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DPC/NRC0849
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Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555

TO: T. R. QUAY

SUBJECT: WESTINGHOUSE RESPONSES TO NRC REQUESTS FOR ADDITIONAL INFORMATION ON THE AP600.

Dear Mr. Quay:

Enclosed are three copies of the Westinghouse responses to open items on AP600 topics. Responses to nine RAIs are included in this transmittal. RAIs 410.244, 245, 246, 247, and 410.248 provide additional information on HVAC systems. RAI 440.337 addresses a question on WCAP-14206 (NOTRUMP-CAD) and 440.385 a question on OSU scaling. RAIs 471.22 and 471.23 provide additional information on plant radiation levels.

The NRC technical staff should review these responses as a part of their review of the AP600 design. These responses close, from a Westinghouse perspective, the addressed questions. The NRC should inform Westinghouse of the status to be designated in the "NRC Status" column of the OITS.

Please contact Brian A. McIntyre on (412) 374-4334 if you have any questions concerning this transmittal.

Brian A. McIntyre

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

jml

E004/1

Enclosures

cc: T. Kenyon, NRC - (w/o Enclosures)
D. T. Jackson, NRC - (w/Enclosures)
W. Huffman, NRC - (w/Enclosures)

Question 410.244 Revision 1

Provide the following information regarding the radwaste building HVAC system (VRS):

a. Provide data for the men's and women's locker room exhaust fans, and revise Table 9.4.8-1 of the SSAR accordingly.

b. Figure 9.4.8-1 of the SSAR shows both high efficiency filters and low efficiency filters, while Table 9.4.8-1, Sheet 2 of 2, only discusses prefilters. Provide efficiency data for both high and low efficiency filters in Tables 9.4.8-1, Sheet 2 of 2 for the VRS. Also, show all HEPA filters and prefilters (18 of each type as indicated in Table 9.4.8-1, Sheet 2 of 2) on Figure 9.4.8-1, Sheets 1 and 2 of 2.

Response

The radwaste building HVAC system serves no safety-related function and therefore has no nuclear safety design basis. The level of design information presented in the SSAR for this system has been reduced from that presented in Revision 2 of the SSAR. Consequently, Table 9.4.8-1 and Figure 9.4.8-1 are no longer presented in the SSAR.

The following information addresses the above requests:

a. Men's and women's lockers have been deleted from the Radwaste Building; therefore, the associated exhaust fans are also deleted.

b. The revised Radwaste Building and radwaste process no longer require local filtration; therefore, these local filters have been deleted. Exhaust filters have been deleted. HEPA filters are not required to meet offsite dose releases. Descriptions of the low efficiency filters and high efficiency filters are included in subsection 9.4.8.2.2

SSAR Revision: Radwaste Building Ventilation System components will be added to Table 3.2-3 as follows:

Radwaste Building Ventilation System (VRS)				Location: Radwaste Building
n/a	Shutoff, Isolation, and Balancing Dampers	L	NS	ANSI/AMCA-500
n/a	Fire Damper	Note 3	NS	UL-555

Balance of system components are Class E or Class L

Question 410.245

Provide the following information regarding the diesel generator building heating and ventilation system (VZS):

a. The March 30, 1993, response to Q410.103 states that the information contained in NUREG/CR-0660 was considered in the design of the VZS. Provide pertinent information considered, including intake louver locations.

b. Provide an assessment of the operability of the equipment located inside the diesel generator area exposed to 130 °F while the diesel generator is in operation.

c. Why is the VZS not classified as a DID system since other DID systems, including the VBS and subsystems of the VAS and the VWS, are primarily powered during loss of offsite power from an on- site power system consisting of the two diesel generators which are cooled by VZS. The staff believes that this system should be classified as a DID system. Therefore, provide the following information with appropriate justification to demonstrate that the criteria identified in the questions are met by this system, or justify the deviation, if any.

   1. Does the system have an electric supply from both normal station ac and on-site non-safety-related ac power supplies that is separated, to the extent practicable?

   2. Is the system designed and arranged for conditions or an environment anticipated during and after events to ensure functional operability, maintenance accessibility, and plant recovery?

   3. Is the system protected against internal flooding and other in-plant hazards, such as the effects of pipe ruptures, jet impingement, fires, and missiles?

   4. Can the system withstand the effects of natural phenomena that have a reasonable likelihood? Important systems and components should be designed to remain functional after a natural phenomena, such as a seismic event, that is of reasonable likelihood or may persist longer than 72 hours.

   5. Is there a quality assurance program applied to the system that follows guidelines comparable to those of Generic Letter 85-06 for ATWS, and Appendices A and B of Regulatory Guide 1.155, "Station Blackout," for station blackout non-safety-related equipment?

   6. Is the system included in the reliability assurance and maintenance programs for proper maintenance, surveillance, and inservice inspection and testing to ensure the system's reliability is consistent with the determined goals for this system?

