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Calculation Cover Sheet

Project KIS	Calculation No. U-CLC-K-00007	Project No. N/A
Title Volume Determination for RFETS, SRS and Hanford 3013 Convenience Cans	Functional Classification NA Discipline NMM Engineering	Sheet 2 of 9
Calc Level ☒ Type 1 ☐ Type 2	Type 1 Calc Status ☐ Preliminary ☒ Confirmed	
Computer Program No. ☒ N/A	Version/Release No. N/A	
Purpose and Objective This calculation documents the material volume of the convenience cans found in the Rock Flats Environmental Technology Site (RFETS), Savannah River Site (SRS) and Hanford 3013 package configurations based on the design drawings.	DC/RO Date See AIM Coversheet	

Summary of Conclusion

The following material volumes were determined for the Rock Flats Environmental Technology Site (RFETS), Savannah River Site (SRS) and the Hanford 3013 convenience cans:

3013 Convenience Can Material Volumes

RFETS	0.218 L $\pm$ 0.022 L
SRS	0.106 L $\pm$ 0.011 L
Hanford	0.191 L $\pm$ 0.019 L

Revisions

Rev. No.	Revision Description
0	Initial Issue

Sign Off

Rev. No.	Originator (Print) Sign/Date	Verification/ Checking Method	Verifier/Checker (Print) Sign/Date	Manager (Print) Sign/Date
0	M.J. Arnold Approvals in AIM	Document Review	L. E. Traver Approvals in AIM	D. M. Barnes Approvals in AIM

Additional Reviewer -- (Print) E.R. Hackney	Signature Approvals in AIM	Date See AIM
Design Authority -- (Print) E.R. Hackney	Signature Approvals in AIM	Date See AIM
Release to Outside Agency -- (Print) N/A	Signature N/A	Date N/A
Security Classification of the Calculation Classification in AIM		

1.0 OPEN ITEM

There are no open items affecting this calculation.

2.0 REFERENCES

1. United States Department of Energy, *Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*, DOE-STD-3013-2004, April 2004.
2. SRS Can Dimensions:
   a. R-R1-F-0098, FB-Line Convenience Can Assembly and Details, Rev 2.
3. Hanford Can Dimensions:
   a. R-R1-F-0131, Hanford Convenience Can Assembly, Rev. 0.
   b. R-R4-F-0143, Hanford Convenience Can Lid Detail, Rev. 0.
   c. R-R4-F-0144, Hanford Convenience Can Detail, Rev. 0.
4. RFETS Can Dimensions:
   a. Hackney, B., "KIS Can Puncture Parameter Study," WSRC Calculation Note, M-CLC-K-00700, 2006, Sections 4.2.1 through 4.2.3.
5. Density of Stainless Steel:
   a. A.K.Steel.com website for 304L SS – Product data sheet: http://www.aksteel.com/pdf/markets_products/Stainless/austenitic/304_304L_Data_Bulletin.pdf - page 6.
   b. A.K.Steel.com website for 430 SS – Product data sheet: http://www.aksteel.com/pdf/markets_products/Stainless/ferritic/430_Data_Sheet.pdf - page 1.

3.0 INPUT AND ASSUMPTIONS

The container dimensions were taken from the reference drawings. The convenience cans are assumed to be manufactured in accordance with the applicable design drawing. Since all of the dimensions on the drawings have plus/minus tolerances, a 10 percent uncertainty will be applied to the total material volumes.

Each type of container was weighed to calculate the volume of the containers using the density of the metal in order to compare and confirm the volumes calculated from the drawings. Only one container from each site was weighed. This weight is assumed to be representative of all of the convenience cans used by each site.

3.1 Mass of Convenience Cans

RFETS	Body (304L Stainless Steel) = 1054.5 g	Lid (430 SS) = 561.8 g
SRS	Container Assembly (304L Stainless Steel) = 791.0 g	
Hanford	Container Assembly (304L Stainless Steel) = 1499.4 g	

Density of stainless steel is 8.03 g/cm^3 for 304L SS and 7.74 g/cm^3 for 430 SS which were obtained from references 5a and 5b, respectively.

