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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 388 Related to ESBWR Design Certification Application – Control Room Habitability – RAI Numbers 9.4-29 S04 and 9.4-57**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Requests for Additional Information (RAIs) 9.4-29 S04 and 9.4-57 sent by NRC Letter No. 388, Reference 1.

GEH responses to RAIs 9.4-29 S04 and 9.4-57 are addressed in Enclosure 1. Enclosure 2 contains the DCD markups associated with these responses.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. MFN 09-689, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 388 Related to ESBWR Design Certification Application*, November 2, 2009

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 388 Related to ESBWR Design Certification Application – Control Room Habitability – RAI Numbers 9.4-29 S04 and 9.4-57
2. Response to Portion of NRC Request for Additional Information Letter No. 388 Related to ESBWR Design Certification Application – Control Room Habitability – RAI Numbers 9.4-29 S04 and 9.4-57 – DCD Markups

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	eDRF Section	0000-0110-3589

Enclosure 1

MFN 09-767

Response to Portion of NRC Request for Additional Information Letter No. 388 Related to ESBWR Design Certification Application

Control Room Habitability

RAI Numbers 9.4-29 S04 and 9.4-57

NRC RAI 9.4-29 S04

In DCD Revision 6 GEH added the following statement in section 6.4.2 and Section 9.4.1.1 System Design basis:

> *"The EFU delivery and discharge system is optimized to ensure that there is adequate fresh air delivered and mixed in the CRHA. This is accomplished by using multiple supply registers, which distribute the incoming supply air with the Control Room air volume, and a remote exhaust to prevent any short cycling. The EFU operation results in turning over the Control Room volume approximately 7-9 times per day. This diffusion design (mixing and displacement) in conjunction with the known convective air currents (due to heat loads/sinks) and personnel movement ensures that occupied zone temperature is within acceptable limits, buildup of contaminants (e.g., CO2) minimal, and a freshness of air is maintained."*

1. *This paragraph has the term "occupied zone." Based on the response to RAI 9.4-29 S03 and previous responses to this RAI, NRC staff understands the CRHA "occupied zone" to be a subset of the CRHA, specifically the MCR area from the top of the raised floor to an elevation of two meters. GEH stated that this would be the region where operators are expected to be stationed during accident conditions. In addition GEH provided additional EFU delivery and discharge design information in the response to RAI 9.4-29 S02, where GEH stated that the EFU does not supply air to the bathroom, kitchen, shift supervisors office and other areas not continuously occupied during emergency conditions.*

   The staff considered this design information when evaluating the suitability of the control building ventilation system (CBVS) to maintain a habitable environment during design basis accidents. In order to provide that, when built, the EFU delivery and discharge system will be correctly optimized to preferentially deliver air to those areas of the CRHA that are expected to be occupied, in Tier 2 Sections 6.4 and 9.4.1, include a definition of the term "CRHA occupied zone" in respect to what areas of the of the CRHA will be preferentially delivered forced air by the EFU delivery and discharge system. In addition, in Tier 2 Chapters 6.4 and 9.4.1, specify those areas of the CRHA that the EFU delivery and distribution system is not designed to serviced with forced air.

2. *The above statement added to Revision 6 also discusses the design concern of "short cycling," i.e. a condition where fresh air entering the CRHA stratifies to a degree that it does not provide the anticipated breathing quality air to the CRHA occupied zone, or bypasses the CRHA occupied zone to the remote exhaust. In response to RAI 9.4-29, GEH added a controlled leakage path to the CRHA air outlet connections as a means of assuring that the design EFU flow rate of 466 cfm will be supplied. In subsequent responses to this RAI GEH provided a GOTHIC heat up analysis which demonstrated the potential for convective*

currents and air flow, and further justified the placement of the controlled leakage device below the CRHA occupied zone. The above DCD statement implies that the placement of the controlled leakage device is the sole means to address the concern of the adverse effects of thermal stratification and short cycling in the ESBWR CRHA design. Since GEH uses a simple single node analysis (using the CONTAIN code), which assumes a uniformly mixed CRHA, yet bases its argument on adequate air quality on a non-uniformly mixed CRHA, the ESBWR design basis heat up analysis does not model this concern, and subsequent ITAAC to update this model with as-built information would not be able to detect those CRHA design changes that cause adverse consequences for short cycling of supply air.

Therefore staff requires that more specific discussion of the potential of short cycling, and the EFU delivery and discharge system, control building (CB) and CBVS design features designed to mitigate this phenomenon is required in the DCD. Such information could include the following:

a. *Add Enclosure 1 of MFN 09-380 "Figure 9.4-29 S3-2, Control Room Habitability Areas Airflows Emergency Operation" or similar illustrative drawing of the design intent of airflows in the CRHA, to Tier 2 of the DCD. Illustrative drawings, which describe how mixing occurs, should be added to the DCD to capture the insights obtained from the GOTHIC analyses.*

b. *Describe requirements for emergency actions (i.e., when the EFU is providing ventilation to the CHRA) to promote convective currents and improve CRHA air quality, such as identifying specific doors to be shut in the CRHA.*

c. *Provide more specific discussion of any other design features or actions that will assure that the CRHA will be optimized to prevent short cycling and promote the development of convective air flows in the CRHA.*

