12.3 Radiation Protection Design Features

The information in this section of the reference ABWR DCD, including all subsections, tables, and figures, is incorporated by reference with the following departures and supplements.

STD DEP T1 3.4-1

STD DEP 1.2-2 (Figures 12.3-49 thru 12.3-53, 12.3-69 thru 12.3-73)

STD DEP 3.8-1 (Table 12.3-7, and Figures 12.3-37 thru 12.3-41, 12.3-65 thru 12.3-68)

STP DEP 9.4-1

STD DEP 12.3-1

STD DEP 12.3-2

STD DEP 12.3-3

STD DEP 12.3-4 (Tables 12.3-3, 12.3-6, and Figures 12.3-56 thru 12.3-58, 12.3-60, 12.3-62)

STD DEP Admin (Figures 12.3-1, 12.3-3, 12.3-6 and 12.3-74)

12.3.1 Facility Design Features

STD DEP Admin

The ABWR Standard Plant is designed to meet the intent of Regulatory Guide 8.8 (i.e., to keep radiation exposures to plant personnel as low as reasonably achievable (ALARA)). This section describes the component and system designs, in addition to the equipment layout, employed to maintain radiation exposures ALARA. Where possible, consideration of individual systems is provided to illustrate the application of these principles. ~~Owing to the ABWR being a standard plant, specific details as to precise equipment definition are not available and are to be provided by the COL applicant during the final design detail stage.~~ To insure that the plant as designed meets all applicable radiation criteria, a two-step process is then applied where design details not included in this document are then subject to review and confirmation in accordance with radiation protection criteria. Therefore, the details in this section serve as input to the final design configuration and serve to determine the adequacy of the design with respect to radiation protection.

12.3.1.1.2 Material Selection

STD DEP 12.3-1

In the ABWR design maintaining radiation exposure ALARA has been considered in the material selection of systems and components exposed to reactor coolant. For example, radiation exposure potential has been reduced appreciably through the removal or reduction of cobalt from many components as compared to current BWR *fleet. Much of the cobalt is removed from contact with reactor coolant by eliminating Stellite where practical and reducing cobalt in the core stainless steel components.* ~~*The cost of using very low cobalt materials through out the plant is prohibitive with the cost of 0.02 wt percent cobalt stainless steel approximately 8 times that of 0.05 wt percent stainless steel. Therefore, the*~~ The *ABWR design has taken a graded approach* to using various grades of low cobalt stainless steel, *by using the* ~~*most expensive though*~~ *lowest cobalt bearing materials in the most radiologically significant areas with increasing cobalt content in less sensitive areas. The ABWR standards for cobalt are: 0.02 wt percent for those items in the core; 0.03 wt percent for those items in the vessel internals; and 0.05 wt percent for all other components. Also, with the current materials, there are no proven substitutes for Stellite for many hard surface applications shuch as MSIV seats. Current efforts by the nuclear and metallurgical industry indicate that in the future, practical alternatives to Stellite maybe feasible and are being researched.*

~~*The COL applicant shall address material selection of systems and components exposed to reactor coolant to maintain radiation exposures ALARA. See Subsection 12.3.7.4 for COL license information requirements.*~~ These cobalt contents are target values for reduced occupational exposure per ALARA principles and are not specifications.

The estimation of occupational exposure for the ABWR, was generated by reviewing current plant work records and practices at operating BWRs, and taking into account distinct plant features in the ABWR. An estimate of the average annual occupational exposure was made during the US Standard ABWR certification work. It is noted that the reduced cobalt loadings (i.e. target values) were not considered in the estimation. Therefore, based upon the methods used and assumptions made in evaluating occupational exposure, the materials procured with 0.05 wt percent maximum cobalt have no adverse effect on the estimated occupational exposure.

