Exelon Generation
4300 Winfield Road
Warrenville, IL 60555

www.exeloncorp.com

Exelon Nuclear

10 CFR 50.90

RS-11-016
February 7, 2011

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

LaSalle County Station, Units 1 and 2
Facility Operating License Nos. NPF-11 and NPF-18
NRC Docket Nos. 50-373 and 50-374

Peach Bottom Atomic Power Station, Units 2 and 3
Renewed Facility Operating License Nos. DPR-44 and DPR-56
NRC Docket Nos. 50-277, and 50-278

Subject: Clarification of Supplemental Information - License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at LaSalle County Station, Units 1 and 2 and Peach Bottom Atomic Power Station, Units 2 and 3

References:

1) Letter from D. M. Benyak (Exelon Generation Company, LLC) to U. S. NRC, "Request for License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at LaSalle County Station, Units 1 and 2," dated January 6, 2010

2) Letter from D. M. Benyak (Exelon Generation Company, LLC) to U. S. NRC, "Request for License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at Peach Bottom Atomic Power Station, Units 1, 2, and 3," dated January 6, 2010

3) Letter from D. M. Benyak (Exelon Generation Company, LLC) to U. S. NRC, "Supplemental Information Concerning License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at Peach Bottom Atomic Power Station, Units 1, 2, and 3," dated August 20, 2010

In Reference 1, Exelon Generation Company, LLC (EGC) submitted a request to amend Facility Operating License (FOL) Nos. NPF-11 and NPF-18 for LaSalle County Station (LSCS), Units 1 and 2, respectively. The proposed change will enable LSCS to store Class B and Class C (Class B/C) low-level radioactive waste (LLRW) Braidwood Station, Units 1 and 2 (Braidwood), Byron Station, Units 1 and 2 (Byron), and Clinton Power Station, Unit 1 (CPS) in the LSCS Interim Radwaste Storage Facility (IRSF).

In Reference 2, EGC submitted a request to amend FOL No. DPR-12, and Renewed FOLs DPR-44 and DPR-56 for Peach Bottom Atomic Power Station (PBAPS), Units 1, 2, and 3, respectively. The proposed change, as supplemented will enabled PBAPS to store Class B/C LLRW from Limerick Generating Station, Units 1 and 2 (LGS) in the PBAPS LLRW Storage Facility (LLRWSF). In Reference 3, EGC provided supplemental information concerning the Reference 2 license amendment request (LAR) and withdrew the LAR for PBAPS Unit 1.

The attachments to this letter provide additional clarifying information pertaining to the Reference 1 and 2 LARs and a supporting calculation that was described in Attachment 3 of the Reference 1 LAR (i.e., LSCS Analysis L-003388, Revision 0, "LaSalle IRSF Shielding Calculations for Class B & C Waste"). However, the Reference 1, Attachment 3 description of the calculation indicates Revision 1. This letter clarifies that the correct version of the calculation is Revision 0, and the Attachment 3 description should state Revision 0. EGC previously provided the corresponding calculation for the PBAPS LLRWSF which was described in Attachment 3 of the Reference 2 LAR (i.e., ADAMS Accession number ML110310236).

EGC has reviewed the information supporting a finding of no significant hazards consideration, and the environmental consideration that were previously provided to the NRC in References 1 and 2. The additional information provided in this submittal does not affect the bases for concluding that the proposed license amendments do not involve a significant hazards consideration. In addition, the information provided in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment is required for the proposed amendment. There are no regulatory commitments in this letter or the attachments.

Should you have any questions or require additional information, please contact Mr. John L. Schrage at (630) 657-2821.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 7th day of February 2011.

Respectfully,

Darin M. Benyak
Director - Licensing
Exelon Generation Company, LLC

Attachments:

1. Clarifying Information Concerning License Amendments to Allow Receipt and Storage of Low-Level Radioactive Waste at LaSalle County Station, Units 1 and 2, Facility Operating Licenses NPF-11 and NPF-18, and Peach Bottom Atomic Power Station, Units 2 and 3, Renewed Facility Operating Licenses DPR-44 and DPR-56.

2. LaSalle County Station Analysis L-003388, Revision 0, "LaSalle IRSF Shielding Calculations for Class B & C Waste."

cc: Administrator – NRC Region I
Administrator – NRC Region III
NRC Senior Resident Inspector – Peach Bottom Atomic Power Station
NRC Senior Resident Inspector – LaSalle County Station
NRC Project Manager, NRR – Peach Bottom Atomic Power Station
NRC Project Manager, NRR – LaSalle County Station
Director, Bureau of Radiation Protection - Pennsylvania Department of Environmental Resources
Illinois Emergency Management Agency – Division of Nuclear Safety Resources

Attachment 1

Clarifying Information Concerning License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at LaSalle County Station, Units 1 and 2, Facility Operating Licenses NPF-11 and NPF-18 and Peach Bottom Atomic Power Station, Units 2 and 3, Renewed Facility Operating Licenses DPR-44 and DPR-56

In Attachment 1 of References 1 and 2, Section 4.6, "Summary," Exelon Generation Company, LLC (EGC) described the results of a container integrity evaluation for the High Integrity Containers (HICs) that would be used to store Class B and Class C low level radioactive waste (LLRW) at LaSalle County Station and Peach Bottom Atomic Power Station. Attachment 3 of References 1 and 2, Section 7.2, and Appendix C, "HDPE (Poly) High Integrity Containers (HIC) Container Integrity Assessment" provided specific details regarding this evaluation.

EGC conducted the HIC integrity evaluation, and provided the information to the NRC to document consistency with the applicable regulatory guidance concerning on-site storage of LLRW, specifically, the regulatory guidance concerning minimization of container corrosion over the expected storage period.

In that this guidance does not establish nor specify a regulatory requirement, the proposed license amendment only requests approval to revise a license condition. EGC does not request NRC review or approval for either the containers or the expected storage duration of 80 years. EGC understands that the NRC is not reviewing, nor will it address the HIC integrity or the expected storage duration in a Safety Evaluation.

References

1. Letter from D. M. Benyak (Exelon Generation Company, LLC) to U. S. NRC, "Request for License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at LaSalle County Station, Units 1 and 2," dated January 6, 2010

2. Letter from D. M. Benyak (Exelon Generation Company, LLC) to U. S. NRC, "Request for License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at Peach Bottom Atomic Power Station, Units 1, 2, and 3," dated January 6, 2010

Attachment 2

LaSalle County Station Analysis L-003388, Revision 0
LaSalle IRSF Shielding Calculations for Class B & C Waste

LaSalle County Station, Units 1 and 2,
Facility Operating Licenses NPF-11 and NPF-18

CC-AA-309-1001
Revision 5
Page 27 of 66

ATTACHMENT 1
Page 1 of 5

EB 11/13/09

Design Analysis Major Revision Cover Sheet

Design Analysis (Major Revision)		**Last Page No.** [6] 15/ Att. P, Page P11	
Analysis No.: [1]	L-003388	**Revision:** [2]	000
Title: [3]	LaSalle IRSF Shielding Evaluations for Class B & C Waste		
EC/ECR No.: [4]	375636	**Revision:** [5]	0

Station(s): [7]	LaSalle	**Component(s):** [14] ~~IRSF~~	
Unit No.: [8]	1&2	N/A	
Discipline: [9]	MECH		
Descrip. Code/Keyword: [10]	R04 / IRSF		
Safety/QA Class: [11]	Non-Safety Related		
System Code: [12]	N/A		
Structure: [13]	N/A		

EB 11/13/09

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To
LSCS Drawing S-1470	From	LSCS Drawing A-961	From
LSCS Drawing S-1472	From	LSCS Drawing A-962	From
LSCS Drawing S-1473	From	LSCS Drawing A-964	From
LSCS Drawing S-1474	From	LSCS Drawing A-965	From
LSCS Drawing S-1475	From	LSCS Drawing A-966	From
LSCS Drawing S-1476	From	CY-LA-170-301	From
LSCS Drawing S-1479	From		

Is this Design Analysis Safeguards Information? [16] Yes ☐ No ☒ If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] Yes ☐ No ☒ If yes, ATI/AR#:

This Design Analysis SUPERCEDES: [18] None In its entirety.

Description of Revision (list of affected pages for portions): [19]
Original Analysis

EB 11/13/09

Preparer: [20]

URS notes → **Body, Attach. A, C- I, L, O** — Paul Reichert (Print Name) — Paul Reichert (Sign Name) — 9/30/2009 (Date)

URS notes → **Attachment B, J, M, N** — Sara Amitrani (Print Name) — Kry Ulrich for Sara Amitrani (Sign Name) — (Date)

Method of Review: [21] **Detailed Review** ☒ **Alternate Calculations (attached)** ☐ **Testing** ☐

Reviewer: [22] Andy Woodruffe (Print Name) — R Woodruffe (Sign Name) — 9/30/2009 (Date)

Review Notes: [23] Independent review ☒ Peer review ☐

URS notes → **Attach. K,P** — All inputs, assumptions, approaches, numerical analyses, and results were independently reviewed and checked.

