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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: T. R. QUAY

SUBJECT: AP600 MAIN CONTROL ROOM RADIOLOGICAL CONSEQUENCE MODELING

Dear Mr. Quay:

Attached for your information and use is information for modeling the AP600 main control room for detrermining radiological consequences to control room operators in the event of a design basis accident. This information includes modeling of ingress and egress and resulting unfiltered inleakage of air into the main control room in response to a November 20, 1996 request.

Please contact John C. Butler on (412) 374-5268 if you have any questions concerning this transmittal.

B. A. McIntyre, Manager
Advanced Plant Safety and Licensing

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cc: T. Kenyon, NRC (w/o Attachments)
B. Huffman, NRC
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Attachment 1to NSD-NRC-96-4905
AP600 Main Control Room Dose Modeling

This document identifies the approaches and assumptions that are being used for calculating the doses to the operators due to their presence in the Main Control Room (MCR) following a postulated design basis accident.

Two separate operating modes are considered. The first is the expected mode in which the normal MCR ventilation system (VBS), which is not a safety-related system, continues to operate but switches to the mode in which the supplemental air filtration equipment is brought into service. In this mode the MCR is pressurized by filtered air and a portion of the recirculating air is also filtered. The second operating mode is the one in which the VBS is not operable or in which the VBS is not capable of preventing the iodine activity levels in the MCR from reaching the high-high radiation setpoint. In this case the MCR is isolated and the MCR emergency habitability system (VES) is actuated; the MCR is then pressurized by air from the safety-related compressed air storage and there is no recirculation cleanup.

General Assumptions Applying to Both Cases

- Although it is anticipated that the operators would observe an eight hour shift schedule, the occupancy of the control room is conservatively based on a twelve hour shift duration (present in the MCR every other shift) to address the potential for an individual to spend extended periods of time in the control room.

  For the first part of the accident, operator occupancy is modeled discretely (e.g., 1.0 for 0 to 12 hours and 0.0 for 12 to 24 hours). After the initial part of the accident when there is little additional activity being released to the environment, the operator occupancy can be modeled by averaging (e.g., for time past 36 hours the occupancy could be 0.5 reflecting the operator being present for 12 out of 24 hours.

- The calculation of operator doses only includes the dose incurred while in the MCR (not while approaching or departing the MCR).

- The normal VBS inflow rate is 1750 cfm. This is adjusted upward by 10% (for an analysis value of 1925 cfm) to address uncertainties in flow control setpoints and measurements. This unfiltered inflow is assumed to continue until the emergency mode of operation is entered into.

- The MCR volume is 35,700 cubic feet.

- The volume of the TSC (Technical Support Center) is 69,800 cubic feet.

VBS Operable

- Only one of the two supplemental filtration trains is assumed to be in operation. [If there were two trains in operation, there would be additional inflow of pressurization air - and of activity - but the higher level of recirculation cleanup would more than compensate for the increase in the amount of activity entering the control room.]

- It is assumed that activity released due to the accident reaches the radiation monitor instantaneously at a level sufficient to trigger the high radiation alarm and actuation of the supplemental filtration train. The time delay to fully enter the supplemental filtration mode is assumed to be 30 seconds.

- Both the MCR and the TSC are maintained in service.
- During supplemental air filtration mode, the filtered inflow is 860 cfm.
- The filtered recirculation flow through the supplemental air filtration train is 2740 cfm. This value reflects the design flow rate of 4000 cfm, reduced by 10% to account for uncertainties in flow control setpoints and measurements and reduced by the pressurization air flow of 860 cfm.
- The filter efficiencies for the supplemental air filtration train are 99% for particulates and 90% for elemental and organic iodine. These filter efficiencies are consistent with the guidance of Reference 1 for a HEPA filter and for a 4-inch deep charcoal filter which are provided in the VBS supplemental air filtration units.
- The unfiltered inleakage rate is 140 cfm.