   7. Does the system have availability control mechanisms, including allowable outage time and surveillance requirements?

   8. Does the system have proper administrative controls for shutdown configurations?

9. Does the system have sufficient redundancy to ensure defense-in-depth functions, assuming a single active failure of equipment or unavailability due to maintenance.

Provide a detailed assessment regarding conformance with the above criteria in order for the staff to evaluate the defense-in-depth capabilities of the VZS system. Revise the SSAR accordingly to reflect this information.

Response:

a. The diesel generator building ventilation system (VZS) and standby power system (ZOS) are not safety-related. The NUREG/CR-0660 recommendations have been considered and addressed by the following AP600 diesel generator building ventilation system design features:

- Louvers for ventilation air are located as high as practical on the outside walls, approximately 16 feet above grade or higher for normal ventilation air.

- Engine combustion air is filtered and ducted directly from outside the building. The intake is located approximately 10 feet above grade in a wind shielded building alcove.

- Normal ventilation air (DG not operating) into the building is filtered. Outside air to the service module is filtered to prevent the spread of dust/dirt onto electrical equipment.

- The intake to the service module, which houses the major electrical equipment associated with the diesel generator (DG) unit, is located as high up on the building as practical, approximately 16 feet above grade.

- Engine combustion air and ventilation air are kept separate.

- Engine exhaust gas, air exhausted from the Fuel Oil tank vaults and the standby exhaust fans discharge from the DG room are exhausted directly to outdoors and are not circulated back to the room or other plant areas.

b. Equipment located inside the diesel generator area will be specified for continuous operation at expected temperature during diesel generator operation. See subsection 8.3.1.1.2.1.

c. The diesel generator building ventilation system is a defense-in-depth (DID) system since portions of the system are required to support operation of standby power system. The defense-in-depth portions of diesel generator building ventilation system are the standby exhaust fans, the service module cooling system and the diesel oil transfer module temperature control system..

(1) The diesel generator buiding is divided into two areas each housing a diesel generator unit with its associated supporting equipment. The diesel generator building ventilation system consists of two independent subsystems, each providing heating and ventilation the associated diesel generator area. These

two subsystems are independent of each other. The electrical components of each of the diesel generator building ventilation subsystems are supplied from different non-Class 1E electrical load group motor control centers. Power supplies to the diesel generator building ventilation subsystem components are not required to be separated but are separated where practical.

(2) The design of the diesel generator building ventilation system does not require functional operability, maintenance access or support plant recovery following design basis events. Maintenance accessibility is provided consistent with the system nonsafety-related functions and plant availability goals. While not part of the design basis, the diesel generator building ventilation system could be available following a design basis accident to support recovery.

(3) Protection from internal hazards is neither required or provided for the standby power system. The diesel generators and their associated auxiliary systems are located in different fire areas such that a fire within one diesel generator does not affect the other.

(4) The diesel generator building ventilation system is not protected from natural phenomenon and is not required to remain functional after a natural phenomenon. There is no requirement for diesel generator building ventilation system functionality after 72 hours following an event.

(5) As a defense-in-depth system, the diesel generator building ventilation system is classified as an AP600 Class D system. As discussed in SSAR Subsection 3.2.2.6, this classification invokes industrial quality assurance and industry design standards.

(6) The extent of diesel generator building ventilation system inclusion in reliability assurance and maintenance programs is discussed in SSAR Subsection 3.2.2.6 for Class D structures, systems and components. The Reliability Assurance Program is further described in SSAR Section 16.2 and includes a discussion of the applicability to the nonsafety-related defense-in-depth systems, which includes the diesel generator building ventilation system

(7) The diesel generator building ventilation system is nonsafety-related and therefore not included in Technical Specification LCO and surveillance requirements. The diesel generator function is identified in Reference 410.245-1 as an RTNSS important function at reduced inventory conditions during shutdown operations. This reference also provides no short-term availability recommendations for the equipment used to support these functions.

(8) The diesel generator building ventilation system provides the same functions in plant shutdown conditions as they provide during normal plant operation.

(9) The diesel generator building ventilation system provides redundancy on a train basis to perform its defense-in-depth function since there are two identical standby diesel generator units each complete with its diesel generator building ventilation system subsystem.

Reference:

410.245-1 WCAP-13856, AP600 Implementation of the Regulatory Treatment of Nonsafety-Related Systems Process. September 1993.

SSAR Revision: NONE

Question 410.246

Table 9.4.11-1, Sheet 2 of 2, of the SSAR regarding the health physics and hot machine shop HVAC system (VHS) should state "filter requirements," not "heating coil requirements." Also, show the six HEPA filters in Figure 9.4.11-1 for the VHS.

Response:

The health physics and hot machine shop HVAC system has been revised to provide 100 percent redundancy and exhaust filter units have been deleted. HEPA filters are not required to meet offsite dose releases.

