                       input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
     1       2.7000E-03  1.9000E-02  2.1100E-02  0.0000E+00
     2       0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp      mean       energy        direct beam  mean buildup         dose rate
 no      energy   group limits        flux        factors     direct beam  with buildup
          mev         mev         photons/cm**                         mrem/hr
                                  2/sec
 total    .6399    0.15-1.75      2.3915E+02   1.4457E+00     2.9880E-01   4.3198E-01

  1       .0300    0.025-0.035    8.0343E-08   1.5734E+01     2.3862E-11   3.7544E-10
  2       .0400    0.035-0.045    4.6463E-04   2.8652E+01     8.2239E-08   2.3563E-06
  3       .0600    0.055-0.070    1.1415E-01   2.2902E+01     1.3583E-05   3.1108E-04
  4       .6000    0.550-0.700    2.2030E+02   1.4741E+00     2.5775E-01   3.7995E-01
  5      1.0000    0.900-1.250    9.0841E+00   1.3100E+00     1.6715E-02   2.1896E-02
  6      1.5000    1.250-1.750    9.6526E+00   1.2261E+00     2.4325E-02   2.9824E-02
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

D Box, 300 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z
```

body data

rpp	1	.0000000D+00	.1066800D+03	.0000000D+00	.1181100D+03	.0000000D+00	.8382000D+02	3
rpp	2	.1066800D+03	.1069460D+03	.0000000D+00	.1181100D+03	.0000000D+00	.8382000D+02	11
rpp	3	-.1000000D+02	.1166800D+03	-.1000000D+02	.1281100D+03	-.1000000D+02	.9382000D+02	19

```
*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone
```

input zone data

src	0	1	0	0	0	0	0	0	0	0	z	1
box	0	2	-1	0	0	0	0	0	0	0	z	2
air	0	3	-2	0	0	0	0	0	0	0	z	3

```
***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
```

comp/mat	h	c	o	fe
1	8.0000E-03	5.7000E-02	6.3400E-02	0.0000E+00
2	0.0000E+00	0.0000E+00	0.0000E+00	7.8600E+00
3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6406	0.15-1.75	1.8645E+02	1.7607E+00	2.3403E-01	4.1206E-01
1	.0300	0.025-0.035	3.5169E-08	1.6063E+01	1.0445E-11	1.6778E-10
2	.0400	0.035-0.045	2.3191E-04	3.0555E+01	4.1048E-08	1.2542E-06
3	.0600	0.055-0.070	6.4944E-02	2.8205E+01	7.7284E-06	2.1798E-04
4	.6000	0.550-0.700	1.7083E+02	1.8158E+00	1.9988E-01	3.6294E-01
5	1.0000	0.900-1.250	7.3994E+00	1.5210E+00	1.3615E-02	2.0708E-02
6	1.5000	1.250-1.750	8.1484E+00	1.3730E+00	2.0534E-02	2.8192E-02

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            D Box, 500 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rpp    1   .0000000D+00   .1066800D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02    3
  rpp    2   .1066800D+03   .1069460D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02   11
  rpp    3  -.1000000D+02   .1166800D+03  -.1000000D+02   .1281100D+03  -.1000000D+02
.9382000D+02   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
      1       1.3300E-02  9.5000E-02  1.0570E-01  0.0000E+00
      2       0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
      3       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean      energy         direct beam  mean buildup          dose rate
 no     energy   group limits        flux        factors      direct beam  with buildup
          mev        mev          photons/cm**                          mrem/hr
                                  2/sec
 total   .6414   0.15-1.75        1.5018E+02   2.0310E+00      1.8922E-01   3.8430E-01

  1      .0300   0.025-0.035      2.1417E-08   1.6116E+01      6.3608E-12   1.0251E-10
  2      .0400   0.035-0.045      1.4578E-04   3.1154E+01      2.5802E-08   8.0384E-07
  3      .0600   0.055-0.070      4.3071E-02   3.1030E+01      5.1255E-06   1.5904E-04
  4      .6000   0.550-0.700      1.3700E+02   2.1113E+00      1.6028E-01   3.3840E-01
  5     1.0000   0.900-1.250      6.1605E+00   1.7045E+00      1.1335E-02   1.9321E-02
  6     1.5000   1.250-1.750      6.9820E+00   1.5013E+00      1.7595E-02   2.6414E-02
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

D Box, 700 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                              body data
  rpp    1   .0000000D+00   .1066800D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02    3
  rpp    2   .1066800D+03   .1069460D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02   11
  rpp    3  -.1000000D+02   .1166800D+03  -.1000000D+02   .1281100D+03  -.1000000D+02
.9382000D+02   19

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                              input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat       h            c            o            fe
     1       1.8600E-02  1.3300E-01  1.4800E-01  0.0000E+00
     2       0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6423	0.15-1.75	1.2430E+02	2.2532E+00	1.5709E-01	3.5395E-01
1	.0300	0.025-0.035	1.5299E-08	1.6124E+01	4.5439E-12	7.3265E-11
2	.0400	0.035-0.045	1.0486E-04	3.1319E+01	1.8560E-08	5.8129E-07
3	.0600	0.055-0.070	3.1616E-02	3.2397E+01	3.7623E-06	1.2189E-04
4	.6000	0.550-0.700	1.1298E+02	2.3552E+00	1.3219E-01	3.1132E-01
5	1.0000	0.900-1.250	5.2275E+00	1.8596E+00	9.6187E-03	1.7886E-02
6	1.5000	1.250-1.750	6.0631E+00	1.6114E+00	1.5279E-02	2.4621E-02

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

D Box, 900 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                              body data
  rpp    1   .0000000D+00   .1066800D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02    3
  rpp    2   .1066800D+03   .1069460D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02    11
  rpp    3  -.1000000D+02   .1166800D+03  -.1000000D+02   .1281100D+03  -.1000000D+02
.9382000D+02    19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                              input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
     1      2.3900E-02  1.7090E-01  1.9020E-01  0.0000E+00
     2      0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean       energy        direct beam  mean buildup          dose rate
 no     energy    group limits       flux        factors      direct beam  with buildup
          mev         mev         photons/cm**                          mrem/hr
                                  2/sec
 total   .6432    0.15-1.75       1.0525E+02   2.4322E+00     1.3333E-01   3.2430E-01

  1      .0300    0.025-0.035     1.1894E-08   1.6126E+01     3.5326E-12   5.6967E-11
  2      .0400    0.035-0.045     8.1654E-05   3.1366E+01     1.4453E-08   4.5333E-07
  3      .0600    0.055-0.070     2.4812E-02   3.3052E+01     2.9527E-06   9.7590E-05
  4      .6000    0.550-0.700     9.5386E+01   2.5520E+00     1.1160E-01   2.8480E-01
  5     1.0000    0.900-1.250     4.5105E+00   1.9884E+00     8.2994E-03   1.6503E-02
  6     1.5000    1.250-1.750     5.3293E+00   1.7050E+00     1.3430E-02   2.2898E-02
```

```
             qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

D Box, 1000 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rpp    1   .0000000D+00   .1066800D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02    3
  rpp    2   .1066800D+03   .1069460D+03   .0000000D+00   .1181100D+03   .0000000D+00
.8382000D+02    11
  rpp    3  -.1000000D+02   .1166800D+03  -.1000000D+02   .1281100D+03  -.1000000D+02
.9382000D+02    19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h            c            o            fe
     1       2.6600E-02   1.9070E-01   2.1220E-01   0.0000E+00
     2       0.0000E+00   0.0000E+00   0.0000E+00   7.8600E+00
     3       0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00

 grp     mean       energy        direct beam  mean buildup         dose rate
 no      energy   group limits       flux        factors      direct beam  with buildup
           mev        mev         photons/cm**                        mrem/hr
                                  2/sec
 total    .6436   0.15-1.75       9.7248E+01   2.5109E+00     1.2333E-01   3.0967E-01

  1       .0300   0.025-0.035     1.0655E-08   1.6127E+01     3.1645E-12   5.1035E-11
  2       .0400   0.035-0.045     7.3186E-05   3.1377E+01     1.2954E-08   4.0645E-07
  3       .0600   0.055-0.070     2.2282E-02   3.3248E+01     2.6516E-06   8.8160E-05
  4       .6000   0.550-0.700     8.8021E+01   2.6384E+00     1.0298E-01   2.7172E-01
  5      1.0000   0.900-1.250     4.2009E+00   2.0465E+00     7.7296E-03   1.5819E-02
  6      1.5000   1.250-1.750     5.0043E+00   1.7479E+00     1.2611E-02   2.2043E-02
```

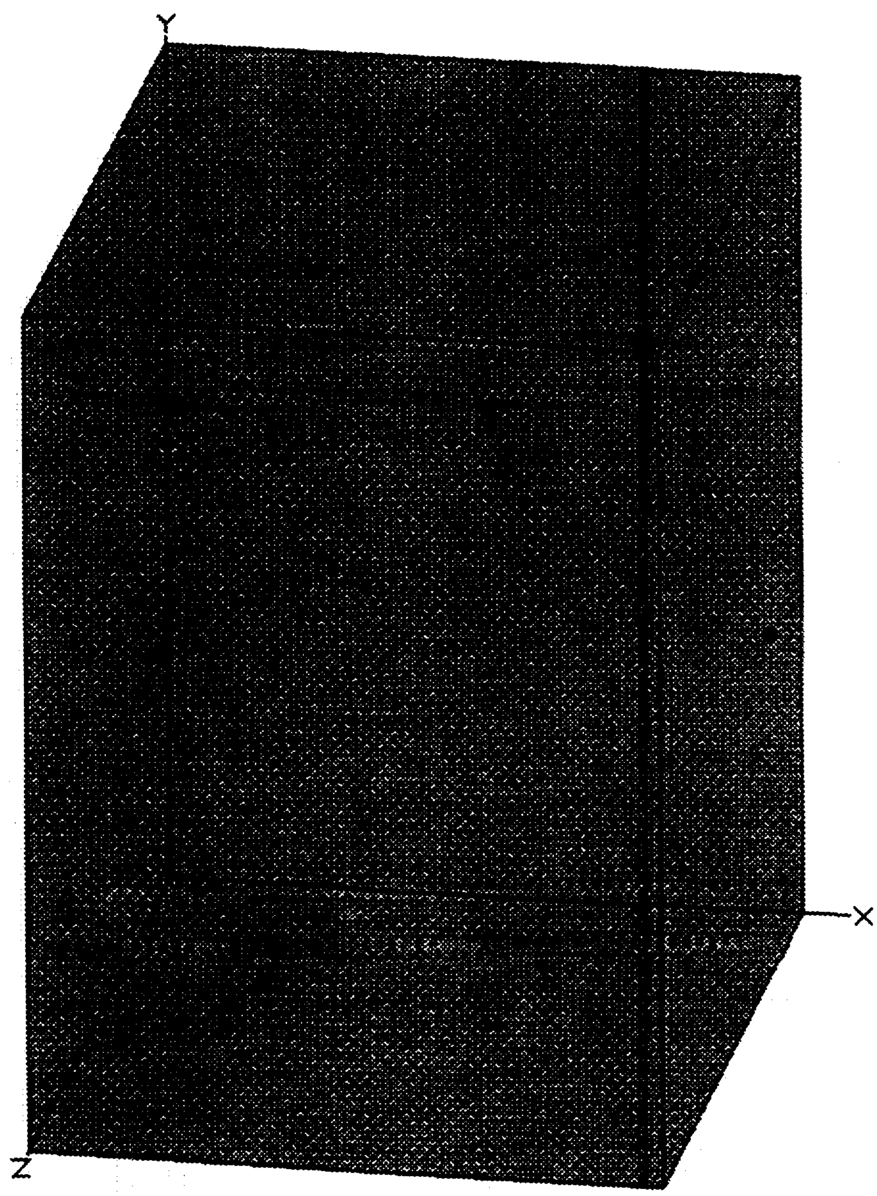
Description: D Box - JN Std Mix
Geometry: 13 - Rectangular Volume

Source Dimensions

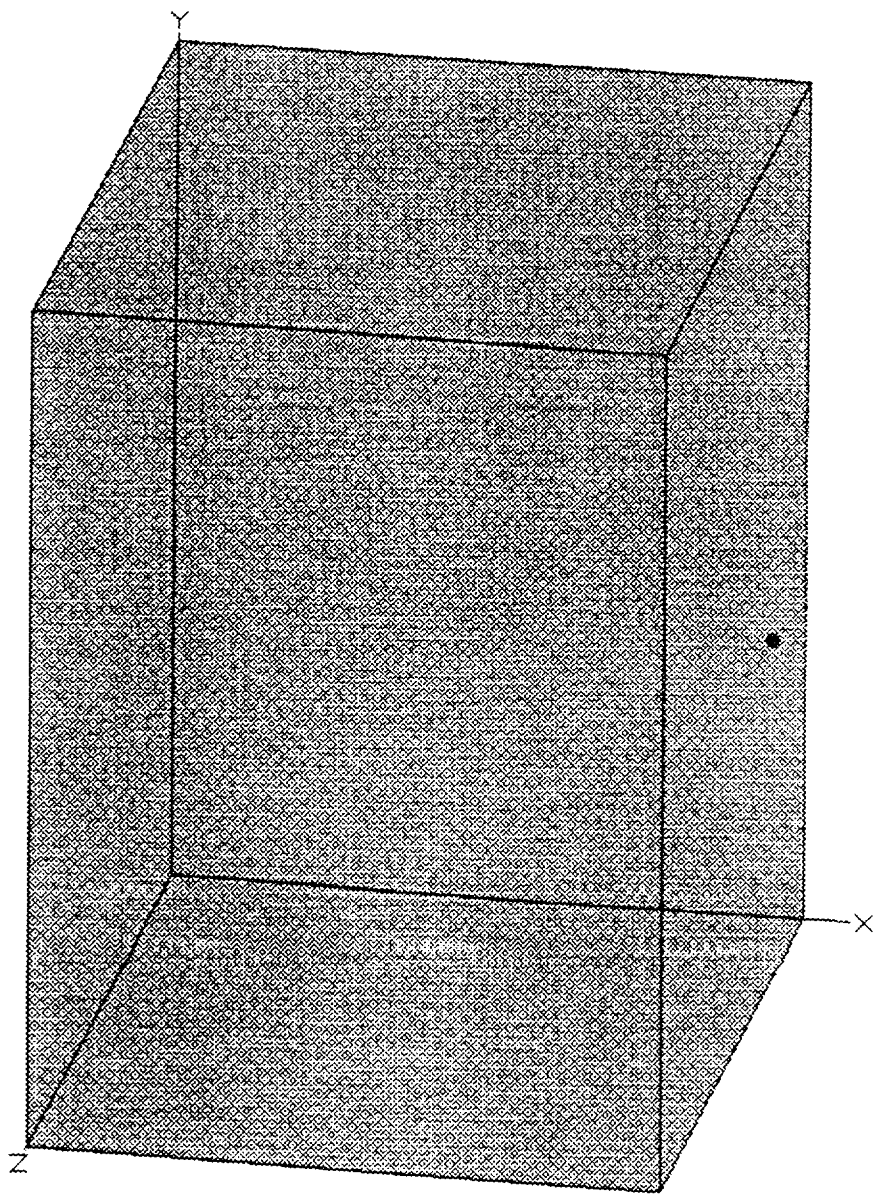
Length	83.82 cm	2 ft 9.0 in
Width	106.68 cm	3 ft 6.0 in
Height	116.84 cm	3 ft 10.0 in