12.3.1.4.1 Reactor Water Cleanup (CUW) System

STD DEP 12.3-2

The CUW System is provided with chemical cleaning connections which can utilize the condensate system to flush piping and equipment prior to maintenance. The CUW filter/demineralizers can be remotely backflushed to remove spent resins and filter aid material. If additional decontamination is required, chemical addition connections are provided in the piping to clean piping as well as equipment prior to maintenance. The backwash tank employs an arrangement to agitate resins prior to discharge. ~~*The tank vent is fitted with a charcoal filter canister to reduce emission of radioiodines into the plant atmosphere.*~~ *The HVAC System is designed to limit the spread of contaminants from these shielded cubicles by maintaining a negative pressure in the cubicles relative to the surrounding areas.*

12.3.1.4.4 Main Steam System

STD DEP 12.3-3

Penetrations through the steam tunnel walls are minimized to reduce the streaming paths made available by these penetrations. ~~*The blowout panels for the steam tunnel are located in the relatively inaccessible upper section of the RHR heat exchanger shielded cubicles which are controlled access areas.*~~ *Penetrations through the steam tunnel walls, when they are required, are located so as to exit in controlled access areas or in areas that are not aligned with the steamlines. A lead-loaded silicone foam* <u>or equivalent</u> *is employed whenever possible for these penetrations to reduce the available streaming area presented.*

12.3.2.3 Plant Shielding Description

STD DEP 12.3-3

(6) *The main steam tunnel extends from the primary containment boundary in the Reactor Building through the Control Building up to the turbine stop valves. The primary purpose of the steam tunnel is to shield the plant complex from N-16 gamma shine in the main steamlines. A minimum of 1.6 meters of concrete or its equivalent (other material or distance) is required on any ray pathway from the main steamlines to any point which may be inhabited during normal operations. The design of the steam tunnel is shown on Figures 1.2-14, 1.2-15, 1.2-20, 1.2-21, and 1.2-28. The tunnel is classified as Seismic Category I in the Reactor Building and in the Control Building and is designed to UBC Seismic Standards in the Turbine Building. The interface between the buildings provides for bayonet connection to permit differential building motion during seismic events and shielding in the areas between buildings. The exact details on the bayonet design are not shown on the referenced arrangement drawings but requires complete shielding in the building interface area.* ~~*The tunnel also serves a secondary purpose as a relief and release pathway for high energy events in the Reactor Building. Any high energy event (line break) in the Reactor Building will, through a series of blow out panels, vent into the steam tunnel and from the steam tunnel through the tunnel vent shaft to the Turbine Building (Figure 1.2-28) for processing to the plant stack. See Subsection 6.2.3.3.1 for more complete description of this function.*~~

12.3.3.2.1 Control Room Ventilation

STD DEP Admin

Outside air coming into the intakes is normally filtered by a particulate filter. If a high radiation level in the air is detected by the ~~*Airborne*~~ <u>Process</u> *Radiation Monitoring System, flow is automatically diverted to another filter train (an outdoor air cleanup unit) that has:*

(1) A ~~*particular*~~ <u>particulate</u> *filter*

(2) A HEPA filter

(3) A charcoal filter

(4) Another HEPA filter

The outdoor cleanup units are located in individual, closed rooms that help prevent the spread of any radiation during maintenance. Adequate space is provided for maintenance activities. The particulate and HEPA filters can be bagged when being removed from the unit. Before removing the charcoal, any radioactivity is allowed to decay to minimal levels, and is then removed through a connection in the bottom of the filter by a pneumatic transfer system. Air used in the transfer system goes through a HEPA filter before being exhausted, or equivalent. Face masks can be worn during maintenance activities, if desired.

12.3.3.2.4 Radwaste Building

Subsection 12.3.3.2.4 has been replaced in its entirety with the following standard departure.

STP DEP 9.4-1

The Radwaste Building HVAC is described in detail in subsection 9.4.6.

The radwaste building ventilation systems are engineered and designed to provide the proper environmental conditions within all areas of the radwaste building during normal plant operation. The radwaste building ventilation systems include:

- Radwaste building process area HVAC system.
- Radwaste control room HVAC system.
- Non-Class IE electrical, and HVAC equipment rooms ventilation system.

From a radiological perspective the system is designed to:

- Provide an environment with controlled temperature and airflow patterns to ensure the comfort and safety of plant personnel and to allow for the continuous operation of the equipment and components.
- Maintain positive pressure within the radwaste control room, electrical room and other areas not containing radioactive materials.
- Limit exfiltration from the radwaste areas with potential airborne radioactive contaminants by maintaining sub atmospheric pressure during the normal plant operation.
- Maintain airflow from areas of low potential radioactivity to areas of progressively higher potential radioactivity.