GEH Response

Question/Comment:

In DCD Revision 6 GEH added the following statement in section 6.4.2 and Section 9.4.1.1 System Design basis:

> *"The EFU delivery and discharge system is optimized to ensure that there is adequate fresh air delivered and mixed in the CRHA. This is accomplished by using multiple supply registers, which distribute the incoming supply air with the Control Room air volume, and a remote exhaust to prevent any short cycling. The EFU operation results in turning over the Control Room volume approximately 7-9 times per day. This diffusion design (mixing and displacement) in conjunction with the*

known convective air currents (due to heat loads/sinks) and personnel movement ensures that occupied zone temperature is within acceptable limits, buildup of contaminants (e.g., CO2) minimal, and a freshness of air is maintained."

1. *This paragraph has the term "occupied zone." Based on the response to RAI 9.4-29 S03 and previous responses to this RAI, NRC staff understands the CRHA "occupied zone" to be a subset of the CRHA, specifically the MCR area from the top of the raised floor to an elevation of two meters. GEH stated that this would be the region where operators are expected to be stationed during accident conditions. In addition GEH provided additional EFU delivery and discharge design information in the response to RAI 9.4-29 S02, where GEH stated that the EFU does not supply air to the bathroom, kitchen, shift supervisors office and other areas not continuously occupied during emergency conditions.*

   The staff considered this design information when evaluating the suitability of the control building ventilation system (CBVS) to maintain a habitable environment during design basis accidents. In order to provide that, when built, the EFU delivery and discharge system will be correctly optimized to preferentially deliver air to those areas of the CRHA that are expected to be occupied, in Tier 2 Sections 6.4 and 9.4.1, include a definition of the term "CRHA occupied zone" in respect to what areas of the of the CRHA will be preferentially delivered forced air by the EFU delivery and discharge system. In addition, in Tier 2 Chapters 6.4 and 9.4.1, specify those areas of the CRHA that the EFU delivery and distribution system is not designed to serviced with forced air.

Response:

The term CRHA "occupied zone" will be defined in DCD Tier 2 Subsection 6.4.2 as shown in the attached markup. DCD Tier 2 Subsection 6.4.2 is also updated to state, "The EFU delivered supply air is distributed in the MCR area of the CRHA." It should be noted that the whole CRHA remains habitable throughout an event as discussed in the GEH response to RAI 9.4-29 S03 (Letter MFN 09-380, June 12, 2009).

Question/Comment:

2. *The above statement added to Revision 6 also discusses the design concern of "short cycling," i.e. a condition where fresh air entering the CRHA stratifies to a degree that it does not provide the anticipated breathing quality air to the CRHA occupied zone, or bypasses the CRHA occupied zone to the remote exhaust. In response to RAI 9.4-29, GEH added a controlled leakage path to the CRHA air outlet connections as a means of assuring that the design EFU flow rate of 466 cfm will be supplied. In subsequent responses to this RAI GEH provided a GOTHIC heat up analysis which demonstrated the potential for convective*

currents and air flow, and further justified the placement of the controlled leakage device below the CRHA occupied zone. The above DCD statement implies that the placement of the controlled leakage device is the sole means to address the concern of the adverse effects of thermal stratification and short cycling in the ESBWR CRHA design. Since GEH uses a simple single node analysis (using the CONTAIN code), which assumes a uniformly mixed CRHA, yet bases its argument on adequate air quality on a non-uniformly mixed CRHA, the ESBWR design basis heat up analysis does not model this concern, and subsequent ITAAC to update this model with as-built information would not be able to detect those CRHA design changes that cause adverse consequences for short cycling of supply air.

Therefore staff requires that more specific discussion of the potential of short cycling, and the EFU delivery and discharge system, control building (CB) and CBVS design features designed to mitigate this phenomenon is required in the DCD. Such information could include the following:

a. Add Enclosure 1 of MFN 09-380 "Figure 9.4-29 S3-2, Control Room Habitability Areas Airflows Emergency Operation" or similar illustrative drawing of the design intent of airflows in the CRHA, to Tier 2 of the DCD. Illustrative drawings, which describe how mixing occurs, should be added to the DCD to capture the insights obtained from the GOTHIC analyses.

Response:

DCD Tier 2, Subsection 6.4.4, Emergency Mode, will be updated to include the RAI 9.4-29 S03 (Letter MFN 09-380, June 12, 2009) airflow and mixing discussion; and the CRHA Airflows Emergency Operation basic drawing will be added as a new figure to DCD Tier 2, Section 6.4.

Question/Comment:

b. Describe requirements for emergency actions (i.e., when the EFU is providing ventilation to the CHRA) to promote convective currents and improve CRHA air quality, such as identifying specific doors to be shut in the CRHA.