Dose Points

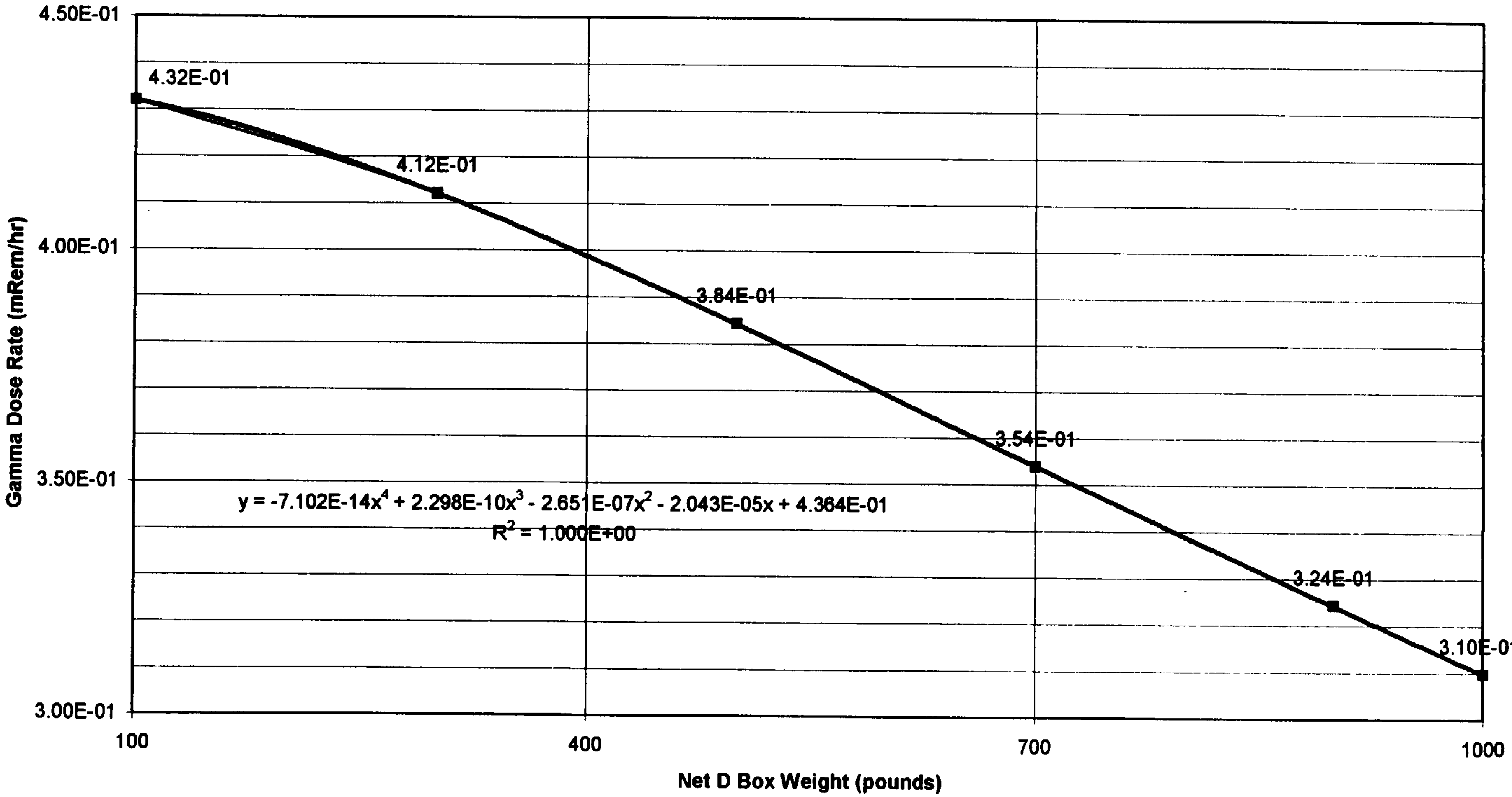
	X	Y	Z
# 1	88.9 cm	58.42 cm	53.34 cm
	2 ft 11.0 in	1 ft 11.0 in	1 ft 9.0 in

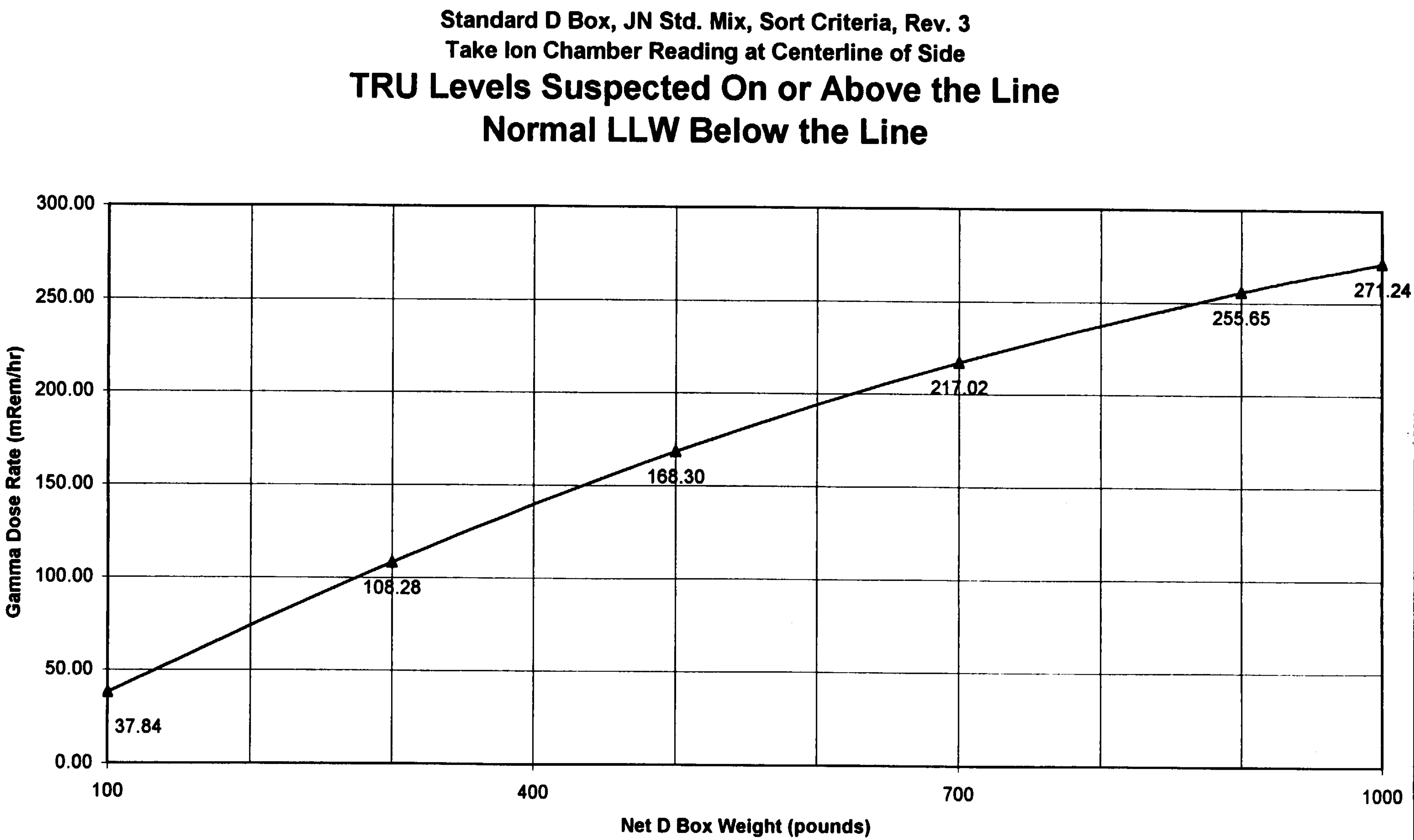


```
Description:          D Box - JN Std Mix
   Geometry: 13 - Rectangular Volume

           Source Dimensions
 Length     83.82 cm       2 ft 9.0 in
 Width     106.68 cm       3 ft 6.0 in
 Height    116.84 cm       3 ft 10.0 in

              Dose Points
          X           Y            Z
# 1     88.9 cm     58.42 cm    53.34 cm
   2 ft 11.0 in 1 ft 11.0 in 1 ft 9.0 in
```



JND Data Plot - Gamma Dose Rate vs. Standard D Box Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)




Standard D Box, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line
Gamma Dose Rate (mRem/hr)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
37.84
108.28
168.30
217.02
255.65
271.24
100
400
700
1000
Net D Box Weight (pounds)

Standard D Box, JN Std. Mix, Corrected
REV 3

y = -7.102E-14x4 + 2.298E-10x3 - 2.651E-07x2 -
2.043E-05x + 4.364E-01

Enter Container Number --------- -	1	2				
Enter Net Container Weight -----	1000	1000				
Enter Contact Dose Rate --------	9	15	0	0	0	0
Dose Rate for 1mCi mix ---------	0.310	0.310	0.000	0.000	0.000	0.000
MCi per container ----------------- -	29.07	48.44	0.00	0.00	0.00	0.00

										Uncertainty Range	
Isotope	dist/mCi		dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	Total mCi	-30.8%	+30.8%
Sr-90	2.52E-01		7.324	12.207	0.000	0.000	0.000	0.000	19.532	13.51596	25.5475
Cs-137	3.83E-01		11.132	18.553	0.000	0.000	0.000	0.000	29.685	20.54211	38.82815
U-234	6.70E-06		1.9E-04	3.2E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.2E-04	0.000359	0.000679
U-235	9.80E-08		2.8E-06	4.7E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.6E-06	5.26E-06	9.94E-06
U-236	1.30E-06		3.8E-05	6.3E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-04	6.97E-05	0.000132
U-238	1.88E-06		5.5E-05	9.1E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-04	0.000101	0.000191
Pu-238	1.40E-02	1.40E-02	0.407	0.678	0.000	0.000	0.000	0.000	1.085	0.750886	1.419306
Pu-239/40	5.00E-03	5.00E-03	0.145	0.242	0.000	0.000	0.000	0.000	0.388	0.268174	0.506895
Pu-241	3.10E-01		9.010	15.017	0.000	0.000	0.000	0.000	24.027	16.62677	31.42748
Am-241	1.20E-02	1.20E-02	0.349	0.581	0.000	0.000	0.000	0.000	0.930	0.643617	1.216548
Cm-244	1.00E-02		0.291	0.484	0.000	0.000	0.000	0.000	0.775	0.536347	1.01379
Co-60	1.30E-02		0.378	0.630	0.000	0.000	0.000	0.000	1.008	0.697252	1.317927
U-233	2.07E-10		0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.11E-08	2.1E-08
Pu-242	1.14E-05	1.14E-05	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000611	0.001156
	SUM	TRUSUM									
Total mCi	9.99E-01	3.101E-02	29.037	48.394	0.000	0.000	0.000	0.000	77.431	53.58226	101.2798
		TRUSUM	9.0E-01	1.5E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00			
		TRU nCi/g	1.987	3.312	0.000	0.000	0.000	0.000			

DD-98-04 Rev. 3

APPENDIX D

IP-2 Box Case

Contents:

```
qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
```

IP-2 147 Box 2000 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rpp    1   .0000000D+00    .1397000D+03    .0000000D+00    .2083000D+03    .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03    .1402310D+03    .0000000D+00    .2083000D+03    .0000000D+00
.1435000D+03   11
  rpp    3  -.1000000D+02    .2397000D+03   -.1000000D+02    .3083000D+03   -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h            c            o            fe
     1       1.3500E-02   9.6500E-02   1.0730E-01   0.0000E+00
     2       0.0000E+00   0.0000E+00   0.0000E+00   7.8600E+00
     3       0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00

 grp     mean       energy         direct beam  mean buildup          dose rate
 no     energy    group limits        flux        factors       direct beam  with buildup
         mev         mev          photons/cm**                           mrem/hr
                                  2/sec
 total   .6529    0.015-1.75      3.4377E+01   2.1489E+00      4.3776E-02   9.4070E-02

  1      .0300    0.025-0.035     1.8840E-16   1.0895E+00      5.5954E-20   6.0960E-20
  2      .0400    0.035-0.045     1.4494E-08   1.1635E+00      2.5654E-12   2.9848E-12
  3      .0600    0.055-0.070     6.5282E-04   1.3505E+00      7.7686E-08   1.0492E-07
  4      .6000    0.550-0.700     3.0968E+01   2.2309E+00      3.6232E-02   8.0830E-02
  5     1.0000    0.900-1.250     1.5365E+00   1.9002E+00      2.8272E-03   5.3722E-03
  6     1.5000    1.250-1.750     1.8718E+00   1.6679E+00      4.7168E-03   7.8672E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
```

IP-2 147 Box 3000 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3  -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
```

comp/mat	h	c	o	fe
1	2.0200E-02	1.4470E-01	1.6100E-01	0.0000E+00
2	0.0000E+00	0.0000E+00	0.0000E+00	7.8600E+00
3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6559	0.015-1.75	2.5332E+01	2.3186E+00	3.2401E-02	7.5124E-02
1	.0300	0.025-0.035	1.2526E-16	1.0895E+00	3.7203E-20	4.0532E-20
2	.0400	0.035-0.045	9.6609E-09	1.1636E+00	1.7100E-12	1.9898E-12
3	.0600	0.055-0.070	4.3678E-04	1.3507E+00	5.1977E-08	7.0208E-08
4	.6000	0.550-0.700	2.2696E+01	2.4114E+00	2.6555E-02	6.4034E-02
5	1.0000	0.900-1.250	1.1670E+00	2.0614E+00	2.1472E-03	4.4262E-03
6	1.5000	1.250-1.750	1.4679E+00	1.8015E+00	3.6990E-03	6.6636E-03

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
          IP-2 147 Box  4000 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    11
  rpp    3  -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03    19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h           c           o           fe
      1      2.6900E-02  1.9290E-01  2.1460E-01  0.0000E+00
      2      0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
      3      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean       energy          direct beam  mean buildup          dose rate
 no      energy    group limits       flux         factors     direct beam  with buildup
          mev          mev         photons/cm**                          mrem/hr
                                   2/sec
 total    .6582    0.015-1.75      1.9808E+01   2.4191E+00     2.5407E-02   6.1462E-02

  1       .0300    0.025-0.035     9.3652E-17   1.0895E+00     2.7815E-20   3.0303E-20
  2       .0400    0.035-0.045     7.2377E-09   1.1636E+00     1.2811E-12   1.4906E-12
  3       .0600    0.055-0.070     3.2744E-04   1.3510E+00     3.8965E-08   5.2643E-08
  4       .6000    0.550-0.700     1.7686E+01   2.5161E+00     2.0693E-02   5.2066E-02
  5      1.0000    0.900-1.250     9.2856E-01   2.1661E+00     1.7085E-03   3.7009E-03
  6      1.5000    1.250-1.750     1.1925E+00   1.8954E+00     3.0050E-03   5.6956E-03
```

qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000

IP-2 147 Box 5000 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3  -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  box    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
```

comp/mat	h	c	o	fe
1	3.3700E-02	2.4110E-01	2.6830E-01	0.0000E+00
2	0.0000E+00	0.0000E+00	0.0000E+00	7.8600E+00
3	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6599	0.015-1.75	1.6152E+01	2.4806E+00	2.0754E-02	5.1483E-02
1	.0300	0.025-0.035	7.4594E-17	1.0895E+00	2.2154E-20	2.4137E-20
2	.0400	0.035-0.045	5.7771E-09	1.1636E+00	1.0225E-12	1.1899E-12
3	.0600	0.055-0.070	2.6148E-04	1.3511E+00	3.1116E-08	4.2040E-08
4	.6000	0.550-0.700	1.4390E+01	2.5786E+00	1.6836E-02	4.3414E-02
5	1.0000	0.900-1.250	7.6510E-01	2.2346E+00	1.4078E-03	3.1458E-03
6	1.5000	1.250-1.750	9.9606E-01	1.9613E+00	2.5101E-03	4.9230E-03

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
          IP-2 147 Box  6000 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                               body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3  -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                               input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
     1      4.0400E-02  2.8940E-01  3.2200E-01  0.0000E+00
     2      0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean       energy         direct beam  mean buildup          dose rate
 no     energy   group limits         flux        factors      direct beam  with buildup
         mev         mev          photons/cm**                         mrem/hr
                                  2/sec
 total   .6611   0.015-1.75       1.3588E+01   2.5198E+00      1.7481E-02   4.4049E-02

  1      .0300   0.025-0.035      6.1859E-17   1.0895E+00      1.8372E-20   2.0016E-20
  2      .0400   0.035-0.045      4.8022E-09   1.1636E+00      8.4999E-13   9.8908E-13
  3      .0600   0.055-0.070      2.1747E-04   1.3511E+00      2.5879E-08   3.4965E-08
  4      .6000   0.550-0.700      1.2089E+01   2.6176E+00      1.4144E-02   3.7024E-02
  5     1.0000   0.900-1.250      6.4785E-01   2.2805E+00      1.1920E-03   2.7184E-03
  6     1.5000   1.250-1.750      8.5131E-01   2.0077E+00      2.1453E-03   4.3071E-03
```

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
            IP-2 147 Box  7000 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp     1   .0000000D+00    .1397000D+03    .0000000D+00    .2083000D+03    .0000000D+00
.1435000D+03    3
  rpp     2   .1397000D+03    .1402310D+03    .0000000D+00    .2083000D+03    .0000000D+00
.1435000D+03    11
  rpp     3  -.1000000D+02    .2397000D+03   -.1000000D+02    .3083000D+03   -.1000000D+02
.2435000D+03    19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src     0      1      0      0      0      0      0      0      0      0   z   1
  box     0      2     -1      0      0      0      0      0      0      0   z   2
  air     0      3     -2      0      0      0      0      0      0      0   z   3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
     1      4.7100E-02  3.3760E-01  3.7560E-01  0.0000E+00
     2      0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp      mean       energy         direct beam   mean buildup          dose rate
 nc      energy    group limits        flux         factors      direct beam  with buildup
           mev         mev         photons/cm**                          mrem/hr
                                   2/sec
 total    .6620    0.015-1.75      1.1705E+01    2.5459E+00      1.5071E-02   3.8369E-02

  1       .0300    0.025-0.035     5.2746E-17    1.0895E+00      1.5666E-20   1.7067E-20
  2       .0400    0.035-0.045     4.1052E-09    1.1637E+00      7.2661E-13   8.4553E-13
  3       .0600    0.055-0.070     1.8601E-04    1.3512E+00      2.2135E-08   2.9909E-08
  4       .6000    0.550-0.700     1.0403E+01    2.6432E+00      1.2172E-02   3.2173E-02
  5      1.0000    0.900-1.250     5.6046E-01    2.3119E+00      1.0312E-03   2.3841E-03
  6      1.5000    1.250-1.750     7.4114E-01    2.0412E+00      1.8677E-03   3.8123E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
```