- Limit airborne fission product release to the atmosphere from the ventilation system exhaust during normal plant operation.

- Limit concentration of airborne radioactivity to levels below the values specified in Appendix B to 10CFR20.

Exhaust air from the Radwaste Building is routed to and exhausted through the plant stack. Upon radiation detection in the main exhaust duct, the exhaust air is automatically routed to the air filtration equipment to be filtered through a prefilter and a HEPA filter before being released through the plant stack. A high level of radioactivity detected by a radiation monitor downstream of the HEPA filter also activates an alarm in the radwaste and the main control rooms.

12.3.4.1 ARM System Description

STD DEP T1 3.4-1

The Area Radiation Monitoring (ARM) System consists of gamma sensitive detectors, digital area radiation monitors, local auxiliary units with indicators and local audible warning alarms, and recording devices. The detector signals are ~~digitized and optically multiplexed for transmission~~ transmitted *to the radiation monitors in the main control room. Each ARM radiation channel has two independently adjustable trip alarm circuits, one is set to trip on high radiation and the other is set to trip on downscale indication (loss of sensor input). Also, each ARM monitor is equipped with self-test feature that monitors for gross failures and will activate an alarm on loss of power or when a failure is detected. Auxiliary units with local alarms are provided in selected local areas for radiation indication and for activating the local audible alarms on abnormal levels. Each area radiation channel is powered from the non-Class 1E vital 120 VAC source, which is continuously available during loss of offsite power. The recording devices are powered from the 120 VAC instrument bus.*

12.3.7 COL License Information

12.3.7.1 Airborne Radionuclide Concentration Calculation

The following site specific supplement addresses COL License Information Item 12.6.

Calculations of the expected airborne radionuclide concentrations are performed, as part of the plant inspections, tests, analyses and acceptance criteria (ITAAC Tier 1 Table 3.2b), to verify the adequacy of the ventilation system prior to fuel load.

12.3.7.2 Operational Considerations

The following site specific supplement addresses COL License Information Item 12.7.

Alarm setpoints are established based on design background radiation levels, which are then, confirmed during the Startup Test Program. The Preoperational Test Program will check for proper calibration of the detectors, and then check the proper functioning of alarms (local and remote, audible and visual) and protective features including alarm setpoints. The Preoperational Test Program will also check for proper response to various loss of power conditions.

Airborne radiation monitoring operational considerations, such as procedures for operation and calibration of monitors and placement of portable monitors, are established in accordance with the Operational Radiation Protection Program described in Section 12.5S.

12.3.7.3 Requirements of 10CFR70.24

The following site specific supplement addresses COL License Information Item 12.8.

The information demonstrating that the plant meets the criticality accident monitoring requirements of 10CFR70.24 will be provided as an amendment to the FSAR in accordance with 10 CFR 50.71(e), or an exemption from this 10 CFR 70.24 requirement will be requested, at least six months prior to fuel load (COM 12.3-1).

12.3.7.4 Material Selection

The following site specific supplement addresses the unnumbered COL License Information Item contained in this section of the reference ABWR DCD.

STPNOC continues to monitor industry state-of-the-art developments in material selection options for maintaining exposure ALARA, including Stellite reduction efforts. A graded approach to using the various levels of cobalt in the primary systems has been undertaken as discussed in Subsection 12.3.1.1.2.

12.3.8 Radiation Exposure to Construction Workers During Plant Construction

The following site specific supplement provides information to address RG 1.206, CIII Subsection 12.3.5, dealing with dose to construction workers for multi-unit sites.

Regulatory Guide 1.206, Section C.III.12.3.5, states in part, for multi unit sites, the COL applicant will provide estimated annual dose to construction workers in a new construction area, as a result of radiation from on-site radiation sources from the existing operating plant(s).

During the construction of STP 3 & 4, workers will be exposed to several potential sources of radiation. This section identifies the potential sources of radiation and estimates the doses that workers would receive during the construction of STP 3 & 4 due to the operation of STP 1 & 2. In addition, with STP 3 scheduled to be operational one year earlier than STP 4, STP 3 will be a source of radiation for STP 4 construction workers during that year. Thus, the dose contribution from STP 3 sources of radiation is also evaluated.