Response:

There are no emergency actions to promote any mixing or improve CRHA air quality during an accident. The automatic actions of isolating the CRHA and starting the EFU will ensure that the CRHA is habitable. The heat sources and heat sink assumptions will be designed into the CRHA to ensure the passive heat sink is maintained. DCD Tier 2 Subsection 6.4-1-A specifies that the COL Applicant will verify that procedures and training for control room habitability address applicable aspects of NRC Generic

Letter 2003-01 which requires confirmation that the facility's control room meets the applicable habitability regulatory requirements (e.g., GDC 1, 3, 4, 5, and 19) and that the CR Habitability Systems are designed, constructed, configured, operated, and maintained in accordance with the facility's design and licensing bases.

Question/Comment:

c. *Provide more specific discussion of any other design features or actions that will assure that the CRHA will be optimized to prevent short cycling and promote the development of convective air flows in the CRHA.*

Response:

A discussion of how the CRHA heat is dissipated during an Emergency event will be added to DCD Tier 2, Subsection 6.4.4, System Operation Procedures, Emergency Mode. This DCD description is similar to that discussed in the GEH response to RAI 9.4-29 S03 (Letter MFN 09-380, June 12, 2009). DCD Tier 2, Subsection 6.4.2 will be updated to include a discussion on "short cycling".

DCD Impact

The following DCD changes, as indicated within boxes on markup pages in Enclosure 2, will be made in response to this RAI:

DCD Tier 2, Subsection 6.4.2 will be updated as attached to include a definition/ discussion of "Occupied Zone" and "Short Cycling".

DCD Tier 2, Subsection 6.4.4, System Operation Procedures, Emergency Mode will be updated to include a discussion on airflows during Emergency Mode.

New Figure 6.4-2, "Control Room Habitability Area Airflows Emergency Operation – FOR ILLUSTRATIVE PURPOSES ONLY" will be added to DCD Tier 2, Section 6.4.

DD Tier 2, Subsection 9.4.1.1, Design Bases, will be updated to make reference to changes in DCD Tier 2, Subsection 6.4, as stated above.

NRC RAI 9.4-57

In DCD sections 9.4.1, 9.4.6 and 6.4, GEH describes design features of the passive heat sinks that provide assurance that the equipment zone temperatures will remain below the design basis limits that are established for equipment qualification and habitability. In Tier 1, GEH includes ITAAC that must be performed using as-built information to verify that critical design information such as heat sink thermo-physical properties and geometry confirms the analysis results.

1. *What controls will be in place to ensure that these critical assumptions and parameters will be maintained throughout the life of the plant? The application of passive heat sinks to a normally occupied area is currently a unique application. In occupied spaces, actions normally considered of no consequence to design basis assumptions, such as hanging pictures on walls, installing rugs, painting walls etc., may have adverse consequences on the ESBWR control room passive heat sink design. Similar considerations are applicable to the reactor building. The staff considers this issue as something that should be specifically addressed in the certification information.*

2. *In regard to the CRHA heat up analysis, a significant percentage of the heat load is due to people. Although, DCD Tier 2, Table 9.4-1 indicates that breathing air is adequate for up to 11 persons, the DCD does not discuss how MCR occupancy would be monitored and limited during accident events in order to maintain this design basis parameter. Conditions during accidents such as shift turnover or need for the presence of supplementary personnel could cause assumptions regarding CRHA heat load and fresh air adequacy to be inadvertently invalidated. Identify where you address this concern in the DCD or add additional description of the controls as appropriate.*

GEH Response

Question/Comment:

In DCD sections 9.4.1, 9.4.6 and 6.4, GEH describes design features of the passive heat sinks that provide assurance that the equipment zone temperatures will remain below the design basis limits that are established for equipment qualification and habitability. In Tier 1, GEH includes ITAAC that must be performed using as-built information to verify that critical design information such as heat sink thermo-physical properties and geometry confirms the analysis results.

1. *What controls will be in place to ensure that these critical assumptions and parameters will be maintained throughout the life of the plant? The application of passive heat sinks to a normally occupied area is currently a unique application. In occupied spaces, actions normally considered of no consequence to design*

basis assumptions, such as hanging pictures on walls, installing rugs, painting walls etc., may have adverse consequences on the ESBWR control room passive heat sink design. Similar considerations are applicable to the reactor building. The staff considers this issue as something that should be specifically addressed in the certification information.

Response:

DCD Tier 2, Section 17.4, Reliability Assurance Program During Design Phase, presents the ESBWR Design Reliability Assurance Program (D-RAP) which ensures relevant aspects of plant operation, maintenance, and performance monitoring of important Structures, Systems, and Components for owner/operator consideration for assuring safety of the equipment and risk to the public is maintained through design change control. Specifying CRHA design input assumptions and parameters in DCD Tier 2 ensures that critical assumptions and parameters are maintained throughout the life of the plant. These assumptions will be incorporated into the plant design change process by the COL Applicant for the life of the plant. DCD Tier 2, Subsection 6.4-1-A specifies that the COL Applicant will verify procedures and training for control room habitability address applicable aspects of NRC Generic Letter 2003-01 which requires confirmation that the facility's control room meets the applicable habitability regulatory requirements (e.g., GDC 1, 3, 4, 5, and 19) and that the CR Habitability Systems are designed, constructed, configured, operated, and maintained in accordance with the facility's design and licensing bases.