IP-2 147 Box 8000 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3  -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
     1       5.3900E-02  3.8580E-01  4.2930E-01  0.0000E+00
     2       0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3       0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6627	0.015-1.75	1.0262E+01	2.5646E+00	1.3220E-02	3.3904E-02
1	.0300	0.025-0.035	4.5868E-17	1.0895E+00	1.3623E-20	1.4842E-20
2	.0400	0.035-0.045	3.5796E-09	1.1637E+00	6.3359E-13	7.3730E-13
3	.0600	0.055-0.070	1.6230E-04	1.3513E+00	1.9313E-08	2.6099E-08
4	.6000	0.550-0.700	9.1142E+00	2.6613E+00	1.0664E-02	2.8379E-02
5	1.0000	0.900-1.250	4.9289E-01	2.3339E+00	9.0693E-04	2.1167E-03
6	1.5000	1.250-1.750	6.5467E-01	2.0659E+00	1.6498E-03	3.4082E-03

qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000

IP-2 147 Box 9000 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3 -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                input zone data
  src    0      1     0      0      0      0      0      0      0      0  z  1
  box    0      2    -1      0      0      0      0      0      0      0  z  2
  air    0      3    -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       h           c           o           fe
     1      6.0600E-02  4.3410E-01  4.8290E-01  0.0000E+00
     2      0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean      energy         direct beam  mean buildup        dose rate
 no     energy   group limits        flux        factors      direct beam  with buildup
         mev         mev         photons/cm**                         mrem/hr
                                 2/sec
 total   .6632   0.015-1.75      9.1273E+00   2.5785E+00      1.1764E-02   3.0333E-02

  1      .0300   0.025-0.035     4.0502E-17   1.0895E+00      1.2029E-20   1.3106E-20
  2      .0400   0.035-0.045     3.1702E-09   1.1637E+00      5.6112E-13   6.5298E-13
  3      .0600   0.055-0.070     1.4384E-04   1.3514E+00      1.7117E-08   2.3132E-08
  4      .6000   0.550-0.700     8.1022E+00   2.6749E+00      9.4796E-03   2.5357E-02
  5     1.0000   0.900-1.250     4.3938E-01   2.3506E+00      8.0845E-04   1.9003E-03
  6     1.5000   1.250-1.750     5.8556E-01   2.0842E+00      1.4756E-03   3.0754E-03
```

```
             qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
             IP-2 147 Box  10000 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3  -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
     1      6.7400E-02  4.8230E-01  5.3660E-01  0.0000E+00
     2      0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

grp    mean      energy        direct beam  mean buildup       dose rate
no    energy   group limits       flux        factors     direct beam  with buildup
       mev        mev         photons/cm**                        mrem/hr
                              2/sec
total  .6635   0.015-1.75     8.2098E+00   2.5896E+00     1.0585E-02   2.7410E-02

 1     .0300   0.025-0.035    3.6182E-17   1.0895E+00     1.0746E-20   1.1708E-20
 2     .0400   0.035-0.045    2.8409E-09   1.1637E+00     5.0284E-13   5.8517E-13
 3     .0600   0.055-0.070    1.2900E-04   1.3516E+00     1.5351E-08   2.0748E-08
 4     .6000   0.550-0.700    7.2848E+00   2.6857E+00     8.5232E-03   2.2891E-02
 5    1.0000   0.900-1.250    3.9591E-01   2.3636E+00     7.2847E-04   1.7218E-03
 6    1.5000   1.250-1.750    5.2901E-01   2.0984E+00     1.3331E-03   2.7974E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
```

IP-2 147 Box 11000 lb, 1 mCi, Cellulose Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rpp    1   .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2   .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3  -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h            c            o            fe
     1      7.4100E-02   5.3050E-01   5.9030E-01   0.0000E+00
     2      0.0000E+00   0.0000E+00   0.0000E+00   7.8600E+00
     3      0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00

 grp     mean       energy       direct beam  mean buildup          dose rate
 no     energy    group limits      flux        factors       direct beam  with buildup
         mev          mev       photons/cm**                         mrem/hr
                                2/sec
 total   .6638    0.015-1.75    7.4547E+00   2.5989E+00     9.6140E-03   2.4986E-02

  1      .0300    0.025-0.035   3.2632E-17   1.0895E+00     9.6917E-21   1.0559E-20
  2      .0400    0.035-0.045   2.5708E-09   1.1638E+00     4.5504E-13   5.2956E-13
  3      .0600    0.055-0.070   1.1684E-04   1.3517E+00     1.3904E-08   1.8794E-08
  4      .6000    0.550-0.700   6.6124E+00   2.6951E+00     7.7366E-03   2.0851E-02
  5     1.0000    0.900-1.250   3.6004E-01   2.3740E+00     6.6247E-04   1.5727E-03
  6     1.5000    1.250-1.750   4.8215E-01   2.1095E+00     1.2150E-03   2.5631E-03
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/14/2000
IP-2 147 Box  12000 lb, 1 mCi, Cellulose Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                             body data
  rpp    1  .0000000D+00   .1397000D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03    3
  rpp    2  .1397000D+03   .1402310D+03   .0000000D+00   .2083000D+03   .0000000D+00
.1435000D+03   11
  rpp    3 -.1000000D+02   .2397000D+03  -.1000000D+02   .3083000D+03  -.1000000D+02
.2435000D+03   19

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                             input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  box    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      h           c           o           fe
     1      8.0800E-02  5.7880E-01  6.4390E-01  0.0000E+00
     2      0.0000E+00  0.0000E+00  0.0000E+00  7.8600E+00
     3      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00

 grp     mean       energy        direct beam  mean buildup          dose rate
 no     energy   group limits        flux         factors      direct beam  with buildup
         mev         mev         photons/cm**                         mrem/hr
                                 2/sec
 total   .6641   0.015-1.75      6.8218E+00   2.6072E+00      8.7999E-03   2.2943E-02

  1      .0300   0.025-0.035     2.9657E-17   1.0895E+00      8.8082E-21   9.5966E-21
  2      .0400   0.035-0.045     2.3449E-09   1.1638E+00      4.1504E-13   4.8302E-13
  3      .0600   0.055-0.070     1.0667E-04   1.3518E+00      1.2694E-08   1.7160E-08
  4      .6000   0.550-0.700     6.0492E+00   2.7034E+00      7.0776E-03   1.9133E-02
  5     1.0000   0.900-1.250     3.2991E-01   2.3826E+00      6.0703E-04   1.4463E-03
  6     1.5000   1.250-1.750     4.4257E-01   2.1189E+00      1.1153E-03   2.3632E-03
```

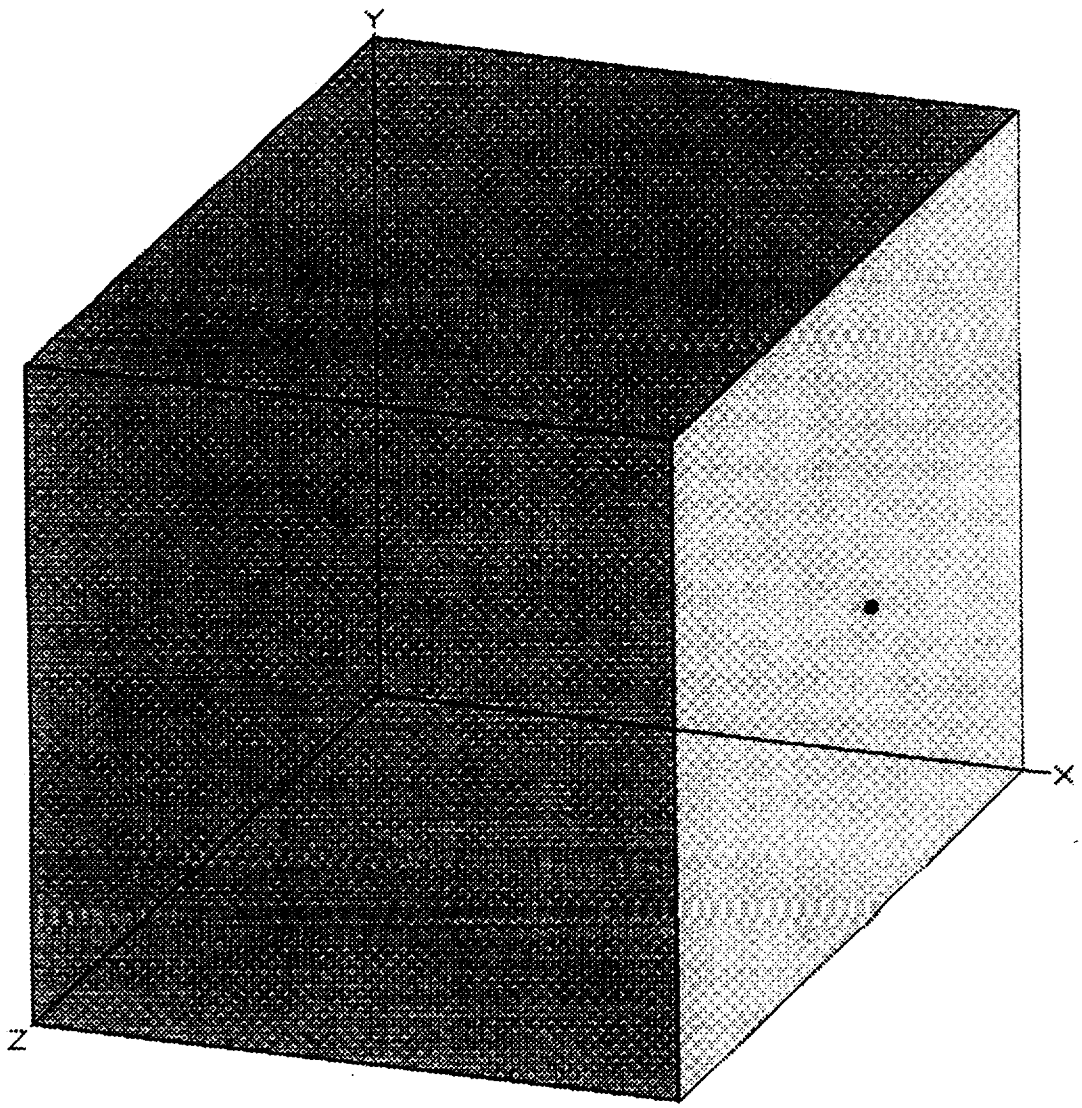
Description: Full IP-2 Box 72" x 45" x 47" tall, 1 mCi JN Std
Geometry: 13 - Rectangular Volume

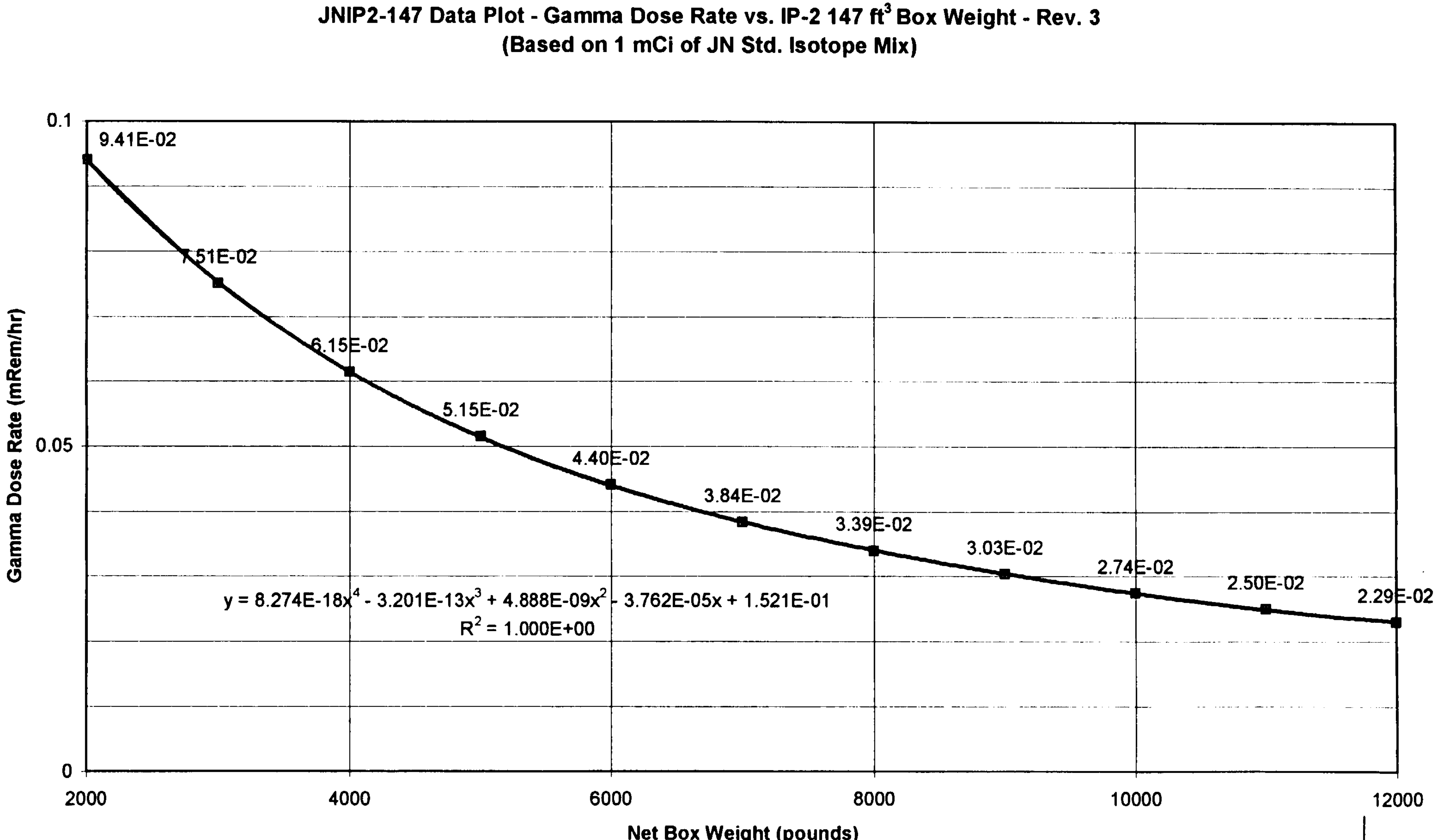
Source Dimensions

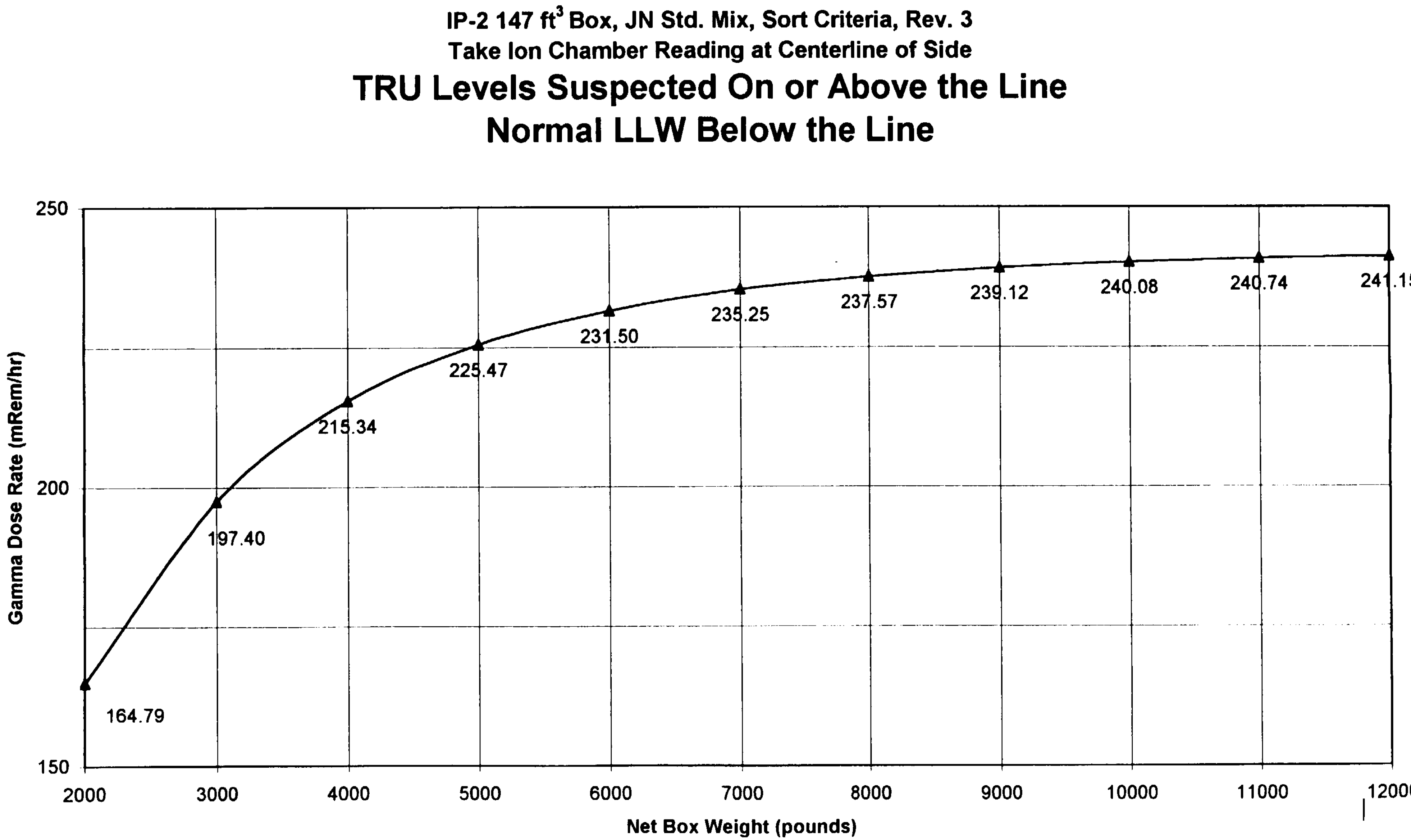
Length	139.7 cm	4 ft 7.0 in
Width	208.28 cm	6 ft 10.0 in
Height	143.51 cm	4 ft 8.5 in