Three types of sources are considered: direct radiation, gaseous effluents, and liquid effluents. The maximum annual doses from all three pathways during any year of the construction of STP 3 & 4 occur during the year that STP 3 is operational and STP 4 is under construction. A comparison of these calculated doses for this time period shows that the limits in 10 CFR 20.1301 and 40 CFR 190.10 for members of the public are satisfied. For 10 CFR 20.1301 the calculated annual dose is 18 mrem TEDE and the limit is 100 mrem TEDE; the unrestricted area calculated dose rate is 0.0088 mrem/hr and the limit is 2 mrem/hr. For 40 CFR 190.10 the calculated annual doses for whole body, thyroid and other organ are all 18 mrem and the limits are whole body (25 mrem), thyroid (75 mrem) and other organ (25 mrem).

Annual Doses for Individuals Working on Unit 4

	Worker Annual Dose (mrem)	
	From Unit 3	**From Units 1, 2 & 3**
Whole body dose from liquid effluents	0.00026	0.032
Organ dose from liquid effluentst	0.00043	0.032
Whole body dose from gaseous effluents	6.6	8.3
Skin dose from gaseous effluents	16	17
Organ dose from radioactive iodine and radioactive material in particulate form from gaseous effluents	12	18

These calculated doses assume a full power equilibrium core with power history for the entire year. It is not expected that Unit 3 will be at 100% power during the full year that STP 4 is still under construction. During this period, STP 3 will be undergoing startup testing. Full power operation is likely to occur only for about 25% of this first year, resulting in decreased annual doses from those presented in the table.

The STP 3 & 4 site will be continually monitored during the construction period and appropriate actions taken to ensure that doses to the construction workers remain ALARA. In addition, the Operational Radiation Protection Program described in Section 12.5S will be in place while Unit 3 is operating with Unit 4 still under construction. Thus, there will be ample oversight to ensure that doses to construction workers remain ALARA during the construction period.

12.3.9 References

STD DEP Admin

12.3-1 N. M. Schaeffer, “Reactor Shielding for Nuclear Engineers”, TID-25951, U.S. Atomic Energy Commission (1973).

12.3-2 J. H. Hubbell, “Photon Cross Sections, Attenuation Coefficients, and Energy Absorption Coefficients from 10 KeV to 100 GeV”, NSRDS-NBS 29, U.S. Department of Commerce, August 1969.

12.3-3 “Radiological Health Handbook”, U.S. Department of Health, Education, and Welfare, Revised Edition, January 1970.

12.3-4 “Reactor Handbook”, Volume III, Part B, E.P. Blizzard, U.S. Atomic Energy Commission (1962).

12.3-5 Lederer, Hollander, and Perlman, “Table of Isotopes”, Sixth Edition (1968).

12.3-6 M.A. Capo, “Polynomial Approximation of Gamma Ray Buildup Factors for a Point Isotropic Source”, APEX-510, November 1958.

12.3-7 Reactor Physics Constants, Second Edition, ANL-5800, U.S. Atomic Energy Commission, July 1963.

12.3-8 ENDF/B-III and ENDF/B-IV Cross Section Libraries, Brookhaven National Laboratory.

12.3-9 PDS-31 Cross Section Library, Oak Ridge National Laboratory.

12.3-10 DLC-7, ENDF/B Photo Interaction Library.

Table 12.3-3 Area Radiation Monitors Reactor Building

No.	Location & Description	Figure #	Sensitivity Range	Local Alarms
2	Reactor area (B)-4F	12.3-62	LL	X
4	Fuel storage pool area (B)-4F	12.3-62	LL	X
5	R/B 4F south area	12.3-62	H	X
7	R/B 3F NW area	12.3-60	H	X
9	CUW control panel area-B3F	12.3-56	H	X
14	R/B 1F SE hatch area	12.3-59	H	X
17	R/B B1F SE hatch area	12.3-58	H	X
26	R/B B3F SW area-RHR “C” equip area	12.3-56	H	X
27	R/B Operating Deck C	12.3-62	H	X
28	R/B Corridor D	12.3-57	M	X
29	R/B Cask Pil	12.3-60	M	X
30	R/B Sampling Room	12.3-58	M	X