(For External Analyses Only)

External Approver: [24] Don Gardner (Print Name) — Harold Rotstein for Don Gardner (Sign Name) — 9/30/2009 (Date)

Exelon Reviewer: [25] Jessica Delaney / Eric Baum (Print Name) — J. Delaney / Eric Baum (Sign Name) — 10/4/09 / (Date) — 11/13/09 *

Independent 3rd Party Review Reqd? [26] Yes ☐ No ☒

Exelon Approver: [27] DAN SCHMIT (Print Name) — D J Schmit (Sign Name) — 11/18/09 (Date)

* Note: This cover sheet form matches that in CC-AA-309-1001 rev. 5 (contains all the form information)

EB 11/13/09

Calc # L-003388 page 12 of 15 ~~page 16 of~~ 11/13/09.

ATTACHMENT 1
Owners Acceptance Review Checklist for External Design Analysis
Page 1 of 1

DESIGN ANALYSIS NO. L-003388 **REV:** 0

		Yes	No	N/A	
1.	Do assumptions have sufficient rationale?	☒	☐	☐	
2.	Are assumptions compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐	
3.	Do the design inputs have sufficient rationale?	☒	☐	☐	
4.	Are design inputs correct and reasonable with critical parameters identified, if appropriate?	☒	☐	☐	
5.	Are design inputs compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐	
6.	Are Engineering Judgments clearly documented and justified?	☒	☐	☐	
7.	Are Engineering Judgments compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐	
8.	Do the results and conclusions satisfy the purpose and objective of the Design Analysis?	☒	☐	☐	
9.	Are the results and conclusions compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐	
10.	Does the Design Analysis include the applicable design basis documentation?	☒	☐	☐	
11.	Have any limitations on the use of the results been identified and transmitted to the appropriate organizations?	☒	☐	☐	11/13/09
12.	Are there any unverified assumptions?	☐	☒	☐	
13.	Do all unverified assumptions have a tracking and closure mechanism in place?	☐	☐	☒	
14.	Have all affected design analyses been documented on the Affected Documents List (ADL) for the associated Configuration Change?	☒	☐	☐	11/13/09
15.	Do the sources of inputs **and** analysis methodology used meet current technical requirements and regulatory commitments? (If the input sources **or** analysis methodology are based on an out-of-date methodology or code, additional reconciliation may be required if the site has since committed to a more recent code)	☒	☐	☐	
16.	Have vendor supporting technical documents and references (including GE DRFs) been reviewed when necessary?	☒	☐	☐	
17.	Have margin impacts been identified and documented appropriately for any negative impacts (Reference ER-AA-2007)?	☐	☐	☒	

EXELON REVIEWER: Jessica Delaroosa / [signature] **DATE:** 10/9/09
Print / Sign

Eric Ballou / [signature] 11/13/09.

Table of Contents

Attachments

1. PURPOSE/OBJECTIVE

The purpose of this calculation is to determine input to procedural operationing restrictions on the use of the existing LaSalle (LSCS) Interim Radwaste Storage Facility (IRSF) for the storage of Class B and C radioactive waste that would assure that dose rates inside and outside the IRSF will be acceptable. On average, this waste is anticipated to contain more radioactivity and have a higher contact dose rate than that assumed in the initial IRSF design. Assessments herein will credit certain available design margins, various administrative controls, and the use of supplementary shielding on an as-needed basis.

Analyses herein are generally based on a filled IRSF. Additional flexibility and options will exist for placement and container shield options, particularly in initial loading periods. Ad hoc analyses may be required during these periods to credit related shielding and distance effects.

Analyses herein are performed with conservative assumptions of a filled building condition. Dose rates outside of the storage area will generally not increase quickly, i.e. they will rise slowly as additional waste is introduced into the facility (offset somewhat by the radioactive decay of waste already within the building). It is expected that surveys will also be used to confirm and maintain dose rates within operational dose goals.

1.1. Additional Topics

During the preparation of this design analysis the following additional topics were identified and addressed:

- The starting analysis was a square pitch 9 x 14 container storage array that is 126 positions per layer. Currently used and crane indexed layouts use an approximately hexagonal array with 135 positions per layer. While the effects of this change are small, they are re-analyzed to determine dose rates outside the IRSF, and in the truck bay. The starting analysis with the 126 positions per layer is included in this analysis for a historical perspective of calculation progression.
- The layout is analyzed only with containers without shield bells. The relative effectiveness of shield bells as determined in the starting analysis is considered applicable, therefore the hexagonal array with shield bells is not analyzed.
- The impacts of potentially storing waste from Exelon's Clinton, Byron and Braidwood Stations at the LaSalle Station are also evaluated.
- The starting analysis determined that an average contact dose rate for upwardly exposed containers (over all positions) should be maintained at less that 25 R/hr, on a bare (no shield bells) container basis. These additional analyses are principally for the purpose of justifying a value of 50 R/hr, based on a review of analytical margins and dose acceptance criteria. Specifically,

    1. Crediting the impact of the mass of wall and roof concrete steel reinforcement and steel I-beams supporting the IRSF roof
    2. Consideration of alternative dose rate acceptance criteria in the near vicinity of the IRSF on an ALARA basis, particularly on the side of the IRSF with HVAC openings. (See Attachment O.)
    3. Alternatives such as consideration of mitigation of streaming through the HVAC opening that contributes to higher dose rates on the affected side of the IRSF. (See Attachment M and O)

1.2. Historical Background and IRSF Design Bases

The LaSalle IRSF was designed principally for storage of the byproducts from water cleanup systems and from the processing of liquid radioactive waste. This waste includes items such as spent resins and filter sludges that would be packaged in metal liners or High Integrity Containers (HICs). These wastes could have been from systems such as Reactor Water Cleanup (RWCU), Fuel Pool Cooling and Cleanup (FPCC), Liquid Radwaste, and Condensate Demineralization and could have been Class A, B or C, per 10CFR61.55.

An average contact dose rate of 15 R/hr, on an all Co-60 basis, was used in the final evaluation of required thicknesses for shielding. It was recognized that some containers may exceed the average condition, and hot-container procedures were established to allow credit for efforts such as use of intervening low activity containers as shields, and control of the average upwardly exposed container contact dose rates.

Key radiation transport pathways and criteria were as follows:

1. Radiation directly through walls exterior to the storage bay. Dose rates within one foot of the exterior wall were to be maintained at less than 1 mrem/hr. A 30 inch concrete wall thickness was selected for the IRSF design used at LaSalle.
2. Radiation directed through the roof (12" to 15" thick) and walls above the crane rail (15" thick). One wall above the crane rail also has HVAC openings that influence exterior dose rates. Dose rates in the immediate vicinity of the IRSF still needed to be on the order of 1 mrem/hr total, including both radiation through the thicker lower walls, external air scatter (skyshine) and radiation redirected to the ground by the thinner walls and HVAC openings above the crane rail.
   The 1 mrem/hr criterion conforms to the Zone 1 limit in the LaSalle UFSAR (Ref. 7). [This criterion was reconsidered on a 10CFR20 compliance and an ALARA basis as part of this calculation].
3. Skyshine at 40CFR190 receptors. The initial design goal was less than 1 mrem/yr at any designated 40CFR190 receptor.
4. Radiation from stored waste, roof scattered into the truck bay, was determined likely to be sufficiently low such that the truck bay would not be a radiation area ($\geq$ 5 mrem/hr) except during waste handling. However, this was based on the assumption that the average contact dose rate would actually be less than 15 R/hr. Provisions for adding a floor (acting as a shield) over the truck bay were made, as shown in Reference 18.

These original analyses were also used as a basis for earlier IRSF calculations in Reference 5 to establish dose rates for 40CFR190 compliance applicable to certain onsite or boundary locations where members of the public may be for limited periods of time.

1.3. New Operation Bases for IRSF Use

1.3.1. Sources and Supplementary Shielding

The currentproposed use of the IRSF is for the storage of Class B and C radioactive waste, in liners or HICs. As discussed in Attachment D (for Quad Cities as an example), the potential stored waste could be Fuel Pool Resin in the range of 15-20 R/hr on contact, and Reactor Water Cleanup Resin in the range of 100-250 R/hr on contact. A review of isotopic data (Attachment D) indicated that the "all Co-

60" assumption remains conservative. This conservatism is applied for LaSalle waste and for waste that may be transferred from the Byron, Braidwood, or Clinton stations.

Because the anticipated waste exceeds the original design basis average radioactivity level, combinations of the use of supplementary shielding using shield bells, and administrative controls in container placement, and possibly managed decay credit will be required. Analyses also credit justified concrete densities that are larger than certain arbitrarily conservative values used in the original design shielding calculation. Additionally, dose criteria in the IRSF and its immediate vicinity are subjected to an ALARA review as discussed in Attachment O.

One goal of these steps is to maintain any IRSF storage consistent with LaSalle Offsite Dose Calculation Manuals ODCM's supporting references. In that regard, the following limits are applied:

1. The ODCM, Reference 60 allowance for contained sources is 10% of the 40CFR190 limit of 25 mrem/yr, or 2.5 mrem/yr. Consistent with the original design basis and to allow for other contained sources, the IRSF dose rate at offsite 40CFR190 receivers is limited to 1 mrem/yr, with continuous occupancy at the nearest residence. This receptor is in the SSW direction at ~880 meters. (See Attachment H)
2. Earlier versions of the ODCM also identifies a maximum target contact dose rate for future HICs intended for IRSF storage as 380 R/hr on contact. While this has been eliminated, meeting this criterion is practical and would only require shield bell use if it needed to be placed near an outside wall, or the average upwardly exposed HIC dose limit cannot be met.
3. The onsite dose locations with limited public occupancy as discussed in Reference 5 will be evaluated to assure that the stated 2.5 mrem/yr limit is met with the identified occupancy assumptions.