3.2 Convenience Can Dimensions

3.2.1 SRS Convenience Can Dimensions (Ref. 2)

Body
Outside Diameter = 4.395”
Inside Diameter = 4.311”
Bottom Outside Diameter = 3.896”
Bottom Inside Diameter = 3.812”
Height of Can = 7.40”
Lower Neck Height = 0.540”
Bottom Height = 0.750”
Bottom Thickness = 0.048”
Wall Thickness = 0.042”

Lid
Lid Thickness = 0.063”
Outer Thread Diameter = 4.270”
Inner Thread Diameter = 4.000”
Thread Height = 0.270”
Outer Lip Diameter = 4.395”
Inner Lip Diameter = 4.269”
Lip Height = 0.317”
Bar Length = 4.250”
Bar Width = 0.063”
Bar Height = 0.250”

3.2.2 Hanford Convenience Can Dimensions (Ref. 3)

Body
Outside Diameter = 4.270”
Inside Diameter = 4.150”
Bottom Outside Diameter = 3.398”
Bottom Inside Diameter = 3.278”
Height of Can = 8.031”
Lower Neck Height = 0.922”
Bottom Thickness = 0.250”
Base Diameter = 3.140”
Wall Thickness = 0.060”

Lid
Lid Thickness = 0.130”
Outer Thread Diameter = 4.275”
Inner Void Diameter = 0.500”
Filter Diameter = 1.000”
Filter Thickness = 0.150”
Inner Lid Diameter = 3.910”
Thread Height = 0.350”
Outer Lip Diameter = 4.335”
Inner Lip Diameter = 3.367”
Lip Height = 0.120”

3.3 Rocky Flats (RFETS) Convenience Can (Ref. 4)

The total volume of the RFETS convenience can is 218 cm^3 as calculated in reference 4.

4.0 ANALYTICAL METHODS AND COMPUTATIONS

4.1 Volume of Metal Based on Mass and Density

Volume = Mass/density

RFETS = 1054.5/8.03 + 561.8/7.74 = 203.9 cm^3/1000cm^3 per L = 0.204 L
SRS = 791.0/8.03 = 98.5 cm^3/1000cm^3 per L = 0.099 L
Hanford = 1499.4/8.03 = 186.7 cm^3/1000cm^3 per L = 0.187 L

4.2 Calculated Convenience Can Material Volumes

4.2.1 SRS Convenience Can Material Volume

The volume of the convenience can metal can be calculated as a sum of separate parts. The first part is the majority of the can is the difference between the outside and inside cylinder of the body using:

$$V_{Outside\ Cylinder} - V_{Inside\ Cylindar} = \pi \frac{D_O}{4}^2 h - \pi \frac{D_I}{4}^2 h = \frac{\pi h}{4} \cdot \left(D_O^{\ 2} - D_I^{\ 2}\right)$$

$$V_{Body\ Cylinder} = \pi \frac{6.110}{4} \cdot \left(4.395^2 - 4.311^2\right) = 3.508\ in^3$$

The second part is the sloped section of the body that can be estimated using the formula for the frustum of a right circular cone:

$$V_{Sloped\ Body} = \frac{1}{3}\pi h\left(\frac{D_O^2}{4} + \frac{D_{BO}^2}{4} + \frac{D_O D_{BO}}{4}\right) - \frac{1}{3}\pi h\left(\frac{D_I^2}{4} + \frac{D_{BI}^2}{4} + \frac{D_I D_{BI}}{4}\right)$$

$$V_{Sloped\ Body} = \frac{1}{3}\pi h\left[\left(\frac{D_O^2}{4} + \frac{D_{BO}^2}{4} + \frac{D_O D_{BO}}{4}\right) - \left(\frac{D_I^2}{4} + \frac{D_{BI}^2}{4} + \frac{D_I D_{BI}}{4}\right)\right]$$

$$V_{Sloped\ Body} = \frac{1}{3}\pi\, 0.54\left[\left(\frac{4.395^2}{4} + \frac{3.896^2}{4} + \frac{4.395 \cdot 3.896}{4}\right) - \left(\frac{4.311^2}{4} + \frac{3.812^2}{4} + \frac{4.311 \cdot 3.812}{4}\right)\right]$$

$$V_{Sloped\ Body} = 0.292\ in^3$$

Volume of the narrowed bottom:

$$V_{Outside\ Bottom} - V_{Inside\ Bottom} = \pi \frac{D_{BO}}{4}^2 h - \pi \frac{D_{BI}}{4}^2 h = \frac{\pi h}{4} \cdot \left(D_{BO}^{\ 2} - D_{BI}^{\ 2}\right)$$

$$V_{Bottom\ Cylinder} = \pi \frac{0.75}{4} \cdot \left(3.896^2 - 3.812^2\right) = 0.381\ in^3$$