<u>VES In Operation</u>

- It is assumed that the VBS is operating at the beginning of the accident and continues to operate in its normal mode despite a high radiation signal that demands actuation of the supplementary filtration train. In this situation, a high volume of unfiltered air will continue to be drawn into the MCR (and the TSC) which will rapidly raise the activity level inside the MCR. After a high-high radiation setpoint is reached for particulates or iodines, the MCR is isolated and the VES is actuated.
- The high-high radiation setpoint is 2.0E-6 Ci/m^3 D.E. I-131. After this limit is reached, it takes another 30 seconds to isolate the MCR and actuate the VES.
- With actuation of the VES, the MCR is isolated and the TSC is not supplied with makeup air.
- Only one train of VES operates. [If both trains operate, there would be additional dilution of the control room atmosphere and a resulting reduction in the doses to the operators.]
- The operating train of VES has a minimum flow rate of 23 scfm to pressurize the MCR (based on a design basis flow rate of 25$\pm$2 scfm).
- After actuation of the VES, the unfiltered inleakage is limited to the air coming in due to ingress/egress. For the design basis LOCA with core melt, this is modeled as 2.5 cfm during the first 12 hours and 5.0 cfm after 12 hours into the accident since, with the high level of radioactivity assumed to be in the environment, access to the MCR would be restricted during the early part of the accident. (The basis for these inleakage rates is discussed in Attachment 2.) For accidents other than the LOCA with core melt, the 5.0 cfm inleakage rate should be assumed from the initiation of VES operation based on the assumption that the activity release would not warrant restriction in MCR access.

- For accidents of short duration (e.g., the fuel handling accident has an assumed two hour activity release and the main steam line break accident has a nominal duration of eight hours), it is assumed that the VES is kept in operation beyond the duration of the accident. This addresses the issue of activity being retained in the control room beyond the identified end of accident.

References

1. Regulatory Guide 1.140, "Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants"

Attachment 2 to NSD-NRC-96-4905

Basis for MCR Infiltration Rate During VES Operation

The Murphy - Campe paper (Reference 1) specifies an ingress/egress inleakage of 10 cfm for a design lacking a vestibule and then goes on to say that, with a vestibule, the inleakage would be reduced or eliminated. The AP600 has a vestibule entrance and the inleakage associated with ingress/egress is assumed to be 5 cfm, half the value associated with a design with no vestibule. Reference 1 does not specify any limit on ingress/egress associated with the specified inleakage value and it is assumed that there is "unrestricted" access to the MCR. "Unrestricted" access needs to be further defined since, otherwise, there is the image of the door being continuously open. With a vestibule volume of 365 cubic feet, a limiting approach is to assume that the total inventory in the vestibule enters the MCR each time the MCR is accessed - but this is excessively conservative - a 5 cfm inleakage rate translates to 10 ingress/egress operations over the 12 hour shift. This level of MCR access can not be called "unrestricted". For the AP600 application "unrestricted" access is taken as being one ingress or egress every 30 minutes - this would be 24 openings of the MCR door over the 12 hour shift. With 24 ingress/egress operations resulting in an averaged 5 cfm inleakage to the MCR, the inleakage associated with one ingress/egress operation would be 150 cubic feet (41 percent of the vestibule volume). This is a reasonably conservative value for the volume of air that might enter the MCR. Note that the number of personnel passing into or out of the MCR during any ingress/egress operation is variable. There would be a minimum of one to a reasonable maximum of six to eight (the vestibule can accommodate more than eight but it is not reasonable to assume that more would be sharing the same ingress/egress). If only one or two people pass through the door, there would be a smaller air transfer and, if there are six to eight people, it would be expected that more than half of the air in the vestibule might exchange with the air in the MCR. On the average, the assumption of 150 cubic feet per ingress/egress operation is appropriate.

It is desirable to decrease the amount of inleakage to the MCR if the activity level in the environment is high as it would be for the early part of the postulated Loss-of-Coolant Accident (LOCA) with core melt. The model for specifying the amount of air leaking into the MCR for is based on administratively limiting the number of ingress/egress operations for the first 12 hours of the LOCA such that the inleakage is reduced by a factor of two to 2.5 cfm. After the first 12 hours, the restrictions on MCR access could be relaxed and the 5 cfm inleakage would apply.

During the time that MCR access is administratively controlled, the number of people involved in each I/E operation would tend to be greater and this would increase the air transfer into the MCR for each ingress/egress operation. Thus, for the early stages of the accident it is assumed that, instead of 150 cubic feet per ingress/egress (41% of the vestibule volume), a value of 200 cubic feet (55% of vestibule volume) per ingress/egress is used. With a target of 2.5 cfm, this is equivalent to nine ingress/egress operations over the twelve hour shift.

Reference 1: Nuclear Power Plant Control Room Ventilation System Design for Meeting General Design Criterion 19, K. G. Murphy & Dr. K. M. Campe, 13th AEC Air Cleaning Conference