In addition, recent EPRI and NRC guidance and criteria from References 1, 2 and 3, with respect to radiation protection provided by IRSF shielding are considered to be met based on historical design criteria for onsite and offsite dose rates. Additionally, the assessments herein may aid in maintaining occupational doses resulting from IRSF storage ALARA as recommended.

Attachment A, shows the general layout of the LaSalle IRSF.

The shield bells, which could be used to provide supplementary shielding, are shown in Attachment G. These bells provide 3 inches of steel shielding over the high integrity container stack and 2.5 inches laterally. The dose reduction benefits are addressed in this calculation. For financial reasons, efforts to minimize, if not eliminate, shield bell use are desirable.

1.3.2. Credit for Analytical Margins

This calculation takes credit for the following:

1. Actual package geometry and positioning. Historical analyses were performed with conservative assumptions and simplified approximations that did not credit some of these factors. These will be credited based on crane travel limitations and actual shielding available. This allows average dose limits that are somewhat above the 15 R/hr originally assumed.
2. Skyshine analyses were originally performed based on a "sea" of design basis waste (uncontainerized) filling the IRSF to a height equivalent to four high stacking. The revised analysis will model individual container positions, with two high stacking. Analyses will be performed with and without shield bells to define their effective attenuation factor.

1.3.3. Supported Operational Criteria

The container layout, as analyzed for shield bell effectiveness, was a 9x14 square pitch array of 126 positions and two high container stacking. Current procedurally controlled layout is a hexagonal array with a maximum of 135 positions, again with two high container stacking. As noted in Attachment D, a station production rate of approximately 4 containers per year is expected. Thus the IRSF would have a capacity well in excess of life of plant storage, even with no stacking. Two high stacking is considered nonetheless, so that it is not precluded by analysis limitations. Outside row criteria will be established for bare and belled containers. These criteria are expected to accommodate the full range of expected Type B and C containers, but with some bare containers required to be away from the outside walls. Bases for evaluation credit for containers shielded by other containers is also included (in Attachment E).

If Type B and C wastes are transferred to LaSalle Station from Clinton, Byron, and Braidwood, the loading rate for storage could approach 10 per year. At that rate the LaSalle IRSF would have a capacity for 25+ years of storage.

Dose control for skyshine (and thin wall to ground radiation scatter) will be based on the product of number of filled locations and the average contact dose rate (with and without bell credit). As an example, with the existing analytical basis, 135 positions were identified with an average of 15 R/hr. Thus the existing basis limit would be 2025 R/hr-position. This value will be <u>increased</u>, and a credit established for shield bell use if needed. Based on a 50 R/hr average contact dose rate for upwardly exposed containers and storage in 135 positions the new bare container limit being evaluated is 6750 R/hr-position.

Analyses herein justify a 50 R/hr average upwardly exposed container contact dose rate for LaSalle.

2. METHOD OF ANALYSIS AND ACCEPTANCE CRITERIA

Analyses of radiation shielding effectiveness in this calculation are performed using the following computer programs, both of which are qualified for safety related calculation use under Washington Division of URS procedures:

1. **MicroShield (5.05)**: computer program used for evaluation of normalized source strength determinations and certain wall thicknesses effectiveness evaluations. This program, using point-kernel methodology is suitable for simple geometries such as a container being shielded by a simple wall.
2. **MCNP (5)**: computer program used for complex geometry calculations. This program, using Monte Carlo methodology is suitable for geometries such as skyshine from radiation exiting from the IRSF through the roof and thin walls above the crane rail, which is then air or wall scattered to ground elevations onsite and offsite.

The basic approach is:

1. Review recent RWCU and FPCC waste characteristics and determine a nominal design basis container that can be analyzed, and then prorated for other source strengths, based on contact or 1 meter measured doses.
2. As discussed in Section1.3.1, the goal is to assure that the IRSF can store a building limit container with a contact dose rate of 380 R/hr, as well as average conditions for expected

waste. Nominal analyses are performed with 100 R/hr contact containers, with the results pro-ratable for other contact dose rates.

3. Evaluate dose from nominal stacked containers, with and without a shield bell, for the wall thicknesses on the periphery of the IRSF.
4. Evaluate doses, with the IRSF filled with nominal containers, with and without shield bells, to determine dose rates in the truck bay, in the immediate vicinity of the IRSF, and at onsite and offsite 40CFR190 receptors.
5. Establish contact dose rate limits that meet dose rate acceptance criteria, with and without shield bells.

Dose rate acceptance criteria that are used in this evaluation are as follows, and are essentially the same as used in the original IRSF design, except for the truck bay:

1. Radiation directly through walls exterior of the storage bay, within one foot of the exterior wall will be maintained at less than 1 mrem/hr.
2. For radiation directed through the roof (12” to 15” thick) and walls above the crane rail (15” thick), dose rates in the immediate vicinity of the IRSF will still be on the order of 1 mrem/hr total (no more than ~25% above), including both radiation through the thicker lower walls, external air scatter (skyshine) and radiation redirected to the ground by the thinner walls above the crane rail. This exterior dose rate, for a filled IRSF and on the side with the HVAC openings, is allowed to be slightly higher, but less than 2 mrem/hr.
3. Skyshine at the offsite 40CFR190 receptor will be less than 1 mrem/yr. Based on Attachment H (Google Earth Review), this receptor is 880 meters from the waste storage bay center.
4. Onsite 40CFR190 receptors will be as described in Reference 5, with previously established locations and occupancy assumptions. The ODCM’s Reference 60 limit of 2.5 mrem/hr will be used.
5. Radiation from stored waste, roof scattered into the truck bay, will be calculated for conditions where the storage bay is filled with waste such that exterior dose criteria are just met. These conditions could eventually result in the truck bay dose rates such that it would be a radiation area (i.e. >5 mrem/hr). It is recognized that the dose rate will buildup slowly, particularly if loading begins from the far end. The provisions for a shield floor over the truck bay remains an as-needed future option.

For items 2-5 above, a filled storage area is assumed. For simplicity and consistency with typical practice, all storage positions are considered equal. As noted, the complete filling of the storage area will take an extended period of time, if ever. Therefore, operationally, control of item 2-5 dose rate is anticipated to be based on average contact dose rates, including zero values for unfilled positions. This is a simplification and approximation, but its effectiveness can readily be monitored by radiation surveys.

3. ASSUMPTIONS

Assumptions and bounding analyzed conditions include:

1. A nominal contact dose rate of 100 R/hr is the basis for all initial evaluations.
2. Dose rates at locations of interest and contact dose rates are assumed to remain proportional so that an increase in contact dose rates will lead to proportional increases in the dose rate. This is recognized as an approximation, but dose rate effects will increase gradually as waste accumulates, and radiation surveys can be used to assure the dose rate goals will continue to be met.
3. It is assumed that the primary means of managing doses in and around the IRSF will be based on measured container contact dose rates.
4. The sources are assumed to be dewatered resins in an EnergySolutions HIC 8-120. Sources are treated being at a HIC diameter of 60 to 61 inches and filled to a 72 inch height. When stacked, conservatively a height of 150 inches effective is used.

4. DESIGN INPUT

Design input consists of the following:

1. LaSalle IRSF configuration information based on general arrangement and detail drawings as listed in the References (in Section 5).
2. Dose criteria are essentially the same as used in the original design, as modified above.
3. Shield bell configurations are taken from the vendor supplied drawing in Attachment G.
4. Shield densities are based on Reference 20, as discussed and included in Attachment I.