GEH will update DCD Tier 2, Section 6.4 as described below.

Question/Comment:

2. *In regard to the CRHA heat up analysis, a significant percentage of the heat load is due to people. Although, DCD Tier 2, Table 9.4-1 indicates that breathing air is adequate for up to 11 persons, the DCD does not discuss how MCR occupancy would be monitored and limited during accident events in order to maintain this design basis parameter. Conditions during accidents such as shift turnover or need for the presence of supplementary personnel could cause assumptions regarding CRHA heat load and fresh air adequacy to be inadvertently invalidated. Identify where you address this concern in the DCD or add additional description of the controls as appropriate.*

Response:

The CRHA procedures will be developed under DCD Tier 2 COL Item 6.4-1-A which specifies that the COL Applicant will verify procedures and training for control room habitability address applicable aspects of NRC Generic Letter 2003-01 which requires confirmation that the facility's control room meets the applicable habitability regulatory requirements (e.g., GDC 1, 3, 4, 5, and 19) and that the CR Habitability Systems are designed, constructed, configured, operated, and maintained in accordance with the facility's design and licensing bases.

DCD Impact

The following DCD changes, as indicated within boxes on markup pages in Enclosure 2, will be made in response to this RAI:

DCD Tier 2, Section 6.4.5 will be updated to add a statement regarding the critical design input heat sink mechanisms located in DCD Tier 2, Table 3H-14.

DCD Tier 2, Section 6.4.7 will be updated to specify critical key assumptions.

Enclosure 2

MFN 09-767

Response to Portion of NRC Request for Additional Information Letter No. 388 Related to ESBWR Design Certification Application

Control Room Habitability

RAI Numbers 9.4-29 S04 and 9.4-57

DCD Markups

The EFU delivery and a variable orifice relief device discharge system is optimized to ensure that there is adequate fresh air delivered and mixed in the CRHA. This is accomplished by using multiple supply registers, which distribute the incoming supply air with the control room air volume, and a remote exhaust to prevent any short cycling. The EFU delivered supply air is distributed in the MCR area of the CRHA. The EFU operation results in turning over the CR volume approximately seven to nine times per day. This diffusion design (mixing and displacement) in conjunction with the known convective air currents (due to heat loads/sinks) and personnel movement ensures that occupied zone temperature is within acceptable limits, buildup of contaminants (e.g., CO_2) is minimal and a freshness of air is maintained.

The occupied zone of the MCR region is normally occupied by personnel, and is generally considered to be between the raised floor and 2 m (6.6 ft) above the floor. Short Cycling refers to the design condition where the outside air transits the served space and exhausts to the outside without mixing. This occurs when the outside air inlet and room exhaust are in close proximity. The CRHA has the fresh air supplied at a high elevation and the exhaust removed low, below the floor, so they are not in close proximity to each other.

6.4.3 Control Room Habitability Area

The CRHA boundary is located on elevation –2000 mm in the Control Building. The layout of the CRHA, which includes the MCR, is shown on Figure 3H-1, Control Room Habitability Area. The CRHA envelope includes the following areas:

- Admin Area (Room 3270)
- RE/Shift Technical Advisor Office (Room 3271)
- Shift Supervisor Office (Room 3272)
- Kitchen (Room 3273)
- Main Control Room (Room 3275)
- Restroom A (Room 3201)
- Restroom B (Room 3202)
- Main Control Room Storage Room (Room 3204)
- Electrical Panel Board Room (Room 3205)
- Gallery (Room 3206)
- Auxiliary Equipment Operators (AEOs) Workshop (Room 3207)
- Air Handling Unit (AHU) Room (Room 3208)

These areas constitute the operation control area, which can be isolated and remain habitable for the duration of a DBA if high radiation conditions exist. Potential sources of danger such as steam lines, pressurized piping, pressure vessels, CO_2 fire fighting containers, etc. are located outside of the CRHA.

least 31 Pa (⅛ inch w.g.) positive differential pressure with respect to the adjacent areas. Excess air is exhausted from the CRHA via the variable orifice relief device. This device is a locked in place orifice or valve set up to maintain CRHA pressure at the delivered flow. The EFU system air flow rate is also sufficient to supply the fresh air requirement of 10.5 l/s (22 cfm) per person for up to 21 occupants (Reference 6.4-4).

Airflow in Emergency Mode:

The mixing of the EFU supplied inlet air with the general CRHA air is performed via the following mechanisms:

1. Supply / Inlet registers mixing - The mixing is continuous as EFU provided outside air is delivered to the CRHA. For each cfm delivered it generates mixing with the CR air as it exits the supply registers. This is the most common type of space air diffusion called a Mixing System. The supply air jet is delivered by the air inlet registers, which create an air jet that then mixes the outside air with the room air by entrainment (induction), which helps to reduce the jet velocity and equalize the supply air temperature as it enters the CRHA.
2. Displacement (Ventilation) Supply / Exhaust - As air is supplied to the CRHA, an amount is similarly exhausted from the space. This exhaust air is designed to be at a remote location to ensure no short cycling and a properly scavenged control room.
3. Equipment and Personnel Convective Plumes due to air differential temperature / density – The higher temperature of the air surrounding operating equipment and personnel, generates convective air plumes which rise out of the occupied zone, along with any pollutants (body odors, etc.). The rising air is replaced by cooler air from below.
4. Personnel Movement – It is assumed that a certain activity level by the CRHA occupants which derived the airflow requirements. This activity generates mixing of the CRHA air.
5. Molecular Dispersion - For Contaminants, CO_2 and others, the movement of CO_2 and other molecules across a space is via molecular dispersion.

