10 CFR 50.4(b)(1)

May 27, 2015 ZS-2015-0078

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Zion Nuclear Power Station, Units 1 and 2
Facility Operating License Nos. DPR-39 and DPR-48
NRC Docket Nos. 50-295 and 50-304

Subject: License Termination Plan Request for Additional Information

References:

1) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "License Amendment Request for the License Termination Plan", dated December 19, 2014
2) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "License Termination Plan Update of the Site-Specific Decommissioning Costs", dated February 26, 2015
3) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "License Termination Plan Request for Additional Information", dated April 29, 2015

The Zion Station License Termination Plan (LTP) was submitted to the U.S Nuclear Regulatory Commission (NRC) for review on December 19, 2014 as documented in Reference 1. Following initial NRC review, an e-mail Request for Additional Information (RAI) was received on April 8, 2015 requesting the following information in support of the technical review process:

- Energy Services Commercial Services Group Report CS-RS-PN-028, "Background Reference Area Report - Zion Nuclear Power Station", – February 2012.
- Technical Support Document (TSD) describing the use of ISOCS.
- ZionSolutions Technical Support Document 14-003, Conestoga Rovers & Associates (CRA) Report, "Zion Hydrogeologic Investigation Report," Including all hydrogeologic investigation reports or documentation completed by Conestoga-Rovers & Associates (CRA), Exelon, and ZionSolutions from August 2006 through September 2013, used to develop TSD 14-003.
- Conestoga-Rovers and Associates, "Hydrogeologic Investigation Report, Fleetwide Assessment, Zion Station, Zion Illinois", Revision 1 – September 2006.

NMSS20

The requested information, with the exception of the TSD describing the use of ISOCS, was previously submitted as documented in Attachment 3. The TSD describing the use of ISOCS is included in the enclosure sent with this correspondence.

There are no regulatory commitments made in this submittal. If you should have any questions regarding this submittal, please contact Robert Yetter at (224) 789-4250.

Respectfully,

Donald E. Williams, Jr.
VP Radiological and Environmental Controls

Enclosure:
Technical Support Document (TSD) describing the use of ISOCS.

cc: John Hickman, U.S. NRC Senior Project Manager (2 copies of the enclosure)
Regional Administrator, U.S. NRC, Region III (1 copy of the enclosure)
Service List (Cover letter only, no enclosures)

Ken Robuck
President Logistics Processing and
Disposal Group
Energy*Solutions*
423 West 300 South, Suite 200
Salt lake City, UT 84101

John Sauger
Executive VP & General Manager
Zion*Solutions*, LLC
101 Shiloh Boulevard
Zion, IL 60099

Gerard van Noordennen
VP Regulatory Affairs
Zion*Solutions*, LLC
101 Shiloh Boulevard
Zion, IL 60099

Anthony Orawiec
Decommissioning Plant Manager
Zion*Solutions*, LLC
101 Shiloh Boulevard
Zion, IL 60099

Dan Shrum
Senior VP Regulatory Affairs
Energy*Solutions*
423 West 300 South, Suite 200
Salt Lake City, UT 84101

Russ Workman
General Counsel
Energy*Solutions*
423 West 300 South, Suite 200
Salt Lake City, UT 84101

Alwyn C. Settles
Section Head, Nuclear Facility Inspection
Bureau of Nuclear Facility Safety
Illinois Emergency Management Agency
1011 North Street, PO Box 250
Mazon, IL 60444

Kelly F. Grahn
Senior Health Physicist, Unit Supervisor
Low Level Radioactive Waste and Site
Decommissioning
Illinois Emergency Management Agency
Bureau of Radiation Safety, Environmental
Management
245 W Roosevelt Road, Building 8, Suite 55
West Chicago, IL 60185

Kent McKenzie
Emergency Management Coordinator
Lake County Emergency Management Agency
1303 N. Milwaukee Avenue
Libertyville, IL 60048-1308

John E. Matthews
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004

ZionSolutions, Inc.
Technical Support Document

ZIONSOLUTIONS LLC
An EnergySolutions Company

# TSD 14-022

## Use of In-Situ Gamma Spectroscopy for Source Term Survey of End State Structures

**Revision 0**

Originator: _____ Date: 5/26/2015
Harvey Farr

Reviewer: _____ Date: 5/26/2015
David Fauver

Approval: _____ Date: 5/27/15
Robert Yetter

Summary of Changes in this Revision:

- Rev. 0 –Initial issuance.

**Table of Contents**

## List of Tables



## List of Figures

# 1. PURPOSE

The primary purpose of this TSD is to describe the efficiency calibration methods and results for the use of in-situ gamma spectroscopy to perform the Source Term Surveys (STS) of the Zion Station Restoration Project (ZSRP) end state structure basements. This TSD also provides a general description of the in-situ gamma spectroscopy system application during STS including nominal minimum detectable concentration (MDC) values.

As described in the ZSRP License Termination Plan (LTP), (1) the objective of the STS is to determine the total activity remaining in each end state structure at the time of license termination. The Canberra In-Situ Object Counting System (ISOCS) gamma spectroscopy instrumentation will be used. The source term geometry in concrete (and remaining steel liner in the case of the Containment basement) and the corresponding efficiency calibration for the ISOCS measurements are described for each structure. The efficiency calibrations apply to the expected general condition of the structures after remediation and will be used during STS design. However, the efficiency calibrations may be modified during STS design as necessary, using the general approach and methods described in this TSD, if the actual post-remediation conditions of the structures are significantly different than assumed.

The efficiency calibrations are intended to be conservative. If the STS results are such that a reduction in conservatism is deemed necessary for a given measurement or survey unit, additional characterization or data analysis may be performed to refine the efficiency calibration.

The efficiency calibrations assume a uniform areal distribution of residual radioactivity. The effects of non-uniform areal distributions are also evaluated to ensure that a conservative estimate of total activity inventory is generated for a reasonable range of distributions.

Finally, this TSD identifies areas where additional characterization or information is required to sufficiently define the source term geometry. The ISOCS efficiencies will be determined for these areas after the additional data is available.

# 2. DISCUSSION

## 2.1. Application of ISOCS in Source Term Survey

As described in Zion LTP Chapter 6, the total activity inventory in each basement is the metric that will be used to demonstrate compliance with the 25 mrem/yr dose criteria in 10 CFR 20.1402. The total activity is the source term input for the Basement Fill Dose Model (BFM) and activity values that correspond to 25 mrem/yr are provided in Table 5-9 of the LTP. (1) Note that the BFM source term is total activity only which is independent of radionuclide concentrations.

Consistent with the graded approach recommended in the Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM) (2), the number of ISOCS measurements in each basement is a function of the potential for residual radioactivity to be present (see LTP Chapter 5). The Auxiliary Basement floor and portions of the Fuel Pool/Transfer Tunnels to remain are known to be contaminated. ISOCS measurements will be performed over 100% of these surfaces. The number of measurements in the other basements represents less than 100% coverage of the surfaces depending on contamination potential. For survey planning purposes and the assessments provided in this TSD, the assumed configuration of the ISOCS system during STS is a three meter distance from the surface to be measured with a 90 degree, 50 mm lead collimator. This results in a 28.3 $m^2$ field of

view (FOV). This configuration may be changed as necessary depending on actual conditions encountered during STS.

## 2.2. Source Term Geometry for ISOCS Efficiency Calibration

The source term geometry, i.e., concentration depth profile and areal distribution of the residual radioactivity in structures, is required to generate efficiency curves (i.e., efficiency as a function of energy) for the ISOCS gamma spectroscopy measurements. The concrete cores obtained during characterization, as described in LTP Chapter 2 (1), provide information regarding the distribution of activity with depth for each structure. The areal distribution is assumed to be uniform for the efficiency calibration. The effect of non-uniform areal distribution is evaluated separately in Section 5.

The basement structures that will remain at license termination include:

- Unit 1 & 2 Containment Buildings,
- Auxiliary Building,
- Spent Fuel Pool (SFP) and the Fuel Transfer Canal,
- Crib House and Forebay,
- Turbine Building, Steam Tunnels, Circulating Water Intake Pipe and Circulating Water Discharge Tunnels, and
- Waste Water Treatment Facility (WWTF).

The characterization data is documented in LTP Chapter 2 and analyzed in the following TSDs:

- TSD 13-005, Unit 1 & 2 Reactor Building Estimated End State Concrete and Liner Volumes and Surface Areas (3),
- TSD 13-006, Reactor Building Units 1 and 2 End State Concrete and Liner Initial Characterization Source Terms and Distributions (4),
- TSD 14-013, Zion Auxiliary Building End State Estimated Concrete Volumes, Surface Areas, and Source Terms (5), and
- TSD 14-014, End State Surface Areas, Volumes, and Source Terms of Ancillary Buildings (6).

Several structures were in use during characterization including the SFP, Transfer Canal, Unit 2 Discharge Tunnel and WWTF and were therefore not surveyed. The Forebay and Circulating Water Intake Pipe are submerged and were not characterized but the concrete in these structures have very low potential of containing contamination. Conservative assumptions regarding the source term distribution, and corresponding ISOCS efficiency calibration, in these structures can be made based on the results of cores collected in the Crib House without additional characterization. The Spent Fuel Pool, Transfer Canal, WWTF and Unit 2 Discharge Tunnel will be characterized when access is available and the resulting data used to develop the source term geometry and corresponding ISOCS efficiency calibration using the methods outlined in this TSD.

There was no detectable activity in the Crib House cores and no contamination is expected in the Forebay (6) or Circulating Water Intake Pipes. Cores from the Turbine Building and Steam

Tunnels exhibited very low levels of Cs-137 in the first half inch of some of the cores (6) with locations very localized. (6) Minimal activity was found below the first half inch.

The steel liner walls in the containments extend from the 588 foot elevation to the basement floor at the 568 foot elevation with no interior concrete (3). The In-Core area consists of the area directly below the reactor vessel and an access tunnel. All have walls and floors with the access tunnel also having a concrete ceiling. The concrete wall and floor below the vessel is neutron activated. (4) As noted in Chapter 5 of the LTP, current plans are to remove all concrete inside the liners in both Containments. The source term geometry for the containment basements will therefore be a thin layer of surface contamination on the remaining steel liners. In the event that some concrete is left inside the liner in either Containment at the 568 foot elevation floors or the In-Core areas under the vessel, core data is available to develop concentration profiles at depth and corresponding ISOCS efficiency calibration (4).

A total of seventeen cores were collected from biased locations in the Auxiliary Building Basement 542 foot elevation and are sufficient to determine the concentration profiles at depth and to develop a conservative ISOCS efficiency calibration for the Auxiliary Basement.

## 2.3. ISOCS Geometry Composer Software: Circular Plane Geometry and Exponential Circular Plane Geometry

The ISOCS Geometry Composer Software contains a number of geometry templates that allow physical parameters to be varied to determine efficiency curves for a variety of source term geometries. The Exponential Circular Plane (ECP) and Circular Plane (CP) templates, as applicable, were used to develop efficiency curves for the ISOCS measurements in basement structures. The general circular plane geometry is shown in Figure 1.

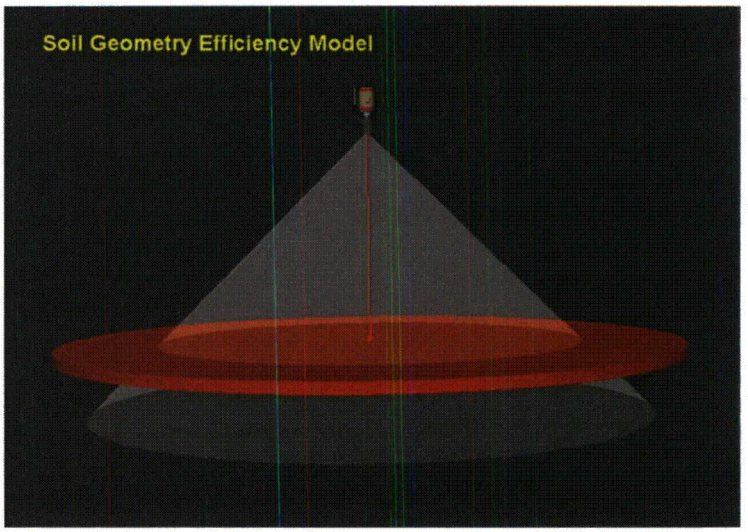
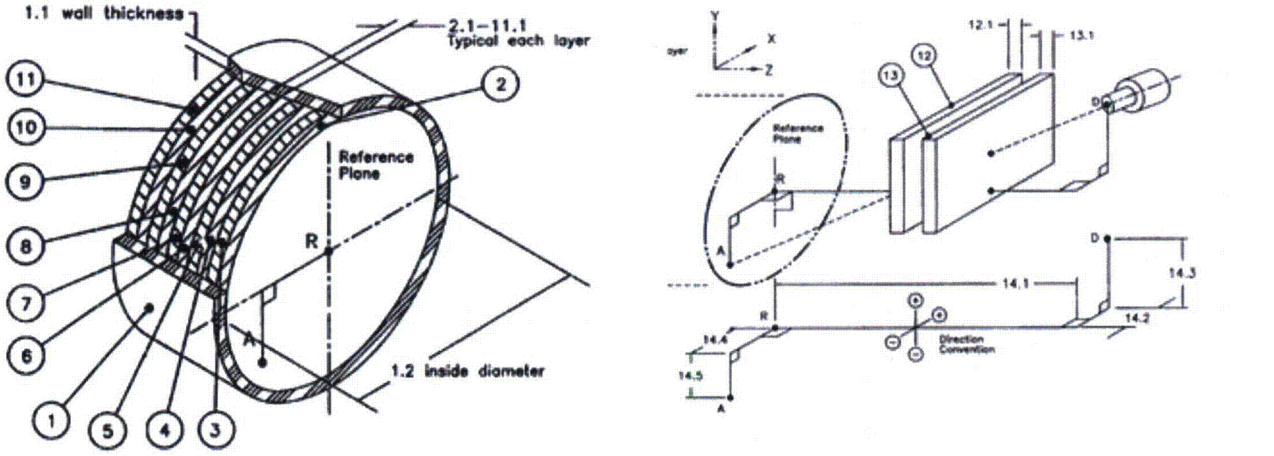



**Figure 1 - 90 Degree Collimator Field of View (FOV)**

The CP Template allows the radioactivity to be distributed in any manner in up to ten layers of sources/ absorbers (i.e., Items 2 through 11 in Figure 2). Item 1.1, wall thickness, is set to zero for end state floors and walls. Item 1.2 is the circular plane diameter which will typically be set to 6.0 meters when the source to detector distance is set to 3.0 meters (Item 4.1).




Description:

Comment:

Units: mm cm m in ft

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 0 | | | | | 0 | |
| 2 | Layer 1 | 0 | | | | | | 0 | 0.00 |
| 3 | Layer 2 | 0 | | | | | | 0 | 0.00 |
| 4 | Layer 3 | 0 | | | | | | 0 | 0.00 |
| 5 | Layer 4 | 0 | | | | | | 0 | 0.00 |
| 6 | Layer 5 | 0 | | | | | | 0 | 0.00 |
| 7 | Layer 6 | 0 | | | | | | 0 | 0.00 |
| 8 | Layer 7 | 0 | | | | | | 0 | 0.00 |
| 9 | Layer 8 | 0 | | | | | | 0 | 0.00 |
| 10 | Layer 9 | 0 | | | | | | 0 | 0.00 |
| 11 | Layer 10 | 0 | | | | | | 0 | 0.00 |
| 12 | Absorber 1 | 0 | | | | | | 0 | |
| 13 | Absorber 2 | 0 | | | | | | 0 | |
| 14 | Source-Detector | 0 | 0 | 0 | 0 | 0 | | | |

**Figure 2 - ISOCS Calibration Software Circular Plane Template**

The ISOCS ECP template is similar to the CP template but the distribution of radioactivity with depth in the ECP template is defined by a single exponential function as opposed to 10 layers of user input concentrations in the CP template. As seen in Figure 3 and Figure 4 the ECP template allows source concentrations to be distributed such that they first increase in concentration with depth, to a depth at which the maximum concentration occurs, and then decrease in concentration. This "increase then decrease" distribution is often encountered in soils as surface contamination migrates through the soil column. It is also a typical distribution for activated concrete as was seen in the ZSRP Containment In-Core areas. (4) However, the ECP is fully applicable to profiles in which the maximum concentration is at the surface and concentration falls off in an exponential fashion which is the distribution generally expected for contaminated concrete. As discussed in

detail below, the Auxiliary Building cores confirm the exponential decrease of concentration with depth.

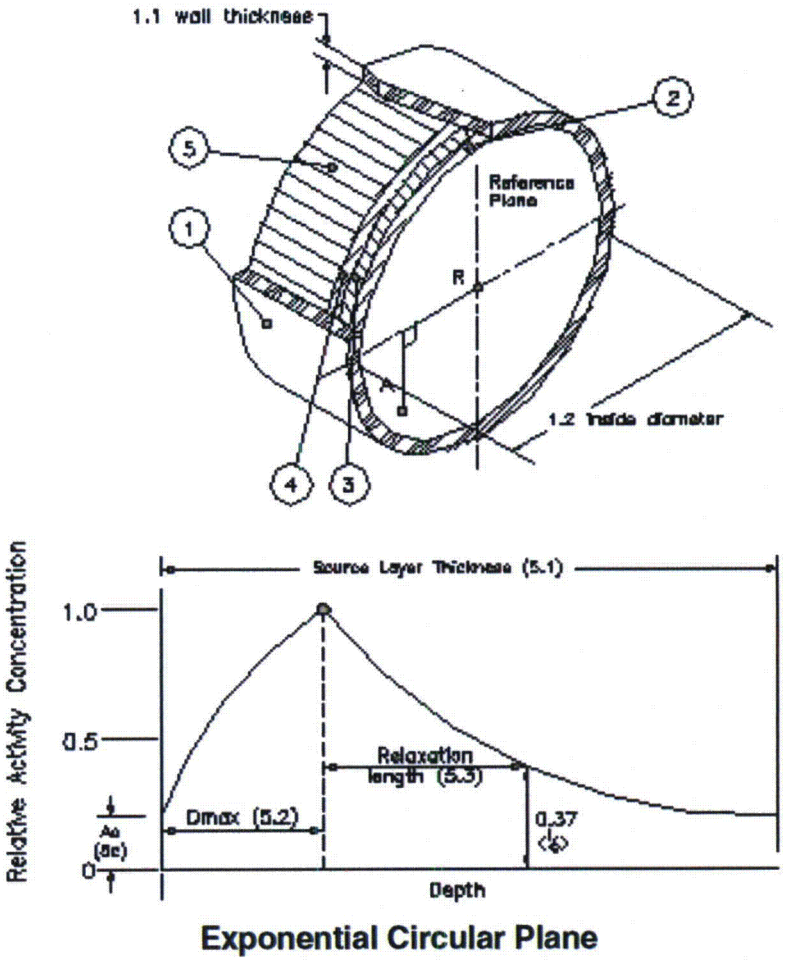
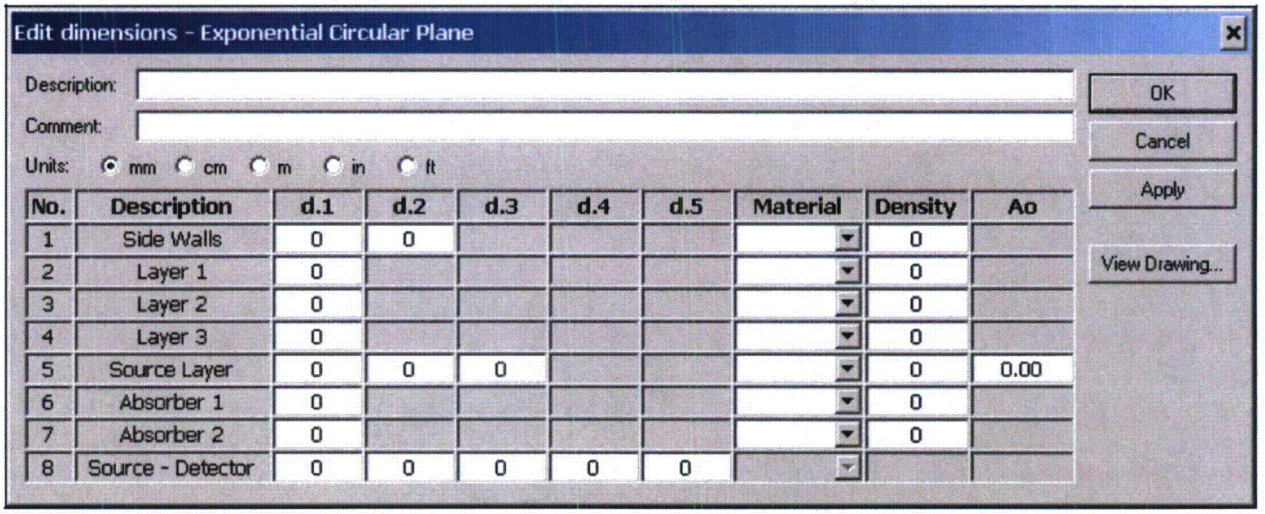



**Figure 3 - ISOCS Calibration Software Exponential Circular Plane Template**




| | |
|---|---|
| Row 1, d.1 | Container side wall thickness |
| Row 1, d.2 | Diameter of the source |
| Rows 2 to 4, d.1 | Thickness of absorber layers |
| Row 5, d.1 | Thickness of source layer |
| Row 5, d.2 | Depth at which maximum activity concentration occurs (Dmax) |
| Row 5, d.3 | Relaxation length for the exponential distribution, DRL, the depth at which the activity concentration falls by a factor of 1/e of its value at Dmax |
| Row 5, A0 | Relative source concentration at zero depth ($A_0$), $0 \leq A_0 \leq 1$ |

Rows 6 and 7 describe any absorber layers that may be between the detector and the source, and Row 8 describes the position and angle between the detector and source, just as in all other ISOCS templates.

**Figure 4 - Exponential Circular Plane Input Parameters**

The basic input parameters that are applicable to both the ECP and CP are;

- Source to Detector Distance
- Side wall thickness which is set to zero for floors and walls.
- Material Density
- Diameter of the source which equals the field of view based on distance from the floor or wall.
- Thickness of absorber layers.
- Thickness of source layer(s).
- Depth at which maximum activity concentration occurs ($C_{max}$) for the ECP. Characterization data indicates that this should be set to zero at ZSRP unless assaying activated concrete. Using the Circular Plane the Relative Concentration for each layer is entered. For the cores, the concentration (pCi/g) of each core layer segment was entered.

The source term definition differs for ECP and CP. For CP, actual (or extrapolated) concentrations are entered into a maximum of 10 layers with user defined layer thicknesses. There is no requirement that the source term fit a given function with depth. For the ECP, the source term is defined as an exponential function that is continuous from the surface to a user defined depth. Three input parameters are needed to define the source term distribution in the ECP template

- Concentration at zero depth ($A_0$).
- Depth Relaxation Length (DRL) for the exponential distribution. This is the depth at which the activity concentration falls by a factor of 1/e of its value at $C_{max}$. Where ***e*** is Euler's number 2.71828, the base of natural logarithms such that 1/e equals 0.368. The equation is described on page 9-8 of the Advanced ISOCS Measurement Training Course (7)
- Depth of contamination

Contamination depth profiles vary in the end state concrete as described in TSD 13-006 (4), TSD 14-013, and TSD 14-014 which provide the results of core samples from Containment, Auxiliary Building (5), and Turbine Building (6), respectively. The core depth profiles and other information regarding post-remediation source term geometry are used to develop ISOCS efficiency calibration files for each building. The ECP template is most applicable to areas with significant concrete contamination at various depths such as the Auxiliary Building basement. The ECP may also be the best template to use for the Fuel Pool/Transfer Canals but this will not be determined until characterization in these areas is completed. The CP template is applied to the remaining basements which contain low levels of contamination that are limited to a near surface layer. This source term geometry can be conservatively modeled by a single uniformly contaminated source term layer from the surface to a given depth (assumed to be ½ inch to correspond to the core sample slice thickness and maximum contamination depth expected).

## 2.4. Determination of Depth Relaxation Lengths (DRLs) from Concrete Core Data

The ISOCS software uses the term Depth Relaxation Length (DRL) in place of the standard rate constant term, i.e., λ. This section describes the derivation of the DRL value and how the DRL is calculated when core data is curve fitted and a λ value generated.

The radionuclide concentration at the DRL is defined by Equation 1. From Equation 1 it is seen that concentration at the DRL depth ($C_{DRL}$) is the depth at which the concentration is equal to 0.368 of the maximum concentration ($C_{max}$), i.e., $C_{DRL} = 0.368\ C_{max}$.

**Equation 1 – Concentration $C_{DRL}$ at Depth Relaxation Length (DRL)** (7)

$$C_{DRL} = \left[\left({}^{1}/_{e}\right) = \frac{1}{2.7183} = 0.368\right]\ C_{max}$$

The ECP template uses the DRL as an alternative expression of the rate constant (λ) in the basic exponential function shown in Equation 2.

**Equation 2- Exponential Function**

$$A = A_0 e^{-\lambda X\, cm}$$

Where:

A = Activity at depth X

$A_0$ = Activity at depth 0

λ = rate constant

X = depth in cm

The conversion of λ to DRL is performed as follows. By definition, $A/A_0 = 0.368$ when X equals the DRL. Substituting and taking the natural log of both sides, results in the Equation 3:

**Equation 3 - Exponential Function When A/A0 = 0.368**

$$ln(0.368) = -\lambda DRL\, cm = -1$$

Therefore,

$$\lambda = \frac{1}{DRL\, cm}$$

This confirms the equation on page 3-34 of the Advanced ISOCS Measurement Training Course (7) which is copied as Equation 4 below. Note that the ISOCS formula nomenclature uses L as term for DRL. As seen in Equation 4 form, if X = L (i.e., DRL), then -X/L = -1. Then $A/A_0 = e^{-1} = 0.368$.

**Equation 4 - ISOCS Exponential Circular Plane Equation**

$$A = A_o e^{-X/L}$$

Where

$A = 0.368 * C_{max}$

$Ao = C_{max}$

L = DRL

X = depth in cm

Equation 3 is used in this TSD to convert, when necessary, the λ value generated by curve fitting exponential functions to core data to the DRL value used in the ISOCS ECP template.

# 3. ISOCS EFFICIENCY CALCULATION

## 3.1. Auxiliary Building Basement Floor and Lower 1 m of Wall

The Auxiliary Building floor is likely to contain the majority of the end state source term and be the bounding source term for compliance with the 25 mrem/yr dose criterion. The Auxiliary Building concentration profile with depth has been determined using the core data documented in TSD 14-013 (5). The ECP template is used to develop the ISOCS efficiency calibration for the Auxiliary basement floor.