The health physics and hot machine shop HVAC system serves no safety-related function and therefore has no nuclear safety design basis. The level of design information presented in the SSAR for this system has been reduced from that presented in Revision 2 of the SSAR. Consequently, Table 9.4.11-1 and Figure 9.4.11-1 are no longer present in the SSAR.

SSAR Revision: NONE

Question 410.247

Provide the following information regarding the annex/auxiliary non-radioactive ventilation system (VXS):

a. Provide men's and women's locker room exhaust fans data for the general area HVAC system in Table 9.4.2-2 of the SSAR.

b. Provide air and water temperature data (entrance and exit conditions) for the air handling unit (AHU) heating and cooling coils for the general area HVAC system, the equipment room HVAC system, the switchgear room HVAC system, the MSIV compartment HVAC system, the demineralized water degasifier room HVAC system, and the valve/piping penetration room HVAC system in Tables 9.4.2-2 through 9.4.2-7 of the SSAR, respectively.

c. Explain how 2,400 SCFM is accounted for from the equipment room HVAC system AHU since it supplies 27,600 SCFM, while the return flow is only 25,200 SCFM and 1,200 SCFM is exhausted from the battery room. Table 9.4.2-3 of the SSAR shows two 100-percent capacity battery room exhaust fans, each rated at 1,200 SCFM.

d. Provide the rationale for selecting the MSIV compartment HVAC system's only filter with an efficiency of 25 percent. Is this correct? If not, revise Table 9.4.2-5 of the SSAR accordingly.

e. Table 9.4.2-6 of the SSAR for the demineralized water degasifier room HVAC system shows two 50-percent AHUs while Figure 9.4.2-3 shows a single AHU. Reconcile the difference and revise the SSAR accordingly. Also, provide data for the low efficiency filter efficiency in this table.

f. Table 9.4.2-7 of the SSAR for the valve/piping penetration room HVAC system shows two 100-percent AHUs while Figure 9.4.2-3 shows a single AHU. Reconcile the difference and revise the SSAR accordingly.

Response:

a. and b. The annex/auxiliary non-radioactive ventilation system is nonsafety-related system. The information requested is typically not provided for nonsafety related systems. Fans are addressed in subsection 9.4.2.2.1.1. Air temperatures are addressed in subsection 9.4.2.1.2.

c. Each of two non-1E battery rooms is provided with one 100% capacity exhaust fan. Both fans normally operate for a total exhaust flow of 2400 cfm (1200 cfm per fan).

d. Cooling of the main steam isolation valve compartments is accomplished by recirculating fan coil units. The filters are provided solely to prevent the buildup of dirt on the cooling and heating coils. The use of 25% ASHRAE Standard 52 Dust Spot Test filters for the protection of heating and cooling coils is in conformance with the guidelines contained in the ASHRAE 1988 Equipment Handbook, Chapter 10, Table 2.

e. There are two 50 percent AHU's for the mechanical equipment area HVAC subsystem serving the demineralized water deoxygenating room. As discussed in subsection 9.4.2.2.2 of the SSAR, the low efficiency filters and high efficiency filters have a rated 25% and 80% dust spot efficiencies, respectively, based on ASHRAE Standard 52.

f. There are two 100 percent AHU's for the valve/piping penetration room HVAC system.

SSAR Revision: NONE

Question 410.248

Provide the following information regarding conformance with generic letters, NRC bulletins, unresolved safety issues, generic safety issues, and industrial codes and standards:

a. Table 1.9-2 of the SSAR (page 1.9-131) states that Generic Safety Issue 83, "Control Room Habitability," is discussed in Section 1.9.4 of the SSAR. However, the discussion on control room habitability does not specifically address GSI 83. Provide an evaluation of GSI 83 in Section 1.9.4 of the SSAR.

b. Section 1.9.4 of the SSAR provides a general overview of the applicability of unresolved safety issues and generic safety issues, including Issues B-36 and B-66. However, the detailed conformance and proposed resolution is not evaluated. Provide appropriate evaluations of these issues in this section.

c. The VBS should be evaluated in accordance with Generic Safety Issue B-36. Provide that evaluation.

d. The acceptance criteria to resolve Issue B-66 should include conformance of the VBS design with the guidance of Sections 6.4, 9.4.1, and 15.6.5.5 of the SRP. Section 9.4.1 of the SSAR should state that all ducts and equipment housings outside of the MCR envelope of the VBS are of welded construction, and that flanged connections will be pressure tight and periodically visually examined and tested to maintain a positive pressure with respect to the adjacent areas, such that any unfiltered inleakages inside the MCR envelope are precluded.

e. Section 9.4.1 of the SSAR should state that the VBS charcoal trays and screen will be all welded construction to preclude the potential loss of charcoal from the adsorber cells, in accordance with IE Bulletin 80-03 for VBS adsorbers.