The airflow developed in the ESBWR control room during worst case (outside air temp of 117ºF) accident conditions when the CRHA is isolated and the EFU is in operation with passive cooling is as follows and is illustrated in Figure 6.4-2.

The EFU is operating providing 466 cfm clean outside airflow into the CRHA. This is delivered to the occupied MCR area, primarily since this area has the personnel on duty and houses the active electronic equipment. This supply air exits the ductwork at supply air diffusers (4), which perform mixing, mechanism 1) above. Depending upon the delivered air temperature, the combined mixed volume either rises or drops. At the worst case outside air condition of 117ºF, modeling shows this air mixture rises above the ceiling with a larger quantity of MCR heated air; the balance driven primarily by the equipment and personnel convective plumes, mechanism 3) above. The combined, rising air above the ceiling tiles draws the same quantity of air into the MCR space from the area below the raised floor volume, mechanism 2). This cooler, slow moving air slowly spreads over the raised floor and displaces the warmer, stale air toward the ceiling, where it leaves the room. The MCR with the high ceiling becomes thermally stratified, i.e., warmer stale air is concentrated above the occupied zone and cool, fresher air is concentrated in the occupied zone. When the cool air encounters a heat source, such as a person or heat generating equipment, the air heats up and buoyantly rises out of the occupied zone.

The hot air that collects above the suspended ceiling, with CO_2 and body generated odors, spills over into the adjacent rooms due to the air density difference due to differential temperature where heat is released to the cooler walls and concrete. Cooler lower temperature air in these adjacent rooms drops to the raised floor level where air continues to drop thru to the common space below the floor. Discharge flow of 466 cfm of this air, exits the main control room at a remotely opposite location from EFU supply to prevent any short cycle of the supply air and ensure a constant turnover of the CRHA air. This air then is drawn into the MCR and a circuit is complete.

A positive pressure is maintained in the CRHA. There is no buildup of any CO_2 in any of these areas since the areas are scavenged continuously by the EFU supply with exhaust airflow of 466 cfm. The exhaust is remote to the supply at one of the adjacent rooms lower common area.

With a source of AC power available, the EFU can operate and is controlled indefinitely through Q-DCIS. In the event that normal AC power is not available, the safety-related battery power supply is sized to provide the required power to the operating EFU fan for 72 hours of operation. For longer-term operation, from post 72 hrs, each EFU fan is powered via an electrical bus supplied by one (1) of two (2) ancillary diesel generators. The temperature and humidity in the CRHA pressure boundary following a loss of the normal portion of the CRHAVS remain within the limits for reliable human performance (References 6.4-1 and 6.4-2) over a 72-hour period. The CRHA isolation dampers fail closed on a loss of normal AC power or instrument air.

Backup power to the safety-related Control Room EFU fans (post 72 hours) if normal AC power is not available is provided by two (2) ancillary diesel generators. These generators are required to support operation of the Control Room EFU beyond 72 hours after an accident. For a period between 7 days and the duration of the design basis accident, the safety-related function of the EFU can be powered from either offsite power, onsite diesel generator powered Plant Investment Protection (PIP) bus, or by continued use of the ancillary diesel generators. The requirements for the ancillary generators are described in Appendix 19A.

Upon a loss of normal AC power, the initial ranges of temperature/relative humidity in the CRHA are 21.1-23.3°C (70-74°F) and 25%-60% RH. The CRHA temperature / humidity values calculated during the 72 hours following a design basis accident equate to less than 30°C (86°F) wet bulb globe temperature and psychrometric wet bulb temperature. The 30°C (86°F) value is the recommended threshold limit for instituting hot weather practices and the recommended upper limit appropriate for assessing heat stress and predicting heat strain for moderate levels of work respectively. The pyschrometric wet bulb temperature is an appropriate index for assessing heat stress and predicting heat strain under conditions where radiant temperatures and air velocity are not large factors and where increased humidity exists. National Institute for Occupational Safety and Health (NIOSH) 86-113 provides a wet bulb temperature limit of about 30°C (86°F) for unimpaired performance on sedentary tasks (moderate levels of physical work) for normally clothed individuals at low airflows (Reference 6.4-5). During the first two hours of loss of normal AC power, most of the equipment in the MCR remains powered by the nonsafety-related battery supply. Anytime during a loss of normal AC power, once either ancillary diesel is available, the environmental conditions are maintained indefinitely. This is accomplished via the continued operation of a CRHA recirculation AHU and auxiliary cooling unit supplied with each recirculation AHU. Power is provided during the initial two hours from the same nonsafety-related battery supply that powers the non-safety MCR equipment. At any discussed in Subsection 9.4.1. The exhaust stacks of the onsite standby power diesel generators and ancillary diesel generators are located in excess of 48 m (157 ft) away from the fresh air intakes of the main control room. The onsite standby power system fuel oil storage tanks and ancillary diesel generators are located in excess of 55 m (180 ft) feet from the main control room fresh air intakes. These separation distances reduce the possibility that combustion fumes or smoke from an oil fire would be drawn into the main control room.