Table 12.3-6 Area Radiation Monitors Radwaste Building

No.	Location and Description	Figure #	Sensitivity Range	*Local Alarms*
1	Electrical Equipment Room El 5300	12.3 - 66	H	X
2	Control Room El 12300	12.3 - 67	H	X
3	High Activity Spent Resin Tank Room Tank A El 5300	12.3 - 66	H	X
4	High Activity Spent Resin Tank Room Tank B El 5300	12.3 - 66	H	X
5	Trailer Access Area El 12300	12.3 - 67	H	X
6	LRW Mobile Skid Area El 12300	12.3 - 67	H	X
7	DAW & Wet Solid Waste Accumulation Area El 12300	12.3 - 67	H	X
8	High Activity Waste Storage Area El 12300	12.3 - 67	H	X
9	Waste Sorting Area El 12300	12.3 - 67	H	X
10	Phase Separator Tank A El 5300	12.3 - 66	H	X
11	Phase Separator Tank B El 5300	12.3 - 66	H	X

Table 12.3-7 Area Radiation Monitors Turbine Building

No.	Location & Description	Figure #	Sensitivity Range	Local Alarms
1	Condensate Pump Maintenance Area	12.3-70	M	X
6	Demineralizer Area	12.3-71	H	X
7	SJAE A & Recombiner Area	12.3-71	H	X
8	SJAE B & Recombiner Area	12.3-71	H	X
9	HP Heaters & Drain Tank Area 1	12.3-71	H	X
10	HP Heaters & Drain Tank Area 2	12.3-71	H	X
11	MSR 1A & 1C Area	12.3-72	H	X
12	MSR 1B & 1D Area	12.3-72	H	X

The following figures are located in Chapter 21:

- Figure 12.3-1 Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation – 8200 mm
- Figure 12.3-3 Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 4800/8500 mm
- Figure 12.3-6 Reactor Building Radiation Zone Map for Full Power and Shutdown Operation at Elevation 18100 mm
- Figure 12.3-37 Radwaste Building, Radiation Zone Map, Normal Operation at Elevation – 1700 mm
- Figure 12.3-38 Radwaste Building, Radiation Zone Map, Normal Operation at Elevation 5300 mm
- Figure 12.3-39 Radwaste Building, Radiation Zone Map, Normal Operation at Elevation 12300 mm
- Figure 12.3-40 Radwaste Building, Radiation Zone Map, Normal Operation at Elevation 18300 mm
- Figure 12.3-41 Radwaste Building, Radiation Zone Map, Normal Operation at Cross Section A-A
- Figure 12.3-49 Turbine Building, Radiation Zone Map, at Elevation 5300 mm
- Figure 12.3-50 Turbine Building, Radiation Zone Map, at Elevation 12300 mm
- Figure 12.3-51 Turbine Building, Radiation Zone Map, at Elevation 20300 mm
- Figure 12.3-52 Turbine Building, Radiation Zone Map, at Elevation 30300 mm
- Figure 12.3-53 Turbine Building, Radiation Zone Map, at Elevation Longitudinal Section A-A
- Figure 12.3-56 Reactor Building, Area Radiation Monitors, – 8200 mm
- Figure 12.3-57 Reactor Building, Area Radiation Monitors, – 1700 mm and 1500 mm
- Figure 12.3-58 Reactor Building, Area Radiation Monitors, 4800 mm
- Figure 12.3-60 Reactor Building, Area Radiation Monitors, 23500 mm
- Figure 12.3-62 Reactor Building, Area Radiation Monitors, 31700 mm
- Figure 12.3-65 Not used

The following figures are located in Chapter 21 (continued):

- Figure 12.3-66 Radwaste Building, Area Radiation Monitors, Elevation 5300 mm
- Figure 12.3-67 Radwaste Building, Area Radiation Monitors, Elevation 12300 mm
- Figure 12.3-68 Not used
- Figure 12.3-69 Turbine Building, Grade Level 1, Area Radiation Monitors, Elevation 5300 mm
- Figure 12.3-70 Turbine Building, Grade Level 2, Area Radiation Monitors, Elevation 12300 mm
- Figure 12.3-71 Turbine Building, Grade Level 3, Area Radiation Monitors, Elevation 20300 mm
- Figure 12.3-72 Turbine Building, Grade Level 4, Area Radiation Monitors, Elevation 30300 mm
- Figure 12.3-73 Turbine Building, Area Radiation Monitors, Longitudinal Section A-A