5. REFERENCES

1. "EPRI Guidelines for Operating and Interim On Site Low Level Radioactive Waste Storage Facility – Revision 1", Report Number 1018644, Final Report February 2009
2. NRC Regulatory Issue Summary 2008-32, "Interim Low Level Radioactive Waste Storage at Reactor Sites", December 30, 2008.
3. NUREG-0800, Rev. 3, Appendix 11.4-A "Design Guidance for Temporary Storage of Low-level Radioactive Waste"
4. NOT USED.
5. LaSalle Calculation ATD-0173, Rev. 0,"Annual Dose to Members of the Public Due to the LaSalle IRSF" [Reference 60 in current LSCS ODCM].
6. NOT USED.
7. LaSalle UFSAR Section 12.3.1.3, Zone 1 Definition
8. Exelon Drawing S-1470, Rev. C, IRSF Site Plan
9. Exelon Drawing S-1473, Rev. C, Foundation Plan-IRSF
10. Exelon Drawing S-1474, Rev. C, Crane Rail Level Plan-IRSF

11. Exelon Drawing S-1475, Rev. C, Roof Framing Plan-IRSF
12. Exelon Drawing S-1476, Rev. C, Structural Elevations-IRSF
13. Exelon Drawing A-961, Rev. C, General Arrangement – Plan IRSF
14. Exelon Drawing A-962, Rev. C, Architectural – Floor Plan
15. Exelon Drawing A-964, Rev. B, Architectural – Exterior Elevations
16. Exelon Drawing A-965, Rev. B, General Arrangement – Sections IRSF
17. Exelon Drawing A-966, Rev. C, General Arrangement – Sections IRSF
18. Exelon Drawing S-1472, Rev. B, Provision for Truck Bay Shielding - IRSF
19. Exelon Drawing S-1479, Revision B, General Arrangement {Sections}
20. Study Report 6464.007-S-M-005, R0, 06/11/1992, "Generic IRSF Radiological Assessment Using Morse-CGA-PC"
21. CY-LA-170-301, Revision 1, "Offsite Dose Calculation Manual"

6. CALCULATIONS

6.1. Source Term and Historical Waste Evaluation

Attachment D contains Exelon data for typical package dose rates, production rates, and a sample isotopic mix for the more limiting RWCU resin. Attachment D also contains a MicroShield run with this isotopic mix that shows that Co-60 gamma contributes the majority of the external doses. As discussed in Attachment D, the potential stored waste could be Fuel Pool resin in the range of 15-20 R/hr on contact, and RWCU resin in the range of 100-250 R/hr on contact, with an estimated production rate of 4 HICs per year. LaSalle, and Byron, Braidwood, and Clinton that may use the LaSalle IRSF for storage of Type B and C waste, will have different isotopic mixes and contact dose conditions. The all Co-60 assumption, with dose rates managed on a contact dose basis, assures conservatism for all potential waste configurations.

The source terms used herein are adjusted to yield a contact dose rate of 100 R/hr. The corresponding dose rate at 1 meter from such a HIC would be approximately 20 R/hr, for a uniform concentration and 72 inch fill height, with measurement at a 36 inch height, as shown in Attachment A. Dose results from this mix can be adjusted proportionally. This analysis was performed with the source treated as water for buildup purposes, and with a nominal 1.0 specific gravity. No explicit container material assumptions are needed, since any effects would be offset by arbitrarily increasing concentrations to obtain the stated contact dose rate.

As shown on Attachment A, the container loading corresponding to a 100 R/hr container would be about 157 curies of Co-60 with the assumed waste specific gravity of 1.0. Note that a single curie content limit is not established for the IRSF nor for individual containers for shielding purposes. Dose limits are managed based on container contact dose rates, as analyzed for shielding. Acceptable container curie content is a function of isotopic mix, source specific gravity, container storage position, presence of surrounding or overlying containers, presence of shield bells, wall proximity, etc. A single IRSF curie content limit (as suggested in Reference 3, paragraph III.6.E) would not address any of these factors and therefore would have no value in IRSF loading management.

6.2. Direct Dose Determinations

The IRSF storage area perimeter walls are 30 inches thick poured concrete, with the density defined in Attachment I.

6.2.1. Dose Rates and Controls in Immediate IRSF Vicinity

MCNP is used to evaluate dose rates immediately outside of the IRSF, with and without the use of shield bells for the 100 R/hr contact dose containers. This analysis is contained in Attachment E, which also evaluates shield bell effects, and the effects of "hiding" waste behind other lower activity containers.

As shown in Attachment E, the dose rate at the building exterior surface, with 100 R/hr contact containers, would be about 3.5 mrem/hr. This is rounded to 4.0 mrem/hr for conservatism and uncertainties, and to provide some allowance for somewhat higher contact dose rate for containers immediately behind a row of containers next to the wall. Therefore, to meet the 1 mrem/hr criterion with bare HICs, a 25 R/hr contact dose rate limit would apply. Attachment E also contains a MCNP run that shows that the shield bell reduces direct dose rates by a factor of about 16.4, so containers with bells could have contact dose rates at the ODCM limit of 380 R/hr. It should be noted that these evaluations are for two high stacks of HICs, and in an array where all containers are at the limit.

Dose rates from skyshine, with a 50 R/hr average contact dose rate and a filled IRSF in the immediate vicinity next to the wall (0 to 2 meters) are 0.49 mrem/hr on the building side with HVAC openings, less on the side without HVAC openings. A combination of a filled IRSF with design basis conditions at every position is considered remote enough that the skyshine and direct dose contributions are not added with the total maintained within the dose criteria. With the general guidance from this calculation, and routine radiation surveys after container placements, it is expected that exterior dose criteria will be easily met.

6.2.2. Direct Dose Contributions at Distances Well Away from the IRSF

Evaluation of these doses are principally related to offsite and onsite 40CFR190 receptors. Attachment B MCNP analyses are used to determine dose rates vs. distance for the bare and belled container configurations with the 100 R/hr contact dose rates. Pages B22 and B23[1], address doses to the nearest offsite resident at > 880 meters to the south of the IRSF. These dose rates (actually at 850 meters) are 0.0297 and 0.00201 mrem/yr for bare and belled containers, respectively. 24/7 occupancy is assumed at this location. With the above limits on bare and belled HICs (25 R/hr and 380 R/hr respectively adjacent to the outer walls), the direct dose contribution would be 0.008 mrem/yr. This is a minimal fraction of the 40CFR190 dose goal of 1 mrem/yr, (which is a small fraction of the 40 CFR190 limit of 25 mrem/yr).

The nearest onsite 40CFR190 receptor is 395 meters away (Reference 5). Based on Attachment B, page 22, the direct dose rate for bare, 100 R/hr containers is 3.11E-4 mrem/hr, or 7.8E-5 mrem/hr for 25 R/hr containers.

The bounding onsite location away from the IRSF, based on the evaluation of radiation exiting above the crane rail discussed later, is at about 18 meters from the side of the IRSF. The dose rate at that location from that source is controlled by procedure to less than 1 mrem/hr on the side of the IRSFs

[1] Based on the square array, 126 container, configuration, given the low doses below this analysis was not repeated for the hexagonal array and these results are considered applicable.

without HVAC openings, and less than 2 mrem/hr on the side with HVAC openings, including both direct radiation and skyshine. Attachment A used MicroShield to assess container direct dose contributions at that location. As shown on Attachment A, page A9, the dose contribution is about 0.20 mrem/hr. This would be the case for 28 containers, all at 25 R/hr contact at the wall. As a practical matter, the doses due to a combination of direct and skyshine dose will be maintained within the above dose rate limits with the two selected contact dose rate constraints, and will be verified by survey.

6.3. Scatter and Skyshine Dose Determinations

The fact that the roof and the walls above the crane wall are thinner that the lower shield walls typically causes these types of evaluations to be required.

Evaluations are performed for doses from stored radioactive waste to the truck bay and to locations outside of the IRSF. These evaluations are based on a full IRSF. For initial runs[2], 2 high stacking in a square 9x14 pitch arrangement with 126 positions was used. For final analyses, 2 high stacking in a hexagonal array is used with 135 positions. As an operational approximation, all locations are assumed to have a similar dose effect, and the goal is to determine a contact dose limit (with and without shield bells), such that the product of collected contact dose rate data and number of positions occupied can be used to assure that the external skyshine and wall scatter caused dose criteria are met. (*Note that at the estimated HIC production rate perhaps 10-15 years could be required to fill each of the two layers of the IRSF. Therefore, it may be beneficial to track position, isotopic loading and residence time to allow decay credit effects if high capacity storage is required. See Attachment F for an illustration of decay effects.)*

The historical IRSF design analysis used a Monte Carlo method computer code called MORSE. This has subsequently been supplanted by the computer program MCNP. URS Washington Division no longer maintains MORSE operational. MCNP is a greatly improved option in terms of its geometry modeling and a continuous energy vs. multi-group approach. Since both codes used the Monte Carlo method the differences in the analysis are related to input detail rather than any methodology change.

Use of the Monte Carlo method requires:

(a) description of source and shielding geometry;

(b) description of the source photon spectrum;

(c) material specification, calling appropriate cross-section libraries;

(d) application of suitable variance reduction techniques;

(e) selection of appropriate dose measures and dose conversion factors.

The Monte Carlo method can best be described as simulating the “random walk” of numerous photons, and tallying their arrival at various surfaces. In this case, several tens of millions of photons are initiated randomly in the waste packages, with a variance reduction bias that more highly samples the upper 20% of the waste volume. Importances and the resulting history splitting are used to maintain particle populations throughout the modeled volumes.

Attachments B, M, and N contains the MCNP runs used to perform this evaluation. Only Attachment B is needed to assess shield bell effectiveness. The goal is to establish average container contact dose limits with and without shield bells.

---

[2] used for shield bell effectiveness, direct through wall contribution and effect of a potential future supplemental truck bay roof

6.3.1. Building Interior Runs

The building interior runs have the following features and perform functions as follows:

1. An array of 2 high stacked containers is described in sufficient detail to simulate conservatively a full building.
2. The building walls are simplified as 30 inch thick concrete, with reductions to 15 inches thickness at the crane rail elevation.
3. An average dose rate over a horizontal plane directly over the interior storage bay shield wall is calculated to verify that it is as expected for 100 R/hr packages.
4. An average dose rate in the truck bay from radiation scatter off of the IRSF roof is determined. This average is over the entire truck bay area at a position 7 feet above the floor. The truck bay is simulated without credit for interior walls for simplicity, generally an expected conservatism. A second test case is also run with a 6 inch thick floor over the truck bay to estimate the benefits of such a structure, some provisions for which were made as shown in Reference 18.
5. A surface source file is written tracking all photons (energy, weight, position, direction) that cross the plane described in item number 3 above, which is above the waste. This source is then read as the source for the exterior MCNP analyses described below.