Response:

a. Section 1.9.4 of the SSAR was revised to address GSI 83.

b. As noted in the discussion for issue B-36, the NRC considers this issue technically resolved with the issuance of Regulatory Guides 1.52 and 1.140. Appendix 1A documents the AP600 position with respect to these Regulatory Guides. Witn regards to issue B-66, Section 6.4 addresses control room habitability issues.

c. Generic Safety Issue B-36 addresses the development of revisions to current guidance and technical positions regarding engineering safety features systems and normal ventilation system air filtration and adsorption units. As described in Section 9.4.1 of the SSAR, the nuclear island non-radioactive ventilation system (VBS) supplemental air filtration subsystem is designed, constructed and tested in accordance with ASME N509-1989 and ASME N510-1989 to satisfy the guidelines of Regulatory Guide 1.140. Conformance to the Regulatory Guide 1.140 is described in Appendix 1A of the SSAR.

d. The nuclear island non-radioactive ventilation system supplemental air filtration subsystem is designed, constructed, and tested in accordance with ASME N509-1989 and ASME N510-1989 as described in SSAR

Section 9.4.1. The supplemental filtration subsystem's ductwork, supports and accessories meet the design and construction requirements in accordance with ASME N509 as described in SSAR Section 9.4.1.2.2. Therefore, the nuclear island non-radioactive ventilation system equipment, housings, dampers and ductwork (outside of the main control room envelope) associated with supplemental air filtration subsystem operation are gas tight (positive or negative pressure) low leakage type and subjected to periodic visual examination and testing in accordance with ASME N509-1989 and ASME N510-1989. The ductwork and housing are not required to be all welded construction in accordance with ASME N509-1989. The expected inleakage to the main control room from ductwork under negative pressure has been accounted for in the dose analysis.

e. The nuclear island non-radioactive ventilation system supplemental air filtration subsystem is designed, constructed, and tested in accordance with ASME N509-1989 and ASME N510-1989 as described in SSAR Section 9.4.1. The supplemental air filtration unit charcoal adsorber unit is a 4 inch deep charcoal bed as indicated in SSAR Table 9.4.1-1. The 4 inch deep charcoal bed is a single assembly, fixed and rechargeable type with Type III adsorber cell. A Type III charcoal adsorber has a stainless steel, all welded construction in accordance with ASME N509-1989, Section 5.2.1 (which refers to ASME AG-1-1991, Section FE). Therefore, the potential loss of charcoal from the adsorber cells identified in IE Bulletin 80-03 is addressed.

SSAR Revision: NONE

Question 440.337

Re: WCAP-14206 (NOTRUMP CAD)
Page 4-11, item 4e, "CHF correlation," the use of the Macbeth correlation needs to be justified for low flow, low pressure conditions. Please demonstrate that the Macbeth correlation is adequate for the low flow and pressure conditions expected for AP600.

Response:

The Macbeth critical heat flux correlation is used in two separate models of the NOTRUMP code. One is in the noncritical heat link calculations (which are not used to model core heat transfer) to determine whether a heat link has exceeded the critical heat flux. The other is in the fuel rod-to-fluid heat transfer coefficient calculations (between core nodes and fluid nodes) to determine the time at which DNB occurs.

Noncritical Heat Links

The Macbeth critical heat flux correlation, as implemented in the noncritical heat link calculations of NOTRUMP, is given by Equations 6-39 and 6-45 in Section 6 of Reference 440.337-1. This is the form of the correlation as presented by Tong in Equation 6-3.17 of Reference 440.337-2, which was derived by Macbeth for a uniformly-heated round tube for low flow regimes. As shown in Figure 6-13 and Table 6-3 of Reference 440.337-2, this form of the correlation has a pressure range of applicability of 15 to 2000 psia and a flow (mass flux, G) range of applicability of approximately 10,000 to 750,000 lbm/ft.^{2}-hr. While the low (atmospheric) pressure conditions expected for AP600 are covered by the low pressure limit of the correlation, the low flow conditions expected for AP600 can extend below the low flow limit of the correlation. However, in the NOTRUMP implementation of the correlation for noncritical heat links, a lower limit is placed on the calculated critical heat flux value, and the actual heat flux is expected to exceed the critical heat flux only very infrequently, if at all. This is explained as follows.