TSD 14-019 (8) evaluated the concrete core data from the Auxiliary Building and refined the initial suite of potential radionuclides of concern (ROC) (9) by evaluating the dose significance of each radionuclide. This analysis determined that Co-60, Ni-63, Sr-90, Cs-134 and Cs-137 accounted for 99.5% of all dose in the Auxiliary Basement contaminated concrete mix. (8) Cs-137 is the predominant radionuclide.

After systems and components are removed, areas above 2 mrem/hr contact will be remediated to meet open air demolition limits (10). The STS will then be conducted in accordance with Chapter 5 of the LTP (1) to demonstrate that the total inventory of residual radioactivity in building basements, embedded piping and penetrations is below a total source term inventory commensurate with the 25 mrem/yr dose criterion (11). ISOCS will be used to perform the STS of end state structures.

Seventeen concrete cores were collected during the characterization of the Auxiliary Building. (5) As noted in TSD 14-019 (8) Cs-137 accounts for 75% of the end state source term in the Auxiliary Building while Co-60 only accounts for 1.6% of the source term. In addition, Cs-137 is more mobile than Co-60 and expected to penetrate to a deeper depth on the concrete. Therefore, the evaluation of contamination with depth is performed with the Cs-137 results and assumed to apply to all ROC. Hard-to-Detect fission product radionuclides such as Sr-90 may be surrogated to Cs-137. Activation nuclides such as Ni-63 may be surrogated to Co-60 as appropriate.

As seen in Table 1, the Cs-137 maximum concentration ($C_{max}$) was in the first half inch for all 17 cores. The depth at which detectable activity was found varies from 0.5 to 14 inches. The results for five of the cores (B105103-CJFCCV-001, B105105-CJFCCV-001, B105106-CJFCCV-001, B105108-CJFCCV-001, and B105111 -CJFCCV-001) indicated that detectable contamination was present at depths greater than the deepest core section counted. The deeper concentrations were estimated by extrapolation and included in the evaluation to account for all of the potential source term. As seen in Attachment 1, the depth profile of each core was graphed and fit to an exponential equation using Excel. The concentrations below the last core section were extrapolated using the trend line equation on the Attachment 1 graphs. The calculated values are shown in red in Table 1.

.

**Table 1 - Auxiliary Building In-House Gamma Spectroscopy Cs-137 Core Results Decay Corrected to January 1, 2013.**

| Location | Aux 542 1A RHR Pump | Aux 542 2A RHR Pump | Aux 542 2B RHR | Aux 542 U1 Pipe Tunnel | Aux 542 U2 Hot Pipe Chase | Aux 542 U2 Hot Pipe Chase | Aux 542 HUT | Aux 542 Common Area | Aux 542 Common Central Area | Aux 542 Common Central Area | Aux 542 Common Elevator Shaft | Aux 542 South Area | Aux 542 North Area | Aux 542 North Area | Aux 542 East Area | Aux 542 U1 ABEDCT | Aux 542 U1 ABEDCT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | B105101-CJFCCV-001 | B105103-CJFCCV-001 | B105104-CJFCCV-001 | B105105-CJFCCV-001 | B105106-CJFCCV-001 | B105106-CJFCCV-002 | B105107-CJFCCV-001 | B105108-CJFCCV-001 | B105108-CJFCCV-002 | B105108-CJFCCV-003 | B105108-CJFCCV-004 | B105109-CJFCCV-001 | B105110-CJFCCV-001 | B105110-CJFCCV-002 | B105111-CJFCCV-001 | B105113-CJFCCV-001 | B105113-CJFCCV-002 |
| Depth cm | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g |
| 0.635 | 3198.7 | 22926.4 | 7.1 | 9598.7 | 2506.9 | 2142.2 | 89.5 | 1885.0 | 87.9 | 1215.0 | 111.9 | 1022.6 | 1563.4 | 44.0 | 954.9 | 4119.1 | 1595.2 |
| 1.905 | 654.4 | 12882.2 | ***0.2*** | 7392.5 | 2091.6 | 0.3 | 1.5 | 543.7 | 19.4 | 4.3 | 0.1 | ***0.3*** | 0.5 | ***0.2*** | 322.7 | 165.2 | 354.1 |
| 3.175 | 492.3 | 6161.9 | | 1653.7 | 2027.3 | | 1.0 | 143.5 | 8.0 | 1.0 | 0.2 | | | | 122.0 | 39.9 | 229.2 |
| 4.445 | 231.7 | 2507.9 | | 1869.0 | 1087.8 | | 1.1 | 62.4 | 15.0 | 0.4 | ***0.1*** | | | | 260.3 | 8.0 | 95.1 |
| 5.715 | 128.8 | 2023.0 | | 2153.0 | 416.3 | | 1.5 | 55.9 | 20.7 | ***0.2*** | | | | | 91.6 | 1.1 | 65.4 |
| 6.985 | 118.5 | 1347.0 | | 1438.8 | 528.6 | | 1.1 | 30.0 | 7.8 | | | | | | 56.1 | 1.0 | 18.1 |
| 8.255 | 14.3 | 363.0 | | 1203.9 | 819.3 | | 0.9 | 16.9 | 2.8 | | | | | | 28.9 | 0.9 | 6.0 |
| 9.525 | 4.9 | 221.4 | | 1830.5 | 570.1 | | 0.7 | 32.4 | 0.8 | | | | | | 19.2 | 0.4 | 1.4 |
| 10.795 | 3.4 | 123.2 | | 712.1 | 180.1 | | 0.7 | 15.2 | | | | | | | 11.5 | ***0.2*** | ***0.2*** |
| 12.065 | 0.4 | 63.9 | | 1624.9 | 204.1 | | 0.5 | 3.6 | | | | | | | 6.9 | | 0.1 |
| 13.335 | 0.4 | 33.1 | | 690.5 | 153.7 | | 0.9 | 2.0 | | | | | | | 4.2 | | 0.3 |
| 14.605 | | 17.2 | | 563.6 | 115.8 | | 0.6 | 1.1 | | | | | | | 2.5 | | |
| 15.875 | | 8.9 | | 459.9 | 87.3 | | 1.4 | 0.6 | | | | | | | 1.5 | | |
| 17.145 | | 4.6 | | 375.4 | 65.7 | | 2.8 | 0.3 | | | | | | | 0.9 | | |
| 18.415 | | 2.4 | | 306.3 | 49.5 | | 2.8 | | | | | | | | 0.5 | | |
| 19.685 | | 1.2 | | 250.0 | 37.3 | | 2.8 | | | | | | | | 0.3 | | |
| 20.955 | | 0.6 | | 204.0 | 28.1 | | 1.5 | | | | | | | | | | |
| 22.225 | | 0.3 | | 166.5 | 21.2 | | 1.8 | | | | | | | | | | |
| 23.495 | | 0.2 | | 135.9 | 16.0 | | 1.8 | | | | | | | | | | |
| 24.765 | | | | 110.9 | 12.0 | | 0.6 | | | | | | | | | | |
| 26.035 | | | | 90.5 | 9.1 | | 0.6 | | | | | | | | | | |
| 27.305 | | | | 73.9 | 6.8 | | 0.4 | | | | | | | | | | |
| 28.575 | | | | 60.3 | 5.1 | | 0.5 | | | | | | | | | | |

| Location | Aux 542 1A RHR Pump | Aux 542 2A RHR Pump | Aux 542 2B RHR | Aux 542 U1 Pipe Tunnel | Aux 542 U2 Hot Pipe Chase | Aux 542 U2 Hot Pipe Chase | Aux 542 HUT | Aux 542 Common Area | Aux 542 Common Central Area | Aux 542 Common Central Area | Aux 542 Common Elevator Shaft | Aux 542 South Area | Aux 542 North Area | Aux 542 North Area | Aux 542 East Area | Aux 542 U1 ABEDCT | Aux 542 U1 ABEDCT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | B105101-CJFCCV-001 | B105103-CJFCCV-001 | B105104-CJFCCV-001 | B105105-CJFCCV-001 | B105106-CJFCCV-001 | B105106-CJFCCV-002 | B105107-CJFCCV-001 | B105108-CJFCCV-001 | B105108-CJFCCV-002 | B105108-CJFCCV-003 | B105108-CJFCCV-004 | B105109-CJFCCV-001 | B105110-CJFCCV-001 | B105110-CJFCCV-002 | B105111-CJFCCV-001 | B105113-CJFCCV-001 | B105113-CJFCCV-002 |
| Depth cm | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g |
| 29.845 | | | | 49.2 | 3.9 | | 0.6 | | | | | | | | | | |
| 31.115 | | | | 40.2 | 2.9 | | 0.7 | | | | | | | | | | |
| 32.385 | | | | 32.8 | 2.2 | | 0.6 | | | | | | | | | | |
| 33.655 | | | | 26.7 | 1.7 | | 0.8 | | | | | | | | | | |
| 34.925 | | | | 21.8 | 1.2 | | 0.7 | | | | | | | | | | |
| 36.195 | | | | 17.8 | 0.9 | | | | | | | | | | | | |
| 37.465 | | | | 14.5 | 0.7 | | | | | | | | | | | | |
| 38.735 | | | | 11.9 | 0.5 | | | | | | | | | | | | |
| 40.005 | | | | 9.7 | 0.4 | | | | | | | | | | | | |
| 41.275 | | | | 7.9 | 0.3 | | | | | | | | | | | | |
| 42.545 | | | | 6.4 | 0.2 | | | | | | | | | | | | |
| 43.815 | | | | 5.3 | | | | | | | | | | | | | |
| 45.085 | | | | 4.3 | | | | | | | | | | | | | |
| 46.355 | | | | 3.5 | | | | | | | | | | | | | |
| 47.625 | | | | 2.9 | | | | | | | | | | | | | |
| 48.895 | | | | 2.3 | | | | | | | | | | | | | |
| **Total** | **4847.8** | **48688.6** | **7.3** | **33221.8** | **11054.8** | **2142.5** | **120.2** | **2792.4** | **162.4** | **1220.8** | **112.3** | **1022.9** | **1563.9** | **44.1** | **1884.2** | **4335.8** | **2365.0** |

**Note - *Bold Italic*** Results are MDAs, Blank spaces indicate no sample counted. **Red** results are extrapolated values using Attachment 1 Trend Line equation. Average is total pCi/g at that depth divided by number of results at that depth.

The most direct method for determining the depth distribution of contamination in the Auxiliary Building was deemed to be the use of average concentrations from all 17 cores. If curve fitting of the average data indicates a good fit to an exponential function an argument could be made that the corresponding DRL could be used in the ECP template and the resulting efficiency calibration file applied to all measurements in the Auxiliary basement. This approach was pursued.

To generate the average data for curve fitting, the average concentration in each 0.5 inch slice was converted to total Ci. The extrapolated concentrations shown in red in Table 1were included in the total activity calculations to ensure that all potential activity at depth is accounted for. Note that the average concentration in each slice was conservatively calculated using only the positive results at the respective depths as opposed to including MDC values for cores with non-detectable results at the given depth.

The total Ci in each 0.5inch slice was calculated by multiplying the average activity in a given slice by the total mass in each slice. The total mass was calculated by multiplying the 27,888 square foot surface area of the Auxiliary Building 542 foot elevation floor by a ½ inch thickness and assuming a density of 2.4 g/cc. The result was 7.90E+07 grams. The average concentrations and corresponding total Ci in each ½ inch slice is provided in Table 2.

**Table 2 – Auxiliary Basement Activity Depth Profile and Source Term Using Overall Average of All 17 Cores**

| Depth Inches | Depth cm | Samples with Results | Average for All pCi/g | All Samples Average Source Term Ci |
|---|---|---|---|---|
| 0.25 | 0.635 | 17 | 3121.7 | 2.47E-01 |
| 0.75 | 1.905 | 17 | 1437.2 | 1.14E-01 |
| 1.25 | 3.175 | 12 | 640.0 | 5.05E-02 |
| 1.75 | 4.445 | 12 | 361.1 | 2.85E-02 |
| 2.25 | 5.715 | 11 | 291.6 | 2.30E-02 |
| 2.75 | 6.985 | 10 | 208.6 | 1.65E-02 |
| 3.25 | 8.255 | 10 | 144.5 | 1.14E-02 |
| 3.75 | 9.525 | 10 | 157.7 | 1.25E-02 |
| 4.25 | 10.795 | 9 | 61.6 | 4.86E-03 |
| 4.75 | 12.065 | 8 | 112.0 | 8.85E-03 |
| 5.25 | 13.335 | 8 | 52.1 | 4.11E-03 |
| 5.75 | 14.605 | 6 | 41.2 | 3.26E-03 |
| 6.25 | 15.875 | 6 | 32.9 | 2.60E-03 |
| 6.75 | 17.145 | 6 | 26.5 | 2.09E-03 |
| 7.25 | 18.415 | 5 | 21.3 | 1.68E-03 |
| 7.75 | 19.685 | 5 | 17.2 | 1.35E-03 |
| 8.25 | 20.955 | 5 | 13.8 | 1.09E-03 |
| 8.75 | 22.225 | 5 | 11.2 | 8.82E-04 |
| 9.25 | 23.495 | 4 | 9.0 | 7.15E-04 |
| 9.75 | 24.765 | 3 | 7.3 | 5.74E-04 |

| Depth Inches | Depth cm | Samples with Results | Average for All pCi/g | All Samples Average Source Term Ci |
|---|---|---|---|---|
| 10.25 | 26.035 | 3 | 5.9 | 4.65E-04 |
| 10.75 | 27.305 | 3 | 4.8 | 3.77E-04 |
| 11.25 | 28.575 | 3 | 3.9 | 3.06E-04 |
| 11.75 | 29.845 | 3 | 3.2 | 2.50E-04 |
| 12.25 | 31.115 | 3 | 2.6 | 2.03E-04 |
| 12.75 | 32.385 | 3 | 2.1 | 1.65E-04 |
| 13.25 | 33.655 | 3 | 1.7 | 1.36E-04 |
| 13.75 | 34.925 | 3 | 1.4 | 1.11E-04 |
| 14.25 | 36.195 | 2 | 1.1 | 8.71E-05 |
| 14.75 | 37.465 | 2 | 0.9 | 7.08E-05 |
| 15.25 | 38.735 | 2 | 0.7 | 5.76E-05 |
| 15.75 | 40.005 | 2 | 0.6 | 4.68E-05 |
| 16.25 | 41.275 | 2 | 0.5 | 3.81E-05 |
| 16.75 | 42.545 | 2 | 0.4 | 3.10E-05 |
| 17.25 | 43.815 | 1 | 0.3 | 2.44E-05 |
| 17.75 | 45.085 | 1 | 0.3 | 2.00E-05 |
| 18.25 | 46.355 | 1 | 0.2 | 1.63E-05 |
| 18.75 | 47.625 | 1 | 0.2 | 1.33E-05 |
| 19.25 | 48.895 | 1 | 0.1 | 1.08E-05 |
| | **Total** | | | **5.37E-01** |

The data in Table 2 is plotted as the green line in Figure 5. Curve fitting was performed in two ways. First, the data was fitted to an exponential function using Excel. Second, the depth at which the activity is reduced to 0.368 $A_{max}$ was determined graphically from the plotted data and the rate constant for the exponential function was calculated as described in Equation 4 and used to plot the data.

The black overall trend line equation and the black trend line in Figure 5 show the Excel trend line fitted exponential function. The "goodness" of the fit is described by the regression coefficient which is 0.899 in this case. A regression coefficient of one represents a perfect fit and zero represents no correlation. A regression coefficient of 0.899 indicates reasonable fit but visual inspection reveals a number of disparities between the data and the fitted function. As seen on Figure 5, the fit appears very close to actual data at higher concentrations but diverges to some extent at greater depth and lower concentrations. In general, the black trend line is shifted to the right of the actual data (green plot) at mid to lower depths resulting in an overestimate of total activity.

The purple line draws the exponential function assuming a DRL of 2.3 cm (equivalent to $\lambda = 1/2.3$ cm) which was interpolated from the plotted data as shown in Figure 5. There is no analogy to the regression coefficient for this function but visual inspection confirms a reasonable fit.

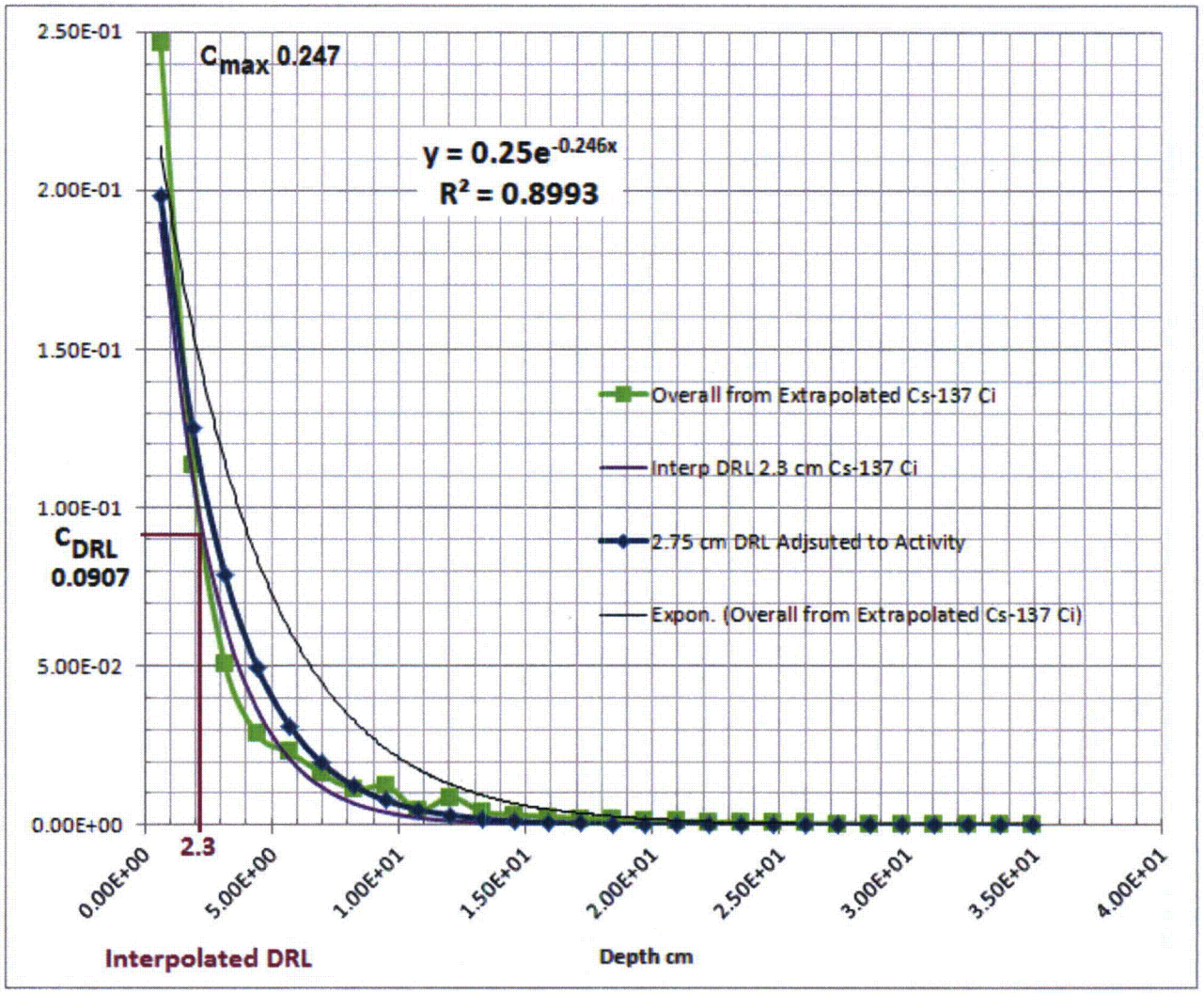



**Figure 5 - Composite Depth Distribution Overall, Trend Lines, and Calculated from Interpolated DRL**

Table 3 calculates the total activity represented by each of the three curves in Figure 5 to a depth of 34.9 cm (i.e., 13.75 inches). As seen in Figure 6, this depth encompasses well over 95% of the activity present in the concrete floor. The calculated Auxiliary Floor total activity based on the 34.9 cm composite profile is 0.537 Ci at a concrete density of 2.40 g/cc. The purple column in Table 3 is the total activity from the interpolated DRL function (purple line in Figure 5) with a total source term of 0.447 Ci. The black overall trend line equation from Figure 5 resulted in a source term that is 48% higher than 0.537 Ci.

A fourth DRL function (blue line in Figure 5) was developed to reconcile the differences in total activity estimates shown in Table 3 by determining a DRL that results in a total activity that is equal to the composite profile from actual core data (green highlight in Table 3). The blue line uses a DRL of 2.75 cm which results in a calculated total activity value of 0.537 Ci (blue highlight in Table 3) that equals the activity from the actual core data.

**Table 3 - Comparison of Overall, Trend Line Overall and Interpolated DRL Source Terms**

| Depth cm | Overall from Extrapolated Cs-137 Ci | Trend Cs-137 Ci | Interp DRL 2.3 cm Cs-137 Ci | 2.75 cm DRL Adjusted to Activity |
|---|---|---|---|---|
| 6.35E-01 | 2.47E-01 | 2.14E-01 | 1.90E-01 | 1.98E-01 |
| 1.91E+00 | 1.14E-01 | 1.56E-01 | 1.09E-01 | 1.25E-01 |
| 3.18E+00 | 5.05E-02 | 1.14E-01 | 6.29E-02 | 7.88E-02 |
| 4.45E+00 | 2.85E-02 | 8.38E-02 | 3.62E-02 | 4.97E-02 |
| 5.72E+00 | 2.30E-02 | 6.13E-02 | 2.08E-02 | 3.13E-02 |
| 6.99E+00 | 1.65E-02 | 4.48E-02 | 1.20E-02 | 1.97E-02 |
| 8.26E+00 | 1.14E-02 | 3.28E-02 | 6.91E-03 | 1.24E-02 |
| 9.53E+00 | 1.25E-02 | 2.40E-02 | 3.98E-03 | 7.83E-03 |
| 1.08E+01 | 4.86E-03 | 1.76E-02 | 2.29E-03 | 4.93E-03 |
| 1.21E+01 | 8.85E-03 | 1.29E-02 | 1.32E-03 | 3.11E-03 |
| 1.33E+01 | 4.11E-03 | 9.40E-03 | 7.59E-04 | 1.96E-03 |
| 1.46E+01 | 3.26E-03 | 6.88E-03 | 4.37E-04 | 1.23E-03 |
| 1.59E+01 | 2.60E-03 | 5.03E-03 | 2.51E-04 | 7.78E-04 |
| 1.71E+01 | 2.09E-03 | 3.68E-03 | 1.45E-04 | 4.90E-04 |
| 1.84E+01 | 1.68E-03 | 2.69E-03 | 8.33E-05 | 3.09E-04 |
| 1.97E+01 | 1.35E-03 | 1.97E-03 | 4.80E-05 | 1.95E-04 |
| 2.10E+01 | 1.09E-03 | 1.44E-03 | 2.76E-05 | 1.23E-04 |
| 2.22E+01 | 8.82E-04 | 1.06E-03 | 1.59E-05 | 7.73E-05 |
| 2.35E+01 | 7.15E-04 | 7.72E-04 | 9.15E-06 | 4.87E-05 |
| 2.48E+01 | 5.74E-04 | 5.65E-04 | 5.27E-06 | 3.07E-05 |
| 2.60E+01 | 4.65E-04 | 4.13E-04 | 3.03E-06 | 1.93E-05 |
| 2.73E+01 | 3.77E-04 | 3.03E-04 | 1.75E-06 | 1.22E-05 |
| 2.86E+01 | 3.06E-04 | 2.21E-04 | 1.01E-06 | 7.68E-06 |
| 2.98E+01 | 2.50E-04 | 1.62E-04 | 5.79E-07 | 4.84E-06 |
| 3.11E+01 | 2.03E-04 | 1.19E-04 | 3.33E-07 | 3.05E-06 |
| 3.24E+01 | 1.65E-04 | 8.67E-05 | 1.92E-07 | 1.92E-06 |
| 3.37E+01 | 1.36E-04 | 6.34E-05 | 1.10E-07 | 1.21E-06 |
| 3.49E+01 | 1.11E-04 | 4.64E-05 | 6.36E-08 | 7.63E-07 |
| **Total** | **5.37E-01** | **7.97E-01** | **4.47E-01** | **5.37E-01** |

From the perspective of total calculated inventory, and visual inspection, the 2.33 cm and 2.75 cm DRL interpolated functions (purple and blue lines in Figure 5) are both better fits to the actual data (green line in Figure 5) than the black Excel trend line.

However, assuming that the average concentrations are a perfect representation of the entire Auxiliary basement, one would conclude that the total inventory would be underestimated using the interpolated function (purple line in Figure 5, purple shade in Table 3). To correct this potential underestimation the DRL of 2.75 cm was selected for the ECP Geometry Template for the Auxiliary basement floor which results in a calculated total activity value that equals the activity from the actual data (green line in Figure 5, green shade in Table 3).

The second primary parameter in the ECP Geometry Template is the depth of contamination. To determine an appropriate value for depth a cumulative curve of total activity with depth was generated (see Figure 6). A depth of 5.8 cm was found to encompass 85% of the core data activity

(green line) and 90% of the activity in the 2.75 cm DRL function (blue line). Therefore, a depth of 5.8 cm was selected to use with the 2.75 cm DRL in the ECP Geometry Template for the Auxiliary Building floor.