6.3.2. Building Exterior Runs

The purpose of the building exterior runs is to simulate skyshine, or the air scatter of photons back to ground locations outside of the IRSF. These runs also simulate the effects of photons that strike the walls above the crane rail and are scattered toward the ground.

The building exterior runs have the following features and perform functions as follows:

1. Surface crossing tallies are used, similar to the interior runs. For distances beyond about 30 meters from the storage area center out past the 40CFR190 receiver at 800+ meters, ground surface increments are defined by intercepting spherical surfaces. These surfaces are also used for importance related splitting to maintain a particle population despite attenuation.
2. An additional set of ground surface tallies are used in the vicinity of the long wall to simulate close-in skyshine effects. This location is chosen on the side that contains HVAC openings, to simulate their worst case effect, compared to other IRSF sides.
3. Finally a set of vertical surface tallies are run to establish the degree to which the ventilation openings side contribute such that dose rates are higher than the average in tallies completely around the IRSF.
4. Since dose rates are higher on the side of the IRSF with HVAC openings, analyses are also performed to assess these differences. These analyses assess these effects with the hexagonal storage array, and with explicit modeling of roof I-beams not previously considered. These analyses are in Attachment M and N, with the latter showing the effects and benefit of an exterior shielding structure outside of the HVAC openings. As discussed in Attachment O, this additional shielding is not considered justified on an ALARA basis to reduce the dose rates to less than 1 mrem/hr under worst case conditions.

Attachment B contains the following:

1. MCNP outputs.

2. Figures showing the scaled geometry used for the source and shielding.
3. MCNP Visual Editor plots showing the as simulated geometry, and particle tracking plots that demonstrate reasonableness of problem behavior.
4. The spreadsheet in Attachment B takes the MCNP tallies and turns them into dose rates for the 100 R/hr contact nominal source strength. This spreadsheet then determines the adjustment in average contact dose rates that would result in dose rates meeting the identified goals.

Attachment M includes runs evaluating the impact of HVAC opening in more detail, including the effects of placing shield plates outside of these openings to control the limited effects of streaming through these openings. These added features have been determined in Attachment O to not be justified on an ALARA basis.

Attachment N provides assessments that illustrate the benefit of filling the IRSF storage bay from the end away from the truck bay to minimize truck bay dose rates..

6.3.3. Scatter and Skyshine Dose Determination Results

The limiting outside dose location is in the vicinity of the IRSF, away from the effects of the building shadow. As demonstrating using Attachment B in conjunction with ALARA evaluations in Attachment O, the limits for average upwardly exposed HIC contact dose rates are 50 R/hr for bare HICs and 1400 R/hr for belled HICs, though a 380 R/hr limit is used. If the IRSF were loaded to this degree, which is considered unlikely, the dose rate in the truck bay could approach 83 mrem/hr, requiring its treatment as a radiation area. (See further discussions in 6.4 below.) Activities in the truck bay can be limited for ALARA. For example, transport cask upper shields can be secured and unsecured outside of the truck bay. Crane operations are controlled from the adjacent IRSF control room. In general, the storage bay should be loaded starting from the end away from the truck bay to maintain dose rates ALARA.

The bounding offsite 40CFR190 receptor is the nearest resident at 880 meters SSW of the IRSF. The LaSalle nearest resident is in a direction not impacted by the HVAC openings above the crane rail. See Attachment H. Dose rates at the offsite receptors are controlled by onsite dose limits so that it is assured that the dose rate at this receptor will be less than 1 mrem/yr.

Onsite 40 CFR190 receptors are identified in Reference 5 as follows:

Nuclear Station	Location of Occupied Areas Outside the restricted Areas Situated Closest to the IRSF	Approximate Distance from Center of IRSF to Occupied Area (meters)	Estimated Occupancy (hours/year)	Annual Dose (mrem)	Container Basis For Skyshine
LaSalle	Nearest Residence	880	8766	0.30	IRSF Limited to 50 R/hr Average Upwardly Facing HIC Contact Dose Rate
	Restricted area boundary fence nearest to the IRSF (i.e., to the west of LaSalle IRSF)	395	20	0.08	
	Gate House	767	20	0.002	
Nearest Residence Dose Criterion is 1 mrem/year per SRP 11.4-A recommendations Onsite 40CFR190 receptors limited to 2.5 mrem/year per ODCM					

Attachment B and M summarize the evaluation of onsite and offsite 40CFR190 dose rates, and shows that limits are met with bare containers controlled to an average contact dose rate of 50 R/hr. The

impact of the shield bells are shown on Attachment B, which demonstrates that a shielding effect factor of 28 is conservative.

With respect to dose rates in the vicinity of the IRSFs, peak dose rates are as follows:

Nuclear Station	Peak Skyshine Dose Rate (mrem/hr)		Container Basis For Skyshine
	HVAC Opening Side	Non-HVAC Opening Side	
LaSalle	1.73	0.79	50 R/hr
Notes with respect to direct radiation:			
1. Through the wall dose contributions are controlled to less that 1 mrem/hr on contact with the walls, based on all containers with a view of the wall being controlled at 25 R/hr contact. Skyshine in this vicinity is about 30% of the peak. 2. Direct doses at the skyshine peak are expected to be much lower, and given the unlikelihood of all containers next to the wall being at 25 R/hr contact, this component is not added to the skyshine value in estimating peak doses.			

6.4. General Approach and Results Observations

This calculation is for the purpose of determining practical contact dose acceptance criteria for waste to be stored in the LaSalle IRSF. This involves a number of simplifications of a potential variety of arrangements and factors. Considerations include:

1. The anticipated Class B & C waste dose rates, and the resulting contact dose restrictions due to radiation directly through walls, are based on an array of stacked packages. Dose rates from single, isolated containers would be lower. Temporary higher dose limits might be applied for the latter case, but are not determined in this calculation.
2. Skyshine analyses are based on a full IRSF and average contact dose rates across the storage positions. This averaging provides flexibility in the use of associated limits for a range of containers. Empty positions can be counted as a container having a contact dose rate of zero in determining the average.
3. The conservatively anticipated placement rate of 4 to 10 HICs/yr for LaSalle with waste from other stations would result in substantial decay in storage as waste is accumulated before the last position is filled. For instance, Attachment F shows that, if all containers initially had the same contact dose rate, upon filling the last position of the first layer the average contact dose rate would be about ¼ of the initial value for a 4 HICs/yr storage rate.
4. The calculated dose rates in the truck bay, with the storage area loaded to the limit for outside locations, appear high from an ALARA perspective. However, with average container conditions, and with decay in place effects, actual dose rates are expected to be substantially lower. The option for a shield floor over the truck bay as shown in Reference 18 remains if needed, in the future, if substantial high radiation container inventories are anticipated. The analysis performed in Attachment B demonstrated that a six inch concrete mezzanine floor over the truck bay is approximately equivalent to shield bell use for purposes of lowering dose rates in the truck bay. The provisions for such a shield are for an even greater 1 ft. thickness.

7. RESULTS AND CONCLUSIONS

Container contact dose rate limits are determined and managed separately for the wall shields lateral to the waste storage area [direct dose] and for the radiation leaving through the roof and the walls above the crane rail [skyshine]. Both can limit container contact dose rates.

Protection by Walls from Direct Radiation:

Based on Attachment E, bare HICs adjacent to storage bay walls should have a contact dose rate limit of 25 R/hr. HICs in shield bells and adjacent to storage bay walls should have a contact dose rate limit of 380 R/hr.

Protection from Skyshine, Wall Scatter and HVAC Opening Effects

Attachment B & M, in conjunction with Attachment O, show the determination that the average upwardly exposed HICs, without a shield bell, should be limited to a 50 R/hr contact dose rate. The integrated limit on this basis is 6750 position-R/hr (i.e., 50 R/hr times 135 positions).

In practice this could allow, as an example for LaSalle:

50 upwardly exposed bare HICs at 100 R/hr average contact	=5000 position-R/hr
50 upwardly exposed bare HICs at 30 R/hr average contact	=1500 position-R/hr
14 upwardly exposed belled HICs at 380 R/hr (/28) average contact	= 190 position-R/hr
21 empty positions	= 0 position-R/hr
Total	=6690 position-R/hr

This example shows shield bells providing a 28 shielding effect dose reduction factor for skyshine.

This approach uses the assumption that all positions are equal, which is not strictly correct. However, dose rate buildup will be slow for these effects, and radiation surveys can provide timely feedback and assure that doses remain ALARA.

Control of skyshine dose rates in the immediate vicinity of the IRSF will inherently provide protection for the 40CFR190 receptor, maintaining dose rate contributions from the IRSF at less than one mrem/year.