The original NOTRUMP implementation (prior to AP600-related code modifications) of the Macbeth critical heat flux correlation for noncritical heat links applied a lower limit of 90,000 Btu/ft.^{2}-hr. to the critical heat flux calculated by the correlation, as shown in Equations 6-39 and 6-45 in Section 6 of Reference 440.337-1. The Macbeth correlation provides the capability to model critical heat flux on heated surfaces adjacent to flow channels, but is not applicable to heated surfaces adjacent to stagnant fluid. In the case of the stagnant fluid in the IRWST pool side of the PRHR in the AP600 design, the original implementation of the correlation would have resulted in the use of the 90,000 Btu/ft.^{2}-hr. lower limit, which then would have resulted in the heat flux exceeding the critical heat flux. Therefore, the Zuber critical heat flux correlation was added (as part of the AP600-related code modifications) to the noncritical heat link calculations of NOTRUMP to provide the capability to model critical heat flux on heated surfaces adjacent to stagnant fluid, as described in Section 2.15 of the NOTRUMP Final Validation Report for AP600 (Reference 440.337-3). When the Zuber option is chosen, the critical heat flux for a noncritical heat link is given by the maximum of that calculated by the Macbeth correlation and that calculated by the Zuber correlation of Equation 2.15-1 of Reference 440.337-3. Otherwise, the critical heat flux for a noncritical heat link is given by Equations 6-39 and 6-45 of Reference 440.337-1, i.e., the maximum of that calculated by the Macbeth correlation and 90,000 Btu/ft.^{2}-hr. For the NOTRUMP AP600 calculations, the Zuber option is employed for the noncritical heat links on the IRWST pool side of the PRHR. It is noted that at atmospheric pressure, the critical heat flux value calculated by the Zuber correlation of Equation 2.15-1 of Reference 440.337-3 is approximately 350,000 Btu/ft.^{2}-hr.

With the aforementioned lower limits placed on the critical heat flux which is calculated by the Macbeth correlation, the actual heat flux is expected to exceed the critical heat flux only very infrequently, if at all, for the noncritical heat links in NOTRUMP AP600 applications. This was confirmed by checking the results of NOTRUMP AP600 plant runs for the entire range of break sizes. The only occurrence of a noncritical heat link exceeding the critical heat flux which was discovered was in the case of a 10-in. cold leg break. In this case, several momentary (unsustained) occurrences of transition boiling or film boiling were found in the steam generator primary side tube inlet (of both loops) during reverse heat transfer.

It is concluded that the Macbeth critical heat flux correlation, as implemented for noncritical heat links with the lower limits described above, is adequate for both the low flow and low pressure conditions expected for AP600, since the critical heat flux is rarely exceeded.

Fuel Rod Heat Transfer

The Macbeth critical heat flux correlation, as implemented in the fuel rod-to-fluid heat transfer coefficient calculations (between core nodes and fluid nodes) of NOTRUMP, is described in Appendix T of Reference 440.337-1, specifically in Section T-3 on page T-25. It is the default model in the code for the calculation of the time at which DNB occurs. This default model is employed in all NOTRUMP AP600 analyses.

The application of the Macbeth critical heat flux correlation in the fuel rod-to-fluid heat transfer coefficient calculations employs the full range of the correlation, i.e., both the low and high flow regimes. The critical heat flux is calculated using both the low and high flow regime forms, and the minimum value of the two is used. The low flow regime form and its pressure and flow ranges are as described above in the discussion on noncritical heat links, except that the lower limit on the critical heat flux (either the 90,000 Btu/ft.^{2}-hr. value or the Zuber option for stagnant fluid) is not implemented here in the fuel rod-to-fluid heat transfer model. Thus, unlike the noncritical heat link situation, if the flow extends below the low limit of the correlation here in the fuel rod-to-fluid heat transfer model, the actual heat flux can exceed the critical heat flux. In this case, DNB will be predicted to occur early in the core, relative to a more applicable correlation such as Zuber. If the core is in the process of uncovering, the calculation is conservative, since cladding heat up begins earlier. If the core is covered, the lower heat transfer coefficients calculated for post-critical heat flux transition boiling will result in a higher cladding temperature sufficient to remove the decay heat generated. However, this increase is estimated to be no more that 10 to 20 °F. Since the heat transferred to the fluid remains the same, the lower critical heat flux should not have any effect in a covered core.

Therefore, the Macbeth critical heat flux correlation employed for fuel rod-to-fluid heat transfer coefficient calculations is conservative for both the low flow and low pressure conditions expected for AP600.

References:

440.337-1. Meyer, P. E., et. al., "NOTRUMP - A Nodal Transient Small-Break and General Network Code," Westinghouse Electric Corporation, WCAP-10079-P-A (Proprietary), WCAP-10080-P-A (Non-Proprietary), August 1985.

440.337-2. Tong, L. S., "Boiling Heat Transfer and Two-Phase Flow," John Wiley & Sons, Inc., New York, pgs. 162-166, 1965.

440.337-3. Fittante, R. L., et. al., "NOTRUMP Final Validation Report for AP600," Westinghouse Electric Corporation, WCAP-14807, Revision 1, January 1997.

SSAR Revision: NONE

Question 440.385

Re: OSU Scaling Report

Provide the basis for Eq. (5-122) on page 5-33. There is no justification given for the assumption of this relationship.