Dose Points

	X	Y	Z
# 1	1.45e+02 cm	71.755 cm	104.14 cm
	4 ft 9.1 in	2 ft 4.2 in	3 ft 5.0 in




JNIP2-147 Data Plot - Gamma Dose Rate vs. IP-2 147 ft3 Box Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)
0.1
0.05
0
Gamma Dose Rate (mRem/hr)
9.41E-02
7.51E-02
6.15E-02
5.15E-02
4.40E-02
3.84E-02
3.39E-02
3.03E-02
2.74E-02
2.50E-02
2.29E-02
y = 8.274E-18x4 - 3.201E-13x3 + 4.888E-09x2 - 3.762E-05x + 1.521E-01
R2 = 1.000E+00
2000
4000
6000
8000
10000
12000
Net Box Weight (pounds)


IP-2 147 ft^3 Box, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line
Gamma Dose Rate (mRem/hr)
250
200
150
164.79
197.40
215.34
225.47
231.50
235.25
237.57
239.12
240.08
240.74
241.15
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
Net Box Weight (pounds)

IP-2 147 ft^3 Box, JN Std. Mix, Corrected
REV 3

y = 8.274E-18x4 - 3.201E-13x3 + 4.888E-09x2 -
3.762E-05x + 1.521E-01

Enter Container Number --------- -	1	2				
Enter Net Container Weight -----	4000	4000				
Enter Contact Dose Rate --------	105	359	0	0	0	0
Dose Rate for 1mCi mix ----------	0.061	0.061	0.000	0.000	0.000	0.000
mCi per container ------------------ -	1708.44	5841.22	0.00	0.00	0.00	0.00

Isotope	dist/mCi		dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	Total mCi	Uncertainty Range -30.8%	+30.8%
Sr-90	2.52E-01		430.526	1471.988	0.000	0.000	0.000	0.000	1902.514	1316.539	2488.488
Cs-137	3.83E-01		654.331	2237.188	0.000	0.000	0.000	0.000	2891.519	2000.931	3782.106
U-234	6.70E-06		1.1E-02	3.9E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.1E-02	0.035003	0.066162
U-235	9.80E-08		1.7E-04	5.7E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.4E-04	0.000512	0.000968
U-236	1.30E-06		2.2E-03	7.6E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.8E-03	0.006792	0.012837
U-238	1.88E-06		3.2E-03	1.1E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-02	0.009822	0.018565
Pu-238	1.40E-02	1.40E-02	23.918	81.777	0.000	0.000	0.000	0.000	105.695	73.14108	138.2493
Pu-239/40	5.00E-03	5.00E-03	8.542	29.206	0.000	0.000	0.000	0.000	37.748	26.12181	49.37476
Pu-241	3.10E-01		529.615	1810.779	0.000	0.000	0.000	0.000	2340.394	1619.552	3061.235
Am-241	1.20E-02	1.20E-02	20.501	70.095	0.000	0.000	0.000	0.000	90.596	62.69235	118.4994
Cm-244	1.00E-02		17.084	58.412	0.000	0.000	0.000	0.000	75.497	52.24363	98.74952
Co-60	1.30E-02		22.210	75.936	0.000	0.000	0.000	0.000	98.146	67.91672	128.3744
U-233	2.07E-10		0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.08E-06	2.04E-06
Pu-242	1.14E-05	1.14E-05	0.019	0.067	0.000	0.000	0.000	0.000	0.086	0.059558	0.112574
	SUM	TRUSUM									
Total mCi	9.99E-01	3.101E-02	1706.763	5835.506	0.000	0.000	0.000	0.000	7542.269	5219.25	9865.288
		TRUSUM	5.3E+01	1.8E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00			
		TRU nCi/g	29.200	99.837	0.000	0.000	0.000	0.000			

DD-98-04 Rev. 3

APPENDIX E

55 Gallon Drum Case

for

Low-Level Waste Sorting

Contents:

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

55 gal drum 50 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                              body data
  rcc    1   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.8382000D+02     3
                 .2857500D+02
  rcc    2   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.8382000D+02    12
                 .2905100D+02
  rpp    3  -.2000000D+03    .2000000D+03   -.2000000D+03    .2000000D+03   -.2000000D+03
.2000000D+03    21

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                              input zone data
  src    0      1      0      0      0      0      0      0      0      0   2   1
  can    0      2     -1      0      0      0      0      0      0      0   2   2
  air    0      3     -2      0      0      0      0      0      0      0   2   3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         1.0550E-01
     2         7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6472	0.015-1.75	4.4201E+02	1.5325E+00	5.5492E-01	8.5042E-01
1	.0300	0.025-0.035	6.2688E-15	1.0885E+00	1.8618E-18	2.0266E-18
2	.0400	0.035-0.045	1.5363E-07	1.1590E+00	2.7193E-11	3.1516E-11
3	.0600	0.055-0.070	6.2351E-03	1.3394E+00	7.4198E-07	9.9380E-07
4	.6000	0.550-0.700	4.0518E+02	1.5661E+00	4.7406E-01	7.4241E-01
5	1.0000	0.900-1.250	1.7558E+01	1.3992E+00	3.2306E-02	4.5202E-02
6	1.5000	1.250-1.750	1.9269E+01	1.2935E+00	4.8558E-02	6.2809E-02

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            55 gal drum 100 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***    rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***    rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
             .2857500D+02
  rcc    2   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02   12
             .2905100D+02
  rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   21

*** Input zones coincide with body zones
***    a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  can    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***    comp is the composition number
***    mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        2.1090E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm** 2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6481	0.015-1.75	3.7171E+02	1.6838E+00	4.6825E-01	7.8843E-01
1	.0300	0.025-0.035	2.7808E-15	1.0886E+00	8.2591E-19	8.9908E-19
2	.0400	0.035-0.045	7.5654E-08	1.1591E+00	1.3391E-11	1.5522E-11
3	.0600	0.055-0.070	3.1220E-03	1.3396E+00	3.7152E-07	4.9768E-07
4	.6000	0.550-0.700	3.3932E+02	1.7291E+00	3.9700E-01	6.8644E-01
5	1.0000	0.900-1.250	1.5240E+01	1.5147E+00	2.8042E-02	4.2475E-02
6	1.5000	1.250-1.750	1.7143E+01	1.3775E+00	4.3200E-02	5.9509E-02

```
          gad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
          55 gal drum 150 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                     body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
            .2857500D+02
  rcc    2   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02   12
            .2905100D+02
  rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                     input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  can    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        3.1640E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6493	0.015-1.75	3.1691E+02	1.8160E+00	4.0044E-01	7.2720E-01
1	.0300	0.025-0.035	1.7058E-15	1.0886E+00	5.0662E-19	5.5152E-19
2	.0400	0.035-0.045	4.9640E-08	1.1593E+00	8.7863E-12	1.0186E-11
3	.0600	0.055-0.070	2.0792E-03	1.3399E+00	2.4742E-07	3.3152E-07
4	.6000	0.550-0.700	2.8822E+02	1.8717E+00	3.3722E-01	6.3118E-01
5	1.0000	0.900-1.250	1.3346E+01	1.6194E+00	2.4557E-02	3.9767E-02
6	1.5000	1.250-1.750	1.5341E+01	1.4550E+00	3.8660E-02	5.6252E-02

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
          55 gal drum 200 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02     3
              .2857500D+02
  rcc    2   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    12
              .2905100D+02
  rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03    21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  can    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         4.2190E-01
     2         7.8600E+00

grp      mean        energy        direct beam  mean buildup          dose rate
no      energy    group limits       flux         factors      direct beam   with buildup
         mev          mev         photons/cm**                          mrem/hr
                                  2/sec
total    .6504    0.015-1.75      2.7370E+02    1.9294E+00     3.4677E-01    6.6906E-01

 1       .0300    0.025-0.035     1.1862E-15    1.0887E+00     3.5229E-19    3.8353E-19
 2       .0400    0.035-0.045     3.6614E-08    1.1594E+00     6.4806E-12    7.5137E-12
 3       .0600    0.055-0.070     1.5572E-03    1.3399E+00     1.8531E-07    2.4830E-07
 4       .6000    0.550-0.700     2.4810E+02    1.9940E+00     2.9028E-01    5.7882E-01
 5      1.0000    0.900-1.250     1.1788E+01    1.7127E+00     2.1690E-02    3.7148E-02
 6      1.5000    1.250-1.750     1.3810E+01    1.5255E+00     3.4801E-02    5.3091E-02
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

55 gal drum 250 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
             .2857500D+02
  rcc    2   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02   12
             .2905100D+02
  rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  can    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        5.2730E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6516	0.015-1.75	2.3923E+02	2.0253E+00	3.0381E-01	6.1530E-01
1	.0300	0.025-0.035	8.7783E-16	1.0887E+00	2.6071E-19	2.8385E-19
2	.0400	0.035-0.045	2.8772E-08	1.1595E+00	5.0926E-12	5.9051E-12
3	.0600	0.055-0.070	1.2438E-03	1.3400E+00	1.4801E-07	1.9833E-07
4	.6000	0.550-0.700	2.1623E+02	2.0971E+00	2.5299E-01	5.3056E-01
5	1.0000	0.900-1.250	1.0496E+01	1.7949E+00	1.9313E-02	3.4666E-02
6	1.5000	1.250-1.750	1.2502E+01	1.5893E+00	3.1505E-02	5.0070E-02

```
              gad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
              55 gal drum 300 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc    1    .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
              .2857500D+02
  rcc    2    .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02   12
              .2905100D+02
  rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  can    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         6.3280E-01
     2         7.8600E+00

 grp     mean       energy         direct beam   mean buildup          dose rate
 no     energy    group limits        flux         factors       direct beam   with buildup
         mev          mev         photons/cm**                           mrem/hr
                                  2/sec
 total   .6528    0.015-1.75      2.1133E+02    2.1057E+00       2.6893E-01    5.6629E-01

  1      .0300    0.025-0.035     6.7220E-16    1.0888E+00       1.9964E-19    2.1737E-19
  2      .0400    0.035-0.045     2.3504E-08    1.1597E+00       4.1603E-12    4.8246E-12
  3      .0600    0.055-0.070     1.0342E-03    1.3401E+00       1.2307E-07    1.6493E-07
  4      .6000    0.550-0.700     1.9054E+02    2.1833E+00       2.2293E-01    4.8674E-01
  5     1.0000    0.900-1.250     9.4151E+00    1.8670E+00       1.7324E-02    3.2344E-02
  6     1.5000    1.250-1.750     1.1376E+01    1.6465E+00       2.8668E-02    4.7204E-02
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
55 gal drum 350 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
 rcc    1  .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
            .2857500D+02
 rcc    2  .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02   12
            .2905100D+02
 rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
 src    0      1      0      0      0      0      0      0      0      0  z  1
 can    0      2     -1      0      0      0      0      0      0      0  z  2
 air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        7.3830E-01
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6539	0.015-1.75	1.8851E+02	2.1726E+00	2.4030E-01	5.2208E-01
1	.0300	0.025-0.035	5.2534E-16	1.0889E+00	1.5603E-19	1.6989E-19
2	.0400	0.035-0.045	1.9711E-08	1.1598E+00	3.4888E-12	4.0463E-12
3	.0600	0.055-0.070	8.8421E-04	1.3402E+00	1.0522E-07	1.4102E-07
4	.6000	0.550-0.700	1.6960E+02	2.2545E+00	1.9843E-01	4.4737E-01
5	1.0000	0.900-1.250	8.5047E+00	1.9295E+00	1.5649E-02	3.0194E-02
6	1.5000	1.250-1.750	1.0404E+01	1.6977E+00	2.6217E-02	4.4509E-02

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
55 gal drum 400 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
            .2857500D+02
  rcc    2   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02   12
            .2905100D+02
  rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                      input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  can    0     2    -1     0     0     0     0     0     0     0  z  2
  air    0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1        8.4370E-01
     2        7.8600E+00

grp     mean       energy        direct beam  mean buildup         dose rate
no     energy   group limits        flux        factors      direct beam  with buildup
        mev         mev         photons/cm**                         mrem/hr
                                2/sec
total   .6550   0.015-1.75      1.6964E+02   2.2278E+00      2.1657E-01   4.8248E-01

 1       .0300  0.025-0.035     4.1584E-16   1.0889E+00      1.2350E-19   1.3449E-19
 2       .0400  0.035-0.045     1.6840E-08   1.1600E+00      2.9807E-12   3.4575E-12
 3       .0600  0.055-0.070     7.7152E-04   1.3403E+00      9.1811E-08   1.2306E-07
 4       .6000  0.550-0.700     1.5235E+02   2.3128E+00      1.7825E-01   4.1226E-01
 5      1.0000  0.900-1.250     7.7324E+00   1.9835E+00      1.4228E-02   2.8220E-02
 6      1.5000  1.250-1.750     9.5599E+00   1.7431E+00      2.4091E-02   4.1994E-02
```

```
           qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
           55 gal drum 450 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                      body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
            .2857500D+02
  rcc    2   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02   12
            .2905100D+02
  rpp    3  -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03   21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                      input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  can    0      2     -1      0      0      0      0      0      0      0  z  2
  air    0      3     -2      0      0      0      0      0      0      0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       fe
     1          9.4920E-01
     2          7.8600E+00

grp      mean        energy        direct beam   mean buildup          dose rate
no      energy    group limits        flux          factors      direct beam   with buildup
         mev          mev         photons/cm**                           mrem/hr
                                  2/sec
total    .6559    0.015-1.75      1.5385E+02    2.2733E+00       1.9665E-01    4.4705E-01

 1       .0300    0.025-0.035     3.3171E-16    1.0890E+00       9.8517E-20    1.0728E-19
 2       .0400    0.035-0.045     1.4581E-08    1.1601E+00       2.5809E-12    2.9941E-12
 3       .0600    0.055-0.070     6.8355E-04    1.3405E+00       8.1342E-08    1.0904E-07
 4       .6000    0.550-0.700     1.3796E+02    2.3603E+00       1.6141E-01    3.8098E-01
 5      1.0000    0.900-1.250     7.0714E+00    2.0298E+00       1.3011E-02    2.6410E-02
 6      1.5000    1.250-1.750     8.8226E+00    1.7834E+00       2.2233E-02    3.9651E-02
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

55 gal drum 500 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    3
             .2857500D+02
  rcc    2   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.8382000D+02    12
             .2905100D+02
  rpp    3 -.2000000D+03   .2000000D+03  -.2000000D+03   .2000000D+03  -.2000000D+03
.2000000D+03    21

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src   0     1     0     0     0     0     0     0     0     0  z  1
  can   0     2    -1     0     0     0     0     0     0     0  z  2
  air   0     3    -2     0     0     0     0     0     0     0  z  3