Radiation Protection in the Truck Bay

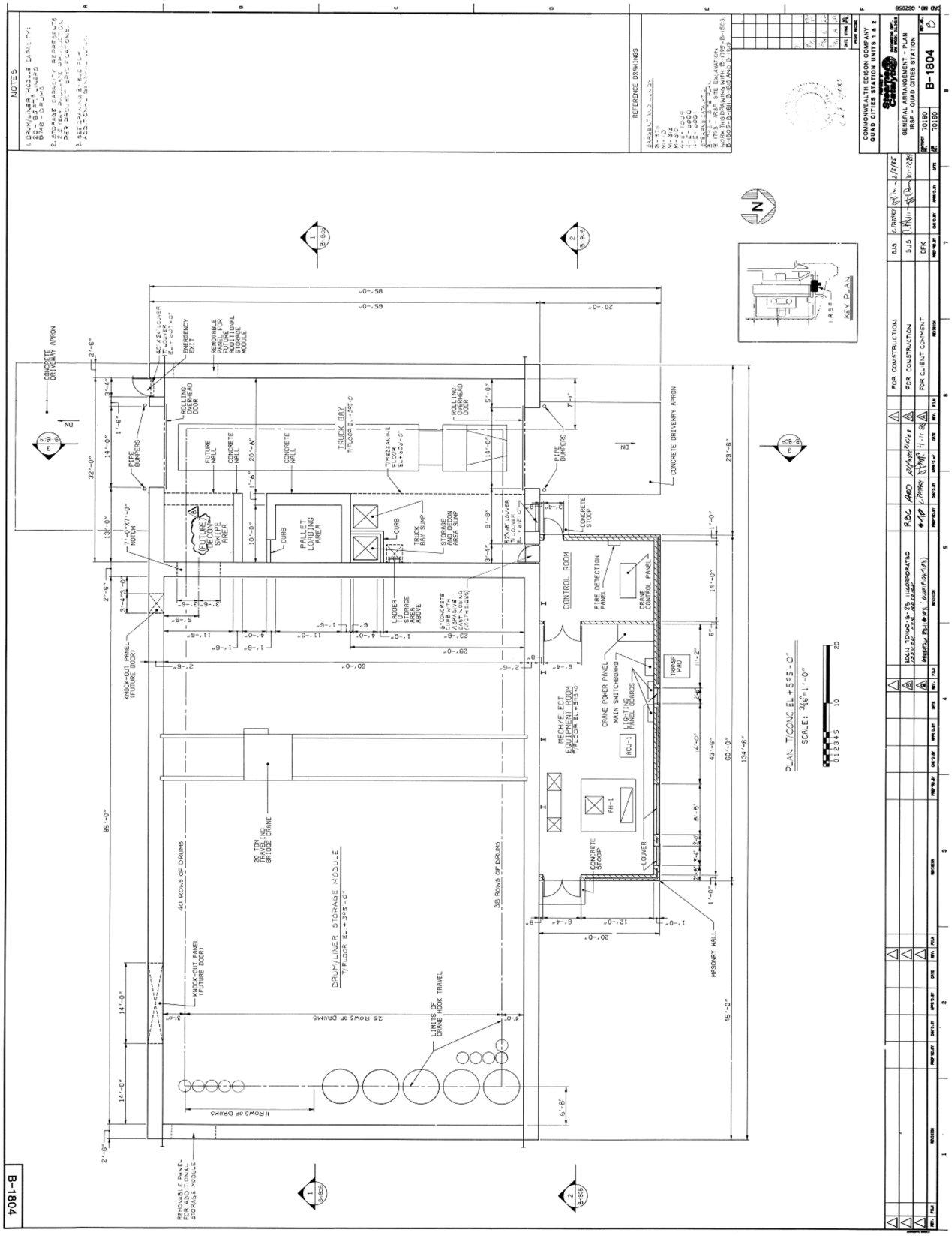
Radiation protection in the truck bay is considered principally an operational ALARA issue. Dose rates will build slowly with waste accumulation but will potentially result in the truck bay becoming a radiation area. This may also extend to the area immediately outside of the truck bay doors.

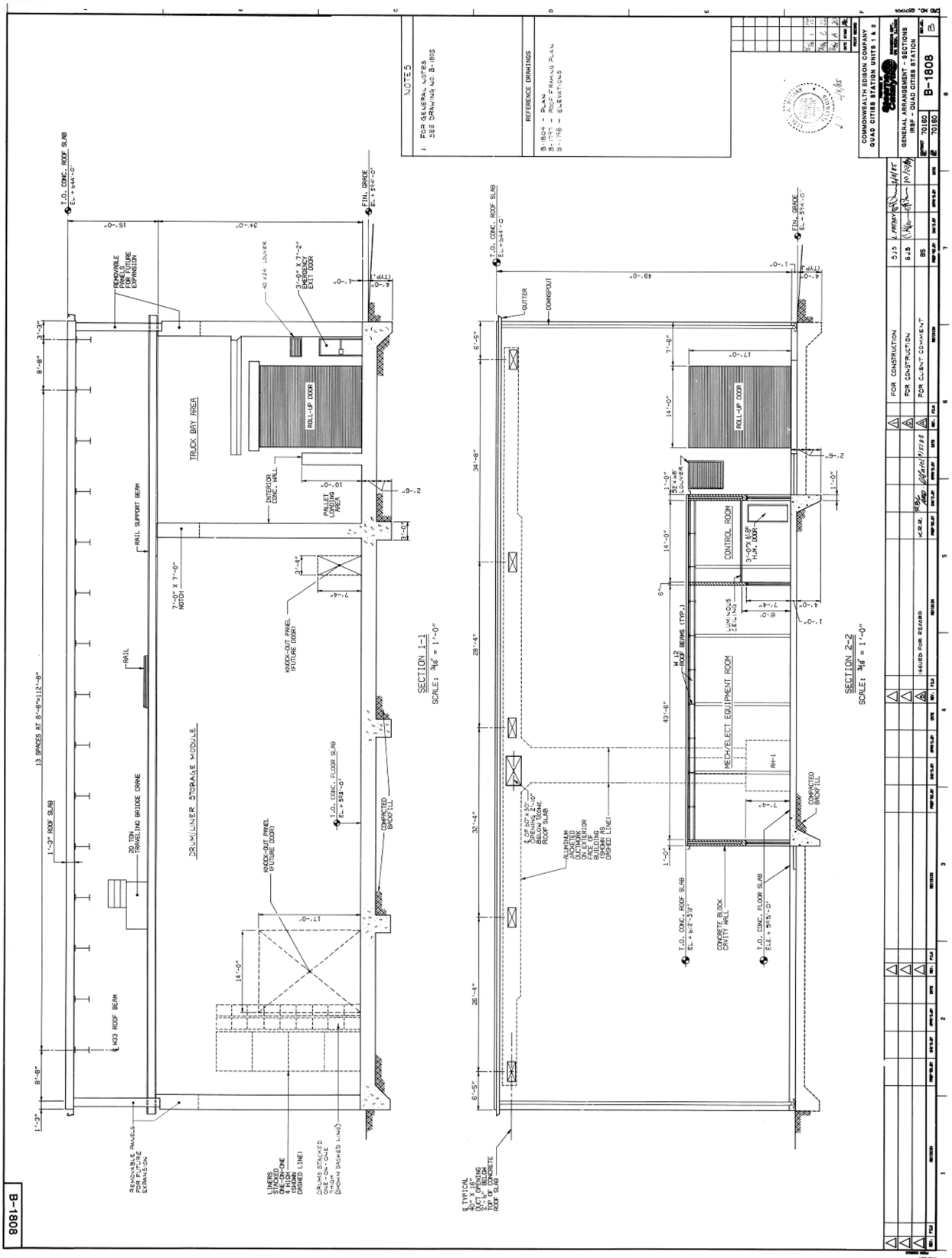
Hot containers can be preferentially positioned well away from the adjoining wall (See Attachment N for example). Occupancy can be minimized by un-securing and securing transport cask container access shielding outside of the truck bay, and by access controls. Crane operation is remotely controlled in any case. Shielding over the truck bay could be added later if necessary. Waste accumulation effects are discussed in Attachment O with respect to ALARA.