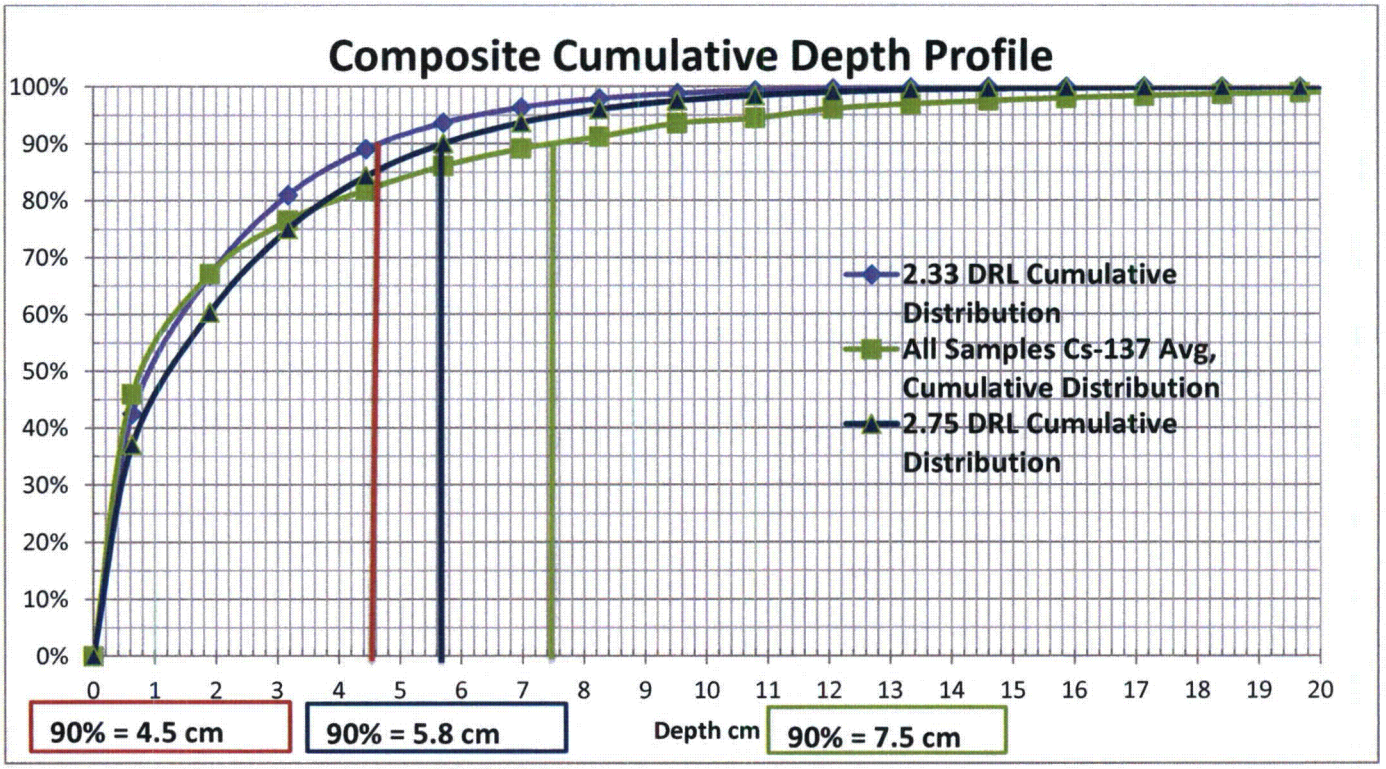



**Figure 6 - Cumulative Activity Distributions for Composite and 2.3 cm DRL**

Section 3.3 below compares ISOCS efficiency data for circular plane geometry templates of individual cores to the extrapolated circular plane efficiency with a $C_{max}$ at 0 cm, a DRL of 2.75 cm and a depth of 5.8 cm.

### 3.2. Auxiliary Floor Concrete Source Term and Density

It should be noted that a concrete density of 2.40 g/cm$^3$ was used in TSD 14-013 (5) to ensure that initial estimates of source term in concrete were bounding and conservative. In order to develop a density specifically for the Auxiliary Building floor concrete (and other end state basements) the volume and mass of a puck from each of the 17 cores was determined and the density calculated. As seen Table 4, the average density was 2.35 g/cm$^3$ which results in a Cs-137 inventory of 0.526 Ci (e.g.2.35/2.40 x 0.537) as opposed to the 0.537 Ci calculated in Table 2 and Table 3. The measured concrete density of 2.35 cm$^3$ was used with the 2.75 cm DRL and 5.8 cm depth in the ECP geometry composer for the Auxiliary basement floor.

**Table 4 - Auxiliary Building Floor Concrete Densities**

| Puck ID | Weight grams | Thickness of puck cm | Volume $cm^3$ | Density $g/cm^3$ |
|---|---|---|---|---|
| B105101-CJFCCV-001 | 126.84 | 1.4 | 54.511 | 2.327 |
| 8105103-CJFCCV-001 | 119.72 | 1.3 | 50.618 | 2.365 |
| 8105104-CJFCCV-001 | 138.86 | 1.5 | 58.405 | 2.378 |
| B105105-CJFCCV-001 | 134.72 | 1.4 | 54.511 | 2.471 |
| B105106-CJFCCV-001 | 135.01 | 1.5 | 58.405 | 2.312 |
| 8105106-CJFCCV-002 | 127.56 | 1.4 | 54.511 | 2.340 |
| 8105107-CJFCCV-001 | 109.06 | 1.2 | 46.724 | 2.334 |
| B105108-CJFCCV-002 | 156.1 | 1.8 | 70.086 | 2.227 |
| 8105108-CJFCCV-003 | 129.24 | 1.4 | 54.511 | 2.371 |
| 8105109-CJFCCV-001 | 125.27 | 1.3 | 50.618 | 2.475 |
| B105110-CJFCCV-001 | 135.86 | 1.5 | 58.405 | 2.326 |
| B105110-CJFCCV-002 | 134.57 | 1.5 | 58.405 | 2.304 |
| B105111-CJFCCV-001 | 130.33 | 1.4 | 54.511 | 2.391 |
| B105113-CJFCCV-001 | 153.68 | 1.7 | 66.192 | 2.322 |
| B105113-CJFCCV-002 | 151.75 | 1.6 | 62.299 | 2.436 |
| 8105113-CJFCCV-003 | 132.6 | 1.5 | 58.405 | 2.270 |
| | | | **Max** | 2.475 |
| | | | **Min** | 2.227 |
| | | | **Average** | **2.353** |

The average density was 2.35 g/cc, which results in a Cs-137 inventory of 0.526 Ci (e.g.2.35/2.40 X 0.537 Ci).

### 3.3. ISOCS Composite Exponential Circular Plane Efficiency and Individual Core Circular Plane Efficiencies

An ECP template was created using the ISOCS geometry composer with a DRL of 2.75 cm, a depth of 5.8 cm and a density of 2.35 $g/cm^3$ where the peak concentration $C_{max}$ occurs at 0 (zero) cm thickness (see Figure 3 and Figure 4). The ISOCS geometry composer refers to $C_{max}$ as "the relative concentration ($A_0$)." The first page of the geometry composer report that shows the input parameters and the comma delimited results showing the efficiencies at the selected energies are presented in a combined report in Attachment 2. The efficiencies in counts per gamma emitted at the energies selected are summarized in Table 5. Selected data from the geometry composer input reports and results are provided in Attachment 2.

As discussed in section 3.4 below the composite ECP efficiencies were compared to the individual core efficiencies (using the CP template) to ensure that the use of the composite ECP geometry was reasonably representative of each individual core's geometry. To make this comparison each of the 17 cores were modeled in the CP geometry and the efficiency curves generated. The efficiencies in

counts per gamma photon emitted at the energies selected are summarized in Table 5. Selected data from the geometry composer input reports and results are provided in Attachment 2.

**Table 5 - Summary of ECP and CP Efficiencies at Specified Energies**

| Description | Core Composite | Aux 542 1A RHR Pump | Aux 542 2A RHR Pump | Aux 542 2B RHR | Aux 542 U1 Pipe Tunnel | Aux 542 U2 Hot Pipe Chase | Aux 542 U2 Hot Pipe Chase | Aux 542 HUT | Aux 542 Common Area |
|---|---|---|---|---|---|---|---|---|---|
| Sample Number | 2.75 DRL | B105101-CJFCCV-001 | B105103-CJFCCV-001 | B105104-CJFCCV-001 | B105105-CJFCCV-001 | B105106-CJFCCV-001 | B105106-CJFCCV-002 | B105107-CJFCCV-001 | B105108-CJFCCV-001 |
| Depth Modeled cm | 5.8 | 13.97 | 24.13 | 2.54 | 49.53 | 43.18 | 2.54 | 35.56 | 17.78 |
| Energy keV | All Cores ECP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g |
| **59.5** | 3.17E-06 | 4.06E-06 | 3.25E-06 | 5.55E-06 | 2.10E-06 | 1.78E-06 | 5.65E-06 | 4.23E-06 | 4.22E-06 |
| **88** | 4.30E-06 | 5.16E-06 | 4.37E-06 | 6.68E-06 | 2.90E-06 | 2.62E-06 | 6.78E-06 | 5.11E-06 | 5.36E-06 |
| **122.1** | 4.51E-06 | 5.27E-06 | 4.57E-06 | 6.64E-06 | 3.07E-06 | 2.87E-06 | 6.71E-06 | 5.08E-06 | 5.45E-06 |
| **165.9** | 4.38E-06 | 5.01E-06 | 4.41E-06 | 6.19E-06 | 2.99E-06 | 2.84E-06 | 6.25E-06 | 4.75E-06 | 5.16E-06 |
| **238.6** | 3.89E-06 | 4.37E-06 | 3.89E-06 | 5.30E-06 | 2.67E-06 | 2.59E-06 | 5.35E-06 | 4.08E-06 | 4.49E-06 |
| **351.9** | 3.33E-06 | 3.69E-06 | 3.33E-06 | 4.40E-06 | 2.32E-06 | 2.28E-06 | 4.44E-06 | 3.40E-06 | 3.79E-06 |
| **583.2** | 2.71E-06 | 2.95E-06 | 2.71E-06 | 3.71E-06 | 1.92E-06 | 1.93E-06 | 3.46E-06 | 2.67E-06 | 3.01E-06 |
| **661.6** | 2.58E-06 | 2.79E-06 | 2.57E-06 | 3.23E-06 | 1.84E-06 | 1.84E-06 | 3.25E-06 | 2.52E-06 | 2.85E-06 |
| **1173.2** | 2.06E-06 | 2.18E-06 | 2.04E-06 | 2.45E-06 | 1.51E-06 | 1.54E-06 | 2.47E-06 | 1.94E-06 | 2.21E-06 |
| **1332.5** | 1.96E-06 | 2.07E-06 | 1.94E-06 | 2.31E-06 | 1.45E-06 | 1.48E-06 | 2.32E-06 | 1.83E-06 | 2.10E-06 |
| **1460.7** | 1.88E-06 | 1.97E-06 | 1.86E-06 | 2.20E-06 | 1.39E-06 | 1.43E-06 | 2.21E-06 | 1.75E-06 | 2.00E-06 |
| **2000** | 1.59E-06 | 1.66E-06 | 1.57E-06 | 1.82E-06 | 1.20E-06 | 1.24E-06 | 1.83E-06 | 1.46E-06 | 1.68E-06 |
| **Ratio 661 keV ECP** | **1.00** | **1.08** | **1.00** | **1.25** | **0.71** | **0.71** | **1.26** | **0.98** | **1.11** |

| Description | Aux 542 Common Central Area | Aux 542 Common Central Area | Aux 542 Common Elevator Shaft | Aux 542 South Area | Aux 542 North Area | Aux 542 North Area | Aux 542 East Area | Aux 542 U1 ABEDCT | Aux 542 U1 ABEDCT |
|---|---|---|---|---|---|---|---|---|---|
| Sample Number | B105108-CJFCCV-002 | B105108-CJFCCV-003 | B105108-CJFCCV-004 | B105109-CJFCCV-001 | B105110-CJFCCV-001 | B105110-CJFCCV-002 | B105111-CJFCCV-001 | B105113-CJFCCV-001 | B105113-CJFCCV-002 |
| Depth Modeled cm | 10.16 | 6.35 | 5.08 | 1.27 | 2.54 | 1.27 | 20.32 | 10.16 | 13.97 |
| Energy keV | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g | CP Eff c/g |
| 59.5 | 3.34E-06 | 5.63E-06 | 5.64E-06 | 5.65E-06 | 5.65E-06 | 5.65E-06 | 3.26E-06 | 5.45E-06 | 4.16E-06 |
| 88 | 4.31E-06 | 6.75E-06 | 6.76E-06 | 6.78E-06 | 6.77E-06 | 6.78E-06 | 4.28E-06 | 6.58E-06 | 5.30E-06 |
| 122.1 | 4.45E-06 | 6.70E-06 | 6.70E-06 | 6.71E-06 | 6.71E-06 | 6.71E-06 | 4.45E-06 | 6.55E-06 | 5.40E-06 |
| 165.9 | 4.26E-06 | 6.23E-06 | 6.24E-06 | 6.25E-06 | 6.25E-06 | 6.25E-06 | 4.27E-06 | 6.11E-06 | 5.12E-06 |
| 238.6 | 3.75E-06 | 5.34E-06 | 5.34E-06 | 5.35E-06 | 5.35E-06 | 5.35E-06 | 3.77E-06 | 5.24E-06 | 4.46E-06 |
| 351.9 | 3.21E-06 | 4.43E-06 | 4.43E-06 | 4.44E-06 | 4.44E-06 | 4.44E-06 | 3.22E-06 | 4.36E-06 | 3.77E-06 |
| 583.2 | 2.60E-06 | 3.45E-06 | 3.45E-06 | 3.46E-06 | 3.46E-06 | 3.46E-06 | 2.62E-06 | 3.40E-06 | 3.22E-06 |
| 661.6 | 2.48E-06 | 3.25E-06 | 3.25E-06 | 3.25E-06 | 3.25E-06 | 3.25E-06 | 2.49E-06 | 3.21E-06 | 2.84E-06 |
| 1173.2 | 1.97E-06 | 2.46E-06 | 2.47E-06 | 2.47E-06 | 2.47E-06 | 2.47E-06 | 1.98E-06 | 2.44E-06 | 2.21E-06 |
| 1332.5 | 1.88E-06 | 2.32E-06 | 2.32E-06 | 2.32E-06 | 2.32E-06 | 2.32E-06 | 1.89E-06 | 2.30E-06 | 2.10E-06 |
| 1460.7 | 1.80E-06 | 2.21E-06 | 2.21E-06 | 2.21E-06 | 2.21E-06 | 2.21E-06 | 1.81E-06 | 2.18E-06 | 2.00E-06 |
| 2000 | 1.53E-06 | 1.83E-06 | 1.83E-06 | 1.83E-06 | 1.83E-06 | 1.83E-06 | 1.53E-06 | 1.81E-06 | 1.68E-06 |
| Ratio 661 keV ECP | 0.96 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | 0.97 | 1.24 | 1.10 |

### 3.4. Comparison of Total Activity Estimate Using Composite and Individual Core Efficiencies

This section compares the efficiency values generated using the composite ECP template (2.75 DRL and 5.8 cm depth) to the efficiency values generated using the actual activity distributions in individual cores modeled with the CP template. The Cs-137 (661.6 keV) efficiency value is used for the comparison. The ratios are listed in the bottom row of Table 5. The objective is to ensure that using the composite ECP depth distribution over the entire Auxiliary basement floor will not underestimate the total activity. The ratios of the average ECP efficiency value to the 17 individual core CP efficiency values are also evaluated to ensure that the average is reasonably representative for each of the cores. This comparison is necessary because it is hypothetically possible that significant variability in the ratios of composite to individual core efficiencies could occur while still resulting in an acceptably close estimate of total activity due to the composite reflecting the average of the activity distribution with depth.

In general, if individual core CP efficiency is higher than the composite ECP efficiency then the use of the composite ECP efficiency to analyze an ISOCS measurement in the area represented by the given core would overestimate activity. This would be conservative in that it would overestimate dose. However, the 17 CP/ECP efficiency ratios do not fully represent the potential effect on the total activity estimate over the entire Auxiliary basement floor. The activity estimate will also depend on the concentrations found in a given core. For example, if a given core contains relatively

high concentrations and therefore represents a high percentage of the total activity in the building, the effect of the CP/ECP efficiency bias for the given core on total activity will be greater than if the core concentrations were low. The analysis in this section accounts for both efficiency bias and relative concentrations of individual cores.

Efficiency curves were generated for each of the 17 cores. For a given core, the actual concentrations in each 0.5 inch puck (see Table 1) were entered into the CP geometry template. This generates an efficiency curve that would be directly applicable to ISOCS measurements in the area represented by core. The efficiency curves for the individual cores were then compared to the composite efficiency curve. Note that the predominant radionuclide is Cs-137 and the comparisons are made using only the Cs-137 efficiency to reduce complexity.

Table 6 provides the results of the efficiency comparison. All total activity entries (Rows 1, 4, and 5) are calculated assuming that each core represents the entire Auxiliary Basement floor. The table entries are:

- Row1 contains the calculated inventory using the results of core analysis directly. The total activity in the Auxiliary Basement was estimated by multiplying the average concentration in the core (pCi/g) by the mass over the entire Auxiliary Basement floor assuming a depth equal to the depth of contamination identified in the core, a surface area of 2591 $m^2$ and a density of 2.35 g/cc.
- Row 2 contains the Cs-137 gamma efficiency from the composite ECP template (from Table 5). Note that only one value is generated and therefore all Row 2 entries are identical.
- Row 3 contains the Cs-137 efficiencies for each core using the CP template (from Table 5).
- Row 4 contains the ratio of the average/individual core efficiencies (from Table 5).
- Row 5 contains the multiple of Row 1 and Row 4 to provide an estimate of the activity that would be reported by an ISOCS measurement in the area represented by the given core assuming that the average ECP efficiency file is used for the analysis.

Reviewing Row 4 shows that the ratios are reasonably close for all cores with the exception of cores B105105 (Aux 542 U1 Pipe Tunnel) and B105106 (Aux 542 U2 Hot Pipe Chase) which are 48.9 and 42.5 cm deep, respectively. Due primarily to the actual depth versus the composite ECP depth of 5.8 cm both have ratios of 0.71 indicating that the ECP will underestimate the activity present under these conditions by 29%. In addition, inspection of Row 1 indicates that these two cores represent the highest activity at 2.57E+12 pCi and 8.55E+11 pCi, respectively. The low ratio and high relative activity results in a potential that the total activity in the Auxiliary Basement floor could be underestimated by ~8% (4.81E+11/5.24E+11) as shown in Table 7, Row 2 if the average efficiency is applied to all areas of the Auxiliary Basement floor. The reason for the low ratio in the Pipe Tunnel cores is the significant depth of the contamination found in these two cores. This is likely due to cracks in the area where the cores were collected. Note that the characterization cores were collected from locations where elevated activity was identified by instrument scan survey or where physical evidence of leaks were observed.

To eliminate the 8% low bias in total activity the ISOCS efficiency files for cores B105105 (Aux 542 U1 Pipe Tunnel) and B105106 (Aux 542 U2 Hot Pipe Chase) will be based on area-specific depth distributions. Because of the unusual depth of contamination in these cores, additional cores

may be collected in the U1 and U2 Pipe Tunnels to ensure that the depth distribution is well understood.

Table 7, Row 3 provides the projected total activity reported by ISOCS measurements assuming that the "Ratio: Individual Core/Average" is 1.0 for Cores B105105 and B105106 under assumption that an area-specific efficiency will be used for ISOCS measurements in the Pipe Tunnels. As seen in Table 7, Row 3 when this adjustment is made the projected total activity using the average ECP efficiency with the average CP efficiency file in all areas except the Pipe Tunnel will result in an overestimate of total activity of ~3% (5.39E+11/5.24E+11). Therefore, use of the composite ECP with a 2.75 cm DRL and 5.8 cm depth will result in a reasonably conservative estimate of total activity in the Auxiliary Basement floor assuming that area specific Geometry Template and efficiency calibration will be performed for the Pipe Tunnels.

**Table 6 – Comparison of Average and Individual Core Efficiency Values and Effect on Total Activity Estimate in Auxiliary Basement Floor**

| Location | Aux 542 1A RHR Pump | Aux 542 2A RHR Pump | Aux 542 2B RHR | Aux 542 U1 Pipe Tunnel | Aux 542 U2 Hot Pipe Chase | Aux 542 U2 Hot Pipe Chase | Aux 542 HUT | Aux 542 Common Area | Aux 542 Common Central Area | Aux 542 Common Central Area | Aux 542 Common Elevator Shaft | Aux 542 South Area | Aux 542 North Area | Aux 542 North Area | Aux 542 East Area | Aux 542 U1 ABEDCT | Aux 542 U1 ABEDCT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample ID** | **B105101-CJFCCV-001** | **B105103-CJFCCV-001** | **B105104-CJFCCV-001** | **B105105-CJFCCV-001** | **B105106-CJFCCV-001** | **B105106-CJFCCV-002** | **B105107-CJFCCV-001** | **B105108-CJFCCV-001** | **B105108-CJFCCV-002** | **B105108-CJFCCV-003** | **B105108-CJFCCV-004** | **B105109-CJFCCV-001** | **B105110-CJFCCV-001** | **B105110-CJFCCV-002** | **B105111-CJFCCV-001** | **B105113-CJFCCV-001** | **B105113-CJFCCV-002** |
| Average pCi/g | 4.41E+02 | 2.70E+03 | 3.63E+00 | 8.52E+02 | 3.25E+02 | 1.07E+03 | 4.29E+00 | 2.15E+02 | 2.03E+01 | 2.44E+02 | 2.81E+01 | 5.11E+02 | 7.82E+02 | 2.21E+01 | 1.18E+02 | 4.82E+02 | 2.15E+02 |
| Core Depth cm | 13.97 | 24.13 | 2.54 | 49.53 | 43.18 | 2.54 | 35.56 | 17.78 | 10.16 | 6.35 | 5.08 | 2.54 | 2.54 | 2.54 | 20.32 | 10.16 | 13.97 |
| Total Cs-137 Activity in Auxiliary Basement Based on Individual Core Data | 3.75E+11 | 3.76E+12 | 5.61E+08 | 2.57E+12 | 8.55E+11 | 1.66E+11 | 9.30E+09 | 2.16E+11 | 1.26E+10 | 9.44E+10 | 8.69E+09 | 7.91E+10 | 1.21E+11 | 3.41E+09 | 1.46E+11 | 2.98E+11 | 1.83E+11 |
| | | | | | | | | | | | | | | | | | |
| Average Cs-137 Efficiency | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 | 2.58E-06 |
| Individual Core Cs-137 Efficiency | 2.79E-06 | 2.57E-06 | 3.25E-06 | 1.84E-06 | 1.84E-06 | 3.25E-06 | 2.52E-06 | 2.85E-06 | 2.48E-06 | 3.25E-06 | 3.25E-06 | 3.25E-06 | 3.25E-06 | 3.25E-06 | 2.48E-06 | 3.21E-06 | 2.84E-06 |
| Ratio: Individual Core/Average | 1.08E+00 | 9.98E-01 | 1.26E+00 | 7.14E-01 | 7.14E-01 | 1.26E+00 | 9.78E-01 | 1.11E+00 | 9.63E-01 | 1.26E+00 | 1.26E+00 | 1.26E+00 | 1.26E+00 | 1.26E+00 | 9.63E-01 | 1.25E+00 | 1.10E+00 |
| | | | | | | | | | | | | | | | | | |
| Projected ISOCS Measured Cs-137 Activity Using 'True' Individual Core Efficiency (pCi) (Note 1) | 4.06E+11 | 3.76E+12 | 7.08E+08 | 1.83E+12 | 6.11E+11 | 2.09E+11 | 9.09E+09 | 2.39E+11 | 1.21E+10 | 1.19E+11 | 1.10E+10 | 9.98E+10 | 1.53E+11 | 4.30E+09 | 1.40E+11 | 3.71E+11 | 2.02E+11 |
| | | | | | | | | | | | | | | | | | |
| Projected ISOCS Measured Cs-137 Activity using 'True' Individual Core Efficiency (pCi) **with adjustment** (Note 2) | 4.06E+11 | 3.76E+12 | 7.08E+08 | 2.57E+12 | 8.55E+11 | 2.09E+11 | 9.09E+09 | 2.39E+11 | 1.21E+10 | 1.19E+11 | 1.10E+10 | 9.98E+10 | 1.53E+11 | 4.30E+09 | 1.40E+11 | 3.71E+11 | 2.02E+11 |

Note 1: Multiple of total Cs-137 activity in Row 1 by the "Ratio: Individual Core/Average" in Row 4
Note 2: Adjustment includes setting the "Ratio: Individual Core/Average" to 1.0 for Cores B105105 and B105106 under assumption that individual core efficiencies will be used in these two areas as opposed to the average efficiency due to relatively low ratios for these two cores.

**Table 7 – Projection of Total Cs-137 Activity in Auxiliary Basement Using Average ECP Efficiency (Note 1)**

| | |
|---|---|
| Total Cs-137 Activity in Auxiliary Basement Based on Core Characterization Data (pCi) at 2.35 g/cc | 5.24E+11 pCi (Note 1) |
| Projected ISOCS Measured Total Cs-137 Activity in Auxiliary Basement using Composite ECP Efficiency (pCi) | 4.81E+11 pCi (Note 2) |
| Projected ISOCS Measured<br>Total Cs-137 Activity in Auxiliary Basement using Average ECP Efficiency File after adjustment for two anomalous cores (pCi) | 5.39E+11 pCi (Note 3) |

Note 1: Average of Table 6, Row 1
Note 2: Average of Table 6, Row 5
Note 3: Average of Table 6, Row 6

## 3.5. Conclusion: Geometry Template for Auxiliary Basement Floor

Based on the discussion above, the ECP Geometry Template using a DRL of 2.75 cm, a depth of 5.8 cm and a density of 2.35 grams will be used for efficiency calibration and applied to all areas of the Auxiliary Basement floor with the exception of the Pipe Tunnels. The geometry template for the pipe tunnels will either be the CP template provided in this TSD or a similar template based on additional characterization if performed. This decision will be made as a part of STS planning and Design Package Preparation.

Note that this conclusion assumes that the configuration of the Auxiliary basement floor is relatively flat concrete surface. If remediation causes a significant change in this assumed 'flat' geometry then adjustments may be made to the geometry template used in the affected areas.

## 3.6. Auxiliary Basement Walls

As seen in Attachment 3, three cores were obtained from walls of the Auxiliary Building. The core locations, results of in-house and off-site laboratory analysis, and estimated wall source term are discussed in TSD 14-013 (5). All three cores exhibited very shallow contamination depth as seen in Table 8. The embedded source term was assumed to be limited to within three feet of the floor with the exception of the HUT cubicles walls which were assumed to be contaminated over the entire wall height with a depth profile the same as the HUT floor core B105107-CJFCCV-001, i.e., down to 14 inches.