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        1.0547E+00
     2        7.8600E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6568	0.015-1.75	1.4051E+02	2.3106E+00	1.7979E-01	4.1543E-01
1	.0300	0.025-0.035	2.6594E-16	1.0891E+00	7.8984E-20	8.6018E-20
2	.0400	0.035-0.045	1.2755E-08	1.1603E+00	2.2576E-12	2.6195E-12
3	.0600	0.055-0.070	6.1295E-04	1.3406E+00	7.2941E-08	9.7786E-08
4	.6000	0.550-0.700	1.2583E+02	2.3990E+00	1.4722E-01	3.5319E-01
5	1.0000	0.900-1.250	6.5022E+00	2.0695E+00	1.1964E-02	2.4759E-02
6	1.5000	1.250-1.750	8.1762E+00	1.8189E+00	2.0604E-02	3.7477E-02

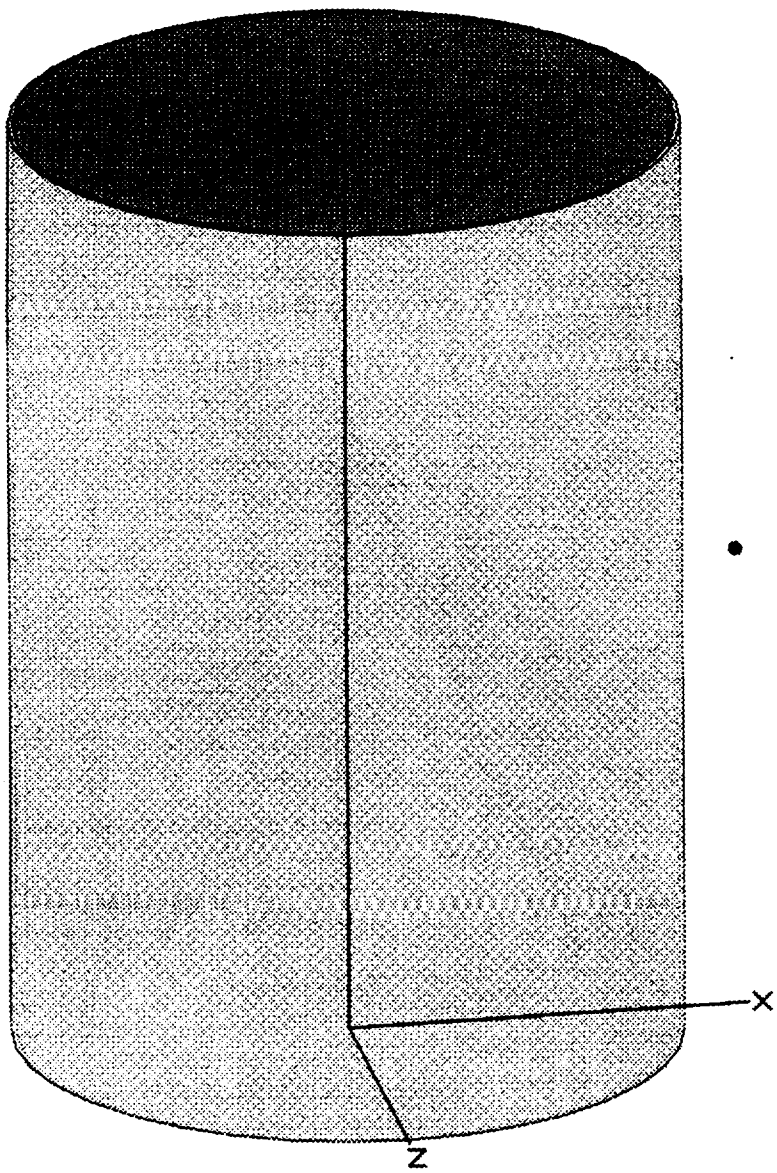
Description: 55 Gal Drum 22.5" dia X 33"tall ID, 1mCi JN Std
Geometry: 7 - Cylinder Volume - Side Shields

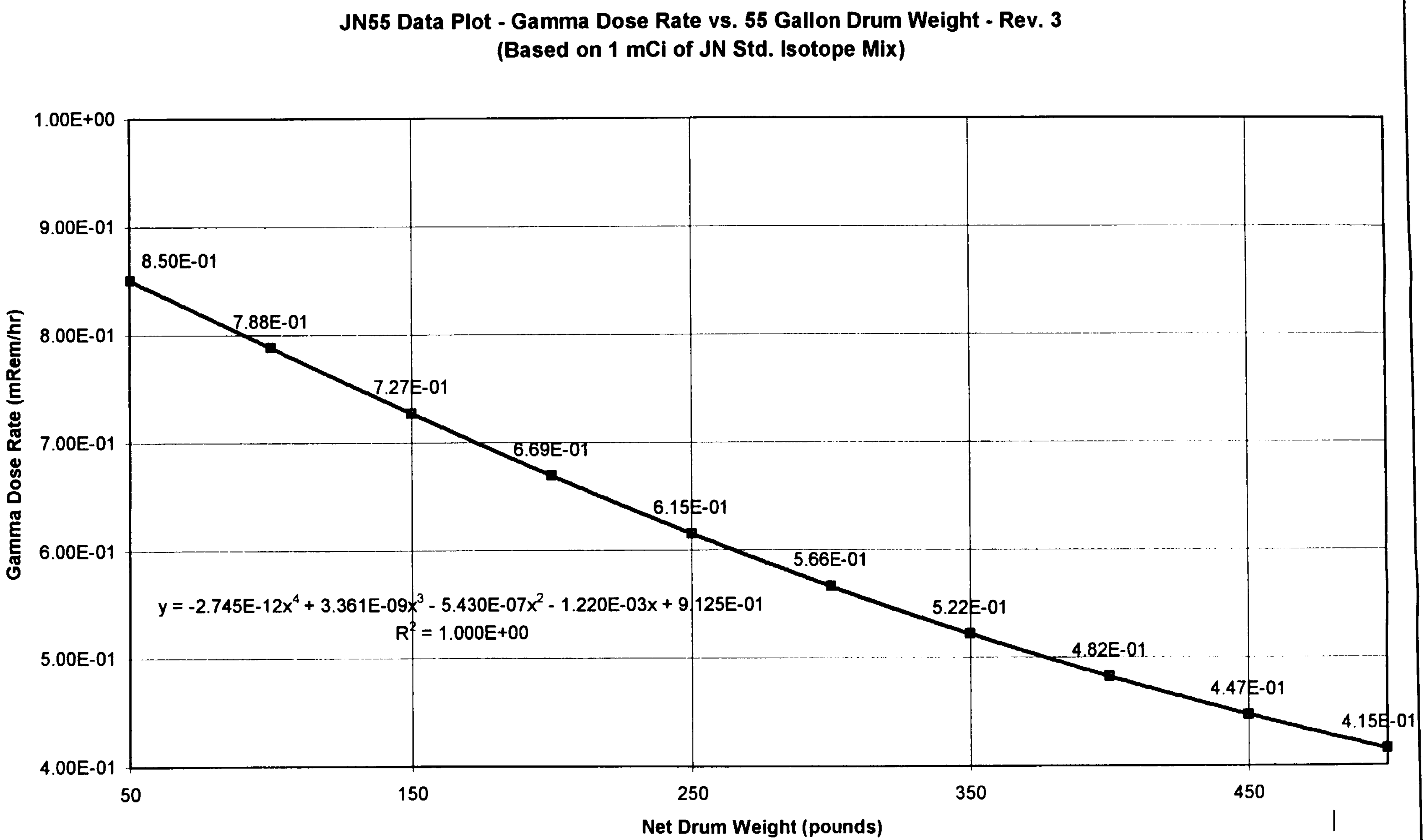
Source Dimensions

Height	83.82 cm	2 ft 9.0 in
Radius	28.575 cm	11.3 in

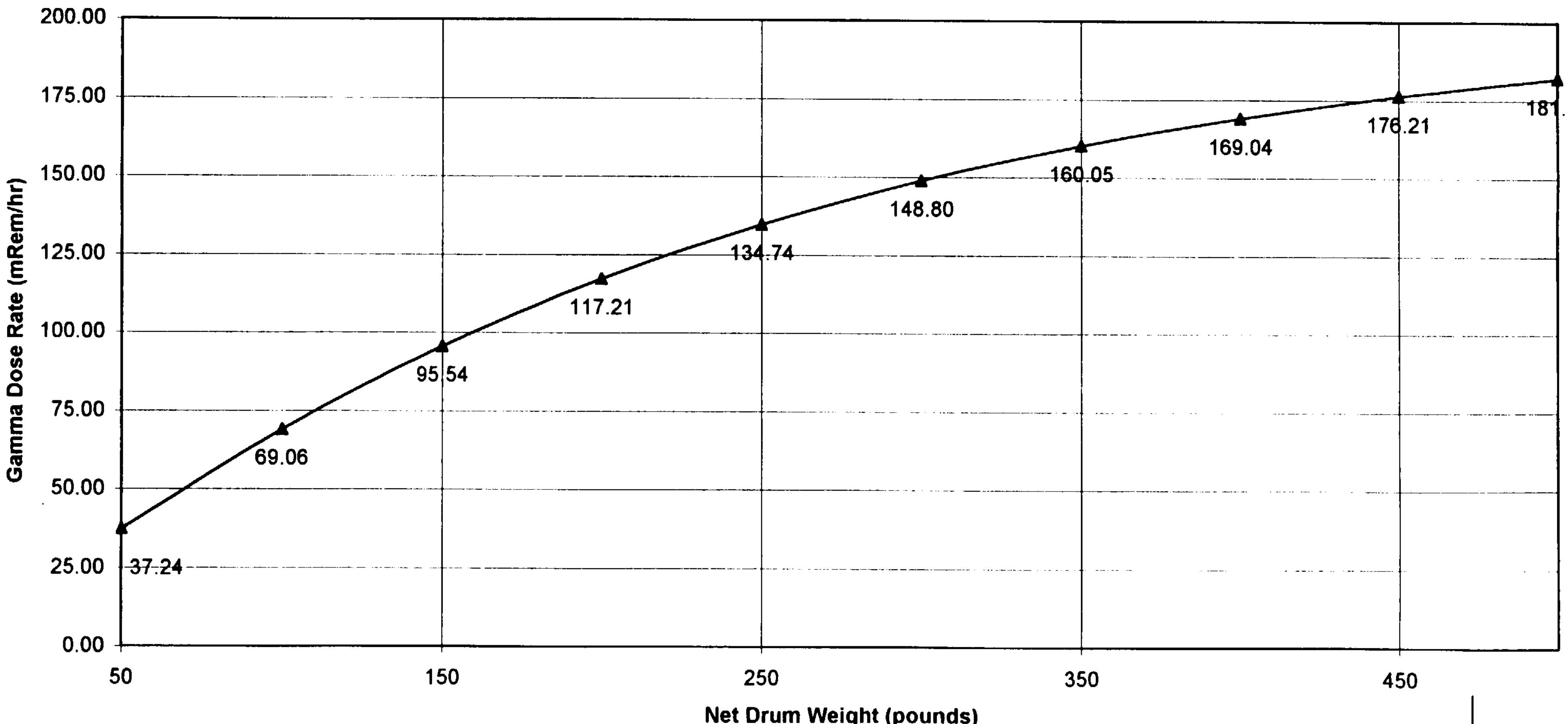
Dose Points

	X	Y	Z
# 1	34.13125 cm	41.91 cm	0 cm
	1 ft 1.4 in	1 ft 4.5 in	0.0 in




JN55 Data Plot - Gamma Dose Rate vs. 55 Gallon Drum Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
Gamma Dose Rate (mRem/hr)
8.50E-01
7.88E-01
7.27E-01
6.69E-01
6.15E-01
5.66E-01
5.22E-01
4.82E-01
4.47E-01
4.15E-01
y = -2.745E-12x^4 + 3.361E-09x^3 - 5.430E-07x^2 - 1.220E-03x + 9.125E-01
R^2 = 1.000E+00
50
150
250
350
450
Net Drum Weight (pounds)

55 Gallon Drum, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line



55 Gal Drum LLW, JN Std. Mix, Corrected
REV 3

y = -2.745E-12x4 + 3.361E-09x3 - 5.430E-07x2 -
1.220E-03x + 9.125E-01

Enter Container Number --------- -			1	2						
Enter Net Container Weight -----			250	250						
Enter Contact Dose Rate --------			66	600	0	0	0	0		
Dose Rate for 1mCi mix ----------			0.615	0.615	0.000	0.000	0.000	0.000		
mCi per container ----------------- -			107.26	975.05	0.00	0.00	0.00	0.00		
									Uncertainty Range	
Isotope	dist/mCi		dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	dist--mCi	Total mCi	-30.8%	+30.8%
Sr-90	2.52E-01		27.028	245.712	0.000	0.000	0.000	0.000	272.740	188.736	356.7438
Cs-137	3.83E-01		41.079	373.443	0.000	0.000	0.000	0.000	414.521	286.8488	542.194
U-234	6.70E-06		7.2E-04	6.5E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.3E-03	0.005018	0.009485
U-235	9.80E-08		1.1E-05	9.6E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E-04	7.34E-05	0.000139
U-236	1.30E-06		1.4E-04	1.3E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-03	0.000974	0.00184
U-238	1.88E-06		2.0E-04	1.8E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-03	0.001408	0.002661
Pu-238	1.40E-02	1.40E-02	1.502	13.651	0.000	0.000	0.000	0.000	15.152	10.48533	19.8191
Pu-239/40	5.00E-03	5.00E-03	0.536	4.875	0.000	0.000	0.000	0.000	5.412	3.744762	7.07825
Pu-241	3.10E-01		33.249	302.264	0.000	0.000	0.000	0.000	335.513	232.1753	438.8515
Am-241	1.20E-02	1.20E-02	1.287	11.701	0.000	0.000	0.000	0.000	12.988	8.98743	16.9878
Cm-244	1.00E-02		1.073	9.750	0.000	0.000	0.000	0.000	10.823	7.489525	14.1565
Co-60	1.30E-02		1.394	12.676	0.000	0.000	0.000	0.000	14.070	9.736382	18.40345
U-233	2.07E-10		0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.55E-07	2.93E-07
Pu-242	1.14E-05	1.14E-05	0.001	0.011	0.000	0.000	0.000	0.000	0.012	0.008538	0.016138
	SUM	TRUSUM									
Total mCi	9.99E-01	3.101E-02	107.150	974.092	0.000	0.000	0.000	0.000	1081.242	748.2195	1414.265
		TRUSUM	3.3E+00	3.0E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00			
		TRU nCi/g	29.502	99.958	0.000	0.000	0.000	0.000			

DD-98-04 Rev. 3

APPENDIX F

Miscellaneous Metal Cases

Contents:

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
              Small Metal Form, 5 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z
                                                        .
                                                       body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         8.1600E-02
     2         0.0000E+00

 grp     mean       energy        direct beam  mean buildup        dose rate
 no     energy   group limits        flux        factors     direct beam  with buildup
         mev         mev         photons/cm**                       mrem/hr
                                 2/sec
 total   .6383    0.015-1.75     3.1970E+03   1.0550E+00     3.9313E+00   4.1475E+00