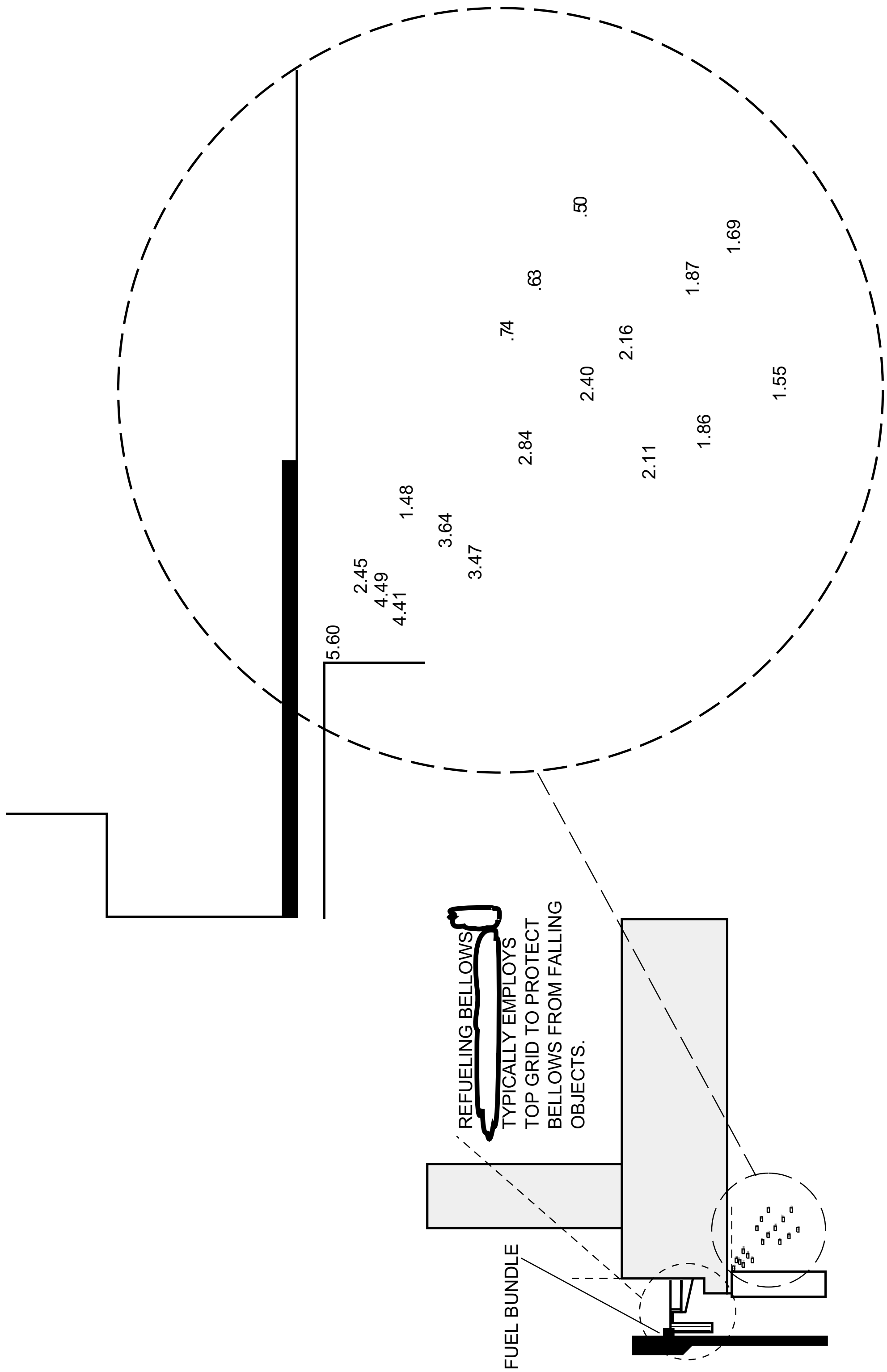

Figure 12.3-74 Upper Drywell Shielding Radiation Dose Rates with Fuel Bundle on Refueling Bellows (Gy/h)