Volume of the solid bottom:

$$V_{Bottom} = \pi \frac{D_{BO}^{\;2}}{4} h = \pi \frac{3.812^2}{4} 0.048 = 0.548\ in^3$$

The volume of the lid can also be calculated from the sum of the separate parts.

The base of the lid:

$$V_{Base} = \pi \frac{D_B^{\;2}}{4} h = \pi \frac{4.270^2}{4} 0.063 = 0.902\ in^3$$

The volume of the threads:

$$V_{Outside\,Threads} - V_{Inside\,Threads} = \pi \frac{D_{OT}^{\;2}}{4} h - \pi \frac{D_{IT}^{\;2}}{4} h = \frac{\pi h}{4} \cdot \left(D_{OT}^{\;2} - D_{IT}^{\;2}\right)$$

$$V_{Threads} = \pi \frac{0.27}{4} \cdot \left(4.270^2 - 4.000^2\right) = 0.473\ in^3$$

Volume of the upper lip on the lid:

$$V_{Outside\,Lip} - V_{Inside\,Lip} = \pi \frac{D_{OL}^{\;2}}{4} h - \pi \frac{D_{IL}^{\;2}}{4} h = \frac{\pi h}{4} \cdot \left(D_{OL}^{\;2} - D_{IL}^{\;2}\right)$$

$$V_{Outside\,Lip} = \pi \frac{0.317}{4} \cdot \left(4.395^2 - 4.269^2\right) = 0.272\ in^3$$

Volume of the cross bar on the lid:

$$V_{Bar} = L \cdot W \cdot H = 4.250 \cdot 0.063 \cdot 0.25 = 0.067\ in^3$$

The total volume is the sum of all the parts from the body and lid:

$$V_{Total} = V_{Body\,Cylinder} + V_{Sloped\,Body} + V_{Bottom\,Cylinder} + V_{Bottom} + V_{Base} + V_{Threads} + V_{Outside\,Lip} + V_{Bar}$$

$$V_{Total} = 3.508 + 0.292 + 0.381 + 0.548 + 0.902 + 0.473 + 0.272 + 0.067 = 6.443\ in^3$$

$$V_{Total} = 6.443\ in^3 \cdot \frac{16.387\ cm^3}{in^3} \cdot \frac{1\ L}{1000\ cm^3} = 0.106\ L$$

The total material volume of the convenience can is 0.106 L ± 0.011 L.

4.2.2 Hanford Convenience Can Material Volume

The volume of the convenience can metal can be calculated as a sum of separate parts. The first part is the majority of the can is the difference between the outside and inside cylinder of the body using:

$$V_{Outside\ Cylinder} - V_{Inside\ Cylindar} = \pi \frac{D_O^{\ 2}}{4} h - \pi \frac{D_I^{\ 2}}{4} h = \frac{\pi h}{4} \cdot \left(D_O^{\ 2} - D_I^{\ 2}\right)$$

$$V_{Body\ Cylinder} = \pi \frac{6.859}{4} \cdot \left(4.270^2 - 4.150^2\right) = 5.440\ in^3$$

The second part is the sloped section of the body that can be estimated using the formula for the frustum of a right circular cone:

$$V_{Sloped\ Body} = \frac{1}{3}\pi h\left(\frac{D_O^2}{4} + \frac{D_{BO}^2}{4} + \frac{D_O D_{BO}}{4}\right) - \frac{1}{3}\pi h\left(\frac{D_I^2}{4} + \frac{D_{BI}^2}{4} + \frac{D_I D_{BI}}{4}\right)$$

$$V_{Sloped\ Body} = \frac{1}{3}\pi h\left[\left(\frac{D_O^2}{4} + \frac{D_{BO}^2}{4} + \frac{D_O D_{BO}}{4}\right) - \left(\frac{D_I^2}{4} + \frac{D_{BI}^2}{4} + \frac{D_I D_{BI}}{4}\right)\right]$$