  1      .0300    0.025-0.035    1.4784E+01   1.0238E+00     4.3909E-03   4.4956E-03
  2      .0400    0.035-0.045    7.7828E+00   1.0473E+00     1.3776E-03   1.4427E-03
  3      .0600    0.055-0.070    1.6369E+01   1.1020E+00     1.9479E-03   2.1466E-03
  4      .6000    0.550-0.700    2.9321E+03   1.0579E+00     3.4306E+00   3.6291E+00
  5     1.0000    0.900-1.250    1.1238E+02   1.0412E+00     2.0679E-01   2.1531E-01
  6     1.5000    1.250-1.750    1.1359E+02   1.0309E+00     2.8624E-01   2.9508E-01
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Metal Form, 10 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02   3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00   -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                  input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
      1        1.6310E-01
      2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6417	0.015-1.75	2.9636E+03	1.1096E+00	3.6648E+00	4.0665E+00
1	.0300	0.025-0.035	7.1688E+00	1.0253E+00	2.1291E-03	2.1829E-03
2	.0400	0.035-0.045	3.9317E+00	1.0491E+00	6.9591E-04	7.3006E-04
3	.0600	0.055-0.070	9.4403E+00	1.1178E+00	1.1234E-03	1.2557E-03
4	.6000	0.550-0.700	2.7285E+03	1.1154E+00	3.1924E+00	3.5609E+00
5	1.0000	0.900-1.250	1.0616E+02	1.0825E+00	1.9534E-01	2.1146E-01
6	1.5000	1.250-1.750	1.0839E+02	1.0618E+00	2.7315E-01	2.9003E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
Small Metal Form, 15 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                             body data
 rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
            .1524000D+02
 rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
            .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                             input zone data
 src    0      1      0      0      0      0      0      0      0      0  1  1
 air    0      2     -1      0      0      0      0      0      0      0  1  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1       2.4470E-01
     2       0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6431	0.015-1.75	2.7625E+03	1.1626E+00	3.4258E+00	3.9828E+00
1	.0300	0.025-0.035	4.5644E+00	1.0268E+00	1.3556E-03	1.3919E-03
2	.0400	0.035-0.045	2.5966E+00	1.0504E+00	4.5960E-04	4.8277E-04
3	.0600	0.055-0.070	6.4883E+00	1.1223E+00	7.7211E-04	8.6654E-04
4	.6000	0.550-0.700	2.5449E+03	1.1713E+00	2.9775E+00	3.4876E+00
5	1.0000	0.900-1.250	1.0043E+02	1.1230E+00	1.8479E-01	2.0751E-01
6	1.5000	1.250-1.750	1.0353E+02	1.0921E+00	2.6090E-01	2.8493E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Metal Form, 20 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       fe
     1          3.2630E-01
     2          0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6439	0.015-1.75	2.5833E+03	1.2134E+00	3.2100E+00	3.8949E+00
1	.0300	0.025-0.035	3.2432E+00	1.0282E+00	9.6323E-04	9.9043E-04
2	.0400	0.035-0.045	1.9194E+00	1.0517E+00	3.3974E-04	3.5730E-04
3	.0600	0.055-0.070	4.9093E+00	1.1244E+00	5.8421E-04	6.5687E-04
4	.6000	0.550-0.700	2.3791E+03	1.2249E+00	2.7836E+00	3.4096E+00
5	1.0000	0.900-1.250	9.5143E+01	1.1622E+00	1.7506E-01	2.0346E-01
6	1.5000	1.250-1.750	9.8987E+01	1.1216E+00	2.4945E-01	2.7979E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Metal Form, 25 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                         body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02     3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03    12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                         input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        4.0780E-01
     2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6445	0.015-1.75	2.4221E+03	1.2618E+00	3.0145E+00	3.8036E+00
1	.0300	0.025-0.035	2.4452E+00	1.0297E+00	7.2622E-04	7.4776E-04
2	.0400	0.035-0.045	1.5092E+00	1.0530E+00	2.6713E-04	2.8129E-04
3	.0600	0.055-0.070	3.9382E+00	1.1256E+00	4.6864E-04	5.2750E-04
4	.6000	0.550-0.700	2.2292E+03	1.2760E+00	2.6082E+00	3.3281E+00
5	1.0000	0.900-1.250	9.0265E+01	1.2001E+00	1.6609E-01	1.9932E-01
6	1.5000	1.250-1.750	9.4736E+01	1.1503E+00	2.3873E-01	2.7461E-01

```
            qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
            Small Metal Form, 30 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        4.8940E-01
     2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6450	0.015-1.75	2.2761E+03	1.3078E+00	2.8367E+00	3.7098E+00
1	.0300	0.025-0.035	1.9117E+00	1.0310E+00	5.6779E-04	5.8541E-04
2	.0400	0.035-0.045	1.2330E+00	1.0543E+00	2.1824E-04	2.3009E-04
3	.0600	0.055-0.070	3.2802E+00	1.1269E+00	3.9034E-04	4.3986E-04
4	.6000	0.550-0.700	2.0932E+03	1.3246E+00	2.4491E+00	3.2440E+00
5	1.0000	0.900-1.250	8.5747E+01	1.2366E+00	1.5778E-01	1.9511E-01
6	1.5000	1.250-1.750	9.0747E+01	1.1781E+00	2.2868E-01	2.6941E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Metal Form, 40 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                            body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                            input zone data
  src    0      1      0      0      0      0      0      0      0      0  1  1
  air    0      2     -1      0      0      0      0      0      0      0  2  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
      1        6.5250E-01
      2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6460	0.015-1.75	2.0230E+03	1.3924E+00	2.5272E+00	3.5189E+00
1	.0300	0.025-0.035	1.2508E+00	1.0336E+00	3.7149E-04	3.8397E-04
2	.0400	0.035-0.045	8.8443E-01	1.0569E+00	1.5654E-04	1.6546E-04
3	.0600	0.055-0.070	2.4483E+00	1.1290E+00	2.9135E-04	3.2893E-04
4	.6000	0.550-0.700	1.8573E+03	1.4139E+00	2.1730E+00	3.0724E+00
5	1.0000	0.900-1.250	7.7700E+01	1.3052E+00	1.4297E-01	1.8660E-01
6	1.5000	1.250-1.750	8.3498E+01	1.2309E+00	2.1041E-01	2.5899E-01

```
             qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
             Small Metal Form, 50 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                 body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
            .1524000D+02
  rcc     2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
            .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                 input zone data
  src     0     1     0     0     0     0     0     0     0     0  z  1
  air     0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        8.1560E-01
     2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6468	0.015-1.75	1.8122E+03	1.4675E+00	2.2683E+00	3.3286E+00
1	.0300	0.025-0.035	8.6477E-01	1.0359E+00	2.5684E-04	2.6606E-04
2	.0400	0.035-0.045	6.7326E-01	1.0595E+00	1.1917E-04	1.2626E-04
3	.0600	0.055-0.070	1.9436E+00	1.1311E+00	2.3128E-04	2.6161E-04
4	.6000	0.550-0.700	1.6608E+03	1.4930E+00	1.9432E+00	2.9012E+00
5	1.0000	0.900-1.250	7.0767E+01	1.3679E+00	1.3021E-01	1.7812E-01
6	1.5000	1.250-1.750	7.7101E+01	1.2799E+00	1.9429E-01	2.4867E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Small Metal Form, 60 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                               body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.3810000D+02    3
            .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
            .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                               input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        9.7880E-01
     2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6477	0.015-1.75	1.6349E+03	1.5335E+00	2.0499E+00	3.1435E+00
1	.0300	0.025-0.035	6.1817E-01	1.0380E+00	1.8360E-04	1.9058E-04
2	.0400	0.035-0.045	5.3176E-01	1.0619E+00	9.4122E-05	9.9952E-05
3	.0600	0.055-0.070	1.6041E+00	1.1333E+00	1.9088E-04	2.1634E-04
4	.6000	0.550-0.700	1.4959E+03	1.5625E+00	1.7502E+00	2.7347E+00
5	1.0000	0.900-1.250	6.4760E+01	1.4248E+00	1.1916E-01	1.6978E-01
6	1.5000	1.250-1.750	7.1432E+01	1.3251E+00	1.8001E-01	2.3853E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Cylindrical Form, 10 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        6.8000E-02
     2        0.0000E+00

 grp     mean      energy        direct beam  mean buildup          dose rate
 no     energy   group limits       flux        factors      direct beam  with buildup
         mev        mev          photons/cm**                         mrem/hr
                                 2/sec
 total   .6388   0.015-1.75      1.7767E+03   1.0609E+00     2.1867E+00   2.3198E+00

  1      .0300   0.025-0.035     7.5280E+00   1.0238E+00     2.2358E-03   2.2889E-03
  2      .0400   0.035-0.045     3.9733E+00   1.0475E+00     7.0327E-04   7.3669E-04
  3      .0600   0.055-0.070     8.5660E+00   1.1048E+00     1.0194E-03   1.1262E-03
  4      .6000   0.550-0.700     1.6307E+03   1.0640E+00     1.9079E+00   2.0301E+00
  5     1.0000   0.900-1.250     6.2605E+01   1.0456E+00     1.1519E-01   1.2045E-01
  6     1.5000   1.250-1.750     6.3345E+01   1.0342E+00     1.5963E-01   1.6509E-01
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Cylindrical Form, 20 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  2  1
  air    0      2     -1      0      0      0      0      0      0      0  2  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1       1.3600E-01
     2       0.0000E+00

grp     mean       energy        direct beam  mean buildup          dose rate
no     energy    group limits       flux        factors       direct beam  with buildup
        mev          mev         photons/cm**                          mrem/hr
                                 2/sec
total   .6420    0.015-1.75      1.6359E+03   1.1211E+00      2.0243E+00   2.2694E+00

 1      .0300    0.025-0.035     3.6618E+00   1.0249E+00      1.0875E-03   1.1147E-03
 2      .0400    0.035-0.045     2.0006E+00   1.0490E+00      3.5410E-04   3.7146E-04
 3      .0600    0.055-0.070     4.8450E+00   1.1190E+00      5.7656E-04   6.4518E-04
 4      .6000    0.550-0.700     1.5064E+03   1.1275E+00      1.7625E+00   1.9873E+00
 5     1.0000    0.900-1.250     5.8794E+01   1.0912E+00      1.0818E-01   1.1805E-01
 6     1.5000    1.250-1.750     6.0155E+01   1.0683E+00      1.5159E-01   1.6195E-01
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Cylindrical Form, 30 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                          body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                          input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         2.0400E-01
     2         0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6433	0.015-1.75	1.5152E+03	1.1789E+00	1.8803E+00	2.2166E+00
1	.0300	0.025-0.035	2.3499E+00	1.0261E+00	6.9792E-04	7.1615E-04
2	.0400	0.035-0.045	1.3225E+00	1.0501E+00	2.3408E-04	2.4580E-04
3	.0600	0.055-0.070	3.3120E+00	1.1228E+00	3.9412E-04	4.4250E-04
4	.6000	0.550-0.700	1.3957E+03	1.1885E+00	1.6330E+00	1.9408E+00
5	1.0000	0.900-1.250	5.5317E+01	1.1356E+00	1.0178E-01	1.1558E-01
6	1.5000	1.250-1.750	5.7196E+01	1.1016E+00	1.4413E-01	1.5877E-01

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
          Cylindrical Form, 40 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                   body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02    3
              .1524000D+02
  rcc     2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
              .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                   input zone data
  src     0      1      0      0      0      0      0      0      0      0  2  1
  air     0      2     -1      0      0      0      0      0      0      0  2  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         2.7200E-01
     2         0.0000E+00

grp     mean       energy          direct beam  mean buildup         dose rate
no      energy   group limits        flux         factors       direct beam  with buildup
        mev          mev         photons/cm**                         mrem/hr
                                 2/sec
total   .6441    0.015-1.75      1.4086E+03   1.2339E+00       1.7515E+00   2.1611E+00

  1     .0300    0.025-0.035     1.6870E+00   1.0273E+00       5.0105E-04   5.1474E-04
  2     .0400    0.035-0.045     9.7942E-01   1.0511E+00       1.7336E-04   1.8222E-04
  3     .0600    0.055-0.070     2.5016E+00   1.1245E+00       2.9769E-04   3.3476E-04
  4     .6000    0.550-0.700     1.2969E+03   1.2466E+00       1.5174E+00   1.8915E+00
  5    1.0000    0.900-1.250     5.2139E+01   1.1783E+00       9.5935E-02   1.1304E-01
  6    1.5000    1.250-1.750     5.4447E+01   1.1339E+00       1.3721E-01   1.5557E-01
```

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Cylindrical Form, 50 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        3.4000E-01
     2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6448	0.015-1.75	1.3135E+03	1.2860E+00	1.6359E+00	2.1036E+00
1	.0300	0.025-0.035	1.2867E+00	1.0285E+00	3.8216E-04	3.9306E-04
2	.0400	0.035-0.045	7.7194E-01	1.0522E+00	1.3663E-04	1.4376E-04
3	.0600	0.055-0.070	2.0046E+00	1.1256E+00	2.3855E-04	2.6852E-04
4	.6000	0.550-0.700	1.2083E+03	1.3015E+00	1.4138E+00	1.8400E+00
5	1.0000	0.900-1.250	4.9227E+01	1.2194E+00	9.0578E-02	1.1045E-01
6	1.5000	1.250-1.750	5.1893E+01	1.1650E+00	1.3077E-01	1.5235E-01

```
              qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
              Cylindrical Form, 60 lb, 1 mCi, Iron Source

*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                    body data
  rcc     1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02    3
              .1524000D+02
  rcc     2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
              .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                    input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       fe
     1          4.0790E-01
     2          0.0000E+00

 grp     mean       energy        direct beam  mean buildup          dose rate
 no     energy    group limits       flux        factors      direct beam  with buildup
         mev          mev        photons/cm**                          mrem/hr
                                 2/sec
 total   .6453    0.015-1.75     1.2283E+03   1.3349E+00     1.5319E+00   2.0449E+00

  1      .0300    0.025-0.035    1.0195E+00   1.0297E+00     3.0279E-04   3.1178E-04
  2      .0400    0.035-0.045    6.3293E-01   1.0532E+00     1.1203E-04   1.1799E-04
  3      .0600    0.055-0.070    1.6699E+00   1.1266E+00     1.9872E-04   2.2389E-04
  4      .6000    0.550-0.700    1.1289E+03   1.3532E+00     1.3208E+00   1.7873E+00
  5     1.0000    0.900-1.250    4.6561E+01   1.2586E+00     8.5673E-02   1.0782E-01
  6     1.5000    1.250-1.750    4.9519E+01   1.1949E+00     1.2479E-01   1.4912E-01
```

qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000

Cylindrical Form, 70 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rcc     1    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.9144000D+02     3
             .1524000D+02
  rcc     2    .0000000D+00    .0000000D+00   -.1000000D+02    .0000000D+00    .0000000D+00
.1000000D+03    12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src     0      1      0      0      0      0      0      0      0      0  z  1
  air     0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat       fe
      1         4.7590E-01
      2         0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6458	0.015-1.75	1.1515E+03	1.3809E+00	1.4379E+00	1.9856E+00
1	.0300	0.025-0.035	8.2844E-01	1.0308E+00	2.4605E-04	2.5363E-04
2	.0400	0.035-0.045	5.3296E-01	1.0543E+00	9.4333E-05	9.9456E-05
3	.0600	0.055-0.070	1.4286E+00	1.1275E+00	1.7000E-04	1.9168E-04
4	.6000	0.550-0.700	1.0573E+03	1.4017E+00	1.2371E+00	1.7340E+00
5	1.0000	0.900-1.250	4.4108E+01	1.2960E+00	8.1159E-02	1.0518E-01
6	1.5000	1.250-1.750	4.7303E+01	1.2238E+00	1.1920E-01	1.4588E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Cylindrical Form, 80 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0     1     0     0     0     0     0     0     0     0  z  1
  air    0     2    -1     0     0     0     0     0     0     0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
     1        5.4390E-01
     2        0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6463	0.015-1.75	1.0821E+03	1.4241E+00	1.3528E+00	1.9265E+00
1	.0300	0.025-0.035	6.8573E-01	1.0319E+00	2.0366E-04	2.1016E-04
2	.0400	0.035-0.045	4.5766E-01	1.0554E+00	8.1005E-05	8.5491E-05
3	.0600	0.055-0.070	1.2466E+00	1.1284E+00	1.4834E-04	1.6739E-04
4	.6000	0.550-0.700	9.9262E+02	1.4473E+00	1.1614E+00	1.6808E+00
5	1.0000	0.900-1.250	4.1851E+01	1.3316E+00	7.7005E-02	1.0254E-01
6	1.5000	1.250-1.750	4.5237E+01	1.2515E+00	1.1400E-01	1.4267E-01

```
qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Cylindrical Form, 90 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rcc    1   .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00    .0000000D+00
.9144000D+02    3
             .1524000D+02
  rcc    2   .0000000D+00    .0000000D+00   -.1000000D+02    .0000000D+00    .0000000D+00
.1000000D+03   12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat     fe
      1       6.1190E-01
      2       0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate direct beam mrem/hr	dose rate with buildup mrem/hr
total	.6468	0.015-1.75	1.0192E+03	1.4643E+00	1.2755E+00	1.8678E+00
1	.0300	0.025-0.035	5.7554E-01	1.0330E+00	1.7093E-04	1.7657E-04
2	.0400	0.035-0.045	3.9889E-01	1.0564E+00	7.0603E-05	7.4588E-05
3	.0600	0.055-0.070	1.1044E+00	1.1293E+00	1.3143E-04	1.4842E-04
4	.6000	0.550-0.700	9.3408E+02	1.4896E+00	1.0929E+00	1.6280E+00
5	1.0000	0.900-1.250	3.9769E+01	1.3655E+00	7.3175E-02	9.9918E-02
6	1.5000	1.250-1.750	4.3307E+01	1.2780E+00	1.0913E-01	1.3948E-01

```
          qad-cggp 95.1 (95-02-01) -- run date: 02/13/2000
```