**Table 8 - Auxiliary Building Wall Core Cs-137 Results**

| | | Sample Description | Aux 542 East Wall | Unit 1 AEDCT Room Wall | AUX 542 U2 EDT Wall |
|---|---|---|---|---|---|
| | | Sample ID | B105111-CJWCCV-002 | B105113-CJWCCV-003 | B105114-CJWCCV-001 |
| | | Sample Date | 5/30/12 | 5/23/12 | 6/4/12 |
| | | Decay To Date | 1/1/13 | 1/1/13 | 1/1/13 |
| Puck | Depth inches | Mid Depth cm | Cs-137 pCi/g | Cs-137 pCi/g | Cs-137 pCi/g |
| Puck 1 | 0 - 0.5 | 0.635 | 0.7 | 13833.9 | 3139.8 |
| Puck 2 | 0.5 - 1.0 | 1.905 | | 0.8 | 0.7 |

The basis for the 3 foot and full height wall contamination assumptions in the general area and HUT, respectively, was operational history that indicates flooding to those heights during operation. (5)

The three wall cores were from locations that exhibited evidence of water staining or high dose rates. While more cores may be required to confirm that wall source terms are confined to the first half inch, it is likely that a Circular Plane model with layer 1 being 1.27 cm will provide an appropriate model for the assay of the Auxiliary Building walls outside the HUT cubicles.

There is evidence that the HUT cubicles may have been flooded based on the presence of boric acid crystals on the walls. The results from HUT floor (AUX 542 HUT B105107-CJFCCV-001) showed the floor in the center cubicle to have relatively low Cs-137 concentrations at 89 pCi/g in the first half inch with levels approximately 1 to 2 pCi/g over the remaining 14 inches of the core. In order to ensure initial estimates of the source term in the walls were bounding, the results of the HUT floor core B105107-CJFCCV-001 were applied to the three end state HUT walls from the 541.5 foot to 588 foot elevation in TSD 14-013 (5). Due to the unusual profile and operational history in the HUT additional cores of the walls and floor should be considered to develop an area specific ISOCS geometry template and efficiency calibration. If there is evidence of elevated readings on walls outside the HUT cubicles, such as in the RHR cubicles, additional core samples should be considered in these areas to augment the results of the three samples obtained.

### 3.7. Containment Basement

As noted above in Section 2.2, the steel liner walls in the containments extend from the 588 foot elevation to the basement floor at the 568 foot elevation with no interior concrete (3). The In-Core area consists of the area directly below the reactor vessel and an access tunnel. The In-Core area below the reactor vessel has 23.5 inch concrete walls and a 30 inch floor inside the liner. The access tunnel has 1 foot of concrete inside the liner on the walls, floors and ceilings. The concrete wall and floor directly below the vessel is neutron activated. (4) As noted in Chapter 5 of the LTP (1), current plans are to remove all concrete inside the liners in both Containments. The source term geometry for the containment basements will be a thin layer of surface contamination on the remaining steel liners. This radionuclide distribution of the residual contamination on the liner may be influenced by the activated concrete from the bioshield removal. (8) The geometry used on the Containment carbon steel liner walls and floors will be a CP geometry with a thin source thickness. (12)

To determine a reasonable source thickness the potential for corrosion to be present that could have trapped contamination during operations was considered. A NRC containment liner corrosion report (13) states that in the absence of foreign materials such as wood, "*Atmospheric corrosion rates for steel are dependent on the type of environment and range from 0.005 to 0.02 mm/yr [0.2 to 0.8 mpy] in rural atmospheres to 0.03 to 0.08 mm/year [1.2 to 3.2 mpy] in marine environments.*" Where mpy equals mils per year which is equivalent to one thousandth of an inch per mil.

The Zion Unit 1 start date was June 19, 1973. The Unit 2 start date was December 24, 1973. (14) (15) Assuming the Containments were constructed six years prior to start up, the liners would have 51 years of corrosion by the time of STS in July of 2018. Using the NRCs atmospheric and marine corrosion levels over a 51 year duration results in the ranges of corrosion to the 0.25 inch (0.635 cm) thick liner shown in Table 9.

**Table 9 – Potential Containment Liner Corrosion Thicknesses Under Atmospheric and Marine Conditions**

| | Corrosion Rate mm/year | 51 year Corrosion Thickness mm | Corrosion Thickness cm | % Liner Thickness |
|---|---|---|---|---|
| Atmospheric | 0.005 | 0.26 | 0.026 | 4% |
| Marine | 0.03 | 1.53 | 0.153 | 24% |

A source thickness of 0.153 cm provides a bounding and conservative depth of contamination for the liner model.

In the event that some concrete inside the liner is left in either Containment at the 568 foot elevation floors or the In Core areas under the vessel, core data is available in TSD 13-006 (4) to develop concentration profiles at depth and corresponding ISOCS efficiency curves as was done for the Auxiliary Building floor. If contamination is found below the liner in areas such as sumps, the depth of contamination can be determined through additional cores.

## 3.8. Turbine Basement

As noted above in Section 2.2, cores from the Turbine Building and Steam Tunnels exhibited very low levels of Cs-137 in the first half inch of some of the cores (6) with locations very localized. (6). As seen in Table 10, the majority of the activity is in the first half inch (1.27 cm) pucks in the locations that exhibited surface contamination.

**Table 10 - Summary of Turbine Building and Main Steam Tunnel Cores**

| | | Unit 1 Turbine 560 North B206104 - CJFCC V-001 | Unit 1 Turbine 560 North B206104 - CJFCC V-002 | Unit 1 Turbine 560 North B206104 - CJFCC V-003 | Turbine 570 U1 Steam Tunnel B206207 - CJFCC V-001 | Turbine 570 U1 Steam Tunnel B206207 - CJFCC V-002 | Turbine 570 U1 Steam Tunnel B206207 - CJFCC V-003 | Turbine 570 U1 Steam Tunnel B206207 - CJFCC V-004 | Turbine 570 U1 Steam Tunnel B206207 - CJFCC V-005 |
|---|---|---|---|---|---|---|---|---|---|
| **Puck** | **Depth** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** |
| Puck 1 | 0.635 | ***0.12*** | 1.10 | 33.5 | 33.45 | 32.9 | 10.75 | 28.1 | 12.79 |
| Puck 2 | 1.905 | ***0.26*** | ***0.14*** | ***0.10*** | ***0.09*** | ***0.09*** | ***0.11*** | ***0.10*** | ***0.07*** |
| Puck 3 | 3.175 | ***0.13*** | ***0.11*** | ***0.13*** | | | ***0.06*** | ***0.08*** | ***0.09*** |
| Puck 4 | 4.445 | | | | | | ***0.12*** | ***0.11*** | |

| | | Unit 1 Main Steam Valve House B209171 - CJFCC V-001 | Unit 1 Main Steam Valve House B209171 - CJFCC V-002 | Unit 1 Main Steam Valve House B209171 - CJFCC V-003 | Unit 1 Main Steam Valve House B209171 - CJFCC V-004 | Unit 1 Main Steam Valve House B209171 - CJFCC V-005 | Unit 1 Main Steam Valve House B209171 - CJFCC V-006 | Unit 1 Main Steam Valve House B209171 - CJFCC V-007 | Unit 1 Main Steam Valve House B209171 - CJFCC V-008 | Unit 1 Main Steam Valve House B209171 - CJFCC V-009 | Unit 1 Main Steam Valve House B209171 - CJFCC V-010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Depth** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** |
| Puck 1 | 0.635 | 488.5 | 578 | 58.35 | 86.05 | 356.5 | 267.5 | 345 | 367 | 66.35 | 551.5 |
| Puck 2 | 1.905 | ***0.13*** | ***0.12*** | 0.81 | ***0.13*** | ***0.09*** | ***0.10*** | 0.60 | ***0.07*** | ***0.11*** | 1.37 |
| Puck 3 | 3.175 | ***0.08*** | ***0.11*** | 0.30 | ***0.11*** | ***0.12*** | ***0.08*** | 0.16 | ***0.05*** | ***0.12*** | 0.42 |
| Puck 4 | 4.445 | | | ***0.12*** | | | | 0.14 | | | 0.16 |
| Puck 5 | 5.715 | | | ***0.12*** | | | | 0.16 | | | 0.13 |
| Puck 6 | 6.985 | | | | | | | ***0.17*** | | | 0.13 |
| Puck 7 | 8.255 | | | | | | | 0.19 | | | |
| Puck 8 | 9.525 | | | | | | | 0.13 | | | |

| | | Turbine 570 U2 Steam Tunnel B206208 - CJFCC V-001 | Turbine 570 U2 Steam Tunnel B206208 - CJFCC V-002 | U2 Main Steam North Valve House 570 B209201 - CJFCC V-001 | U2 Main Steam North Valve House 570 B209201 - CJFCC V-002 |
|---|---|---|---|---|---|
| | **Depth** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** | **Avg pCi/g** |
| Puck 1 | 0.635 | 5.05 | 13.70 | 26.9 | 8.11 |
| Puck 2 | 1.905 | ***0.12*** | 0.24 | ***0.14*** | ***0.10*** |
| Puck 3 | 3.175 | | ***0.15*** | | ***0.14*** |

Note: ***Bold Italic*** equals MDC.

The top puck from five of the above cores was sent for analysis at Eberline Laboratories. The only plant related positively identified radionuclide was Cs-137. (16) A CP model with a 2.54 cm depth will yield a bounding and conservative estimate of the activity for the Turbine Building and Main Steam Tunnels.

### 3.9. Crib House, Forebay, and Circulating Water Intake Pipes

Scoping surveys in the Crib house using an Inspector 1000 instrument and the results of three cores did not detect any plant-derived radionuclides (17). The Forebay and Circulating Water Intake Pipes may have scoping and characterization surveys performed as well once drained if deemed necessary given the Crib House results and low expectation of contamination being present. Based on results of core samples in the Turbine Building which contained little or no contamination,

detectable contamination in the Crib House, if any, is expected to be confined to the upper half inch. A CP model with a depth of 1.27 cm can be used for the STS of these locations. (6)

### 3.10. Fuel Pool and Fuel Transfer Canal

The Spent Fuel Pool and Transfer Canal end states will have the steel liner below the 588 foot elevation removed. Inspection of SFP liner weld leakage occurred once to twice per year by sampling the tell-tale drain system. Some did show very minor leakage but this was all collected and routed to Auxiliary Building sump by design versus uncaptured. (6) The concrete will be cored and characterized when the liner is removed and a methodology similar to that described for the Auxiliary Building floor can be used to determine the parameters of a CP or ECP geometry template.

### 3.11. Waste Water Treatment Facility (WWTF)

The WWTF is an operating facility required for National Pollutant Discharge Elimination System (NPDES) permit compliance. Therefore characterization has been limited to direct radiation and removable contamination surveys. There are indications that detectable levels of plant related radionuclides are present. (6) When the WWTF is removed from service, the concrete below the 588 foot elevation will be characterized. Since the building housed a non-radioactive system it is likely that any contamination present will be in the upper 1.27 cm as in the Turbine Building and Main Steam Tunnels and that CP model with a depth of 1.27 cm can be used.

### 3.12. Circulating Water Discharge Tunnels

The South, Unit 1, Discharge Tunnel was used as a liquid effluent discharge pathway during plant operation. But the waste discharge point was at the far eastern side of the tunnel under the valve house. It is unlikely that the end state concrete structures will have sorbed contamination deeper than 1.27 cm. Confirmatory characterization will be performed when the tunnel becomes accessible during the decommissioning process.

The North, Unit 2, Discharge Tunnel was converted for use as an effluent discharge point during decommissioning. Due to the design of the system, water from the Lake Tanks which could be up to ten times the effluent concentration limits of the Off Site Dose Calculation Manual (ODCM) was released into the far western end of the tunnel while the preponderance of the service water dilution flow entered from the far eastern end under the valve house. (6) This created a dead leg which may have allowed sediments in the tunnel and some of its concrete to sorb contamination. The north Unit 2 tunnel may require a methodology similar to the Auxiliary Building basement to develop an ECP or CP model that accurately represents the depth profile. This will be determined after characterization is completed.

## 4. ISOCS EFFICIENCY UNCERTAINTY ANALYSIS

The ISOCS Geometry Composer was used to test the sensitivity of the parameters in the Auxiliary Floor Composite ECP model (Attachment 2) including density, contamination thickness and DRL. The ranges of the parameter values assessed are based on the analyses shown in Figure 5, Figure 6 and Table 4. The ISOCS reports are provided in Attachment 5 and the Cs-137 results are summarized in Table 11.

**Table 11 - ECP Model Sensitivity for Density, Depth, and DRL**

| Parameter | Reference | Value 1 | Value 2 | Units | Ref Eff c/g | Value 1 Eff c/g | Value 2 Eff c/g | Value 1 % Ref | Value 2 % Ref |
|---|---|---|---|---|---|---|---|---|---|
| Density | 2.35 | 2.3 | 2.4 | g/cc | 2.58E-06 | 2.59E-06 | 2.56E-06 | 101% | 99% |
| Thickness | 58 | 45 | 78 | mm | 2.58E-06 | 2.65E-06 | 2.41E-06 | 103% | 94% |
| DRL | 27.5 | 23.3 | 45 | mm | 2.58E-06 | 2.67E-06 | 2.44E-06 | 104% | 95% |
| | | | | | | | Worst | 104% | 94% |

.

The results indicate that the thickness due to depth of contamination is the most sensitive parameter followed by the DRL. The least sensitive relative to the actual potential range of values is the density. The results indicate that the efficiency values are relatively insensitive to variability in the parameters ranging from 94% to 104% of the reference efficiency (2.75 DRL, 5.8 cm depth, density 2.35 g/cm$^3$).

## 5. SENSITIVITY TO NON-UNIFORM AREAL DISTRIBUITON

The development of geometry templates and efficiency files discussed above assumes that the residual radioactivity is uniformly distributed over the ISOCS FOV. This section reviews the effect of non-uniform areal distributions on the calculation of total activity using ISOCS.

To determine the effect of non-uniform distributions two sets of three ECP Geometry Templates (DRL = 2.75, Depth = 5.8) were developed as shown in Figure 7. The first set assumed that the contaminated area was limited to a 1 m$^2$ circular area as opposed to the full 28.3 m$^2$ field of view. The location of the 1 m$^2$ areas were defined by three offset distances from the detector centerline which were 0 m, 1.22 m, and 2.43 m. The 2.43 m offset places the 1m$^2$ area at the edge of the 28.3 m$^2$ field of view (i.e., the furthest distance from the detector). As seen in Figure 7, the second set of non-uniform distributions evaluated assumed that the contaminated area was a 0.5 m$^2$ circular area with offset distances from the centerline of 0 m, 1.3 m, and 2.60 m.

Efficiency files were generated for each configuration. The relevant excerpts from the geometry composer model report and results reports are provided in Attachment 4 and summarized in Table 12.

Inspection of Table 12 shows that the Cs-137 efficiencies for single 1.0 m$^2$ areas of contamination exceed the uniform ECP efficiency (DRL 2.75 cm, depth 5.8 cm) by a factor of 2.46 and 1.62 at offset distances of 0.0 m and 1.22 m, respectively. At a distance of 1.89 m the efficiencies of the uniform and 1 m$^2$ area are equal. At offset distances greater than 1.89 m the 1 m$^2$ area efficiencies are less than the uniform. In summary, a 1 m$^2$ area with a center that is offset less than 1.89 m$^2$ would result in overestimating the total activity using the uniform ECP efficiency and 1 m$^2$ spots with offsets greater than 1.89 m would result in an underestimate. Calculating an area-weighted 1 m$^2$ efficiency average from the data in Table 12 shows that if a number of 1 m$^2$ spots were randomly distributed in either one or several ISOCS measurement FOVs the effective efficiency would be a factor of 1.2 times higher than the uniform ECP efficiency. This would result in an overestimate of total activity if the ISOCS spectrums were analyzed with the uniform ECP efficiency.

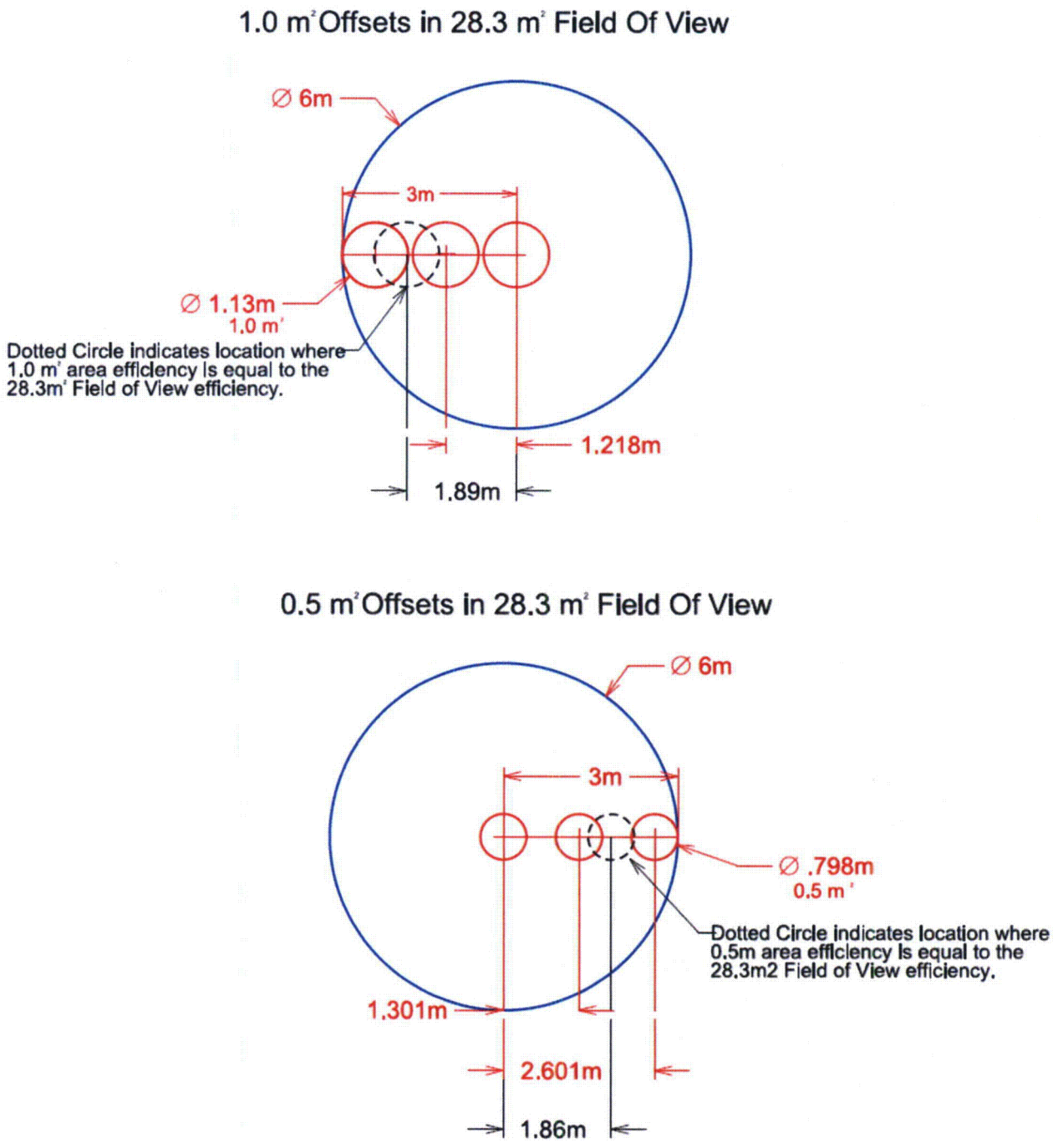



**Figure 7 - Areal Distribution Model Illustration**

**Table 12 - Areal Distribution Efficiency Results**

| Energy keV | All Cores ECP Eff c/g | 1 $m^2$ No Offset | 1 $m^2$ 122 cm Offset | 1 $m^2$ 244 cm Offset | 0.5 $m^2$ No Offset | 0.5 $m^2$ 130 cm Offset | 0.5 $m^2$ 260 cm Offset |
|---|---|---|---|---|---|---|---|
| **59.5** | 3.17E-06 | 6.00E-06 | 4.66E-06 | 2.45E-06 | 6.03E-06 | 4.38E-06 | 2.14E-06 |
| **88** | 4.30E-06 | 8.19E-06 | 6.33E-06 | 3.33E-06 | 8.26E-06 | 5.96E-06 | 2.89E-06 |
| **122.1** | 4.51E-06 | 8.69E-06 | 6.67E-06 | 3.47E-06 | 8.79E-06 | 6.30E-06 | 3.02E-06 |
| **165.9** | 4.38E-06 | 8.81E-06 | 6.59E-06 | 3.28E-06 | 8.94E-06 | 6.22E-06 | 2.84E-06 |
| **238.6** | 3.89E-06 | 8.32E-06 | 5.97E-06 | 2.81E-06 | 8.49E-06 | 5.62E-06 | 2.42E-06 |
| **351.9** | 3.33E-06 | 7.66E-06 | 5.22E-06 | 2.30E-06 | 7.88E-06 | 4.89E-06 | 1.98E-06 |
| **583.2** | 2.71E-06 | 6.62E-06 | 4.37E-06 | 1.79E-06 | 6.83E-06 | 4.32E-06 | 1.52E-06 |
| **661.6** | 2.58E-06 | 6.34E-06 | 4.18E-06 | 1.68E-06 | 6.54E-06 | 3.91E-06 | 1.43E-06 |
| **1173.2** | 2.06E-06 | 5.02E-06 | 3.41E-06 | 1.32E-06 | 5.16E-06 | 3.20E-06 | 1.11E-06 |
| **1332.5** | 1.96E-06 | 4.75E-06 | 3.23E-06 | 1.26E-06 | 4.88E-06 | 3.04E-06 | 1.06E-06 |
| **1460.7** | 1.88E-06 | 4.52E-06 | 3.09E-06 | 1.20E-06 | 4.64E-06 | 2.92E-06 | 1.01E-06 |
| **2000** | 1.59E-06 | 3.77E-06 | 2.62E-06 | 1.02E-06 | 3.86E-06 | 2.48E-06 | 8.57E-07 |
| **Cs-137 661.6 KeV Ratio** | 1.00 | 2.46 | 1.62 | 0.65 | 2.54 | 1.52 | 0.56 |
| **Adjustment Factor** | | 0.41 | 0.62 | 1.53 | 0.39 | 0.66 | 1.80 |
| **Area Weighted Average** | | 1.2 | | | 1.1 | | |

The same general analysis applies to the 0.5 $m^2$ area spots. Figure 7 shows that the 0.5 $m^2$ efficiency equals the uniform ECP efficiency at an offset distance of 1.86 m. From Table 12 the weighted average efficiency of randomly distributed 0.5 $m^2$spots is a factor of 1.1 times higher than the uniform ECP efficiency and would also result in an overestimate of total activity if the ISOCS spectrums were analyzed with the uniform ECP efficiency.

The area weighting was performed by calculating the circular areas inside and outside of the offset distance where the efficiencies of the all cores ECP and spot efficiencies are equal, i.e., 1.89 m and 1.86 m for the 1 $m^2$ and 0.5 $m^2$ spots, respectively. The two adjustment factors listed in Table 12 for offset distances less than the "equal distance" were averaged and applied to the inside circular area. The single adjustment factor in Table 12 with an offset greater than the "equal distance" was applied to the circular area outside of the "equal distance".

The analyses above assume that there is no contamination present in the FOV other than a single at the distances shown. Any increase in the number and areal extent of contamination beyond the single 1 $m^2$ and 0.5 $m^2$ areas assumed in Table 12, up to full uniform contamination over the entire 28 $m^2$ FOV would result in a convergence between non-uniform and uniform efficiencies.

The distribution and location of non-uniform elevated areas are expected to be randomly located with equal probability of being at any distance from the detector centerline. This would lead to the total activity estimate, on average, over an entire basement being reasonably conservative when the composite ECP efficiency file, which is based on uniform areal distribution, is applied. Therefore, no efficiency adjustment for potential non-uniform areal distribution is considered necessary.

Note that the location(s) of small isolated spots, if any, in contaminated areas such as the Auxiliary basement should be well known through the results of the scan surveys that will be performed to identify areas exceeding the 2 mR/hr open air demolition criteria. After remediation of these areas additional scan surveys will be conducted to ensure that the remediation was successful providing additional information in regards to the potential for elevated areas at the time of STS. This scan information will further inform the STS survey design process to ensure that there is no obvious source term geometry present that would result in underestimating total activity in a given basement considering the sample plan and locations for ISOCS STS measurements. Note that this discussion of isolated spots is actually germane only to the Auxiliary Basement and possibly the Fuel Pool/Transfer Canal and north Unit 2 Discharge Canal. Remaining basements are expected to contain very low levels of residual radioactivity at license termination.

## 6. MINIMUM DETECTABLE CONCENTRATIONS OF CP AND ECP MODELS

The Minimum Detectable Concentrations (MDCs) for the ISOCS application during STS of the ZSRP Basements are a small fraction of the contamination levels corresponding to the Basement Fill Model (BFM) activity limits. The Cs-137 MDCs were evaluated for three geometries;

1. The composite ECP that will be used for the STS of the Auxiliary Basement Floors and perhaps the Spent Fuel Pool and Transfer Canal,
2. The 1.27 cm CP used for the Auxiliary Building walls and all other end state structures except the Containments, and
3. The 0.153 cm CP model for the steel liners of the containments.

The ISOCS reports are provided in Attachment 6 and the Cs-137 MDC results are summarized in Table 13.

The predominant radionuclide is Cs-137 which has nominal MDCs of 1.11E+04, 8.94E+03 and 8.21E+03 pCi/m$^2$, respectively for each of the three models. To compare this MDC to the BFM activity limits, the values in LTP Table 5-9 were divided by the surface area of each structure to convert the building limit to pCi/m$^2$. The ISOCS MDC can then be directly compared to the BFM limit. Table 13 provides the results which show that the MDC ranges from 0.004% to 0.294% of the BFM limit (pCi/m$^2$) for the ZSRP basements. Note that the highest MDC percentage 0.294% is in the WWTF which has a relatively low BFM Inventory Limit due to the small size of the structure. This is an artifact of the BFM method which relies on the basement surface area to volume ratio as one of the inputs. However, the low BFM limit for the WWTF is not significant given minimal contamination is expected to be present. The vast majority of the residual radioactivity is known to be contained in the Auxiliary Building basement and Spent Fuel Pool (SFP)/Transfer Canal. The ISOCS MDC percentages are 0.004% and 0.012% for these two basements, respectively.