Typical sources of onsite chemicals are listed in Table 6.4-2, and their locations are shown on Figure 1.1-1. Analysis of these sources is in accordance with RG 1.78 and the methodology in NUREG-0570, "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release" is to be performed on a site-specific basis (Subsection 6.4.9).

During emergency operation, the CRHA emergency habitability system passive heat sink is designed to limit the temperature inside the CRHA to 33.9°C (93°F). This maintains the CRHA within the limits for reliable human performance (References 6.4-1 and 6.4-2) over 72 hours. The walls and ceiling that act as the passive heat sink contain sufficient thermal mass to accommodate the heat sources from equipment, personnel, and lighting for 72 hours. The input parameters assumed in the Control Building Heatup Analyses are listed in Table 3H-14. The EFU portion of the CRHAVS provides a minimum 220 l/s (466 cfm) of ventilation air to the main control room and is sufficient to pressurize the control room to at least a positive 31 Pa (⅛ inch w.g.) differential pressure with respect to the adjacent areas. This flowrate also supplies the recommended fresh air supply of 10.5 l/s (22 cfm) per person for a maximum occupancy of 21 persons (Reference 6.4-4).

The normal and emergency (EFU) filter unit outside air intake flows are adjusted as required to maintain a minimum flow and, in conjunction with a controlled leak path, maintain a 31 Pa (⅛ inch w.g.) minimum positive pressure in the CRHA relative to adjacent areas. Flow instrumentation is provided for the fans and AHUs to ensure airflow is maintained above the minimum required flow. A low airflow alarm is provided. CRHAVS differential pressure transmitters are provided to monitor CRHA pressure with respect to adjacent areas and ensure the pressure is maintained above the minimum positive pressure. A low CRHA differential pressure alarm is provided. A variable leakage device, located under the raised floor to facilitate air circulation and mixing, is provided with sufficient adjustment to maintain the required airflow and CRHA positive pressure relative to adjacent areas under all normal and emergency conditions requiring operation of the CRHA AHU or EFU. Periodic monitoring of the CRHA air intake flows and positive CRHA differential pressure is performed during operation of the CRHA AHU or EFU. Automatic isolation of the normal air intake and transfer of outside air supply to the EFU is initiated by either the following conditions:

- High radioactivity in CRHA normal air supply duct, or
- Extended Loss of Normal AC power.

The airborne fission product source term in the reactor containment following the postulated LOCA is assumed to leak from the containment. The concentration of radioactivity is evaluated as a function of the fission product decay constants, the containment leak rate, and the meteorological conditions assumed. The assessment of the amount of radioactivity within the CRHA takes into consideration the radiological decay of fission products and the infiltration/exfiltration rates to and from the CRHA pressure boundary. Specific radiological protection assumptions used in the generation of post-LOCA radiation source terms are described fully in Chapter 15.

Smoke protection is discussed in Subsection 9.4.1 and evaluated in Subsection 9.5.1. The use of noncombustible construction and heat and flame-resistant materials wherever possible throughout the plant minimizes the likelihood of fire and consequential fouling of the control room atmosphere with smoke or noxious vapor. In the smoke removal mode, a dedicated fan, intake, and exhaust path are utilized to purge the control room with a high volume of outside airflow.

A high radiation condition causes automatic changeover to the operating modes described in Subsection 6.4.4, Subsection 7.3.4.2, and in Subsection 9.4.1.2. The EFUs automatically start during a radiological event, independent of the loss of normal AC power. Through the use of redundant EFU components and dampers, one EFU and supply path to the CRHA would be available during a loss of normal AC power with failure of up to two divisions of safety-related power to provide CRHA breathing air and pressurization during a loss of AC concurrent with a radiological event. Local, audible alarms warn the operators to shut the self-closing doors, if for some reason they are open.

The EFUs are designed in accordance with Seismic Category I requirements. The failure of components (and supporting structures) of any system, equipment or structure, which is not Seismic Category I, does not result in loss of a required function of the EFUs.

Potential site-specific toxic or hazardous materials that may affect control room habitability will be identified by the COL Applicant. The COL Applicant will identify potential site specific toxic or hazardous materials that may affect control room habitability in order to meet the requirements of TMI Action Plan III.D.3.4 and GDC 19. The COL Applicant will determine the protective measures to be instituted to ensure adequate protection for control room operators as recommended under RG 1.78. These protective measures include features to (1) provide capability to detect releases of toxic or hazardous materials, (2) isolate the control room if there is a release, (3) make the control room sufficiently leak tight, and (4) provide equipment and procedures for ensuring the use of breathing apparatus by the control room operators (COL 6.4-2-A).

6.4.6 Life Support

In addition to the supply of vital air, food, water and sanitary facilities are provided.