Cylindrical Form, 100 lb, 1 mCi, Iron Source

```
*** Body Data Format (cm)
***   rcc -- cylinder: bottom x, y, z  top x, y, z  radius
***   rpp -- box: min x, max x, min y, max y, min z, max z

                                                        body data
  rcc    1   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00   .0000000D+00
.9144000D+02     3
             .1524000D+02
  rcc    2   .0000000D+00   .0000000D+00  -.1000000D+02   .0000000D+00   .0000000D+00
.1000000D+03    12
             .1000000D+03

*** Input zones coincide with body zones
***   a ' - ' indicates that this zone is excluded from the input zone

                                                        input zone data
  src    0      1      0      0      0      0      0      0      0      0  z  1
  air    0      2     -1      0      0      0      0      0      0      0  z  2

***   comp is the composition number
***   mat is the density (g/cm^3) of the element in this composition
 comp/mat      fe
     1         6.7990E-01
     2         0.0000E+00
```

grp no	mean energy mev	energy group limits mev	direct beam flux photons/cm**2/sec	mean buildup factors	dose rate mrem/hr direct beam	dose rate mrem/hr with buildup
total	.6472	0.015-1.75	9.6210E+02	1.5018E+00	1.2052E+00	1.8100E+00
1	.0300	0.025-0.035	4.8827E-01	1.0340E+00	1.4502E-04	1.4995E-04
2	.0400	0.035-0.045	3.5174E-01	1.0575E+00	6.2258E-05	6.5838E-05
3	.0600	0.055-0.070	9.9030E-01	1.1302E+00	1.1785E-04	1.3318E-04
4	.6000	0.550-0.700	8.8092E+02	1.5291E+00	1.0307E+00	1.5760E+00
5	1.0000	0.900-1.250	3.7848E+01	1.3975E+00	6.9640E-02	9.7324E-02
6	1.5000	1.250-1.750	4.1502E+01	1.3034E+00	1.0459E-01	1.3632E-01

Description: Small Metal Form 12"dia X 15" tall, 1 mCi JN Std

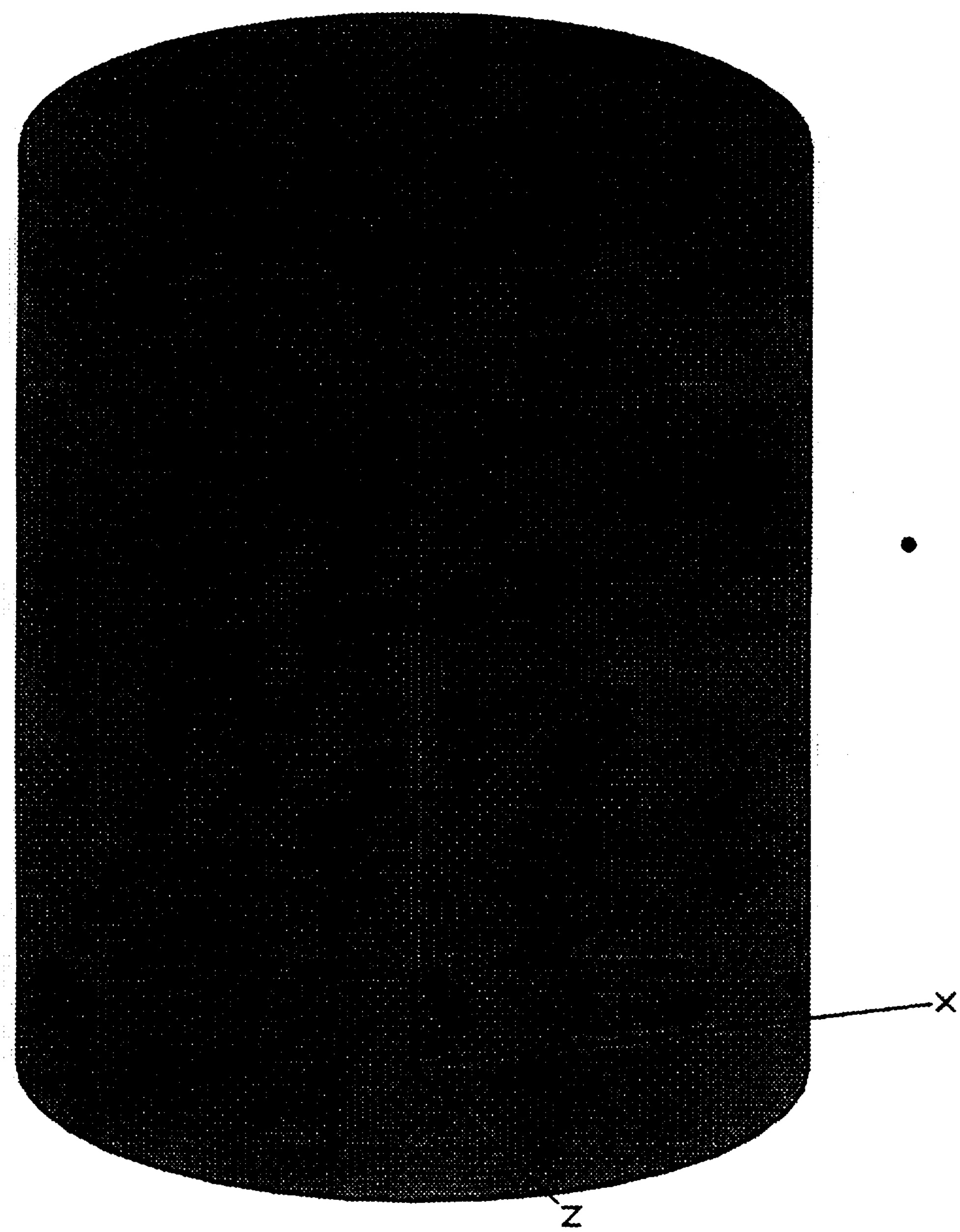
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	38.1 cm	1 ft 3.0 in
Radius	15.24 cm	6.0 in

Dose Points

	X	Y	Z
# 1	20.32 cm	19.05 cm	0 cm
	8.0 in	7.5 in	0.0 in



Description: Small Metal Form 12"dia X 15" tall, 1 mCi JN Std

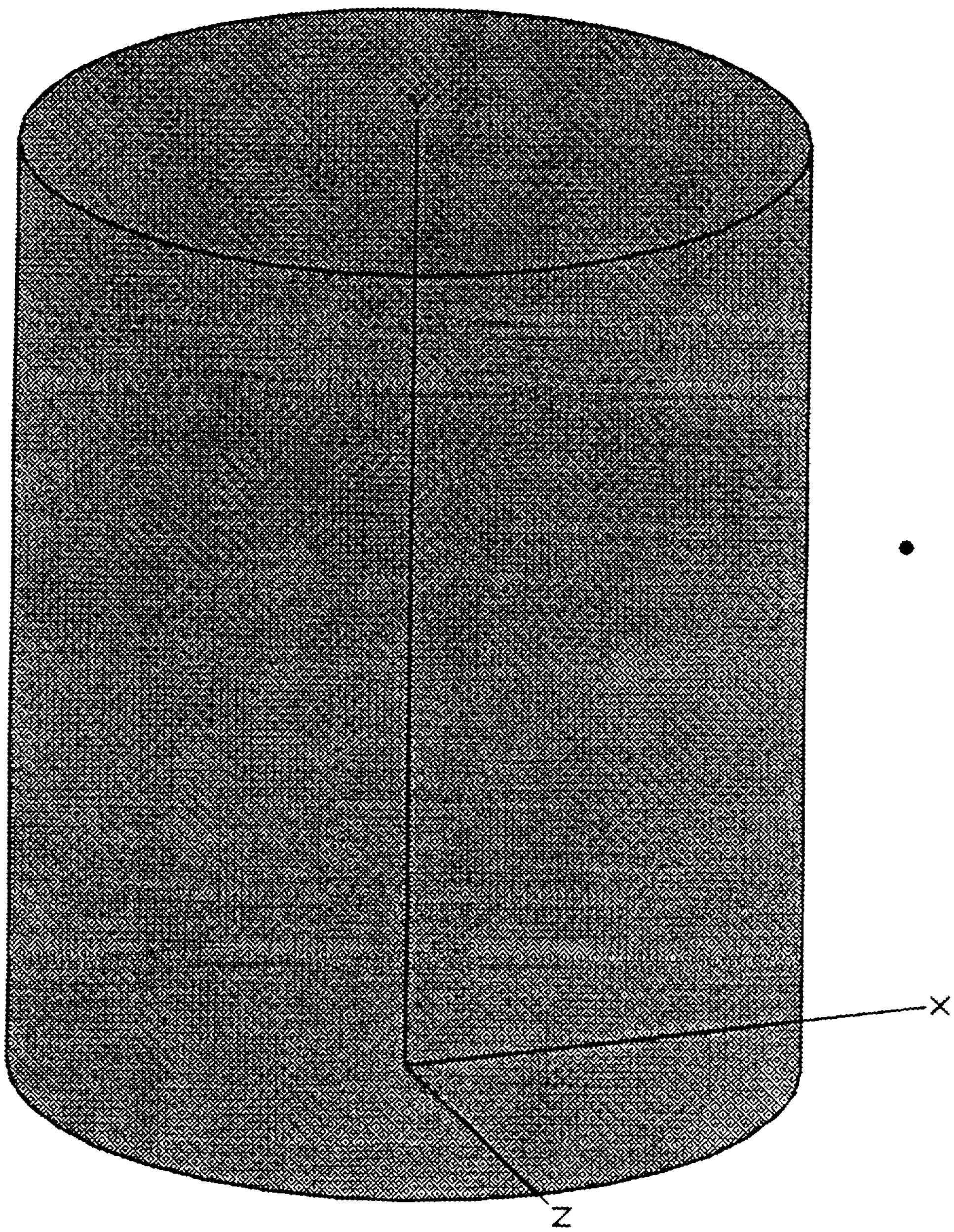
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	38.1 cm	1 ft 3.0 in
Radius	15.24 cm	6.0 in

Dose Points

	X	Y	Z
# 1	20.32 cm	19.05 cm	0 cm
	8.0 in	7.5 in	0.0 in



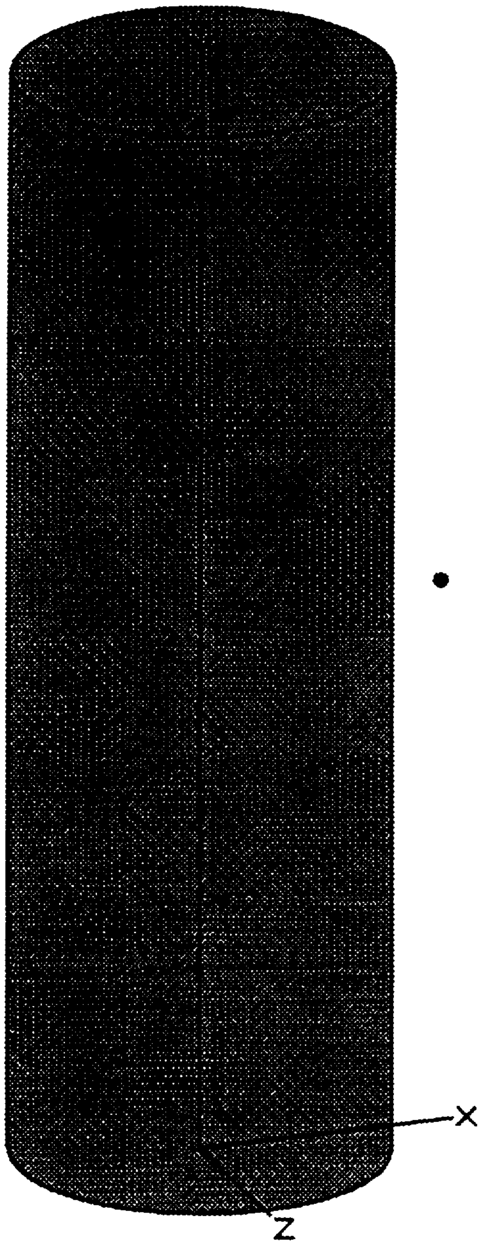
Description: Cylindrical Form 12" diam X 36" tall, 1 mCi JN Std
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	91.44 cm	3 ft
Radius	15.24 cm	6.0 in

Dose Points

	X	Y	Z
# 1	20.32 cm	45.72 cm	0 cm
	8.0 in	1 ft 6.0 in	0.0 in



Description: Cylindrical Form 12" diam X 36" tall, 1 mCi JN Std

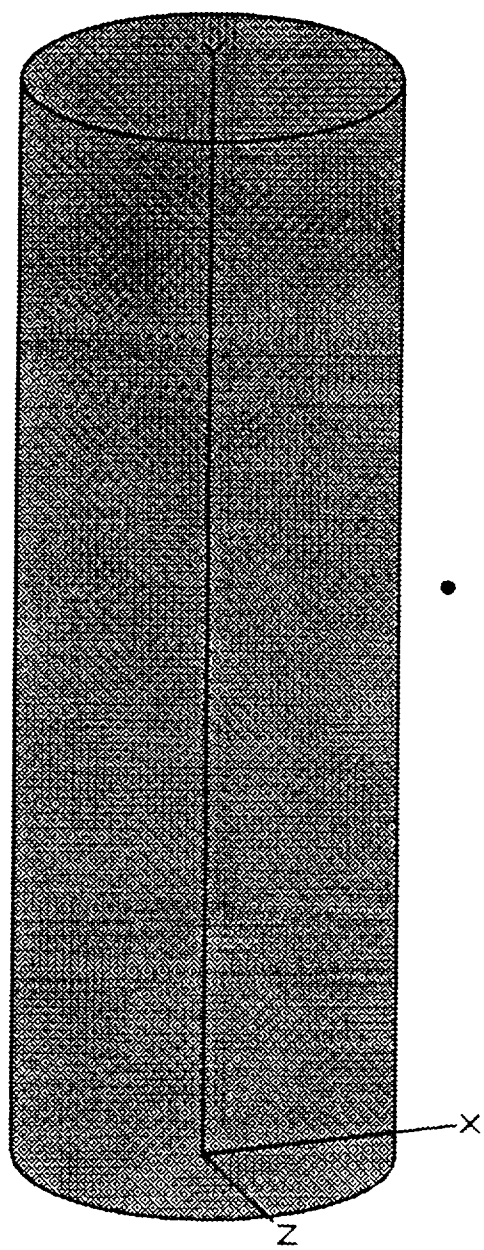
Geometry: 7 - Cylinder Volume - Side Shields