**Table 13 - Comparison of ECP and CP Model MDCs to Basement Fill Model Limits**

| STS Survey Unit | Model | Area ($ft^2$) | Area ($m^2$) | Cs-137 BFM Limit (mCi) LTP Table 5-9 | Cs-137 Activity Limit ($pCi/m^2$) | Cs-137 MDC ($pCi/m^2$) | MDC Percent of Cs-137 Limit (%) |
|---|---|---|---|---|---|---|---|
| Auxiliary Building Floor* | 5.8 cm ECP | 27888 | 2,590.88 | 6.90E+02 | 2.66E+08 | 1.11E+04 | 0.004% |
| Auxiliary Building Walls* | 1.27 cm CP | 42200 | 3,920.51 | 1.45E+02 | 3.70E+07 | 8.94E+03 | 0.024% |
| Unit 1 Containment Liner | 0.153 cm CP | 29687.6 | 2,758.07 | 1.52E+02 | 5.51E+07 | 8.21E+03 | 0.015% |
| Unit 2 Containment Liner | 0.153 cm CP | 29687.6 | 2,758.07 | 1.52E+02 | 5.51E+07 | 8.21E+03 | 0.015% |
| SFP/Transfer Canal | 5.8 cm ECP | 7782.26 | 723.00 | 6.82E+01 | 9.43E+07 | 1.11E+04 | 0.012% |
| Turbine Building and Discharge Tunnels | 1.27 cm CP | 160454 | 14,906.66 | 5.94E+02 | 3.98E+07 | 8.94E+03 | 0.022% |
| Crib House/Forebay | 1.27 cm CP | 74705 | 6,940.32 | 6.52E+02 | 9.39E+07 | 8.94E+03 | 0.010% |
| WWTF | 1.27 cm CP | 12104 | 1,124.50 | 3.42E+00 | 3.04E+06 | 8.94E+03 | 0.294% |

*** BFM Limit Adjusted to 83% of Limit in Floor 17% in Walls**

## 7. CONCLUSION

The ISOCS gamma spectroscopy instrumentation can be used to perform the STS of the ZSRP end state structure basements. ECP and CP Geometry Templates have been developed to accurately assay the gamma emitting source term in the end state basements. This TSD provides recommended Geometry Templates to apply to each end state basement at ZSRP. All of the recommended templates assume uniform contamination. This TSD demonstrates that no adjustment to the ISOCS efficiency calibrations are necessary to account for isolated spots of contamination.

Additional concrete core samples should be collected from the following areas to either validate the limited core data currently available or to provide new data in areas that are considered to have unique operational history or contamination profile relative to other building areas. The ISOCS Geometry Template to apply in these areas will be developed using the methods described in this TSD based on a combination of existing and new core data. The areas are listed below:

- HUT walls and floor. If there is evidence of elevated readings on walls outside the HUT cubicles, additional core samples should be considered in the elevated areas.
- Auxiliary Building Pipe Tunnels
- Fuel Pool and Fuel Transfer Tunnel after Fuel Pool liner removed
- North Unit 2 Discharge Tunnel

## 8. REFERENCES

1. Zion Station Restoration Project License Termination Plan Revision 0.
2. NUREG-1575, Rev. 1, Multi-Agency Radiation Survey And Site Investigation Manual (MARSSIM), August 2000.

3. TSD 13-005, Unit 1 & 2 Reactor Building Estimated End State Concrete and Liner Volumes and Surface Areas.
4. TSD 13-006, Reactor Building Units 1 and 2 End State Concrete and Liner Initial Characterization Source Terms and Distributions.
5. TSD 14-013, Zion Auxiliary Building End State Estimated Concrete Volumes, Surface Areas, and Source Terms.
6. TSD 14-014, End State Surface Areas, Volumes, and Source Terms of Ancillary Buildings.
7. SU-476-3 Advanced ISOCS Measurements Training Course, Canberra Industries Inc, January 2014.
8. TSD 14-019 Radionuclides of Concern for Soil and Basement Fill Model Source Terms.
9. TSD 11-001 Potential Radionuclides of Concern During the Decommissioning of the Zion Station.
10. TSD 10-002 Technical Basis for Radiological Limits for Structure, Building Open Air Demolition.
11. 10 CFR 20 Standards for Protection Against Radiation, Subpart E—Radiological Criteria for License Termination http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/.
12. Canberra 31013E V4.2 Technical Reference Manual, Model S573 ISOCS Calibration Software.
13. NRC ML112140119, Containment Liner Corrosion, Darrell Dunn, U.S.N.R.C, August 2011.
14. WMG Report 07-046D-RE-088, Zion Units 1 and 2 Activation Analysis And Component Characterization, January 2008, WMG Project 07-046D.
15. ComEd Zion Station Historical Site Assessment, Version 1 - August, 1999.
16. EBS-OR-35166, Eberline Case Narrative for Work Order # 13-01030-0R, February 13,2013.
17. EBS-OR-356IS, Case Narrative, Work Order # 13-04120-0R, June 27, 2013.
18. NUREG-1757 Vol. 2, Rev. 1, Consolidated Decommissioning Guidance Characterization, Survey, and Determination of Radiological Criteria, September 2006.

## 9. ATTACHMENTS

9.1. Attachment 1 –Auxiliary Building Cs-137 Depth Profiles

9.2. Attachment 2 -Circular Plane and Exponential Circular Plane Efficiency Comparison Reports

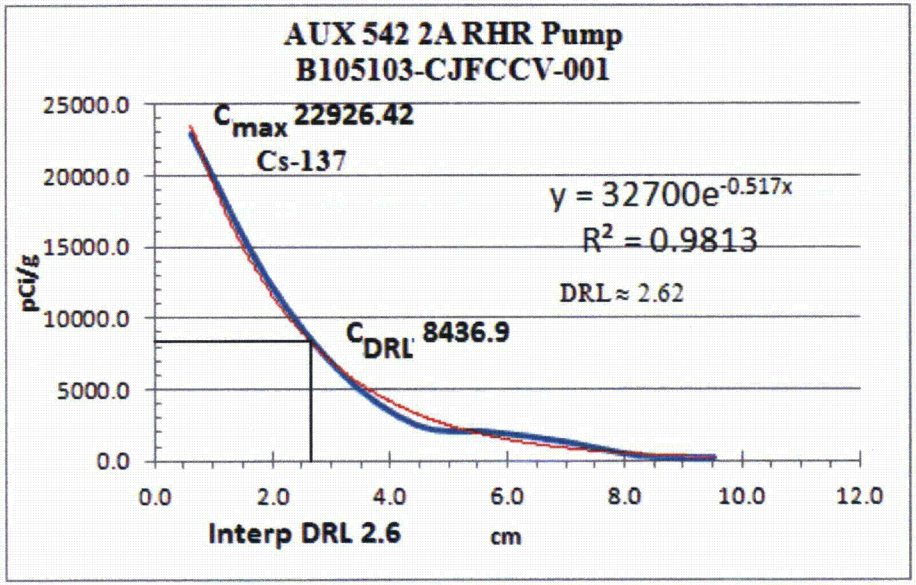
9.3. Attachment 3 - Map of Auxiliary Building Floor and Wall Concrete Core Locations

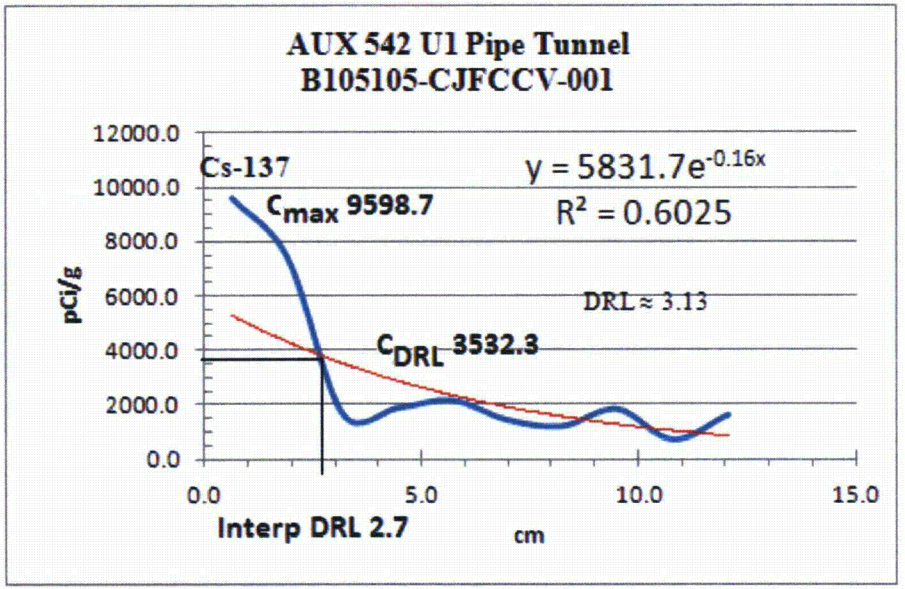
9.4. Attachment 4 - Areal Distribution Input and Results Reports

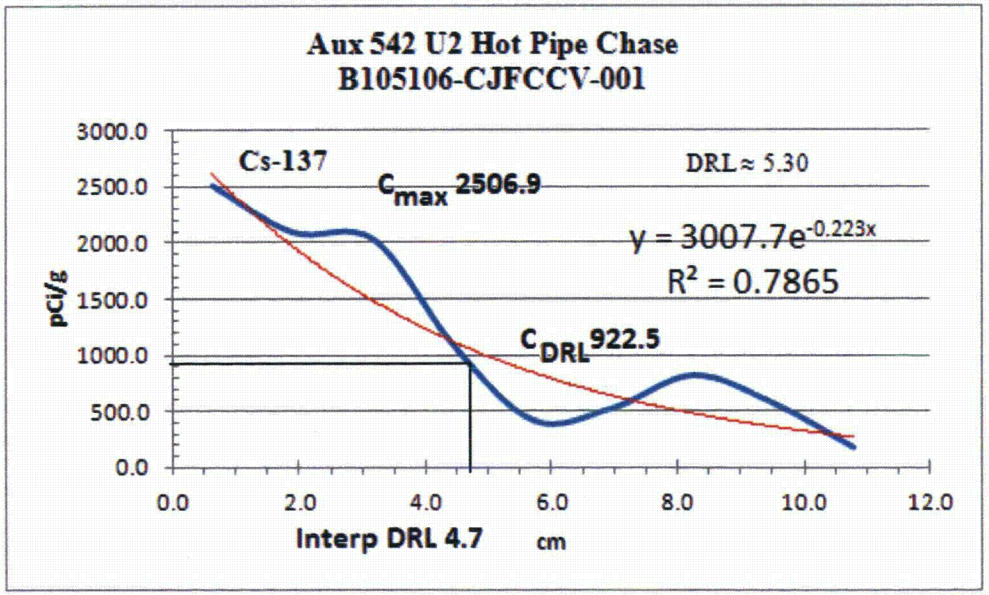
9.5. Attachment 5 - Sensitivity to Density, Depth, and DRL Input and Output

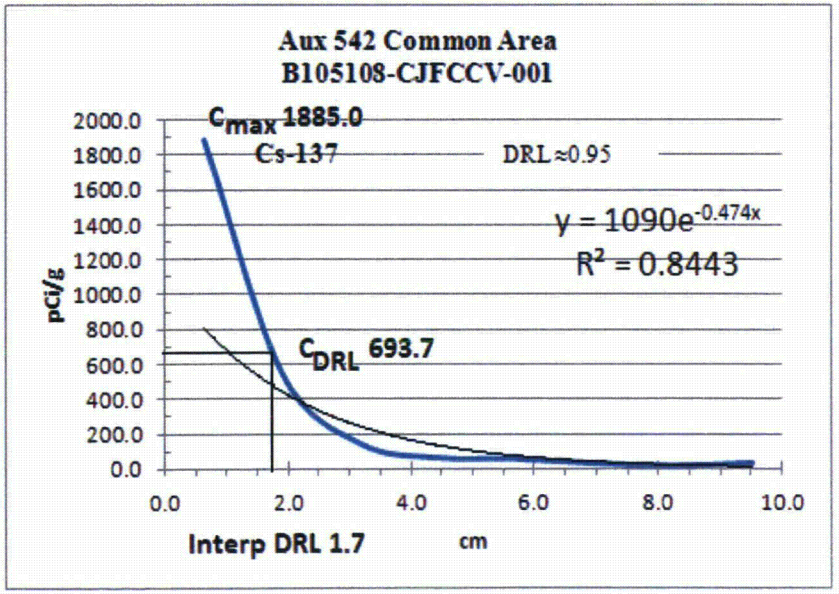
9.6. Attachment 6 - Minimum Detectable Concentrations

**ATTACHMENT 1**
**Auxiliary Building Cs-137 Depth Profiles**
**and Interpolated Relaxation Lengths**

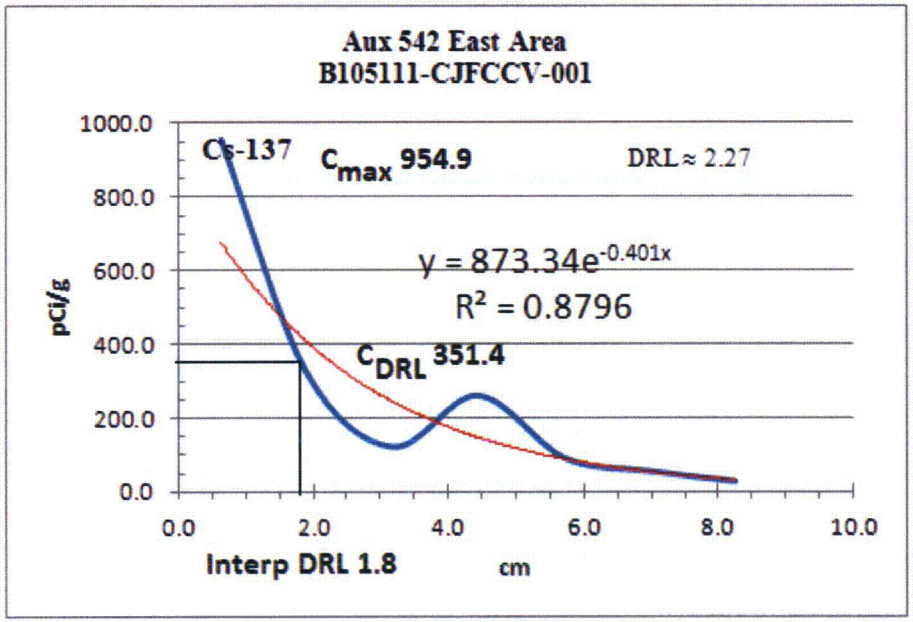


**ATTACHMENT 1**
**Auxiliary Building Cs-137 Depth Profiles**
**and Interpolated Relaxation Lengths**



# Exponential Circular Plane - Aux Floor Cores Composite

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Wednesday, April 29, 2015 - 16:17:20
**Description:** or
**Comment:** 3 m source to detector, 5.8 cm thick, 2.75 DRL, 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR_PLANE\General ECP Model.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.8 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\GENERAL ECP MODEL.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Wed Apr 29 16:14:33 2015
Original gis-file name: general ecp model.gis
Template Type: exponent_circular_plane

efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 3.17E-06 | 4.30E-06 | 4.51E-06 | 4.38E-06 | 3.89E-06 | 3.33E-06 | 2.71E-06 | 2.58E-06 | 2.06E-06 | 1.96E-06 | 1.88E-06 | 1.59E-06 |

# Circular Plane - Aux 542 1A RHR Pump B105101-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 13:26:44
**Description:** Aux 542 1A RHR Pump Room B105101-01 90 degree 50 mm Collimator
**Comment:** Detector 5456, 3.0 m 13.97 cm Thick
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 1A RHR 032715.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 3198.70 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 654.40 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 492.30 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 231.70 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 128.80 |
| 7 | Layer 6 | 1.27 | | | | | | concrete | 2.3 | 118.50 |
| 8 | Layer 7 | 1.27 | | | | | | concrete | 2.3 | 14.30 |
| 9 | Layer 8 | 2.54 | | | | | | concrete | 2.3 | 4.10 |
| 10 | Layer 9 | 2.54 | | | | | | concrete | 2.3 | 0.40 |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 1A RHR 032715~~001.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 13:25:37 2015
Original gis-file name: aux 542 1a rhr 032715.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 4.06E-06 | 5.16E-06 | 5.27E-06 | 5.01E-06 | 4.37E-06 | 3.69E-06 | 2.95E-06 | 2.79E-06 | 2.18E-06 | 2.07E-06 | 1.97E-06 | 1.66E-06 |

# Circular Plane - Aux 542 2A RHR Pump B105103-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Monday, April 27, 2015 - 13:56:44
**Description:** AUX 542 2A RHR_01
**Comment:** Total Thickness 22.86 3.0 m 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 2A RHR 042715.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 22926.40 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 12882.20 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 6161.90 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 2507.90 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 2023.00 |
| 7 | Layer 6 | 1.27 | | | | | | concrete | 2.3 | 1347.00 |
| 8 | Layer 7 | 1.27 | | | | | | concrete | 2.3 | 363.00 |
| 9 | Layer 8 | 5.08 | | | | | | concrete | 2.3 | 124.30 |
| 10 | Layer 9 | 5.08 | | | | | | concrete | 2.3 | 12.50 |
| 11 | Layer 10 | 3.81 | | | | | | concrete | 2.3 | 1.40 |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 59.5 | 88.0 | 122.1 | 165.9 | 238.6 | 351.9 | 583.2 | 661.6 |
| 1173.2 | 1332.5 | 1460.7 | 2000.0 | | | | |

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 2A RHR 042715.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Mon Apr 27 14:00:09 2015
Original gis-file name: aux 542 2a rhr 042715.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 3.25E-06 | 4.37E-06 | 4.57E-06 | 4.41E-06 | 3.89E-06 | 3.33E-06 | 2.71E-06 | 2.57E-06 | 2.04E-06 | 1.94E-06 | 1.86E-06 | 1.57E-06 |

## Circular Plane - Aux 542 2B RHR B105104-CJFCCV-001

### Page 1 of
### Geometry Composer Report

CANBERRA

**Date:** Monday, April 27, 2015 - 14:15:59
**Description:** Aux 542 2B RHR B105104_01
**Comment:** 3.0 m source to detector, 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 2B RHR_01 042715.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 7.00 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 0.20 |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 500.0 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 2B RHR_01 042715.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Mon Apr 27 14:15:38 2015
Original gis-file name: aux 542 2b rhr_01 042715.gis
Template Type: circular_plane
*efficiency of all Models run [Efficiency]*

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 500.0 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.55E-06 | 6.68E-06 | 6.64E-06 | 6.19E-06 | 5.30E-06 | 4.40E-06 | 3.71E-06 | 3.23E-06 | 2.45E-06 | 2.31E-06 | 2.20E-06 | 1.82E-06 |

# Circular Plane - Aux 542 U1 Pipe Tunnel B105105-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Wednesday, April 29, 2015 - 13:35:39
**Description:** Aux U1 Pipe Tunnel B105105_01 3.0 m 90 degree 50 mm collimator
**Comment:** 0-49.53 concrete thickness
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 U1 Pipe Tunnel NU 042815.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

Dimensions (cm)

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 9598.70 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 7392.50 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 1653.70 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 1869.00 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 2153.00 |
| 7 | Layer 6 | 1.27 | | | | | | concrete | 2.3 | 1438.80 |
| 8 | Layer 7 | 1.27 | | | | | | concrete | 2.3 | 1203.90 |
| 9 | Layer 8 | 12.7 | | | | | | concrete | 2.3 | 701.72 |
| 10 | Layer 9 | 12.7 | | | | | | concrete | 2.3 | 78.68 |
| 11 | Layer 10 | 15.24 | | | | | | concrete | 2.3 | 9.03 |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

List of energies for efficiency curve generation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 59.5 | 88.0 | 122.1 | 165.9 | 238.6 | 351.9 | 583.2 | 661.6 |
| 1173.2 | 1332.5 | 1460.7 | 2000.0 | | | | |

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 U1 PIPE TUNNEL NU 042815~~001.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Wed Apr 29 13:25:03 2015
Original gis-file name: aux 542 u1 pipe tunnel nu 042815.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 2.10E-06 | 2.90E-06 | 3.07E-06 | 2.99E-06 | 2.67E-06 | 2.32E-06 | 1.92E-06 | 1.84E-06 | 1.51E-06 | 1.45E-06 | 1.39E-06 | 1.20E-06 |

# Circular Plane - Aux 542 U2 Hot Pipe Chase B105106-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 28, 2015 - 14:07:21
**Description:** Aux 542 U2 Hot Pipe Chase NU B105106_1; 3.0 m 0-43.2 Thickness
**Comment:** 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\U2 Hot Pipe Chase_01 NU 042815.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 2506.90 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 2091.60 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 2027.30 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 1087.80 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 416.30 |
| 7 | Layer 6 | 1.27 | | | | | | concrete | 2.3 | 528.60 |
| 8 | Layer 7 | 1.27 | | | | | | concrete | 2.3 | 819.30 |
| 9 | Layer 8 | 11.43 | | | | | | concrete | 2.3 | 162.63 |
| 10 | Layer 9 | 11.43 | | | | | | concrete | 2.3 | 11.67 |
| 11 | Layer 10 | 11.43 | | | | | | concrete | 2.3 | 0.91 |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 59.5 | 88.0 | 122.1 | 165.9 | 238.6 | 351.9 | 583.2 | 661.6 |
| 1173.2 | 1332.5 | 1460.7 | 2000.0 | | | | |

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\U2 HOT PIPE CHASE_01 NU 042815.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 28 15:20:26 2015
Original gis-file name: u2 hot pipe chase_01 nu 042815.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 1.78E-06 | 2.62E-06 | 2.87E-06 | 2.84E-06 | 2.59E-06 | 2.28E-06 | 1.93E-06 | 1.84E-06 | 1.54E-06 | 1.48E-06 | 1.43E-06 | 1.24E-06 |

# Circular Plane - Aux 542 U2 Hot Pipe Chase B105106-CJFCCV-002

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 28, 2015 - 15:56:47
**Description:** Aux 542 U2 Hot Pipe Chase B105106_02 3.0 m, 90 degree 50 mm collimator
**Comment:** Thickness 0-2.54 Detector 5456
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 U2 Hot Pipe Chase_02 042815.gec
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 2142.20 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 0.25 |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 U2 HOT PIPE CHASE_02 042815.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 28 15:46:32 2015
Original gis-file name: aux 542 u2 hot pipe chase_02 042815.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.65E-06 | 6.78E-06 | 6.71E-06 | 6.25E-06 | 5.35E-06 | 4.44E-06 | 3.46E-06 | 3.25E-06 | 2.47E-06 | 2.32E-06 | 2.21E-06 | 1.83E-06 |

# Circular Plane - Aux 542 HUT B105107-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 14:19:23
**Description:** Aux HUT B105107_01; 3.0 m 90 degree 50 mm collimator
**Comment:** Thickness: 35.56 cm Detector 5456
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 HUT_02 032415.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

Dimensions (cm)

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 89.50 |
| 3 | Layer 2 | 11.43 | | | | | | concrete | 2.3 | 1.00 |
| 4 | Layer 3 | 11.43 | | | | | | concrete | 2.3 | 1.80 |
| 5 | Layer 4 | 11.43 | | | | | | concrete | 2.3 | 0.60 |
| 6 | Layer 5 | 0 | | | | | | none | | |
| 7 | Layer 6 | 0 | | | | | | none | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

List of energies for efficiency curve generation

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 HUT_02 032415~~001.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 14:21:09 2015
Original gis-file name: aux 542 hut_02 032415.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 4.23E-06 | 5.11E-06 | 5.08E-06 | 4.75E-06 | 4.08E-06 | 3.40E-06 | 2.67E-06 | 2.52E-06 | 1.94E-06 | 1.83E-06 | 1.75E-06 | 1.46E-06 |

# Circular Plane - Aux 542 Common Area B105108-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Wednesday, April 29, 2015 - 10:52:09
**Description:** Aux 542 Common Area NU B105108_01 3.0 m 90 degree 50 mm collimator
**Comment:** Thickness 0- 16,51 cm Detector 5456
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 Common 01 NU042815.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 1885.00 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 543.70 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 143.50 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 62.40 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 55.90 |
| 7 | Layer 6 | 5.08 | | | | | | concrete | 2.3 | 23.60 |
| 8 | Layer 7 | 6.35 | | | | | | concrete | 2.3 | 1.50 |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 COMMON 01 NU042815.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Wed Apr 29 10:45:08 2015
Original gis-file name: aux 542 common 01 nu042815.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 4.22E-06 | 5.36E-06 | 5.45E-06 | 5.16E-06 | 4.49E-06 | 3.79E-06 | 3.01E-06 | 2.85E-06 | 2.21E-06 | 2.10E-06 | 2.00E-06 | 1.68E-06 |

# Circular Plane - Aux 542 Common Central Area B105108-CJFCCV-002

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 14:35:35
**Description:** Aux 542 Common Area 02 B105106_02 90 degree 50 mm collimator
**Comment:** Thickness 0-10.16
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 Common Area_02 032415.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

Dimensions (cm)

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 87.90 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 19.40 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 8.00 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 15.00 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 20.70 |
| 7 | Layer 6 | 1.27 | | | | | | concrete | 2.3 | 7.80 |
| 8 | Layer 7 | 2.54 | | | | | | concrete | 2.3 | 1.80 |
| 9 | Layer 8 | 0 | | | | | | none | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

List of energies for efficiency curve generation

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 COMMON AREA_02 032415~~003.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 16:22:24 2015
Original gis-file name: aux 542 common area_02 032415.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 3.34E-06 | 4.31E-06 | 4.45E-06 | 4.26E-06 | 3.75E-06 | 3.21E-06 | 2.60E-06 | 2.48E-06 | 1.97E-06 | 1.88E-06 | 1.80E-06 | 1.53E-06 |

# Circular Plane - Aux 542 Common Central Area B105108-CJFCCV-003

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 14:41:49
**Description:** Aux 542 Common Area B105108+03; 3.0 m 90 degree 50 mm collimator
**Comment:** 7.62 Thickness, Detctor 5456
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 Common Area_03 032515.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 1215.00 |
| 3 | Layer 2 | 3.81 | | | | | | concrete | 2.3 | 1.90 |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 COMMON AREA_03 032515~~003.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 16:27:34 2015
Original gis-file name: aux 542 common area_03 032515.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.63E-06 | 6.75E-06 | 6.70E-06 | 6.23E-06 | 5.34E-06 | 4.43E-06 | 3.45E-06 | 3.25E-06 | 2.46E-06 | 2.32E-06 | 2.21E-06 | 1.83E-06 |