6.4.7 Testing and Inspection

A program of preoperational and post-operational testing requirements is implemented to confirm initial and continued system capability. The CRHAVS is tested and inspected at appropriate intervals consistent with plant technical specifications. Emphasis is placed on tests and inspections of the safety-related portions of the habitability systems. Design changes to the CRHA will ensure key design assumptions are met such as:

- Heat sink / Heat source assumptions
- Air flow assumptions
- Heat transfer values

This will ensure that CRHA calculations and methodologies are maintained and updated throughout the life of the plant.

Preoperational Inspection and Testing

Preoperational testing of the CRHAVS is performed to verify that the minimum air flow rate of 220 l/s (466 cfm) is sufficient to maintain pressurization of the main control room envelope of at least 31 Pa (⅛ inch w.g.) with respect to the adjacent areas. The variable orifice relief device is set during this evolution to ensure an equal amount of air is exhausted from the CRHA. The positive pressure within the main control room is confirmed via the differential pressure transmitters within the control room. The installed flow meters are utilized to verify the system flow rates. The pressurization of the control room limits the ingress of radioactivity to maintain operator dose below regulatory limits. Air quality within the CRHA environment is confirmed to be within the guidelines of American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 62 requirements for continued occupancy via meeting the fresh air supply requirement of 10.5 l/s (22 cfm) per person for the type of occupancy expected in the CRHA. The capacity of the safety-related battery is verified to ensure it can power an EFU fan for a minimum of 72 hours. Heat loads within the CRHA are verified to be less than the specified values. Preoperational testing of the CRHAVS isolation dampers is performed to verify the leaktightness of the dampers. Preoperational testing for CRHA inleakage during EFU operation is conducted in accordance with ASTM E741. Testing and inspection of the radiation monitors are discussed in Section 11.5. The other tests noted above are discussed in Chapter 14.

Inservice Testing

Inservice testing of the CRHAVS includes operational testing of the EFU fans and filter unit combinations, EFU filter performance testing, automatic actuation testing of the CRHA isolation dampers and EFU fans, and unfiltered air inleakage testing of the CRHA envelope boundary. The CRHA boundary is Pressure Tested (PT) periodically to verify leak tightness on the envelope walls, doors, and boundaries. Testing to demonstrate the integrity of the CRHA envelope is performed in accordance with RG 1.197 and ASTM E741.

The Control Room EFU supplies air with a design flow rate of 220 l/s (466 cfm), and it is designed to maintain the control room envelope at a positive pressure with respect to adjacent compartments during normal operation and radiological events. An intake filter efficiency of 99% is assumed for particulate, elemental, and organic iodine species. The system does not include filtered recirculation and the design incorporates leak tightness design requirements (Section 6.4.3). Although the control room is maintained at a positive pressure, the dose analysis assumes a 5.66 l/s (12.0 cfm) unfiltered inleakage. Based on the ESBWR CRHA design and ventilation system operation the acceptance criteria for inleakage associated with CRHA access and egress will be near zero during development of the CRHA Unfiltered Inleakage Test.

Nuclear Air Filtration Unit Testing

The EFU filtration components are periodically tested in accordance with ASME AG-1, Code on Nuclear Air and Gas Treatment, to meet the requirements of RG 1.52.

Periodic surveillance testing of safety-related CRHA isolation dampers and the EFU components are carried out per Institute of Electrical and Electronic Engineers (IEEE)-338. Safety-related