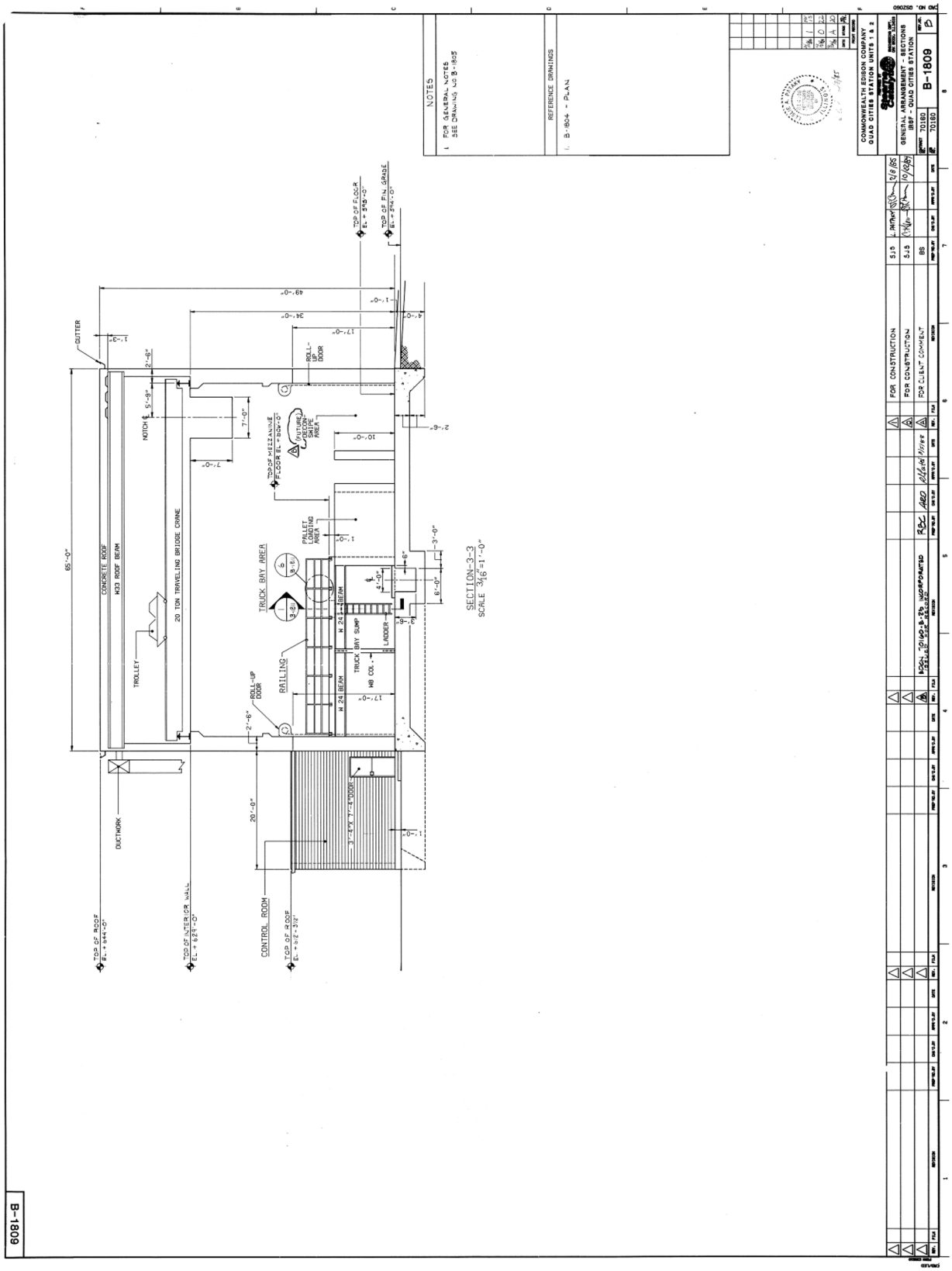
URS
Washington Division

Attachment A

Building Plan and MicroShield Case


COMMONWEALTH EDISON COMPANY
QUAD CITIES STATION UNITS 1 & 2
GENERAL ARRANGEMENT - PLAN
IRSF - QUAD CITIES STATION
B-1804
PLAN T/CONC. EL. +595'-0"
SCALE: 3/16"=1'-0"
DRUMLINER STORAGE MODULE
T/FLOOR EL. +595'-0"
TRUCK BAY
T/FLOOR EL. +595'-0"
PALLET LOADING AREA
CONTROL ROOM
MECH/ELECT EQUIPMENT ROOM
T/FLOOR EL. +595'-0"
CONCRETE DRIVEWAY APRON
20 TON TRAVELING BRIDGE CRANE
40 ROWS OF DRUMS
38 ROWS OF DRUMS
25 ROWS OF DRUMS
11 ROWS OF DRUMS
LIMITS OF CRANE HOOK TRAVEL
MASONRY WALL
KEY PLAN
FOR CONSTRUCTION
FOR CLIENT COMMENT


NOTES
1. FOR GENERAL NOTES SEE DRAWING NO B-1805
REFERENCE DRAWINGS
B-1804 - PLAN
B-1777 - STRUCTURAL FRAMING PLAN
B-1778 - ELEVATIONS
COMMONWEALTH EDISON COMPANY
QUAD CITIES STATION UNITS 1 & 2
GENERAL ARRANGEMENT - SECTIONS
IRSF - QUAD CITIES STATION
B-1808
FOR CONSTRUCTION
FOR CONSTRUCTION
FOR CLIENT COMMENT
ISSUED FOR RECORD
T.O. CONC. ROOF SLAB
EL. +544'-0"
FIN. GRADE
EL. +514'-0"
REMOVABLE PANELS FOR FUTURE EXPANSION
42"x24" LOUVER
3'-0"x7'-2" EXISTING EXIT DOOR
ROLL-UP DOOR
TRUCK BAY AREA
INTERIOR CONC. WALL
PALLET LOADING AREA
RAIL SUPPORT BEAM
7'-0"x7'-0" NOTCH
KNOCK-OUT PANEL (FUTURE DOOR)
T.O. CONC. FLOOR SLAB
EL. +513'-0"
COMPACTED BACKFILL
13 SPACES AT 8'-8"=112'-8"
1'-3" ROOF SLAB
RAIL
20 TON TRAVELING BRIDGE CRANE
DRUM/LINER STORAGE MODULE
W33 ROOF BEAM
REMOVABLE PANELS FOR FUTURE EXPANSION
LINERS STACKED ON TOP OF ONE 4 HIGH (BROWN DASHED LINE)
DRUMS STACKED ONE ONE HIGH (BROWN DASHED LINE)
SECTION 1-1
SCALE: 3/16" = 1'-0"
GUTTER
DOWNSPOUT
CONTROL ROOM
3'-0"x6'-8" H.M. DOOR
2HM DOORS EL. +514
W 12 ROOF BEAMS (TYP.)
MECH/ELECT EQUIPMENT ROOM
RH-1
COMPACTED BACKFILL
CONCRETE BLOCK CAVITY WALL
T.O. CONC. ROOF SLAB
EL. +512'-3/4"
T.O. CONC. FLOOR SLAB
EL. +513'-0"
SECTION 2-2
SCALE: 3/16" = 1'-0"
B-1808

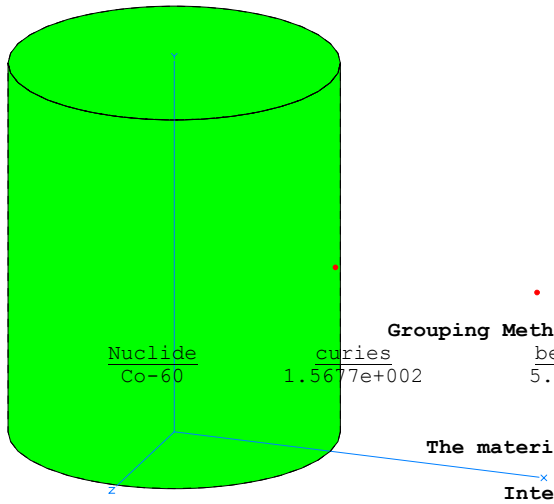

NOTES
1. FOR GENERAL NOTES SEE DRAWING NO B-1805
REFERENCE DRAWINGS
1. B-1804 - PLAN
COMMONWEALTH EDISON COMPANY
QUAD CITIES STATION UNITS 1 & 2
GENERAL ARRANGEMENT - SECTIONS
IBBF - QUAD CITIES STATION
B-1809
FOR CONSTRUCTION
FOR CONSTRUCTION
FOR CLIENT COMMENT
SECTION-3-3
SCALE 3/16"=1'-0"
CONCRETE ROOF
W33 ROOF BEAM
20 TON TRAVELING BRIDGE CRANE
TROLLEY
GUTTER
NOTCH
DUCTWORK
TOP OF ROOF
TOP OF INTERIOR WALL
CONTROL ROOM
TOP OF ROOF
TRUCK BAY AREA
RAILING
ROLL-UP DOOR
PALLET LANDING AREA
TOP OF MEZZANINE FLOOR
FUTURE DECON SPACE AREA
W 24 BEAM
TRUCK BAY SUMP
LADDER
W8 COL.
TOP OF FLOOR
TOP OF FIN GRADE
B-1809

MicroShield v5.05 (5.05-00211)
Raytheon Engineers & Constructors

Page : 1
DOS File: IRSFPEAK.MS5
Run Date: April 2, 2009
Run Time: 11:43:29 AM
Duration: 00:00:15

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: QC IRSF Source
Description: All Co-60 Source
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	182.88 cm	6 ft
Radius	77.47 cm	2 ft 6.5 in

Dose Points

	X	Y	Z
# 1	80.01 cm	91.44 cm	0 cm
	2 ft 7.5 in	3 ft	0.0 in
# 2	180.01 cm	91.44 cm	0 cm
	5 ft 10.9 in	3 ft	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	3.45e+06 cm³	Water	1
Transition		Air	0.00122
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	1.5677e+002	5.8005e+012	4.5465e+001	1.6822e+006

Buildup
The material reference is : Source

Integration Parameters

Radial	30
Circumferential	30
Y Direction (axial)	31

Results - Dose Point # 1 - (80.01,91.44,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	9.462e+08	9.400e+02	2.378e+03	1.815e+00	4.592e+00
1.1732	5.800e+12	1.244e+07	2.629e+07	2.224e+04	4.698e+04
1.3325	5.800e+12	1.505e+07	3.056e+07	2.611e+04	5.302e+04
TOTALS:	1.160e+13	2.749e+07	5.685e+07	4.835e+04	1.000e+05