$$V_{Sloped\ Body} = \frac{1}{3}\pi\, 0.922\left[\left(\frac{4.270^2}{4} + \frac{3.398^2}{4} + \frac{4.270 \cdot 3.398}{4}\right) - \left(\frac{4.150^2}{4} + \frac{3.278^2}{4} + \frac{4.150 \cdot 3.278}{4}\right)\right]$$

$$V_{Sloped\ Body} = 0.656\ in^3$$

Volume of the solid bottom base:

$$V_{Bottom\ Base} = \frac{1}{3}\pi h\left(\frac{D_O^2}{4} + \frac{D_{BO}^2}{4} + \frac{D_O D_{BO}}{4}\right)$$

$$V_{Bottom\ Base} = \frac{1}{3}\pi\, 0.250\left(\frac{3.398^2}{4} + \frac{3.140^2}{4} + \frac{3.398 \cdot 3.140}{4}\right)$$

$$V_{Bottom\ Base} = 2.098\ in^3$$

The volume of the lid can also be calculated from the sum of the separate parts.

The base of the lid:

$$V_{Base} = \pi \frac{D_{OB}^{2}}{4} h - \pi \frac{D_{IB}^{2}}{4} h = \frac{\pi h}{4} \cdot \left(D_{OB}^{2} - D_{IB}^{2}\right)$$

$$V_{Base} = \pi \frac{0.130}{4} \cdot \left(4.275^{2} - 0.500^{2}\right) = 1.840\ in^{3}$$

The volume of the filter:

$$V_{Filter} = \pi \frac{D_{F}^{2}}{4} h = \pi \frac{1.000^{2}}{4}\ 0.150 = 0.118\ in^{3}$$

The volume of the threads:

$$V_{Outside\,Threads} - V_{Inside\,Threads} = \pi \frac{D_{OT}^{2}}{4} h - \pi \frac{D_{IL}^{2}}{4} h = \frac{\pi h}{4} \cdot \left(D_{OT}^{2} - D_{IL}^{2}\right)$$

$$V_{Threads} = \pi \frac{0.350}{4} \cdot \left(4.275^{2} - 3.910^{2}\right) = 0.821\ in^{3}$$

Volume of the upper lip on the lid:

$$V_{Outside\,Lip} - V_{Inside\,Lip} = \pi \frac{D_{OL}^{2}}{4} h - \pi \frac{D_{IL}^{2}}{4} h = \frac{\pi h}{4} \cdot \left(D_{OL}^{2} - D_{IL}^{2}\right)$$

$$V_{Outside\,Lip} = \pi \frac{0.120}{4} \cdot \left(4.335^{2} - 3.367^{2}\right) = 0.702\ in^{3}$$

The total volume is the sum of all the parts from the body and lid:

$$V_{Total} = V_{Body\,Cylinder} + V_{Sloped\,Body} + V_{Bottom\,Base} + V_{Base} + V_{Filter} + V_{Threads} + V_{Outside\,Lip}$$

$$V_{Total} = 5.440 + 0.656 + 2.098 + 1.840 + 0.118 + 0.821 + 0.702 = 11.675\ in^{3}$$

$$V_{Total} = 11.675\ in^{3} \cdot \frac{16.387\ cm^{3}}{in^{3}} \cdot \frac{1\ L}{1000\ cm^{3}} = 0.191\ L$$

The total material volume of the convenience can is 0.191 L ± 0.019 L.

4.3 Rocky Flats Convenience Can Material Volume

The RFETS convenience can is 218 cm^3/1000cm^3 per L = 0.218 L ± 0.022 L

5.0 RESULTS

The material volumes of the convenience cans were determined from published dimensions from the most current revisions of the container drawings. The volumes were also calculated from the field measurements of the mass of each container. The volumes that were calculated from both methods for each type of convenience can are summarized in the table below.

	Mass/Density	Drawing
RFETS	0.204 L	0.218 L ± 0.022 L
SRS	0.099 L	0.106 L ± 0.011 L
Hanford	0.187 L	0.191 L ± 0.019 L

6.0 CONCLUSION

The calculated results of the volumes based on the mass and density are very similar to the volumes calculated from the drawing dimensions and are within the uncertainty range.