## Circular Plane - Aux 542 Common Elevator Shaft B105108-CJFCCV-004

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 14:51:09
**Description:** Aux 543 Common Area Elevator Shaft B015108_04
**Comment:**
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 Common Area_04 032515.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** S456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 111.90 |
| 3 | Layer 2 | 3.81 | | | | | | concrete | 2.3 | 0.10 |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 COMMON AREA_04 032515~~001.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 14:53:03 2015
Original gis-file name: aux 542 common area_04 032515.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.64E-06 | 6.76E-06 | 6.70E-06 | 6.24E-06 | 5.34E-06 | 4.43E-06 | 3.45E-06 | 3.25E-06 | 2.47E-06 | 2.32E-06 | 2.21E-06 | 1.83E-06 |

# Circular Plane - Aux 542 South Area B105109-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 15:00:47
**Description:** Aux 542 South Area B105109_01; 3.0 m 90 degree 50 mm collimaor
**Comment:** 1.27 cm Thick,
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 South Area_01 032515.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 1022.60 |
| 3 | Layer 2 | 0 | | | | | | <none> | | |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 SOUTH AREA_01 032515~~001.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 15:01:53 2015
Original gis-file name: aux 542 south area_01 032515.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.65E-06 | 6.78E-06 | 6.71E-06 | 6.25E-06 | 5.35E-06 | 4.44E-06 | 3.46E-06 | 3.25E-06 | 2.47E-06 | 2.32E-06 | 2.21E-06 | 1.83E-06 |

# Circular Plane - Aux 542 North Area B105110-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 15:05:54
**Description:** Aux 542 North Area B105110_01; 3.0 m 90 degree 50 mm collimaor
**Comment:** 1.27 cm Thick,
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 North Area_01 032515.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 1563.40 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 0.50 |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 NORTH AREA_01 032515~~002.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 15:07:03 2015
Original gis-file name: aux 542 north area_01 032515.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.65E-06 | 6.77E-06 | 6.71E-06 | 6.25E-06 | 5.35E-06 | 4.44E-06 | 3.46E-06 | 3.25E-06 | 2.47E-06 | 2.32E-06 | 2.21E-06 | 1.83E-06 |

# Circular Plane - Aux 542 North Area B105110-CJFCCV-002

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 15:14:29
**Description:** Aux 542 North Area B105110_02; 3.0 m 90 degree 50 mm collimaor
**Comment:** 1.27 cm Thick,
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux 542 North Area_02 032515.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 44.00 |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX 542 NORTH AREA_02 032515~~003.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 15:19:43 2015
Original gis-file name: aux 542 north area_02 032515.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.65E-06 | 6.78E-06 | 6.71E-06 | 6.25E-06 | 5.35E-06 | 4.44E-06 | 3.46E-06 | 3.25E-06 | 2.47E-06 | 2.32E-06 | 2.21E-06 | 1.83E-06 |

## Circular Plane - Aux 542 East Area B105111-CJFCCV-001

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 28, 2015 - 16:19:18
**Description:** Aux 542 East B105111_01 3.0 m, 90 degree 50 mm collimator
**Comment:** Thickness20.32 cm
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux East 542_01 042815.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 954.95 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 322.70 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 122.00 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 260.35 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 91.65 |
| 7 | Layer 6 | 1.27 | | | | | | concrete | 2.3 | 56.10 |
| 8 | Layer 7 | 1.27 | | | | | | concrete | 2.3 | 28.90 |
| 9 | Layer 8 | 3.81 | | | | | | concrete | 2.3 | 12.53 |
| 10 | Layer 9 | 3.81 | | | | | | concrete | 2.3 | 2.72 |
| 11 | Layer 10 | 3.81 | | | | | | concrete | 2.3 | 0.59 |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX EAST 542_01 042815.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 28 16:14:23 2015
Original gis-file name: aux east 542_01 042815.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 3.26E-06 | 4.28E-06 | 4.45E-06 | 4.27E-06 | 3.77E-06 | 3.22E-06 | 2.62E-06 | 2.49E-06 | 1.98E-06 | 1.89E-06 | 1.81E-06 | 1.53E-06 |

## Circular Plane - Aux 542 U1 ABEDCT B105113-CJFCCV-001

### Page 1 of
### Geometry Composer Report

CANBERRA

**Date:** Tuesday, April 21, 2015 - 15:37:04
**Description:** AUX 542 ABEDCT_01; 3.0 m 90 degree 50 mm collimator
**Comment:** Thickness 0- 10.16 Detector 5456
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux ABEDCT_01 032515.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 4119.10 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 165.20 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 39.90 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 8.00 |
| 6 | Layer 5 | 5.08 | | | | | | concrete | 2.3 | 0.80 |
| 7 | Layer 6 | 0 | | | | | | none | | |
| 8 | Layer 7 | 0 | | | | | | none | | |
| 9 | Layer 8 | 0 | | | | | | none | | |
| 10 | Layer 9 | 0 | | | | | | none | | |
| 11 | Layer 10 | 0 | | | | | | none | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 59.5 | 88.0 | 122.1 | 165.9 | 238.6 | 351.9 | 583.2 | 661.6 |
| 1173.2 | 1332.5 | 1460.7 | 2000.0 | | | | |

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX ABEDCT_01 032515~~001.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Tue Apr 21 15:38:38 2015
Original gis-file name: aux abedct_01 032515.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 5.45E-06 | 6.58E-06 | 6.55E-06 | 6.11E-06 | 5.24E-06 | 4.36E-06 | 3.40E-06 | 3.21E-06 | 2.44E-06 | 2.30E-06 | 2.18E-06 | 1.81E-06 |

# Circular Plane - Aux 542 U1 ABEDCT B105113-CJFCCV-002

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Monday, April 27, 2015 - 14:35:57
**Description:** Aux 542 ABEDCT B105113_02
**Comment:** 3.0 m source to detector, 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\Aux ABEDCT_02 042715.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 1595.20 |
| 3 | Layer 2 | 1.27 | | | | | | concrete | 2.3 | 354.10 |
| 4 | Layer 3 | 1.27 | | | | | | concrete | 2.3 | 229.20 |
| 5 | Layer 4 | 1.27 | | | | | | concrete | 2.3 | 95.10 |
| 6 | Layer 5 | 1.27 | | | | | | concrete | 2.3 | 65.40 |
| 7 | Layer 6 | 1.27 | | | | | | concrete | 2.3 | 18.10 |
| 8 | Layer 7 | 1.27 | | | | | | concrete | 2.3 | 6.00 |
| 9 | Layer 8 | 5.08 | | | | | | concrete | 2.3 | 0.50 |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

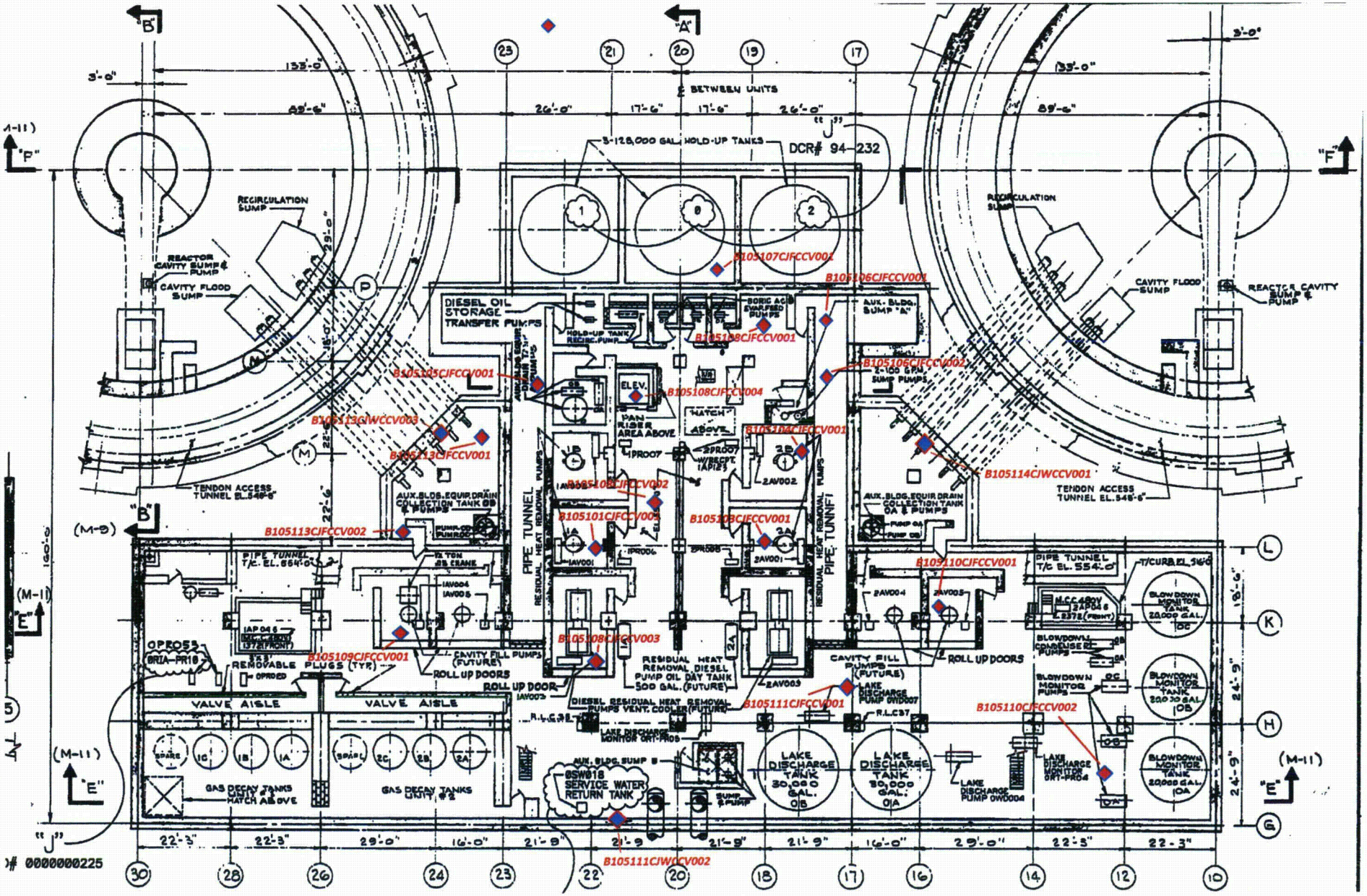
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 59.5 | 88.0 | 122.1 | 165.9 | 238.6 | 351.9 | 500.0 | 661.6 |
| 1173.2 | 1332.5 | 1460.7 | 2000.0 | | | | |

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\AUX ABEDCT_02 042715.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Mon Apr 27 14:35:24 2015
Original gis-file name: aux abedct_02 042715.gis
Template Type: circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 500.0 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 4.16E-06 | 5.30E-06 | 5.40E-06 | 5.12E-06 | 4.46E-06 | 3.77E-06 | 3.22E-06 | 2.84E-06 | 2.21E-06 | 2.10E-06 | 2.00E-06 | 1.68E-06 |

# ATTACHMENT 3
## Map of Auxiliary Building Floor and Wall Concrete Core Locations



# Aux Floor Cores Composite Full 28 $m^2$ Zone

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Thursday, April 30, 2015 - 13:19:04
**Description:** General Model 28.3 m^2 FOV
**Comment:** 5.8 cm, DRL 2.75, Source to Det 3.0 m 90 degree 50 mm Collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR...\General Model 28 m^2 043015.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.8 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 59.5 | 88.0 | 122.1 | 165.9 | 238.6 | 351.9 | 583.2 | 661.6 |
| 1173.2 | 1332.5 | 1460.7 | 2000.0 | | | | |

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\GENERAL MODEL 28 M^2 043015.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Thu Apr 30 13:15:35 2015
Original gis-file name: general model 28 m^2 043015.gis
Template Type: exponent_circular_plane
efficiency of all Models run [Efficiency]

| Item | Desc | Item | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Model | | | | | | | | | | | | |
| | | Reference | 3.17E-06 | 4.30E-06 | 4.51E-06 | 4.38E-06 | 3.89E-06 | 3.33E-06 | 2.71E-06 | 2.58E-06 | 2.06E-06 | 1.96E-06 | 1.88E-06 | 1.59E-06 |

# Aux Floor Cores Composite 1 $m^2$ No Offset

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Thursday, April 30, 2015 - 13:51:53
**Description:** 1.0 M^2 to 28 m^2 043015
**Comment:** 5.8 DRL 2.75 Source to Det 3.0 m 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR_PLANE\1.0 m^2 to 28 m^2 043015.ge
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 112.84 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.08 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 189 | 0 | 189 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 500.0 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\1.0 M^2 NO OFFSET 043015.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Thu Apr 30 10:38:24 2015
Original gis-file name: 1.0 m^2 no offset 043015.gis
Template Type: exponent_circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 6.00E-06 | 8.19E-06 | 8.69E-06 | 8.81E-06 | 8.32E-06 | 7.66E-06 | 6.62E-06 | 6.34E-06 | 5.02E-06 | 4.75E-06 | 4.52E-06 | 3.77E-06 |

# Aux Floor Cores Composite 1 $m^2$ 122 cm Offset

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Thursday, April 30, 2015 - 10:01:58
**Description:** 1.0 m^2 Offset 121.8 cm 043015
**Comment:** 5.8 cm, DRL 2.75 Source to Detr 3.0 m, 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR...\1.0 m^2 Offset 122 cm 043015.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 112.84 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.08 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 121.79 | 0 | 121.79 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\1.0 M^2 OFFSET 122 CM 043015.iue
Report was generated by IUE with program function: <Sensitivity>

Project calculation was started at: Thu Apr 30 10:01:18 2015

Original gis-file name: 1.0 m^2 offset 122 cm 043015.gis

Template Type: exponent_circular_plane

efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 4.66E-06 | 6.33E-06 | 6.67E-06 | 6.59E-06 | 5.97E-06 | 5.22E-06 | 4.37E-06 | 4.18E-06 | 3.41E-06 | 3.23E-06 | 3.09E-06 | 2.62E-06 |

# Aux Floor Cores Composite 1 $m^2$ 244 cm Offset

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Thursday, April 30, 2015 - 10:16:22
**Description:** 1.0 m^2 Offset 243.6 cm 043015
**Comment:** 5.8 cm, DRL 2.75, Source to Det 3.0 m, 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR...\1.0 m^2 Offset 244 cm 043015.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** S456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 112.84 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.08 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 243.58 | 0 | 243.58 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\1.0 M^2 OFFSET 244 CM 043015.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Thu Apr 30 10:15:28 2015
Original gis-file name: 1.0 m^2 offset 244 cm 043015.gis
Template Type: exponent_circular_plane
efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 2.45E-06 | 3.33E-06 | 3.47E-06 | 3.28E-06 | 2.81E-06 | 2.30E-06 | 1.79E-06 | 1.68E-06 | 1.32E-06 | 1.26E-06 | 1.20E-06 | 1.02E-06 |

# Aux Floor Cores Composite 0.5 $m^2$ No Offset

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Thursday, April 30, 2015 - 13:53:08
**Description:** 0.5 m^2 Intersect to 28 m^2
**Comment:** 5.8 cm, DRL 2.75 3.0 m source to det 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR_P...\0.5 m^2 to 28 m^2 043015.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Ao |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 79.79 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.8 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 186 | 0 | 186 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\0.5 M^2 NO OFFSET 043015.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Thu Apr 30 13:03:48 2015
Original gis-file name: 0.5 m^2 no offset 043015.gis
Template Type: exponent_circular_plane

efficiency of all Models run [Efficiency]

| Item Desc Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reference | 6.03E-06 | 8.26E-06 | 8.79E-06 | 8.94E-06 | 8.49E-06 | 7.88E-06 | 6.83E-06 | 6.54E-06 | 5.16E-06 | 4.88E-06 | 4.64E-06 | 3.86E-06 |

# Aux Floor Cores Composite 0.5 $m^2$ 130 cm Offset

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Thursday, April 30, 2015 - 12:34:43
**Description:** 0.5 m^2 Offset 130.cm 042015
**Comment:** 5.8, cm DRL 2.75, 3.0 m source to det,90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR...\0.5 m^2 Offset 130 cm 043015.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 79.79 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.8 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 130.01 | 0 | 130.01 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 500.0 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\0.5 M^2 OFFSET 130 CM 043015.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Thu Apr 30 12:34:09 2015
Original gis-file name: 0.5 m^2 offset 130 cm 043015.gis
Template Type: exponent_circular_plane
efficiency of all Models run [Efficiency]

| Item | Desc | Item | Model | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 500.0 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Reference | 4.38E-06 | 5.96E-06 | 6.30E-06 | 6.22E-06 | 5.62E-06 | 4.89E-06 | 4.32E-06 | 3.91E-06 | 3.20E-06 | 3.04E-06 | 2.92E-06 | 2.48E-06 |

# Aux Floor Cores Composite 0.5 $m^2$ 260 cm Offset

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Thursday, April 30, 2015 - 12:43:51
**Description:** 0.5 m^2 Offset 260 cm 043015
**Comment:** 5.8,cm, DRL 2.75, 3.0 m source to det, 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR...\0.5 m^2 Offset 260 cm 043015.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 79.79 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.8 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 260.1 | 0 | 260.1 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

## Results Report

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\0.5 M^2 OFFSET 260 CM 043015.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Thu Apr 30 12:45:07 2015
Original gis-file name: 0.5 m^2 offset 260 cm 043015.gis
Template Type: exponent_circular_plane
efficiency of all Models run [Efficiency]

| Item | Desc | Item | | 59.5 keV | 88.0 keV | 122.1 keV | 165.9 keV | 238.6 keV | 351.9 keV | 583.2 keV | 661.6 keV | 1173.2 keV | 1332.5 keV | 1460.7 keV | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Model | | | | | | | | | | | | |
| | | | Reference | 2.14E-06 | 2.89E-06 | 3.02E-06 | 2.84E-06 | 2.42E-06 | 1.98E-06 | 1.52E-06 | 1.43E-06 | 1.11E-06 | 1.06E-06 | 1.01E-06 | 8.57E-07 |

**Sensitivity Input**

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\ALL CORE SENSITIVITY 042415.iue
Program Function: Sensitivity Analysis of input parameters
Template Type: exponent_circular_plane
Units: length - MM; density - g/cm3
Convrgence [%]: 1
Abbreviation after detector's name: (f) - facing [normal]; (o) - opposite side; (l) - left side; (r) - right side detector orientation with respect to sample
Collimator Name:! CRPN = 4
Detector's housing : no housing

| # | Descriptic | alue's Typ | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | RelConc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Wall: | Current | | 6.00E+03 | | | | | | | |
| 5 | Source La | Current | 58 | | 27.6 | | | | concrete | 2.35 | 1 |
| | | Low | 45 | | 23.3 | | | | | 2.3 | |
| | | High | 78 | | 45 | | | | | 2.4 | |
| | | | 95% cl | | 95% cl | | | | | 95% cl | |
| | SOURCE-DETECTOR | | | | | | | | | | |
| 8 | 456(f) | Current | 3.00E+03 | 0 | 0 | 0 | 0 | | | | |

**Sensitivity Input**

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\ALL CORE SENSITIVITY 042415.iue
Program Function: Sensitivity Analysis of input parameters
Template Type: exponent_circular_plane
Units: length - MM; density - g/cm3
Convrgence [%]: 1
Abbreviation after detector's name: (f) - facing [normal]; (o) - opposite side; (l) - left side; (r) - right side detector orientation with respect to sample
Collimator Name:: CRPN = 4
Detector's housing : no housing

| # | Descriptic | alue's Typ | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | RelConc |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Wall: | Current | | 6.00E+03 | | | | | | | |
| 5 | Source La | Current | 58 | | 27.6 | | | | concrete | 2.35 | 1 |
| | | Low | 45 | | 23.3 | | | | | 2.3 | |
| | | High | 78 | | 45 | | | | | 2.4 | |
| | | | 95% cl | | 95% cl | | | | | 95% cl | |
| | SOURCE-DETECTOR | | | | | | | | | | |
| 8 | 456(f) | Current | 3.00E+03 | 0 | 0 | 0 | 0 | | | | |

**Sensitivity Results**

Project was loaded from the following file: C:\GENIE2K\ISOCS\DATA\BATCH\ALL CORE SENSITIVITY 042415.iue
Report was generated by IUE with program function: <Sensitivity>
Project calculation was started at: Fri Apr 24 12:04:07 2015
Original gis-file name: all core sensitivity 042415.gis
Template Type: exponent_circular_plane
efficiency of all Models run [Efficiency]

| Item Description | Item | Model | 59.5 ke\ | 88.0 ke\ | 122.1 ke\ | 165.9 ke\ | 238.6 ke\ | 351.9 ke\ | 583.2 ke\ | 661.6 ke\ | 1173.2 ke | 1332.5 ke | 1460.7 ke | 2000.0 keV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Reference | 3.16E-06 | 4.29E-06 | 4.51E-06 | 4.38E-06 | 3.88E-06 | 3.33E-06 | 2.71E-06 | 2.58E-06 | 2.06E-06 | 1.96E-06 | 1.88E-06 | 1.59E-06 |
| Source Layer | 5Density | Value1 | 3.21E-06 | 4.35E-06 | 4.56E-06 | 4.42E-06 | 3.92E-06 | 3.36E-06 | 2.73E-06 | 2.59E-06 | 2.07E-06 | 1.97E-06 | 1.89E-06 | 1.60E-06 |
| | 5Density | Value2 | 3.12E-06 | 4.24E-06 | 4.46E-06 | 4.33E-06 | 3.85E-06 | 3.30E-06 | 2.69E-06 | 2.56E-06 | 2.05E-06 | 1.95E-06 | 1.87E-06 | 1.58E-06 |
| Source Layer | 5 | Value1 | 3.40E-06 | 4.54E-06 | 4.74E-06 | 4.58E-06 | 4.04E-06 | 3.45E-06 | 2.79E-06 | 2.65E-06 | 2.11E-06 | 2.00E-06 | 1.92E-06 | 1.62E-06 |
| Thickness | 5 | Value2 | 2.65E-06 | 3.74E-06 | 4.01E-06 | 3.94E-06 | 3.55E-06 | 3.06E-06 | 2.52E-06 | 2.41E-06 | 1.96E-06 | 1.87E-06 | 1.79E-06 | 1.53E-06 |
| Source Layer | 5 | Value1 | 3.39E-06 | 4.58E-06 | 4.78E-06 | 4.63E-06 | 4.08E-06 | 3.47E-06 | 2.81E-06 | 2.67E-06 | 2.13E-06 | 2.02E-06 | 1.93E-06 | 1.63E-06 |
| DRL | 5 | Value2 | 2.91E-06 | 3.96E-06 | 4.19E-06 | 4.08E-06 | 3.64E-06 | 3.12E-06 | 2.56E-06 | 2.44E-06 | 1.97E-06 | 1.88E-06 | 1.80E-06 | 1.53E-06 |

# Exponential Circular Plane - Aux Floor Cores Composite MDC Input

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Wednesday, April 29, 2015 - 16:17:20
**Description:** or
**Comment:** 3 m source to detector, 5.8 cm thick, 2.75 DRL, 90 degree 50 mm collimator
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\EXPONENT_CIRCULAR_PLANE\General ECP Model.geo
**Software:** ISOCS
**Template:** EXPONENT_CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 0 | | | | | | none | | |
| 3 | Layer 2 | 0 | | | | | | none | | |
| 4 | Layer 3 | 0 | | | | | | none | | |
| 5 | Source Layer | 5.8 | 0 | 2.75 | | | | concrete | 2.3 | 1.00 |
| 6 | Absorber1 | | | | | | | | | |
| 7 | Absorber2 | | | | | | | | | |
| 8 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

```
**********************************************************************
*****        G A M M A   S P E C T R U M   A N A L Y S I S        *****
**********************************************************************

Filename: C:\GENIE2K\CAMFILES\10216-012  7-31-13.CNF

Report Generated On              : 5/12/2015   1:52:44 PM

Sample Title                     : ECP_Aux_BLDG_FLOOR
Sample Description               :
Sample Identification            :
Sample Type                      : concrete
Sample Geometry                  :

Peak Locate Threshold            :  3.00
Peak Locate Range (in channels)  :    50 -  8192
Peak Area Range (in channels)    :    50 -  8192
Identification Energy Tolerance  :    1.000 keV
```

```
Sample Size                    :  1.000E+000 M^2

Sample Taken On                :
Acquisition Started            : 7/31/2013  12:36:59 PM

Live Time                      :      900.0 seconds
Real Time                      :      902.5 seconds

Dead Time                      :   0.28 %
```

```
Energy Calibration Used Done On       : 5/13/2013
Efficiency Calibration Used Done On   : 5/4/2015
Efficiency ID                         : TB_strutur_0-7cm
```

Peak Analysis Report 5/12/2015 1:52:44 PM Page 2

**********
***** P E A K A N A L Y S I S R E P O R T *****
**********

Detector Name: 5452
Sample Title: ECP_Aux_BLDG_FLOOR
Peak Analysis Performed on: 5/12/2015 1:52:44 PM
Peak Analysis From Channel: 50
Peak Analysis To Channel: 8192

| Peak No. | ROI start | ROI end | Peak centroid | Energy (keV) | FWHM (keV) | Net Peak Area | Net Area Uncert. | Continuum Counts |
|---|---|---|---|---|---|---|---|---|
| 1 | 336- | 345 | 340.40 | 84.83 | 1.14 | 3.61E+001 | 40.33 | 1.64E+002 |
| 2 | 946- | 961 | 954.82 | 238.59 | 1.15 | 8.72E+001 | 32.59 | 5.88E+001 |
| 3 | 2327- | 2336 | 2331.97 | 583.12 | 0.53 | 1.90E+001 | 16.02 | 2.00E+001 |
| 4 | 2639- | 2654 | 2644.80 | 661.36 | 0.86 | 4.23E+001 | 17.98 | 1.27E+001 |
| 5 | 5830- | 5852 | 5841.95 | 1460.50 | 1.21 | 2.08E+002 | 31.75 | 1.15E+001 |

M = First peak in a multiplet region
m = Other peak in a multiplet region
F = Fitted singlet

Errors quoted at 2.000 sigma

Interference Corrected Activity Report 5/12/2015 1:52:44 PM Page 3

**********
***** N U C L I D E I D E N T I F I C A T I O N R E P O R T *****
**********

Sample Title: ECP_Aux_BLDG_FLOOR
Nuclide Library Used: C:\GENIE2K\CAMFILES\Zion_LiB.NLB

..... IDENTIFIED NUCLIDES .....

| Nuclide Name | Id Confidence | Energy (keV) | Yield (%) | Activity (pCi/M^2) | Activity Uncertainty |
|---|---|---|---|---|---|
| K-40 | 0.985 | 1460.81* | 10.67 | 1.10239E+006 | 1.91708E+005 |
| CS-137 | 0.986 | 661.65* | 85.12 | 2.03813E+004 | 9.00575E+003 |
| Tl-208 | 0.999 | 583.19* | 84.50 | 8.77286E+003 | 7.47330E+003 |
| PB-212 | 1.000 | 74.81 | 9.60 | | |
| | | 77.11 | 17.50 | | |
| | | 87.20 | 6.30 | | |
| | | 89.80 | 1.75 | | |
| | | 115.19 | 0.60 | | |
| | | 238.63* | 44.60 | 5.25423E+004 | 2.13569E+004 |
| | | 300.09 | 3.41 | | |
| TH-231 | 0.983 | 26.64 | 18.70 | | |
| | | 84.21* | 8.00 | 1.12231E+005 | 1.27238E+005 |
| | | 89.95 | 1.25 | | |

* = Energy line found in the spectrum.
@ = Energy line not used for Weighted Mean Activity

Energy Tolerance : 1.000 keV
Nuclide confidence index threshold = 0.30
Errors quoted at 2.000 sigma

Interference Corrected Activity Report 5/12/2015 1:52:44 PM Page 4

**********
***** I N T E R F E R E N C E C O R R E C T E D R E P O R T *****
**********

| Nuclide Name | Nuclide Id Confidence | Wt mean Activity (pCi/M^2) | Wt mean Activity Uncertainty |
|---|---|---|---|
| K-40 | 0.985 | 1.102386E+006 | 1.917084E+005 |
| CS-137 | 0.986 | 2.038133E+004 | 9.005751E+003 |
| Tl-208 | 0.999 | 8.772863E+003 | 7.473303E+003 |
| PB-212 | 1.000 | 5.254233E+004 | 2.135691E+004 |
| TH-231 | 0.983 | 1.122309E+005 | 1.272381E+005 |

? = nuclide is part of an undetermined solution
X = nuclide rejected by the interference analysis
@ = nuclide contains energy lines not used in Weighted Mean Activity

Errors quoted at 2.000 sigma

********** U N I D E N T I F I E D P E A K S **********

Peak Locate Performed on: 5/12/2015 1:52:44 PM
Peak Locate From Channel: 50
Peak Locate To Channel: 8192

| Peak No. | Energy (keV) | Peak Size in Counts per Second | Peak CPS % Uncertainty | Peak Type | Tol. Nuclide |
|---|---|---|---|---|---|

All peaks were identified.