Response:

Equation (5-122) on page 5-33 is an assumption that relates the volume void fraction in the model to that of the prototype. This relation stems from the following considerations:

- The liquid is treated as an incompressible fluid.
- The vapor volume fraction being considered is representative of the entire system during the depressurization process. That is, the vapor volume fraction is not evaluated on a local basis.
- The dominant phenomena governing the system volume fraction is the volumetric flow rate out of the break. This is typically true of relatively large (i.e., > 2 inch diameter) saturated liquid breaks. See for example the Marviken Test #10, which reveals a nearly linear decrease in system liquid level as a function of time, corresponding to a relatively constant critical mass flow rate out of the break flow.
- The mass flow rate due to injection processes is small compared to the break flow.
- The system is constrained by a rigid boundary. That is, a constant system volume, V_T.

The liquid mass conservation equation is given by:

$$\frac{dM}{dt} = \dot{m}_{in} - \dot{m}_{out} \quad (1)$$

where M is the liquid mass within the system and $\dot{m}$ represents the mass flow rate entering or living the control volume. The axiom of continuity is given by:

$$\alpha_{\ell} + \alpha_{DP} = 1 \quad (2)$$

where the subscripts represent the liquid phase and vapor phase respectively. The liquid mass is given by: Applying equations (2) and (3) to equation (1) for the conditions stated above yields:

$$M = \rho_\ell V_T (1 - \alpha_\ell) \quad (3)$$

$$\rho_\ell V_T \frac{d\alpha_{DP}}{dt} = \dot{m}_{out} \quad (4)$$

where α_{DP} is the average vapor volume fraction during depressurization and ρ_ℓ represents the liquid density. Integrating equation (4) for the case of a constant break flow rate, and expressing it in terms of model to prototype ratios yields:

$$\left[\Delta \alpha_{DP}\right]_R = \left[\frac{\dot{m}_{out} \Delta t}{\rho_\ell V_T}\right]_R \quad (5)$$

The scaling ratios for the facility are $V_{T,R}$ = 1:192, Δt_R = 1:2, $\dot{m}_R$ = 1:96, and ρ_R = 1:1.14. Substituting these values into the ratios on the right-hand side of equation (5) yields:

$$\left[\Delta \alpha_{DP}\right]_R = 1 \quad (6)$$

For the same initial volume fractions in the model and the prototype, equation (6) implies that:

$$\left[\alpha_{DP}\right]_R = 1$$

whish is equation (5-122). It is noted that the this equation is applicable only for the conditions stated above. That is, a break flow rate dominated depressurization even. For smaller breaks, the effects of flashing and boiling will dominated the depressurization rate and the system vapor volume fraction will deviate from equation (7).

SSAR Revision: NONE

Question 471.22 Revision 1

This is to formalize a request for additional information discussed during a telecon in June 1994.

a. The staff's confirmatory shielding calculations confirmed, for the most part, the radiation zone levels described for the AP600 design during normal and accident conditions. However, these shielding calculations indicated rather high (approximately 95 Rem/hr) post-accident radiation levels in the PASS sample room. Determine the time it will take the operators to perform required post-accident actions in all vital areas (as required by 10 CFR 52.79(b) and described in Item II.B.2 of NUREG-0737), and provide estimated personnel doses for each of these activities for the total length of the accident.

b. Justify why the remote shutdown workstation is not considered a vital area.

Response:

a Commitment to the requirements of 10 CFR52.79(b) relative to plant area access and post-accident sampling (10 CFR 50.34 Items (2)(viii)) is included in Section 1.9.3 of the SSAR. The radiation zones for the post-accident actions in the required areas have been provided in SSAR Figure 12.3-2. Time estimates have been made for ingress, egress, and performance of actions at the location for each of the post-accident functions. These times are considered with the post-accident dose rates at the various locations along the access routes and at the areas, when determining the total integrated dose to an operator for each post-accident action. The elapsed time from the accident to the time that the action is performed is also considered in determining the radiation environment at the locations of interest. The maximum integrated dose for each of the actions satisfies the NUREG-0737 requirement of less than 5 Rem whole body, or its equivalent to any part of the body of an individual, for the duration of the accident.

b. Although the remote shutdown workstation is considered to be a vital area as defined in the Security Plan, it is not required to be accessible following a design basis event. As stated in Section 7.4.3.1.1, the remote shutdown workstation "is designed to allow control of a shutdown following an evacuation of the control room, coincident with the loss of offsite power and a single active failure. No other design basis event is postulated." The design basis for the remote shutdown workstation is provided in SSAR Section 7.4.3.1.3 and, as specified, the AP600 design conforms with Reference 471.22-1. Since no design basis events are postulated beyond the scenario resulting in evacuation of the main control room, no emergency habitability provisions (including post-accident radiation protection and shielding measures) are provided for the workstation area. The design provisions incorporated in AP600 to protect the habitability of the main control room are discussed in SSAR Section 9.4.1.2.4 for the nuclear island non-radioactive ventilation system and Section 6.4 for the main control room emergency habitability system.