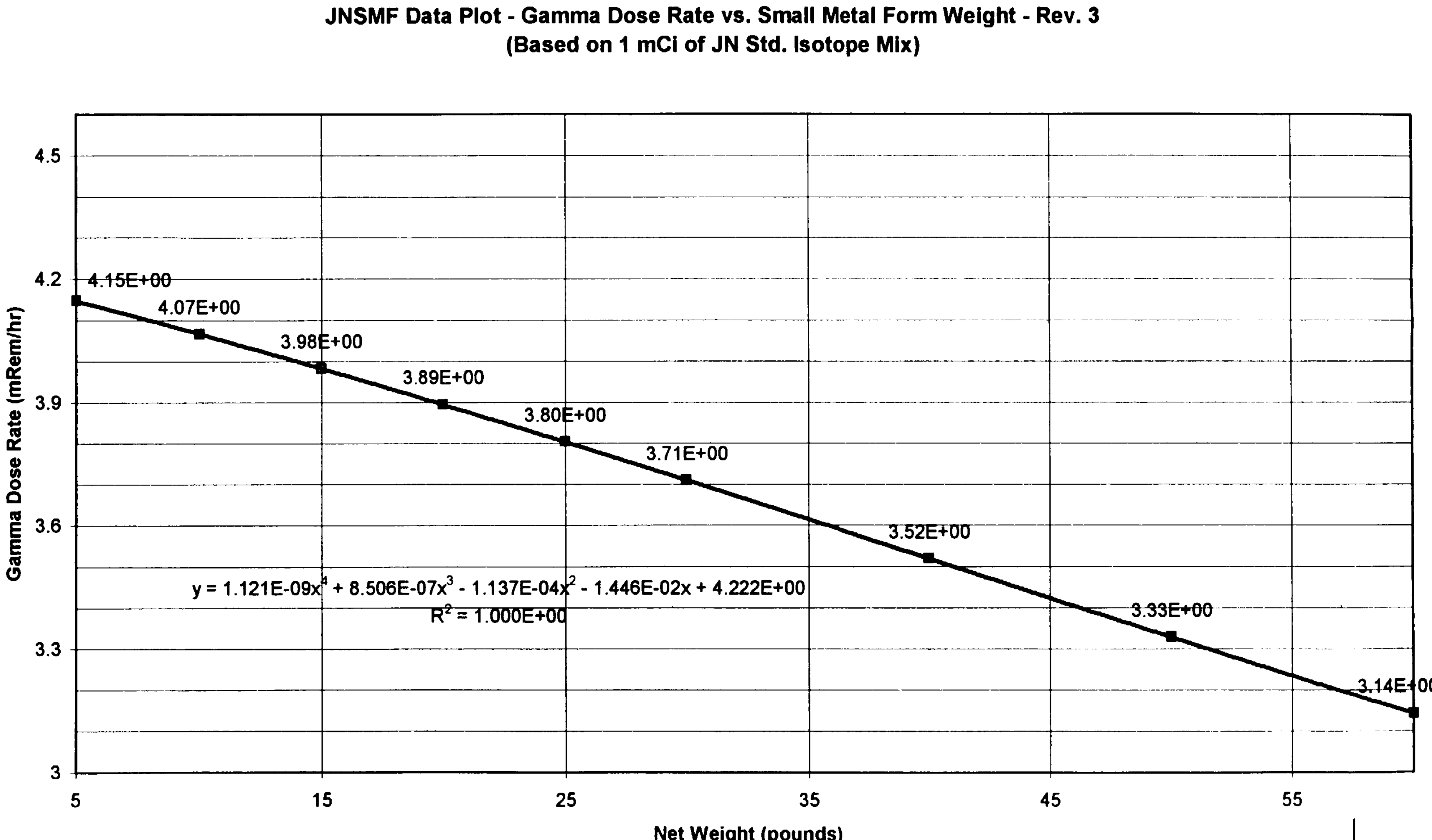
Source Dimensions

Height	91.44 cm	3 ft
Radius	15.24 cm	6.0 in

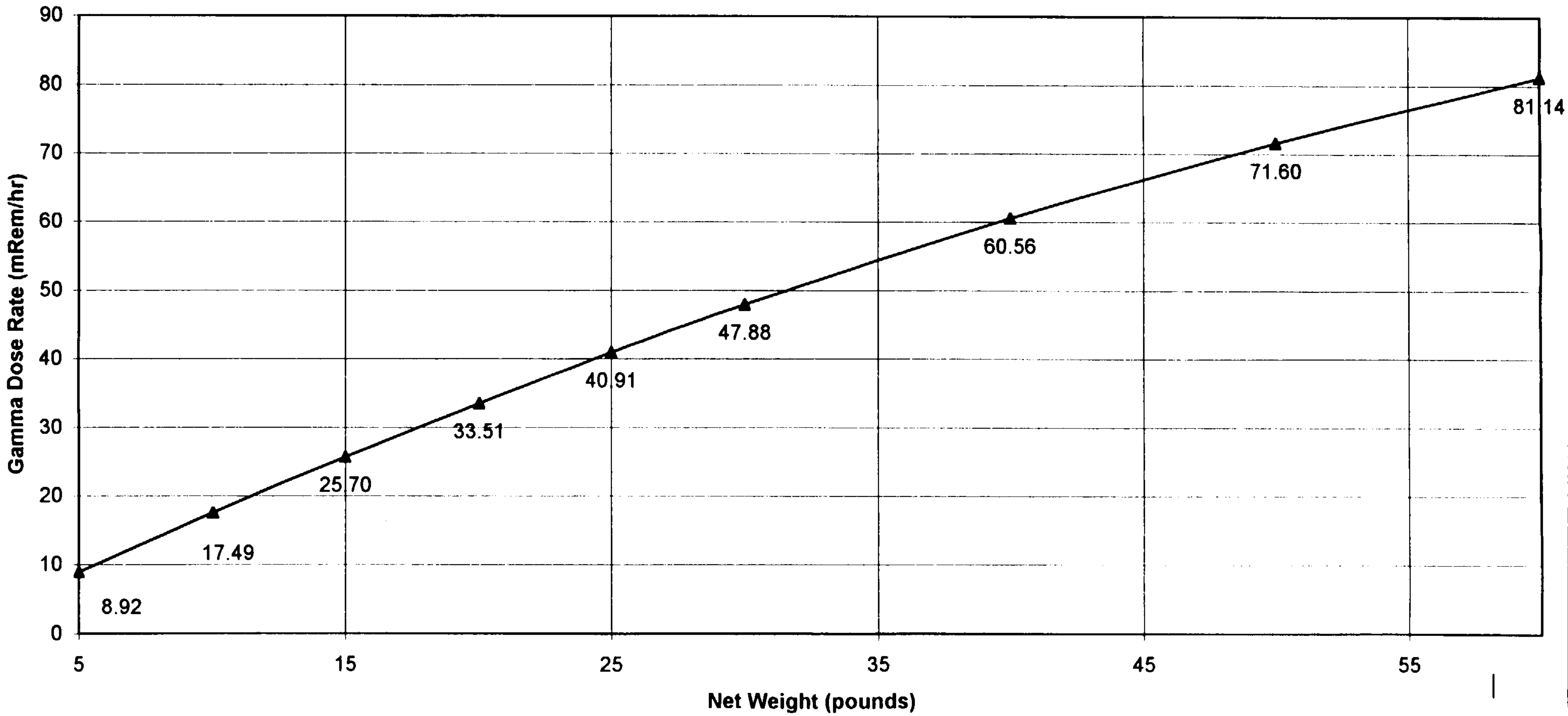
Dose Points

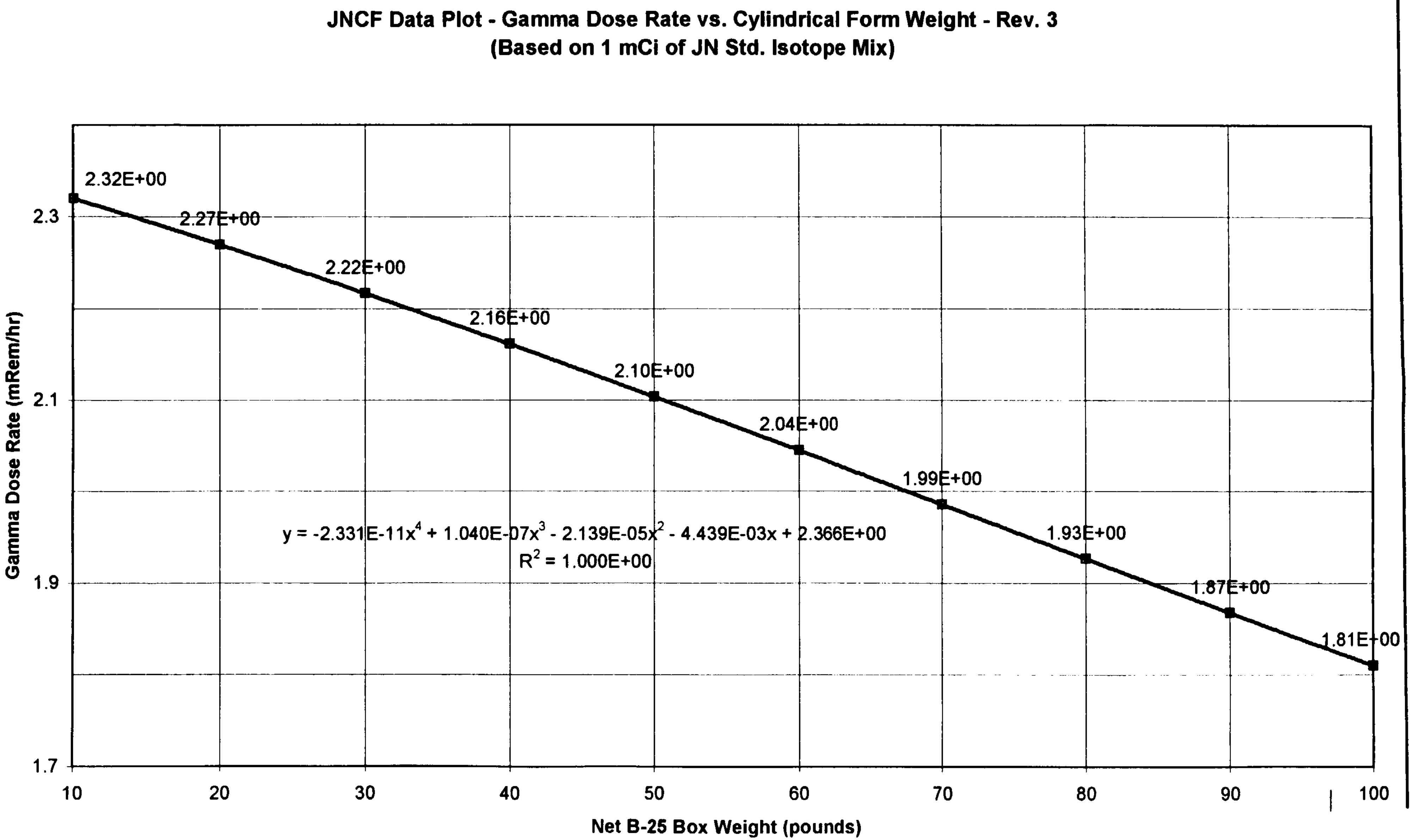
	X	Y	Z
# 1	20.32 cm	45.72 cm	0 cm
	8.0 in	1 ft 6.0 in	0.0 in

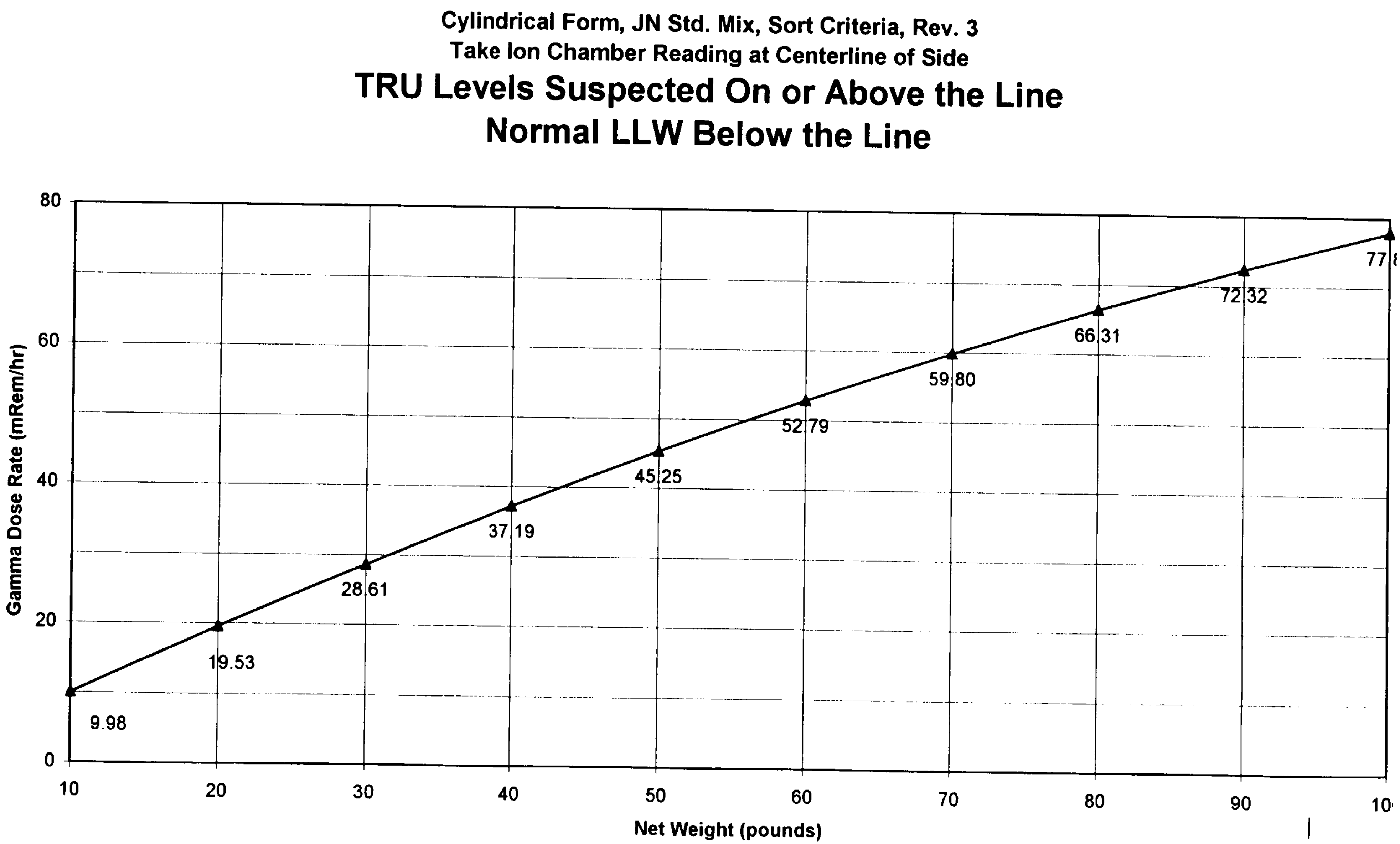



JNSMF Data Plot - Gamma Dose Rate vs. Small Metal Form Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)
Gamma Dose Rate (mRem/hr)
4.5
4.2
3.9
3.6
3.3
3
5
15
25
35
45
55
Net Weight (pounds)
4.15E+00
4.07E+00
3.98E+00
3.89E+00
3.80E+00
3.71E+00
3.52E+00
3.33E+00
3.14E+00
y = 1.121E-09x^4 + 8.506E-07x^3 - 1.137E-04x^2 - 1.446E-02x + 4.222E+00
R^2 = 1.000E+00

Small Metal Form, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line




JNCF Data Plot - Gamma Dose Rate vs. Cylindrical Form Weight - Rev. 3
(Based on 1 mCi of JN Std. Isotope Mix)
Gamma Dose Rate (mRem/hr)
2.3
2.1
1.9
1.7
2.32E+00
2.27E+00
2.22E+00
2.16E+00
2.10E+00
2.04E+00
1.99E+00
1.93E+00
1.87E+00
1.81E+00
y = -2.331E-11x4 + 1.040E-07x3 - 2.139E-05x2 - 4.439E-03x + 2.366E+00
R2 = 1.000E+00
10
20
30
40
50
60
70
80
90
100
Net B-25 Box Weight (pounds)


Cylindrical Form, JN Std. Mix, Sort Criteria, Rev. 3
Take Ion Chamber Reading at Centerline of Side
TRU Levels Suspected On or Above the Line
Normal LLW Below the Line
Gamma Dose Rate (mRem/hr)
Net Weight (pounds)
0
20
40
60
80
10
20
30
40
50
60
70
80
90
9.98
19.53
28.61
37.19
45.25
52.79
59.80
66.31
72.32

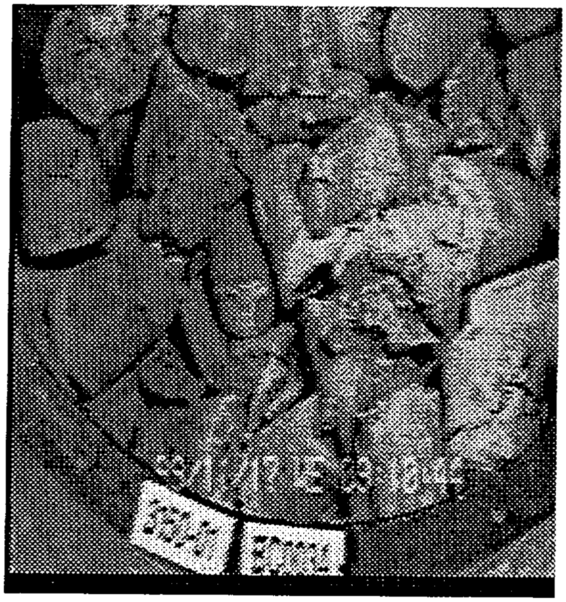
DD-98-04 Rev. 3

APPENDIX G

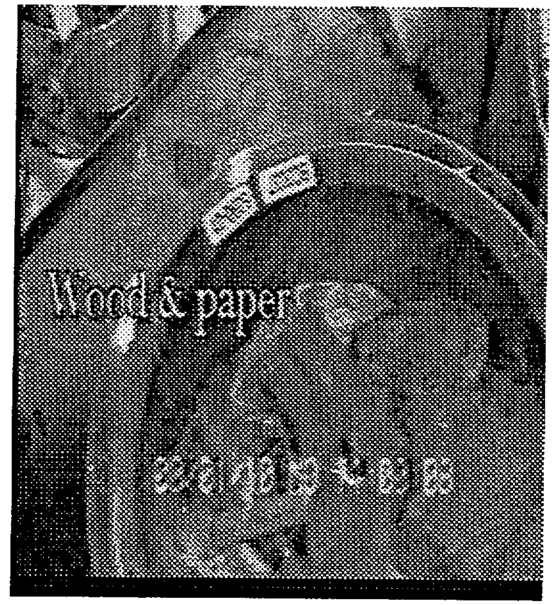
Photographic Samples of TRU Waste Packaging

Contents:

Photographic Samples of TRU Waste Packaging



Cement "Dixie Cups" in Waste Container.



Organic Material (Wood and Paper) in Waste Container

Steel Pieces in Waste Container