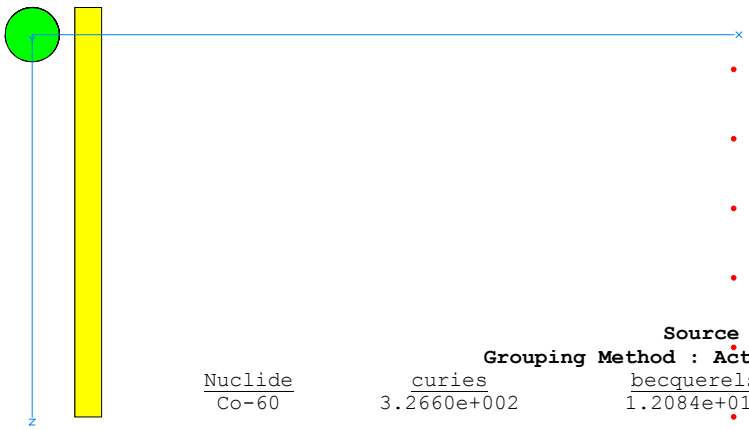
Results - Dose Point # 2 - (180.01,91.44,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	9.462e+08	1.891e+02	4.670e+02	3.651e-01	9.016e-01
1.1732	5.800e+12	2.485e+06	5.126e+06	4.440e+03	9.159e+03
1.3325	5.800e+12	2.998e+06	5.946e+06	5.201e+03	1.032e+04
TOTALS:	1.160e+13	5.483e+06	1.107e+07	9.642e+03	1.948e+04

Page : 1
DOS File: IRSFPK2.MS5
Run Date: April 2, 2009
Run Time: 12:07:27 PM
Duration: 00:00:47

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: QC IRSF Source
Description: All Co-60 Source - For Middle 12 Stacks
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	381.0 cm	12 ft 6.0 in
Radius	77.47 cm	2 ft 6.5 in

Dose Points

	X	Y	Z
# 1	2000 cm	190.5 cm	99.06 cm
	65 ft 7.4 in	6 ft 3.0 in	3 ft 3.0 in
# 2	2000 cm	190.5 cm	297.18 cm
	65 ft 7.4 in	6 ft 3.0 in	9 ft 9.0 in
# 3	2000 cm	190.5 cm	495.3 cm
	65 ft 7.4 in	6 ft 3.0 in	16 ft 3.0 in
# 4	2000 cm	190.5 cm	693.42 cm
	65 ft 7.4 in	6 ft 3.0 in	22 ft 9.0 in
# 5	2000 cm	190.5 cm	891.54 cm
	65 ft 7.4 in	6 ft 3.0 in	29 ft 3.0 in
# 6	2000 cm	190.5 cm	1089.66 cm
	65 ft 7.4 in	6 ft 3.0 in	35 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	7.18e+06 cm³	Water	1
Transition	44.45 cm	Air	0.00122
Shield 2	76.2 cm	Concrete	2.365
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	3.2660e+002	1.2084e+013	4.5465e+001	1.6822e+006

Buildup
The material reference is : Source

Integration Parameters

Radial	30
Circumferential	30
Y Direction (axial)	31

Results - Dose Point # 1 - (2000,190.5,99.06) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.971e+09	2.622e-06	2.130e-04	5.063e-09	4.113e-07
1.1732	1.208e+13	7.563e-01	2.054e+01	1.352e-03	3.670e-02
1.3325	1.208e+13	1.797e+00	3.881e+01	3.117e-03	6.734e-02
TOTALS:	2.417e+13	2.553e+00	5.935e+01	4.469e-03	1.040e-01

Results - Dose Point # 2 - (2000,190.5,297.18) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.971e+09	2.247e-06	1.855e-04	4.339e-09	3.582e-07
1.1732	1.208e+13	6.679e-01	1.836e+01	1.194e-03	3.281e-02
1.3325	1.208e+13	1.597e+00	3.491e+01	2.771e-03	6.057e-02
TOTALS:	2.417e+13	2.265e+00	5.327e+01	3.965e-03	9.338e-02

Results - Dose Point # 3 - (2000,190.5,495.3) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.971e+09	1.665e-06	1.417e-04	3.214e-09	2.736e-07
1.1732	1.208e+13	5.242e-01	1.475e+01	9.368e-04	2.636e-02
1.3325	1.208e+13	1.270e+00	2.837e+01	2.203e-03	4.922e-02
TOTALS:	2.417e+13	1.794e+00	4.312e+01	3.140e-03	7.559e-02

Results - Dose Point # 4 - (2000,190.5,693.42) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.971e+09	1.071e-06	9.527e-05	2.067e-09	1.839e-07

DOS File: IRSFPK2.MS5
Run Date: April 2, 2009
Run Time: 12:07:27 PM
Duration: 00:00:47

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
1.1732	1.208e+13	3.673e-01	1.070e+01	6.564e-04	1.912e-02
1.3325	1.208e+13	9.066e-01	2.092e+01	1.573e-03	3.630e-02
TOTALS:	2.417e+13	1.274e+00	3.162e+01	2.229e-03	5.542e-02

Results - Dose Point # 5 - (2000,190.5,891.54) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.971e+09	6.062e-07	5.704e-05	1.170e-09	1.101e-07
1.1732	1.208e+13	2.324e-01	7.065e+00	4.153e-04	1.263e-02
1.3325	1.208e+13	5.877e-01	1.413e+01	1.020e-03	2.451e-02
TOTALS:	2.417e+13	8.201e-01	2.119e+01	1.435e-03	3.713e-02

Results - Dose Point # 6 - (2000,190.5,1089.66) cm

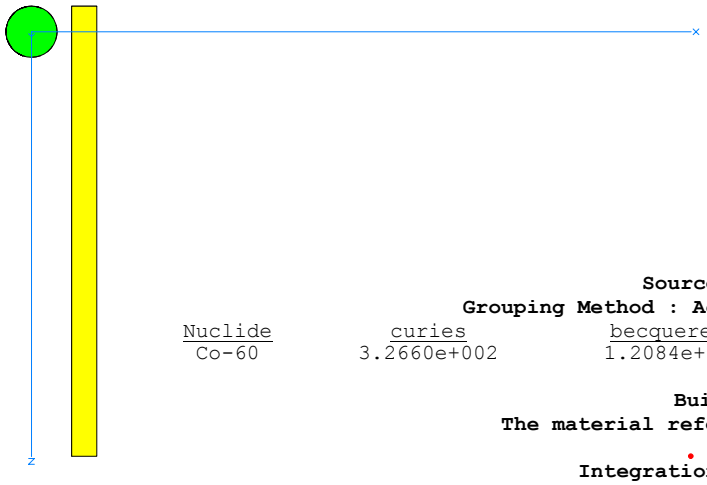
Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.971e+09	3.072e-07	3.083e-05	5.931e-10	5.953e-08
1.1732	1.208e+13	1.345e-01	4.297e+00	2.403e-04	7.679e-03
1.3325	1.208e+13	3.501e-01	8.820e+00	6.075e-04	1.530e-02
TOTALS:	2.417e+13	4.846e-01	1.312e+01	8.478e-04	2.298e-02

MicroShield v5.05 (5.05-00211)
Raytheon Engineers & Constructors

Page : 1
DOS File: IRSFPK3.MS5
Run Date: April 2, 2009
Run Time: 12:12:49 PM
Duration: 00:00:08

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: QC IRSF Source
Description: All Co-60 Source - For Middle 12 Stacks
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	381.0 cm	12 ft 6.0 in
Radius	77.47 cm	2 ft 6.5 in

Dose Points

	X	Y	Z
# 1	2000 cm	190.5 cm	1287.78 cm
	65 ft 7.4 in	6 ft 3.0 in	42 ft 3.0 in

Shields

Shield Name	Dimension	Material	Density
Source	253.686 ft³	Water	1
Transition	1.458 ft	Air	0.00122
Shield 2	2.5 ft	Concrete	2.365
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	3.2660e+002	1.2084e+013	4.5465e+001	1.6822e+006

Buildup
The material reference is : Source

Integration Parameters

Radial	30
Circumferential	30
Y Direction (axial)	31

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.971e+09	1.408e-07	1.519e-05	2.719e-10	2.932e-08
1.1732	1.208e+13	7.184e-02	2.426e+00	1.284e-04	4.336e-03
1.3325	1.208e+13	1.935e-01	5.134e+00	3.356e-04	8.906e-03
TOTALS:	2.417e+13	2.653e-01	7.560e+00	4.640e-04	1.324e-02

Assessment of Direct Radiation Contribution Through Lower Wall to the Area ~18 Meters from the IRSF where the Peak Dose Effects Occur, for Radiation Exiting above the Crane Rail

(mR/hr)	MicroShield Contributor
1.040E-01	Stack1 from center
9.338E-02	Stack2 from center
7.559E-02	Stack3 from center
5.542E-02	Stack4 from center
3.713E-02	Stack5 from center
2.298E-02	Stack6 from center
1.324E-02	Stack7 from center
4.017E-01	Total from 7 contributors
8.035E-01	Total including symetrical 7 contributors
2.009E-01	**Dose adjusted for 25 R/hr contact source**