References:

471.22-1 ANSI 58.6 1983 "Criteria for Remote Shutdown for Light Water Reactors"

SSAR Revision:

Section 12.4, introduction, add a new last sentence: "It also provides estimated maximum personnel exposures for post-accident actions."

Section 12.4.1.8, add a new subsection:

12.4.1.8 Post Accident Actions

Requirements of 10 CFR 52.79(b) relative to plant area access and post-accident sampling (10 CFR 50.34 Item (2)(viii)) are included in Section 1.9.3. If procedures are followed, the design limits radiation exposures to any individual to not exceed 5 rem to the whole-body or 75 rem to the extremities. Figure 12.3-2 in Section 12.3 contains radiation zone maps for plant areas including those areas requiring post accident access. This figure shows projected radiation zones in areas requiring access and access routes for ingress, egress and performance of actions at these locations. The radiation zone maps reflect maximum radiation fields over the course of an accident. The analyses that confirm that the individual personnel exposure limits following an accident are not exceeded reflect the time-dependency of the area dose rates and the required post-accident access times. The areas that require post-accident accessibility are:

1) Main control room
2) Primary sampling room
3) Class 1E regulating transformer areas
4) Ventilation control area for I&C rooms with PAMS equipment
5) Valve area to align spent fuel pool makeup
6) Ancillary diesel room
7) Passive containment cooling water inventory make-up area

The area which results in the highest individual personnel exposures is the primary sampling room. The design provides for access to the primary sampling room as early as eight hours after the accident when radiation fields are high compared to 64 hours or later for the other areas requiring access outside the main control room. In addition to the design provisions, individual exposure for this early sampling operation may be minimized by proper administrative operational controls (for example, splitting tasks among different crews or limiting sample sizes). Special operational controls would only be considered in the event that radiation fields associated with access to the primary sampling room reach the conservatively high levels considered in the evaluations. These conservatively high levels include activity releases as defined in NUREG-1465, maximum design basis leak rate from containment into the access areas and no operable building ventilation systems.

Question 471.23 Revision 2

Verify that the airborne radiation monitors described in Section 11.5.2.3.2 of Chapter 11 of the SSAR will be sensitive enough to detect 10 DAC-hrs in any area of the plant that can be accessed by plant personnel.

Response:

Five (5) airborne radiation monitors are described in Subsection 11.5.2.3.2. An additional six (6) monitors for areas than can be accessed by plant personnel are described in Subsection 11.5.2.3.1. These radiation monitors are part of the permanently installed AP600 radiation monitoring system and provide general area monitoring. These radiation monitors are supplemented by local portable continuous air monitors (CAMs). CAM use is directed by the Health Physics staff during maintenance operations with a high potential for airborne radioactivity levels.

The eleven (11) radiation monitors mentioned above monitor selected areas of the plant that can be accessed by plant personnel. These selected areas are as follows:

1) Fuel Handling Area
2) Auxiliary Building
3) Annex Building
4) Main Control Room and Technical Support Center
5) Containment
6) Health Physics and Hot Machine Shop
7) Radwaste Building

Areas 1, 2, 3, 6, and 7 are monitored by measuring the concentration of radioactive materials in the exhaust air from each area.

Area 4 is monitored by measuring the concentration of radioactive materials in the supply air.

Area 5 is monitored by three separate airborne process monitors:

1) The Containment Air Filtration Exhaust Radiation Monitor measures the concentration of radioactive materials in the containment purge exhaust air.

2) The Containment Atmosphere Radiation Radiogas Monitor measures the radiation from the radioactive gases in the containment atmosphere.

3) The Containment Atmosphere Radiation N^{13}/F^{18} Monitor measures the concentration of radioactive airborne gaseous contamination inside the containment as an indication of reactor coolant pressure boundary leakage.

These eleven (11) monitors are sensitive enough to detect 10 DAC-hours as discussed below.

SSAR Table 11.5-1 provides a listing of each detector, the principal isotope(s) it monitors, and the detector's nominal range. The lower value of the detector's nominal range corresponds to the detector's minimum detectable level. These minimum detectable levels are achieved with a 95% confidence level at standard operating conditions. The following table summarizes Table 11.5-1 and includes the DAC occupational values from Table 1, Column 3, of Appendix B (Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage) of 10 CFR 20.