Nuclide MDA Report 5/12/2015 1:52:44 PM Page 5

**********
***** NUCLIDE MDA REPORT *****
**********

Detector Name: 5452
Sample Geometry:
Sample Title: ECP_Aux_BLDG_FLOOR
Nuclide Library Used: C:\GENIE2K\CAMFILES\Zion_LiB.NLB

| | Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2) | Nuclide MDA (pCi/M^2) | Activity (pCi/M^2) | Dec. Level (pCi/M^2) |
|---|---|---|---|---|---|---|---|
| + | K-40 | 1460.81* | 10.67 | 1.311E+005 | 1.31E+005 | 1.102E+006 | 5.834E+004 |
| | MN-54 | 834.83 | 99.97 | 8.750E+003 | 8.75E+003 | 2.488E+003 | 3.767E+003 |
| | CO-60 | 1173.22 | 100.00 | 4.774E+003 | 4.77E+003 | -6.426E+002 | 1.691E+003 |
| | | 1332.49 | 100.00 | 1.058E+004 | | 6.195E+003 | 4.557E+003 |
| | NB-94 | 702.63 | 100.00 | 8.183E+003 | 7.61E+003 | 1.527E+003 | 3.523E+003 |
| | | 871.10 | 100.00 | 7.607E+003 | | 2.536E+001 | 3.186E+003 |
| | SN-113 | 255.12 | 1.93 | 4.593E+005 | 1.30E+004 | 9.917E+004 | 2.103E+005 |
| | | 391.69 | 64.90 | 1.299E+004 | | -3.900E+003 | 5.806E+003 |
| | CS-134 | 475.35 | 1.46 | 5.094E+005 | 8.60E+003 | -1.155E+005 | 2.215E+005 |
| | | 563.23 | 8.38 | 8.944E+004 | | -3.435E+004 | 3.851E+004 |
| | | 569.32 | 15.43 | 5.482E+004 | | 1.020E+004 | 2.402E+004 |
| | | 604.70 | 97.60 | 1.015E+004 | | 4.056E+002 | 4.525E+003 |
| | | 795.84 | 85.40 | 8.602E+003 | | -3.871E+003 | 3.603E+003 |
| | | 801.93 | 8.73 | 1.137E+005 | | 2.173E+004 | 4.998E+004 |
| | | 1038.57 | 1.00 | 7.345E+005 | | -1.345E+005 | 3.011E+005 |
| | | 1167.94 | 1.80 | 4.021E+005 | | -1.806E+005 | 1.625E+005 |
| | | 1365.15 | 3.04 | 1.678E+005 | | 1.129E+004 | 5.944E+004 |
| + | CS-137 | 661.65* | 85.12 | 1.115E+004 | 1.11E+004 | 2.038E+004 | 4.923E+003 |
| + | Tl-208 | 583.19* | 84.50 | 1.146E+004 | 1.15E+004 | 8.773E+003 | 5.106E+003 |
| | BI-211 | 72.87 | 1.20 | 1.635E+006 | 1.02E+005 | -7.411E+005 | 7.869E+005 |
| | | 351.10 | 12.20 | 1.017E+005 | | 4.319E+004 | 4.737E+004 |
| | | 404.80 | 4.10 | 2.124E+005 | | 3.108E+003 | 9.513E+004 |
| | | 426.90 | 1.90 | 4.337E+005 | | -1.160E+004 | 1.924E+005 |
| | | 831.80 | 3.30 | 2.264E+005 | | -5.435E+004 | 9.484E+004 |
| | PB-211 | 404.80 | 3.00 | 2.903E+005 | 2.67E+005 | 4.247E+003 | 1.300E+005 |
| | | 427.10 | 1.40 | 6.011E+005 | | 3.536E+004 | 2.674E+005 |
| | | 831.80 | 2.80 | 2.669E+005 | | -6.406E+004 | 1.118E+005 |
| | BI-212 | 39.86 | 1.10 | 5.556E+006 | 7.90E+004 | -1.920E+006 | 2.697E+006 |
| | | 727.17 | 11.80 | 7.896E+004 | | 2.095E+004 | 3.460E+004 |
| | | 785.42 | 2.00 | 3.820E+005 | | -2.741E+005 | 1.613E+005 |
| | | 1620.56 | 2.75 | 2.016E+005 | | -3.800E+004 | 7.143E+004 |
| + | PB-212 | 74.81 | 9.60 | 2.212E+005 | 2.81E+004 | 2.366E+005 | 1.068E+005 |
| | | 77.11 | 17.50 | 9.776E+004 | | 4.704E+003 | 4.685E+004 |
| | | 87.20 | 6.30 | 2.302E+005 | | 3.638E+004 | 1.098E+005 |
| | | 89.80 | 1.75 | 6.756E+005 | | -2.448E+005 | 3.190E+005 |
| | | 115.19 | 0.60 | 1.868E+006 | | 4.291E+005 | 8.821E+005 |
| | | 238.63* | 44.60 | 2.809E+004 | | 5.254E+004 | 1.323E+004 |

Nuclide MDA Report 5/12/2015 1:52:44 PM Page 6

Nuclide Energy Yield Line MDA Nuclide MDA Activity Dec. Level

| | Name | (keV) | (%) | (pCi/M^2) | (pCi/M^2) | (pCi/M^2) | (pCi/M^2) |
|---|---|---|---|---|---|---|---|
| + | PB-212 | 300.09 | 3.41 | 2.581E+005 | | -4.956E+004 | 1.174E+005 |
| | BI-214 | 609.31 | 46.30 | 3.191E+004 | 3.19E+004 | 3.410E+004 | 1.480E+004 |
| | | 768.36 | 5.04 | 1.681E+005 | | 6.538E+004 | 7.237E+004 |
| | | 806.17 | 1.23 | 7.465E+005 | | 1.225E+005 | 3.245E+005 |
| | | 934.06 | 3.21 | 2.318E+005 | | 2.649E+004 | 9.615E+004 |
| | | 1120.29 | 15.10 | 9.128E+004 | 3.19E+004 | 4.545E+004 | 4.112E+004 |
| | | 1155.19 | 1.69 | 3.962E+005 | | -9.672E+004 | 1.572E+005 |
| | | 1238.11 | 5.94 | 1.606E+005 | | -1.147E+004 | 6.833E+004 |
| | | 1280.96 | 1.47 | 6.326E+005 | | -3.632E+003 | 2.672E+005 |
| | | 1377.67 | 4.11 | 2.614E+005 | | 1.745E+005 | 1.126E+005 |
| | | 1385.31 | 0.78 | 9.998E+005 | | -2.009E+005 | 4.040E+005 |
| | | 1401.50 | 1.39 | 6.346E+005 | | 1.650E+005 | 2.632E+005 |
| | | 1407.98 | 2.48 | 3.373E+005 | | -6.419E+003 | 1.383E+005 |
| | | 1509.19 | 2.19 | 3.448E+005 | | 3.287E+004 | 1.368E+005 |
| | | 1661.28 | 1.15 | 4.885E+005 | | 0.000E+000 | 1.731E+005 |
| | | 1729.60 | 3.05 | 2.859E+005 | | 4.561E+004 | 1.155E+005 |
| | | 1764.49 | 15.80 | 8.202E+004 | | 3.502E+004 | 3.566E+004 |
| | | 1847.44 | 2.12 | 3.638E+005 | | 1.211E+005 | 1.409E+005 |
| > | | 2118.54 | 1.21 | 0.000E+000 | | 0.000E+000 | 0.000E+000 |
| | PB-214 | 74.81 | 6.33 | 3.355E+005 | 3.53E+004 | 3.588E+005 | 1.620E+005 |
| | | 77.11 | 10.70 | 1.599E+005 | | 7.693E+003 | 7.663E+004 |
| | | 87.20 | 3.70 | 3.920E+005 | | 6.194E+004 | 1.870E+005 |
| | | 89.80 | 1.03 | 1.148E+006 | | -4.160E+005 | 5.420E+005 |
| | | 241.98 | 7.49 | 1.132E+005 | | -1.362E+004 | 5.173E+004 |
| | | 295.21 | 19.20 | 5.383E+004 | | 1.963E+004 | 2.485E+004 |
| | | 351.92 | 37.20 | 3.534E+004 | | 3.472E+004 | 1.652E+004 |
| | | 785.91 | 1.10 | 7.233E+005 | | -1.740E+005 | 3.077E+005 |
| | RA-226 | 186.21 | 3.28 | 3.310E+005 | 3.31E+005 | 1.296E+005 | 1.553E+005 |
| | AC-228 | 89.95 | 2.10 | 5.571E+005 | 4.80E+004 | -3.180E+005 | 2.630E+005 |
| | | 93.35 | 3.50 | 3.850E+005 | | 2.172E+005 | 1.833E+005 |
| | | 129.08 | 2.80 | 3.484E+005 | | 3.200E+004 | 1.631E+005 |
| | | 209.28 | 4.40 | 2.272E+005 | | 5.353E+004 | 1.057E+005 |
| | | 270.23 | 3.60 | 2.633E+005 | | 1.142E+005 | 1.211E+005 |
| | | 327.64 | 3.20 | 2.968E+005 | | 1.065E+005 | 1.354E+005 |
| | | 338.32 | 11.40 | 8.549E+004 | | 2.692E+004 | 3.906E+004 |
| | | 409.51 | 2.13 | 4.253E+005 | | -1.890E+004 | 1.912E+005 |
| | | 463.00 | 4.40 | 2.501E+005 | | 6.442E+004 | 1.141E+005 |
| | | 794.70 | 4.60 | 1.803E+005 | | -1.896E+004 | 7.719E+004 |
| | | 911.60 | 27.70 | 4.799E+004 | | 4.269E+004 | 2.173E+004 |
| | | 964.60 | 5.20 | 1.893E+005 | | 3.152E+004 | 8.231E+004 |
| | | 969.11 | 16.60 | 7.310E+004 | | 3.906E+004 | 3.267E+004 |
| | | 1587.90 | 3.71 | 2.246E+005 | | 9.555E+004 | 9.075E+004 |
| | PA-234M | 766.36 | 0.29 | 3.063E+006 | 8.65E+005 | 5.443E+005 | 1.331E+006 |
| | | 1001.03 | 0.84 | 8.648E+005 | | -2.530E+005 | 3.545E+005 |
| | TH-234 | 92.38 | 2.81 | 4.436E+005 | 4.44E+005 | -2.144E+005 | 2.102E+005 |
| | | 92.80 | 2.77 | 4.733E+005 | | 4.843E+004 | 2.250E+005 |
| | | 112.81 | 0.28 | 3.704E+006 | | -2.115E+006 | 1.740E+006 |

Nuclide MDA Report 5/12/2015 1:52:44 PM Page 7

| Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2) | Nuclide MDA (pCi/M^2) | Activity (pCi/M^2) | Dec. Level (pCi/M^2) |
|---|---|---|---|---|---|---|
| | 92.80 | 2.77 | 4.733E+005 | | 4.843E+004 | 2.250E+005 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 112.81 | 0.28 | 3.704E+006 | | -2.115E+006 | 1.740E+006 |
| U-235 | 89.96 | 1.50 | 7.800E+005 | 1.94E+004 | -4.452E+005 | 3.681E+005 |
| | 93.35 | 2.50 | 5.391E+005 | | 3.041E+005 | 2.566E+005 |
| | 105.00 | 1.00 | 1.133E+006 | | 4.969E+005 | 5.349E+005 |
| | 109.14 | 1.50 | 7.792E+005 | | 4.814E+005 | 3.688E+005 |
| | 143.76 | 10.50 | 9.973E+004 | | 1.200E+004 | 4.687E+004 |
| | 163.35 | 4.70 | 1.645E+005 | | -1.245E+005 | 7.540E+004 |
| | 185.71 | 54.00 | 1.936E+004 | | 1.224E+003 | 9.063E+003 |
| | 202.12 | 1.00 | 8.035E+005 | | -1.098E+005 | 3.675E+005 |
| | 205.31 | 4.70 | 1.962E+005 | | 1.602E+004 | 9.077E+004 |
| AM-241 | 59.54 | 36.30 | 5.851E+004 | 5.85E+004 | -2.143E+004 | 2.802E+004 |

\+ = Nuclide identified during the nuclide identification
* = Energy line found in the spectrum
> = Calculated MDA is zero due to zero counts in the region or
the region is outside the spectrum
@ = Half-life too short to be able to perform the decay correction

# 1.27 cm Circular Plane - Minimum Detectable Concentrations Input

## Page 1 of
## Geometry Composer Report

CANBERRA

**Date:** Monday, May 11, 2015 - 15:07:57
**Description:** CP Turbine Building 1.27 cm Concrete
**Comment:** 90 degree 50 mm collimator, source to detector 3.0 m
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\CP Turbine 1.27 cm 051115.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 1.27 | | | | | | concrete | 2.3 | 1.00 |
| 3 | Layer 2 | 0 | | | | | | <none> | | |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

```
**********************************************************************
*****          G A M M A   S P E C T R U M   A N A L Y S I S          *****
**********************************************************************

Filename: C:\GENIE2K\CAMFILES\10216-012  7-31-13.CNF

Report Generated On              : 5/14/2015  10:10:29 AM

Sample Title                     : CP_1.27cm
Sample Description               :
Sample Identification            :
Sample Type                      : Concrete
Sample Geometry                  :
```

```
Peak Locate Threshold           :  3.00
Peak Locate Range (in channels) :    50 -  8192
Peak Area Range (in channels)   :    50 -  8192
Identification Energy Tolerance :    1.000 keV

Sample Size                     :  1.000E+000 M^2

Sample Taken On                 :
Acquisition Started             : 7/31/2013  12:36:59 PM

Live Time                       :      900.0 seconds
Real Time                       :      902.5 seconds

Dead Time                       :   0.28 %
```

```
Energy Calibration Used Done On       : 5/13/2013
Efficiency Calibration Used Done On   : 5/11/2015
Efficiency ID                         : Tb_Struct_0-1cm
```

Peak Analysis Report 5/14/2015 10:10:29 AM Page 2

**********
*
***** P E A K A N A L Y S I S R E P O R T
*****
**********
*

Detector Name: 5452
Sample Title: CPTurbine_1.27cm
Peak Analysis Performed on: 5/14/2015 10:10:29 AM
Peak Analysis From Channel: 50
Peak Analysis To Channel: 8192

| Peak No. | ROI start | ROI end | Peak centroid | Energy (keV) | FWHM (keV) | Net Peak Area | Net Area Uncert. | Continuum Counts |
|---|---|---|---|---|---|---|---|---|
| 1 | 336- | 345 | 340.40 | 84.83 | 1.14 | 3.61E+001 | 40.33 | 1.64E+002 |
| 2 | 946- | 961 | 954.82 | 238.59 | 1.15 | 8.72E+001 | 32.59 | 5.88E+001 |
| 3 | 2327- | 2336 | 2331.97 | 583.12 | 0.53 | 1.90E+001 | 16.02 | 2.00E+001 |
| 4 | 2639- | 2654 | 2644.80 | 661.36 | 0.86 | 4.23E+001 | 17.98 | 1.27E+001 |
| 5 | 5830- | 5852 | 5841.95 | 1460.50 | 1.21 | 2.08E+002 | 31.75 | 1.15E+001 |

M = First peak in a multiplet region
m = Other peak in a multiplet region
F = Fitted singlet

Errors quoted at 2.000 sigma

Interference Corrected Activity Report 5/14/2015 10:10:29 AM Page 3

**********
***** N U C L I D E I D E N T I F I C A T I O N R E P O R T *****
**********

Sample Title: CPTurbine_1.27cm
Nuclide Library Used: C:\GENIE2K\CAMFILES\Zion_LiB.NLB

..... IDENTIFIED NUCLIDES .....

| Nuclide Name | Id Confidence | Energy (keV) | Yield (%) | Activity (pCi/M^2 ) | Activity Uncertainty |
|---|---|---|---|---|---|
| K-40 | 0.985 | 1460.81* | 10.67 | 9.40449E+005 | 1.63547E+005 |
| CS-137 | 0.986 | 661.65* | 85.12 | 1.63351E+004 | 7.21787E+003 |
| Tl-208 | 0.999 | 583.19* | 84.50 | 6.95508E+003 | 5.92479E+003 |
| PB-212 | 1.000 | 74.81 | 9.60 | | |
| | | 77.11 | 17.50 | | |
| | | 87.20 | 6.30 | | |
| | | 89.80 | 1.75 | | |
| | | 115.19 | 0.60 | | |
| | | 238.63* | 44.60 | 3.85605E+004 | 1.56737E+004 |
| | | 300.09 | 3.41 | | |
| TH-231 | 0.983 | 26.64 | 18.70 | | |
| | | 84.21* | 8.00 | 7.16495E+004 | 8.12302E+004 |
| | | 89.95 | 1.25 | | |

* = Energy line found in the spectrum.
@ = Energy line not used for Weighted Mean Activity

Energy Tolerance : 1.000 keV
Nuclide confidence index threshold = 0.30
Errors quoted at 2.000 sigma

Interference Corrected Activity Report 5/14/2015 10:10:29 AM Page 4

**********
***** I N T E R F E R E N C E C O R R E C T E D R E P O R T *****
**********

| Nuclide Name | Nuclide Id Confidence | Wt mean Activity (pCi/M^2 ) | Wt mean Activity Uncertainty |
|---|---|---|---|
| K-40 | 0.985 | 9.404491E+005 | 1.635471E+005 |
| CS-137 | 0.986 | 1.633509E+004 | 7.217867E+003 |
| Tl-208 | 0.999 | 6.955079E+003 | 5.924795E+003 |
| PB-212 | 1.000 | 3.856048E+004 | 1.567370E+004 |
| TH-231 | 0.983 | 7.164948E+004 | 8.123024E+004 |

? = nuclide is part of an undetermined solution
X = nuclide rejected by the interference analysis
@ = nuclide contains energy lines not used in Weighted Mean Activity

Errors quoted at 2.000 sigma

********** U N I D E N T I F I E D P E A K S **********

Peak Locate Performed on: 5/14/2015 10:10:29 AM
Peak Locate From Channel: 50
Peak Locate To Channel: 8192

| Peak No. | Energy (keV) | Peak Size in Counts per Second | Peak CPS % Uncertainty | Peak Type | Tol. Nuclide |
|---|---|---|---|---|---|

All peaks were identified.

Nuclide MDA Report 5/14/2015 10:10:29 AM Page 5

**********
*
***** N U C L I D E M D A R E P O R T
*****
**********
*

Detector Name: 5452
Sample Geometry:
Sample Title: CPTurbine_1.27cm
Nuclide Library Used: C:\GENIE2K\CAMFILES\Zion_LiB.NLB

| | Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2 ) | Nuclide MDA (pCi/M^2 ) | Activity (pCi/M^2 ) | Dec. Level (pCi/M^2 ) |
|---|---|---|---|---|---|---|---|
| + | K-40 | 1460.81* | 10.67 | 1.118E+005 | 1.12E+005 | 9.404E+005 | 4.977E+004 |
| | MN-54 | 834.83 | 99.97 | 7.153E+003 | 7.15E+003 | 2.033E+003 | 3.080E+003 |
| | CO-60 | 1173.22 | 100.00 | 4.009E+003 | 4.01E+003 | -5.396E+002 | 1.420E+003 |
| | | 1332.49 | 100.00 | 8.970E+003 | | 5.251E+003 | 3.862E+003 |
| | NB-94 | 702.63 | 100.00 | 6.592E+003 | 6.24E+003 | 1.230E+003 | 2.838E+003 |
| | | 871.10 | 100.00 | 6.240E+003 | | 2.080E+001 | 2.613E+003 |
| | SN-113 | 255.12 | 1.93 | 3.391E+005 | 9.95E+003 | 7.321E+004 | 1.553E+005 |
| | | 391.69 | 64.90 | 9.948E+003 | | -2.987E+003 | 4.446E+003 |
| | CS-134 | 475.35 | 1.46 | 3.967E+005 | 7.00E+003 | -8.996E+004 | 1.725E+005 |
| | | 563.23 | 8.38 | 7.070E+004 | | -2.715E+004 | 3.044E+004 |
| | | 569.32 | 15.43 | 4.337E+004 | | 8.071E+003 | 1.900E+004 |
| | | 604.70 | 97.60 | 8.071E+003 | | 3.226E+002 | 3.599E+003 |
| | | 795.84 | 85.40 | 7.003E+003 | | -3.152E+003 | 2.933E+003 |
| | | 801.93 | 8.73 | 9.261E+004 | | 1.771E+004 | 4.072E+004 |
| | | 1038.57 | 1.00 | 6.110E+005 | | -1.119E+005 | 2.504E+005 |
| | | 1167.94 | 1.80 | 3.375E+005 | | -1.516E+005 | 1.364E+005 |
| | | 1365.15 | 3.04 | 1.424E+005 | | 9.587E+003 | 5.047E+004 |
| + | CS-137 | 661.65* | 85.12 | 8.936E+003 | 8.94E+003 | 1.634E+004 | 3.946E+003 |
| + | Tl-208 | 583.19* | 84.50 | 9.087E+003 | 9.09E+003 | 6.955E+003 | 4.048E+003 |
| | BI-211 | 72.87 | 1.20 | 1.002E+006 | 7.72E+004 | -4.541E+005 | 4.822E+005 |
| | | 351.10 | 12.20 | 7.718E+004 | | 3.276E+004 | 3.594E+004 |
| | | 404.80 | 4.10 | 1.631E+005 | | 2.387E+003 | 7.306E+004 |
| | | 426.90 | 1.90 | 3.346E+005 | | -8.953E+003 | 1.485E+005 |
| | | 831.80 | 3.30 | 1.850E+005 | | -4.442E+004 | 7.750E+004 |
| | PB-211 | 404.80 | 3.00 | 2.229E+005 | 2.18E+005 | 3.262E+003 | 9.985E+004 |
| | | 427.10 | 1.40 | 4.638E+005 | | 2.728E+004 | 2.063E+005 |
| | | 831.80 | 2.80 | 2.181E+005 | | -5.235E+004 | 9.134E+004 |
| | BI-212 | 39.86 | 1.10 | 2.530E+006 | 6.38E+004 | -8.743E+005 | 1.228E+006 |
| | | 727.17 | 11.80 | 6.380E+004 | | 1.693E+004 | 2.796E+004 |
| | | 785.42 | 2.00 | 3.107E+005 | | -2.229E+005 | 1.312E+005 |
| | | 1620.56 | 2.75 | 1.732E+005 | | -3.265E+004 | 6.138E+004 |
| + | PB-212 | 74.81 | 9.60 | 1.366E+005 | 2.06E+004 | 1.461E+005 | 6.598E+004 |
| | | 77.11 | 17.50 | 6.089E+004 | | 2.930E+003 | 2.918E+004 |
| | | 87.20 | 6.30 | 1.479E+005 | | 2.337E+004 | 7.059E+004 |
| | | 89.80 | 1.75 | 4.370E+005 | | -1.584E+005 | 2.064E+005 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 115.19 | 0.60 | 1.265E+006 | | 2.907E+005 | 5.975E+005 |