Airborne Process Radiation Monitor	Isotope(s)	Detector Minimum Detectable Level	DAC Occupational Values - 10 CFR 20, Appendix B, Table 1
Fuel Handling Area Exhaust	Kr-85 Xe-133	1.0E-6 μCi/cc 1.0E-6 μCi/cc	1.0E-4 μCi/cc 1.0E-4 μCi/cc
Auxiliary Building Exhaust	Kr-85 Xe-133	1.0E-6 μCi/cc 1.0E-6 μCi/cc	1.0E-4 μCi/cc 1.0E-4 μCi/cc
Annex Building Exhaust	Kr-85 Xe-133	1.0E-6 μCi/cc 1.0E-6 μCi/cc	1.0E-4 μCi/cc 1.0E-4 μCi/cc
MCR Supply Air Duct Particulate	Sr-90 Cs-137	1.0E-12 μCi/cc 1.0E-12 μCi/cc	8.0E-9 μCi/cc 6.0E-8 μCi/cc
MCR Supply Air Duct Iodine	I-131	1.0E-11 μCi/cc	2.0E-8 μCi/cc
MCR Supply Air Duct Gas	Kr-85 Xe-133	1.0E-7 μCi/cc 1.0E-7 μCi/cc	1.0E-4 μCi/cc 1.0E-4 μCi/cc
Containment Air Filtration Exhaust	Kr-85 Xe-133	1.0E-6 μCi/cc 1.0E-6 μCi/cc	1.0E-4 μCi/cc 1.0E-4 μCi/cc

Airborne Process Radiation Monitor	Isotope(s)	Detector Minimum Detectable Level	DAC Occupational Values - 10 CFR 20, Appendix B, Table 1
Health Physics and Hot Machine Shop Exhaust	Sr-90 Cs-137	1.0E-13 μCi/cc 1.0E-13 μCi/cc	8.0E-9 μCi/cc 6.0E-8 μCi/cc
Radwaste Building Exhaust	Sr-90 Cs-137	1.0E-13 μCi/cc 1.0E-13 μCi/cc	8.0E-9 μCi/cc 6.0E-8 μCi/cc
Containment Atmosphere N^{13}/F^{18}	N-13 F-18	1.0E-7 μCi/cc 1.0E-7 μCi/cc	N/A 3.0E-5 μCi/cc
Containment Atmosphere Gas	Kr-85 Xe-133	1.0E-7 μCi/cc 1.0E-7 μCi/cc	1.0E-4 μCi/cc 1.0E-4 μCi/cc

The above table shows that for each principal isotope, the minimum detectable level for each monitors detector(s) is almost two (2) to almost five (5) orders of magnitude below the corresponding 10 CFR 20 DAC occupational value.

These radiation monitors utilize two basic types of detectors, as described in Section 11.5.2.3.2. The particulate (Sr-90/Cs-137) and iodine detectors use shielded fixed filters, located in the sample stream, that are viewed by beta and gamma sensitive scintillators, respectively. The radiogas detectors use beta sensitive scintillators with their sensitive volumes directly exposed to the process or sample stream.

The response time for each fixed filter detector depends upon background radiation levels, airborne radioactivity levels, sample flow rate, and system configuration. When the detectors have achieved statistically accurate operating conditions, the detector response times are as follows:

1) Step change in radioactivity levels above the ALERT setpoint - < 4 seconds, not including sample transport time.

2) Gradually increasing radioactivity levels above the ALERT setpoint - < 2 seconds, not including sample transport time.

The step change requires a longer response time to assure that the change is not a spurious radioactivity spike. The time to achieve statistical accuracy (95% confidence level) can vary from ten minutes to one hour, depending upon radioactivity concentrations. The only time the detectors will not be operating under statistically accurate conditions will be the time following a filter change or a system shutdown for maintenance. Sample transport times are minimized by locating the detectors as close as practicable to the process sample point.

The response time for the in-line detectors is less than ten seconds. These detectors are provided with dynamic background radiation compensation.

Combining the minimum detectable levels shown in the table above with the detector response times discussed above, it has been shown that each monitor is sensitive enough to detect 10 DAC-hours.

SSAR Revision:

Those airborne radiation monitors which monitor plant areas which may be occupied by plant personnel will be capable of detecting 10 DAC-hours. The specific radiation monitors which are included in thes category are identified in Table 11.5-1.

In Table 11.5-1, "Radiation Monitor Detector Parameters", add the following:

- Add "(Note 5)" in the "Service column for:

  Containment Atmosphere Gas
  Containment Atmosphere N^{13}/F^{18}
  Fuel Handling Area Exhaust
  Auxiliary Building Exhaust
  Annex Building Exhaust
  Main Control Room Supply Air Duct (Particulate) - both entries
  MCR Supply Air Duct (Iodine) - both entries
  MCR Supply Air Duct (Gas) - both entries
  Containment Air Filtration Exhaust
  H.P. & Hot Machine Shop Exhaust
  Radwaste Building Exhaust

- In "Notes:" add:

  "5. Monitor is sensitive enough to detect 10 Derived Air Concentration (DAC)-hours."