Nuclide MDA Report 5/14/2015 10:10:29 AM Page 6

| | Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2 ) | Nuclide MDA (pCi/M^2 ) | Activity (pCi/M^2 ) | Dec. Level (pCi/M^2 ) |
|---|---|---|---|---|---|---|---|
| | PB-212 | 238.63* | 44.60 | 2.062E+004 | | 3.856E+004 | 9.711E+003 |
| | | 300.09 | 3.41 | 1.932E+005 | | -3.710E+004 | 8.785E+004 |
| | BI-214 | 609.31 | 46.30 | 2.540E+004 | 2.54E+004 | 2.714E+004 | 1.178E+004 |
| | | 768.36 | 5.04 | 1.365E+005 | | 5.307E+004 | 5.875E+004 |
| | | 806.17 | 1.23 | 6.085E+005 | | 9.981E+004 | 2.645E+005 |
| | | 934.06 | 3.21 | 1.913E+005 | | 2.185E+004 | 7.932E+004 |
| | BI-214 | 1120.29 | 15.10 | 7.637E+004 | 2.54E+004 | 3.803E+004 | 3.441E+004 |
| | | 1155.19 | 1.69 | 3.323E+005 | | -8.112E+004 | 1.319E+005 |
| | | 1238.11 | 5.94 | 1.354E+005 | | -9.671E+003 | 5.760E+004 |
| | | 1280.96 | 1.47 | 5.346E+005 | | -3.069E+003 | 2.258E+005 |
| | | 1377.67 | 4.11 | 2.221E+005 | | 1.482E+005 | 9.563E+004 |
| | | 1385.31 | 0.78 | 8.497E+005 | | -1.707E+005 | 3.433E+005 |
| | | 1401.50 | 1.39 | 5.398E+005 | | 1.403E+005 | 2.239E+005 |
| | | 1407.98 | 2.48 | 2.870E+005 | | -5.462E+003 | 1.177E+005 |
| | | 1509.19 | 2.19 | 2.948E+005 | | 2.811E+004 | 1.170E+005 |
| | | 1661.28 | 1.15 | 4.205E+005 | | 0.000E+000 | 1.490E+005 |
| | | 1729.60 | 3.05 | 2.468E+005 | | 3.937E+004 | 9.971E+004 |
| | | 1764.49 | 15.80 | 7.089E+004 | | 3.027E+004 | 3.082E+004 |
| | | 1847.44 | 2.12 | 3.154E+005 | | 1.050E+005 | 1.222E+005 |
| > | | 2118.54 | 1.21 | 0.000E+000 | | 0.000E+000 | 0.000E+000 |
| | PB-214 | 74.81 | 6.33 | 2.072E+005 | 2.68E+004 | 2.215E+005 | 1.001E+005 |
| | | 77.11 | 10.70 | 9.958E+004 | | 4.792E+003 | 4.773E+004 |
| | | 87.20 | 3.70 | 2.519E+005 | | 3.980E+004 | 1.202E+005 |
| | | 89.80 | 1.03 | 7.425E+005 | | -2.691E+005 | 3.506E+005 |
| | | 241.98 | 7.49 | 8.319E+004 | | -1.001E+004 | 3.801E+004 |
| | | 295.21 | 19.20 | 4.024E+004 | | 1.467E+004 | 1.858E+004 |
| | | 351.92 | 37.20 | 2.682E+004 | | 2.634E+004 | 1.254E+004 |
| | | 785.91 | 1.10 | 5.883E+005 | | -1.415E+005 | 2.503E+005 |
| | RA-226 | 186.21 | 3.28 | 2.375E+005 | 2.38E+005 | 9.300E+004 | 1.115E+005 |
| | AC-228 | 89.95 | 2.10 | 3.605E+005 | 3.95E+004 | -2.058E+005 | 1.702E+005 |
| | | 93.35 | 3.50 | 2.512E+005 | | 1.417E+005 | 1.195E+005 |
| | | 129.08 | 2.80 | 2.399E+005 | | 2.204E+004 | 1.123E+005 |
| | | 209.28 | 4.40 | 1.648E+005 | | 3.883E+004 | 7.668E+004 |
| | | 270.23 | 3.60 | 1.954E+005 | | 8.472E+004 | 8.981E+004 |
| | | 327.64 | 3.20 | 2.238E+005 | | 8.032E+004 | 1.021E+005 |
| | | 338.32 | 11.40 | 6.465E+004 | | 2.035E+004 | 2.954E+004 |
| | | 409.51 | 2.13 | 3.269E+005 | | -1.453E+004 | 1.470E+005 |
| | | 463.00 | 4.40 | 1.943E+005 | | 5.006E+004 | 8.869E+004 |
| | | 794.70 | 4.60 | 1.468E+005 | | -1.543E+004 | 6.283E+004 |
| | | 911.60 | 27.70 | 3.951E+004 | | 3.515E+004 | 1.789E+004 |
| | | 964.60 | 5.20 | 1.566E+005 | | 2.607E+004 | 6.807E+004 |
| | | 969.11 | 16.60 | 6.048E+004 | | 3.232E+004 | 2.703E+004 |
| | | 1587.90 | 3.71 | 1.927E+005 | | 8.199E+004 | 7.787E+004 |
| | PA-234M | 766.36 | 0.29 | 2.486E+006 | 7.17E+005 | 4.417E+005 | 1.081E+006 |
| | | 1001.03 | 0.84 | 7.173E+005 | | -2.098E+005 | 2.940E+005 |

Nuclide MDA Report 5/14/2015 10:10:29 AM Page 7

| | Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2 ) | Nuclide MDA (pCi/M^2 ) | Activity (pCi/M^2 ) | Dec. Level (pCi/M^2 ) |
|---|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| TH-234 | 92.38 | 2.81 | 2.887E+005 | 2.89E+005 | -1.396E+005 | 1.368E+005 |
| | 92.80 | 2.77 | 3.083E+005 | | 3.155E+004 | 1.465E+005 |
| | 112.81 | 0.28 | 2.501E+006 | | -1.428E+006 | 1.175E+006 |
| U-235 | 89.96 | 1.50 | 5.047E+005 | 1.39E+004 | -2.881E+005 | 2.382E+005 |
| | 93.35 | 2.50 | 3.516E+005 | | 1.983E+005 | 1.674E+005 |
| | 105.00 | 1.00 | 7.556E+005 | | 3.315E+005 | 3.568E+005 |
| | 109.14 | 1.50 | 5.233E+005 | | 3.233E+005 | 2.477E+005 |
| | 143.76 | 10.50 | 6.962E+004 | | 8.375E+003 | 3.272E+004 |
| | 163.35 | 4.70 | 1.165E+005 | | -8.817E+004 | 5.339E+004 |
| | 185.71 | 54.00 | 1.389E+004 | | 8.782E+002 | 6.501E+003 |
| | 202.12 | 1.00 | 5.810E+005 | | -7.938E+004 | 2.657E+005 |
| | 205.31 | 4.70 | 1.421E+005 | | 1.160E+004 | 6.573E+004 |
| AM-241 | 59.54 | 36.30 | 3.337E+004 | 3.34E+004 | -1.222E+004 | 1.598E+004 |

\+ = Nuclide identified during the nuclide identification
* = Energy line found in the spectrum
> = Calculated MDA is zero due to zero counts in the region or the region is outside the spectrum
@ = Half-life too short to be able to perform the decay correction

## Containment Liner 0.153 cm Circular Plane - Minimum Detectable Concentrations

### Page 1 of
### Geometry Composer Report

CANBERRA

**Date:** Monday, May 11, 2015 - 14:43:52
**Description:** CP Containment 0.152 cm Steel
**Comment:** 90 degree 50 mm collimator 3.0 m Source to Detector
**File Name:** C:\GENIE2K\isocs\data\GEOMETRY\In-Situ\CIRCULAR_PLANE\CP Containmnet 0.153 Steel 051115.geo
**Software:** ISOCS
**Template:** CIRCULAR_PLANE, Version: (default)
**Detector:** 5456
**Collimator:** 50mm-90d new (newISOCS 50mm side 90deg collimation [large hole collimator])
**Environment:** Temperature = 22 °C, Pressure = 760 mm Hg, Relative Humidity = 30%
**Integration:** Convergence = 1.00%, MDRPN = $2^4$ (16), CRPN = $2^4$ (16)

**Dimensions (cm)**

| No. | Description | d.1 | d.2 | d.3 | d.4 | d.5 | d.6 | Material | Density | Rel. Conc. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Side Walls | 0 | 600 | | | | | none | | |
| 2 | Layer 1 | 0.153 | | | | | | csteel | 7.9 | 1.00 |
| 3 | Layer 2 | 0.182 | | | | | | csteel | 7.9 | |
| 4 | Layer 3 | 0 | | | | | | <none> | | |
| 5 | Layer 4 | 0 | | | | | | <none> | | |
| 6 | Layer 5 | 0 | | | | | | <none> | | |
| 7 | Layer 6 | 0 | | | | | | <none> | | |
| 8 | Layer 7 | 0 | | | | | | <none> | | |
| 9 | Layer 8 | 0 | | | | | | <none> | | |
| 10 | Layer 9 | 0 | | | | | | <none> | | |
| 11 | Layer 10 | 0 | | | | | | <none> | | |
| 12 | Absorber1 | | | | | | | | | |
| 13 | Absorber2 | | | | | | | | | |
| 14 | Source-Detector | 300 | 0 | 0 | 0 | 0 | | | | |

**List of energies for efficiency curve generation**

59.5 88.0 122.1 165.9 238.6 351.9 583.2 661.6
1173.2 1332.5 1460.7 2000.0

```
**********************************************************************
*****          G A M M A   S P E C T R U M   A N A L Y S I S          *****
**********************************************************************


Filename: C:\GENIE2K\CAMFILES\10216-012  7-31-13.CNF

Report Generated On              : 5/14/2015  10:14:45 AM

Sample Title                     : CP_Containment_0.153_Steel
Sample Description               :
Sample Identification            :
Sample Type                      : Steel
Sample Geometry                  :

Peak Locate Threshold            :  3.00
Peak Locate Range (in channels)  :    50 -  8192
Peak Area Range (in channels)    :    50 -  8192
Identification Energy Tolerance  :    1.000 keV
```

```
Sample Size                    :  1.000E+000 M^2

Sample Taken On                :
Acquisition Started            : 7/31/2013  12:36:59 PM

Live Time                      :      900.0 seconds
Real Time                      :      902.5 seconds

Dead Time                      :   0.28 %
```

```
Energy Calibration Used Done On       : 5/13/2013
Efficiency Calibration Used Done On   : 5/11/2015
Efficiency ID                         : U1CT_.153_051115
```

Peak Analysis Report 5/14/2015 10:14:45 AM Page 2

**********
*
***** P E A K A N A L Y S I S R E P O R T
*****
**********
*

Detector Name: 5452
Sample Title: CP_Containment_0.153_Steel
Peak Analysis Performed on: 5/14/2015 10:14:44 AM
Peak Analysis From Channel: 50
Peak Analysis To Channel: 8192

| Peak No. | ROI start | ROI end | Peak centroid | Energy (keV) | FWHM (keV) | Net Peak Area | Net Area Uncert. | Continuum Counts |
|---|---|---|---|---|---|---|---|---|
| 1 | 336- | 345 | 340.40 | 84.83 | 1.14 | 3.61E+001 | 40.33 | 1.64E+002 |
| 2 | 946- | 961 | 954.82 | 238.59 | 1.15 | 8.72E+001 | 32.59 | 5.88E+001 |
| 3 | 2327- | 2336 | 2331.97 | 583.12 | 0.53 | 1.90E+001 | 16.02 | 2.00E+001 |
| 4 | 2639- | 2654 | 2644.80 | 661.36 | 0.86 | 4.23E+001 | 17.98 | 1.27E+001 |
| 5 | 5830- | 5852 | 5841.95 | 1460.50 | 1.21 | 2.08E+002 | 31.75 | 1.15E+001 |

M = First peak in a multiplet region
m = Other peak in a multiplet region
F = Fitted singlet

Errors quoted at 2.000 sigma

Interference Corrected Activity Report 5/14/2015 10:14:45 AM Page 3

**********
***** N U C L I D E I D E N T I F I C A T I O N R E P O R T *****
**********

Sample Title: CP_Containment_0.153_Steel
Nuclide Library Used: C:\GENIE2K\CAMFILES\Zion_LiB.NLB

..... IDENTIFIED NUCLIDES .....

| Nuclide Name | Id Confidence | Energy (keV) | Yield (%) | Activity (pCi/M^2 ) | Activity Uncertainty |
|---|---|---|---|---|---|
| K-40 | 0.985 | 1460.81* | 10.67 | 8.88975E+005 | 1.54596E+005 |
| CS-137 | 0.986 | 661.65* | 85.12 | 1.50062E+004 | 6.63070E+003 |
| Tl-208 | 0.999 | 583.19* | 84.50 | 6.36608E+003 | 5.42305E+003 |
| PB-212 | 1.000 | 74.81 | 9.60 | | |
| | | 77.11 | 17.50 | | |
| | | 87.20 | 6.30 | | |
| | | 89.80 | 1.75 | | |
| | | 115.19 | 0.60 | | |
| | | 238.63* | 44.60 | 3.43311E+004 | 1.39546E+004 |
| | | 300.09 | 3.41 | | |
| TH-231 | 0.983 | 26.64 | 18.70 | | |
| | | 84.21* | 8.00 | 7.04728E+004 | 7.98962E+004 |
| | | 89.95 | 1.25 | | |

* = Energy line found in the spectrum.
@ = Energy line not used for Weighted Mean Activity

Energy Tolerance : 1.000 keV
Nuclide confidence index threshold = 0.30
Errors quoted at 2.000 sigma

Interference Corrected Activity Report 5/14/2015 10:14:45 AM Page 4

**********
***** I N T E R F E R E N C E C O R R E C T E D R E P O R T *****
**********

| Nuclide Name | Nuclide Id Confidence | Wt mean Activity (pCi/M^2 ) | Wt mean Activity Uncertainty |
|---|---|---|---|
| K-40 | 0.985 | 8.889747E+005 | 1.545956E+005 |
| CS-137 | 0.986 | 1.500624E+004 | 6.630698E+003 |
| Tl-208 | 0.999 | 6.366084E+003 | 5.423050E+003 |
| PB-212 | 1.000 | 3.433112E+004 | 1.395459E+004 |
| TH-231 | 0.983 | 7.047283E+004 | 7.989624E+004 |

? = nuclide is part of an undetermined solution
X = nuclide rejected by the interference analysis
@ = nuclide contains energy lines not used in Weighted Mean Activity

Errors quoted at 2.000 sigma

********** U N I D E N T I F I E D P E A K S **********

Peak Locate Performed on: 5/14/2015 10:14:44 AM
Peak Locate From Channel: 50
Peak Locate To Channel: 8192

| Peak No. | Energy (keV) | Peak Size in Counts per Second | Peak CPS % Uncertainty | Peak Type | Tol. Nuclide |
|---|---|---|---|---|---|

All peaks were identified.

Nuclide MDA Report 5/14/2015 10:14:45 AM Page 5

**********
*
***** N U C L I D E M D A R E P O R T
*****
**********
*

Detector Name: 5452
Sample Geometry:
Sample Title: CP_Containment_0.153_Steel
Nuclide Library Used: C:\GENIE2K\CAMFILES\Zion_LiB.NLB

| | Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2 ) | Nuclide MDA (pCi/M^2 ) | Activity (pCi/M^2 ) | Dec. Level (pCi/M^2 ) |
|---|---|---|---|---|---|---|---|
| + | K-40 | 1460.81* | 10.67 | 1.057E+005 | 1.06E+005 | 8.890E+005 | 4.705E+004 |
| | MN-54 | 834.83 | 99.97 | 6.618E+003 | 6.62E+003 | 1.881E+003 | 2.849E+003 |
| | CO-60 | 1173.22 | 100.00 | 3.757E+003 | 3.76E+003 | -5.057E+002 | 1.331E+003 |
| | | 1332.49 | 100.00 | 8.450E+003 | | 4.946E+003 | 3.638E+003 |
| | NB-94 | 702.63 | 100.00 | 6.066E+003 | 5.78E+003 | 1.132E+003 | 2.612E+003 |
| | | 871.10 | 100.00 | 5.782E+003 | | 1.928E+001 | 2.422E+003 |
| | SN-113 | 255.12 | 1.93 | 3.025E+005 | 9.00E+003 | 6.531E+004 | 1.385E+005 |
| | | 391.69 | 64.90 | 9.002E+003 | | -2.703E+003 | 4.023E+003 |
| | CS-134 | 475.35 | 1.46 | 3.611E+005 | 6.47E+003 | -8.188E+004 | 1.570E+005 |
| | | 563.23 | 8.38 | 6.465E+004 | | -2.482E+004 | 2.783E+004 |
| | | 569.32 | 15.43 | 3.967E+004 | | 7.383E+003 | 1.738E+004 |
| | | 604.70 | 97.60 | 7.395E+003 | | 2.956E+002 | 3.298E+003 |
| | | 795.84 | 85.40 | 6.470E+003 | | -2.912E+003 | 2.710E+003 |
| | | 801.93 | 8.73 | 8.558E+004 | | 1.636E+004 | 3.763E+004 |
| | | 1038.57 | 1.00 | 5.698E+005 | | -1.044E+005 | 2.336E+005 |
| | | 1167.94 | 1.80 | 3.162E+005 | | -1.420E+005 | 1.278E+005 |
| | | 1365.15 | 3.04 | 1.343E+005 | | 9.039E+003 | 4.758E+004 |
| + | CS-137 | 661.65* | 85.12 | 8.209E+003 | 8.21E+003 | 1.501E+004 | 3.625E+003 |
| + | Tl-208 | 583.19* | 84.50 | 8.317E+003 | 8.32E+003 | 6.366E+003 | 3.705E+003 |
| | BI-211 | 72.87 | 1.20 | 1.057E+006 | 6.96E+004 | -4.788E+005 | 5.084E+005 |
| | | 351.10 | 12.20 | 6.960E+004 | | 2.955E+004 | 3.240E+004 |
| | | 404.80 | 4.10 | 1.477E+005 | | 2.162E+003 | 6.618E+004 |
| | | 426.90 | 1.90 | 3.036E+005 | | -8.123E+003 | 1.347E+005 |
| | | 831.80 | 3.30 | 1.712E+005 | | -4.109E+004 | 7.170E+004 |
| | PB-211 | 404.80 | 3.00 | 2.019E+005 | 2.02E+005 | 2.955E+003 | 9.044E+004 |
| | | 427.10 | 1.40 | 4.208E+005 | | 2.476E+004 | 1.872E+005 |
| | | 831.80 | 2.80 | 2.018E+005 | | -4.843E+004 | 8.450E+004 |
| | BI-212 | 39.86 | 1.10 | 5.045E+006 | 5.88E+004 | -1.743E+006 | 2.449E+006 |
| | | 727.17 | 11.80 | 5.878E+004 | | 1.560E+004 | 2.575E+004 |
| | | 785.42 | 2.00 | 2.869E+005 | | -2.058E+005 | 1.211E+005 |
| | | 1620.56 | 2.75 | 1.643E+005 | | -3.097E+004 | 5.822E+004 |

Nuclide MDA Report 5/14/2015 10:14:45 AM Page 6

| | Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2 ) | Nuclide MDA (pCi/M^2 ) | Activity (pCi/M^2 ) | Dec. Level (pCi/M^2 ) |
|---|---|---|---|---|---|---|---|
| + | PB-212 | 74.81 | 9.60 | 1.421E+005 | 1.84E+004 | 1.519E+005 | 6.861E+004 |
| | | 77.11 | 17.50 | 6.237E+004 | | 3.001E+003 | 2.989E+004 |
| | | 87.20 | 6.30 | 1.441E+005 | | 2.276E+004 | 6.873E+004 |
| | | 89.80 | 1.75 | 4.213E+005 | | -1.527E+005 | 1.990E+005 |
| | | 115.19 | 0.60 | 1.152E+006 | | 2.646E+005 | 5.440E+005 |
| | | 238.63* | 44.60 | 1.836E+004 | | 3.433E+004 | 8.646E+003 |
| | | 300.09 | 3.41 | 1.733E+005 | | -3.327E+004 | 7.880E+004 |
| | BI-214 | 609.31 | 46.30 | 2.328E+004 | 2.33E+004 | 2.487E+004 | 1.079E+004 |
| | | 768.36 | 5.04 | 1.259E+005 | | 4.897E+004 | 5.421E+004 |
| | | 806.17 | 1.23 | 5.623E+005 | | 9.225E+004 | 2.445E+005 |
| | | 934.06 | 3.21 | 1.777E+005 | | 2.030E+004 | 7.368E+004 |
| | | 1120.29 | 15.10 | 7.144E+004 | 2.33E+004 | 3.558E+004 | 3.218E+004 |
| | | 1155.19 | 1.69 | 3.112E+005 | | -7.597E+004 | 1.235E+005 |
| | | 1238.11 | 5.94 | 1.272E+005 | | -9.082E+003 | 5.409E+004 |
| | | 1280.96 | 1.47 | 5.028E+005 | | -2.887E+003 | 2.124E+005 |
| | | 1377.67 | 4.11 | 2.095E+005 | | 1.398E+005 | 9.020E+004 |
| | | 1385.31 | 0.78 | 8.016E+005 | | -1.611E+005 | 3.239E+005 |
| | | 1401.50 | 1.39 | 5.095E+005 | | 1.325E+005 | 2.113E+005 |
| | | 1407.98 | 2.48 | 2.710E+005 | | -5.156E+003 | 1.111E+005 |
| | | 1509.19 | 2.19 | 2.790E+005 | | 2.660E+004 | 1.107E+005 |
| | | 1661.28 | 1.15 | 3.991E+005 | | 0.000E+000 | 1.414E+005 |
| | | 1729.60 | 3.05 | 2.345E+005 | | 3.741E+004 | 9.475E+004 |
| | | 1764.49 | 15.80 | 6.740E+004 | | 2.878E+004 | 2.930E+004 |
| | | 1847.44 | 2.12 | 3.001E+005 | | 9.994E+004 | 1.162E+005 |
| > | | 2118.54 | 1.21 | 0.000E+000 | | 0.000E+000 | 0.000E+000 |
| | PB-214 | 74.81 | 6.33 | 2.154E+005 | 2.42E+004 | 2.304E+005 | 1.040E+005 |
| | | 77.11 | 10.70 | 1.020E+005 | | 4.909E+003 | 4.889E+004 |
| | | 87.20 | 3.70 | 2.453E+005 | | 3.875E+004 | 1.170E+005 |
| | | 89.80 | 1.03 | 7.158E+005 | | -2.594E+005 | 3.380E+005 |
| | | 241.98 | 7.49 | 7.410E+004 | | -8.915E+003 | 3.386E+004 |
| | | 295.21 | 19.20 | 3.607E+004 | | 1.315E+004 | 1.665E+004 |
| | | 351.92 | 37.20 | 2.418E+004 | | 2.375E+004 | 1.131E+004 |
| | | 785.91 | 1.10 | 5.433E+005 | | -1.307E+005 | 2.311E+005 |
| | RA-226 | 186.21 | 3.28 | 2.105E+005 | 2.10E+005 | 8.241E+004 | 9.877E+004 |
| | | 89.95 | 2.10 | 3.474E+005 | 3.67E+004 | -1.983E+005 | 1.640E+005 |
| | | 93.35 | 3.50 | 2.393E+005 | | 1.350E+005 | 1.139E+005 |
| | | 129.08 | 2.80 | 2.154E+005 | | 1.979E+004 | 1.008E+005 |
| | | 209.28 | 4.40 | 1.462E+005 | | 3.446E+004 | 6.805E+004 |
| | | 270.23 | 3.60 | 1.746E+005 | | 7.572E+004 | 8.027E+004 |
| | | 327.64 | 3.20 | 2.014E+005 | | 7.227E+004 | 9.189E+004 |

Nuclide MDA Report 5/14/2015 10:14:45 AM Page 7

Nuclide MDA Report 5/14/2015 10:14:45 AM Page 7

| | Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2 ) | Nuclide MDA (pCi/M^2 ) | Activity (pCi/M^2 ) | Dec. Level (pCi/M^2 ) |
|---|---|---|---|---|---|---|---|
| | AC-228 | 338.32 | 11.40 | 5.822E+004 | | 1.833E+004 | 2.660E+004 |
| | | 409.51 | 2.13 | 2.963E+005 | | -1.316E+004 | 1.332E+005 |
| | | 463.00 | 4.40 | 1.767E+005 | | 4.552E+004 | 8.066E+004 |
| | | 794.70 | 4.60 | 1.356E+005 | | -1.426E+004 | 5.805E+004 |
| | | 911.60 | 27.70 | 3.667E+004 | | 3.262E+004 | 1.660E+004 |
| | | 964.60 | 5.20 | 1.456E+005 | | 2.424E+004 | 6.331E+004 |
| | | 969.11 | 16.60 | 5.626E+004 | | 3.006E+004 | 2.515E+004 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 1587.90 | 3.71 | 1.827E+005 | | 7.772E+004 | 7.382E+004 |
| PA-234M | 766.36 | 0.29 | 2.293E+006 | 6.68E+005 | 4.076E+005 | 9.970E+005 |
| | 1001.03 | 0.84 | 6.681E+005 | | -1.954E+005 | 2.738E+005 |
| TH-234 | 92.38 | 2.81 | 2.759E+005 | 2.76E+005 | -1.334E+005 | 1.307E+005 |
| | 92.80 | 2.77 | 2.942E+005 | | 3.011E+004 | 1.398E+005 |
| | 112.81 | 0.28 | 2.284E+006 | | -1.304E+006 | 1.073E+006 |
| U-235 | 89.96 | 1.50 | 4.863E+005 | 1.23E+004 | -2.776E+005 | 2.295E+005 |
| | 93.35 | 2.50 | 3.350E+005 | | 1.889E+005 | 1.594E+005 |
| | 105.00 | 1.00 | 6.992E+005 | | 3.068E+005 | 3.302E+005 |
| | 109.14 | 1.50 | 4.806E+005 | | 2.970E+005 | 2.275E+005 |
| | 143.76 | 10.50 | 6.202E+004 | | 7.460E+003 | 2.915E+004 |
| | 163.35 | 4.70 | 1.033E+005 | | -7.818E+004 | 4.735E+004 |
| | 185.71 | 54.00 | 1.231E+004 | | 7.781E+002 | 5.760E+003 |
| | 202.12 | 1.00 | 5.153E+005 | | -7.040E+004 | 2.357E+005 |
| | 205.31 | 4.70 | 1.260E+005 | | 1.029E+004 | 5.831E+004 |

| Nuclide Name | Energy (keV) | Yield (%) | Line MDA (pCi/M^2 ) | Nuclide MDA (pCi/M^2 ) | Activity (pCi/M^2 ) | Dec. Level (pCi/M^2 ) |
|---|---|---|---|---|---|---|
| AM-241 | 59.54 | 36.30 | 4.040E+004 | 4.04E+004 | -1.480E+004 | 1.935E+004 |

\+ = Nuclide identified during the nuclide identification
* = Energy line found in the spectrum
> = Calculated MDA is zero due to zero counts in the region or the region is outside the spectrum
@ = Half-life too short to be able to perform the decay correction