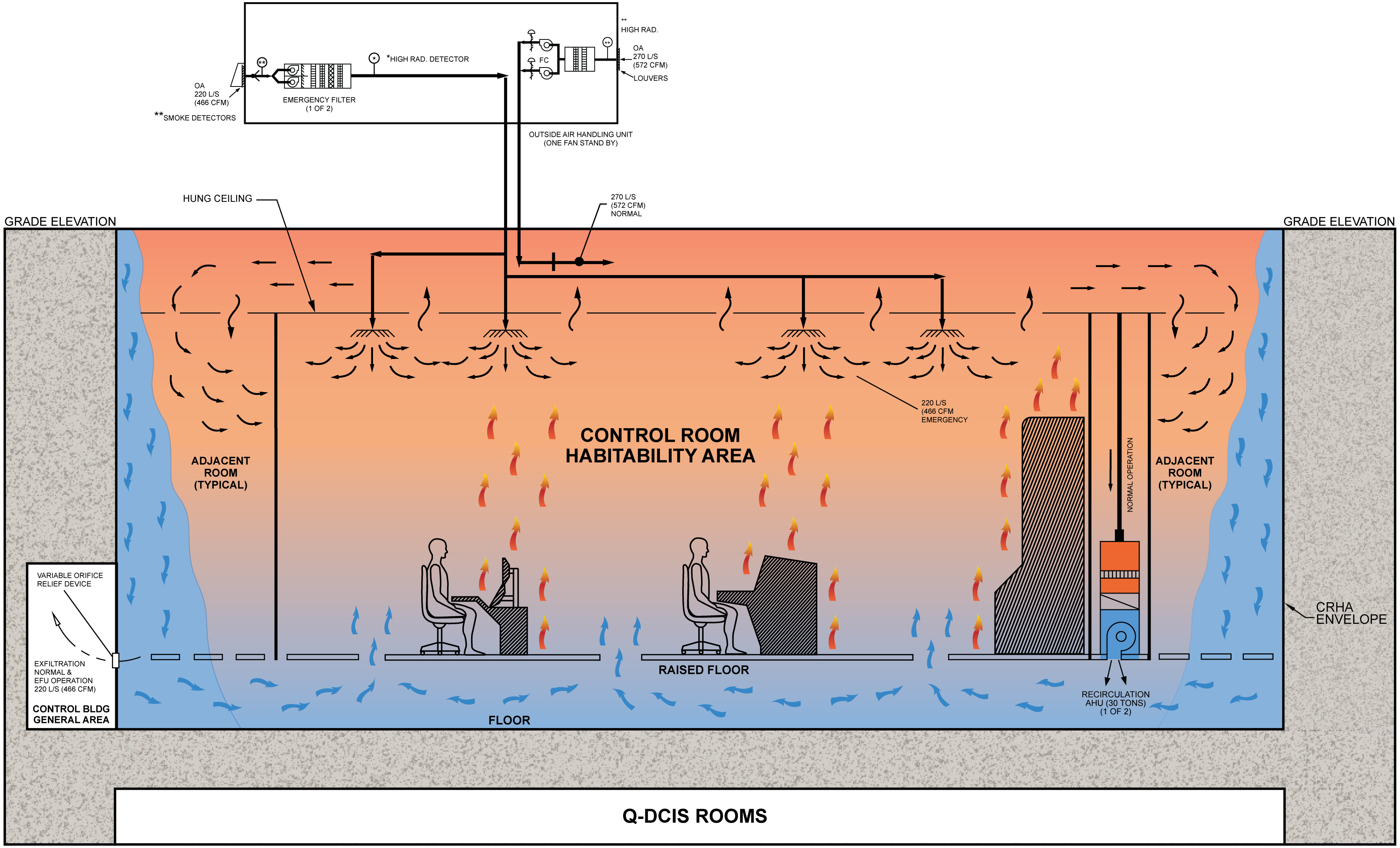

Figure 6.4-2, Control Room Habitability Area Airflows Emergency Operation - FOR ILLUSTRATIVE PURPOSES ONLY

The CBVS provides a safety-related means to passively maintain habitable conditions in the CRHA following a design basis accident (radiological event concurrent with loss of normal AC power).

Radiation detected in the CRHA outside air inlet causes the following actions:

- The normally closed isolation dampers downstream of the operating EFU fan to open;
- The normal outside air inlet and restroom exhaust dampers to close; and
- An EFU fan to automatically start.

The CRHA is isolated during loss of normal AC power conditions and a safety-related EFU provides pressurization and breathing quality air. An EFU is powered from the safety-related battery supply for a 72 hour duration. For longer-term operation, (post 72 hrs) either of two (2) ancillary diesel generators can power either EFU fan system. The EFU delivery and discharge system is optimized to ensure that there is adequate fresh air delivered and mixed in the CRHA. This is accomplished by using multiple supply registers, which distribute the incoming supply air with the Control Room air volume, and a remote exhaust (Variable Orifice Relief Device) to prevent any short cycling. The EFU operation results in turning over the Control Room volume approximately 7-9 times per day. This diffusion design (mixing and displacement) in conjunction with the known convective air currents (due to heat loads/sinks) and personnel movement ensures that occupied zone temperature is within acceptable limits, buildup of contaminants (e.g., CO_2) minimal, and a freshness of air is maintained. Additional details on the above discussion are elaborated upon in DCD Section 6.4.

The CBVS provides the capability to maintain the integrity of the CRHA with redundant safety-related isolation dampers in all ductwork penetrating the CRHA envelope. The active safety-related components (CRHA isolation dampers and EFUs), that ensure habitability in the CRHA envelope, are redundant. Two trains of safety-related EFUs, including HEPA and carbon filters, serve the CRHA envelop. Redundant fans are provided for each EFU to allow continued operability during maintenance of electrical power supplies. Therefore a single active failure cannot result in a loss of the system design function.

During normal modes of operation and emergency modes with electrical power available, the CRHA is maintained within the temperature and relative humidity ranges noted in Table 9.4-1 by the nonsafety-related CRHAVS Recirculation AHU. During emergency operation, with a loss of normal AC power, a nonsafety-related CRHA recirculation air handling unit (AHU), powered from the nonsafety-related Uninterruptible AC Power Supply System, maintains the CRHA within the normal operating temperature range for two hours. This allows the continued operation of certain high heat producing nonsafety-related MCR DCIS electric loads.

Anytime during a loss of normal AC power, once either ancillary diesel generator is available, the power for either Recirculation AHU fan with auxiliary cooling unit can be provided via the ancillary diesel-powered generator. Thus, a Recirculation AHU can operate indefinitely during a CRHA isolation event. If the Recirculation AHUs are not available during the loss of normal AC power, safety-related temperature sensors with two-out-of-four logic automatically trip the power to selected N-DCIS components in the MCR, thus removing the heat load due to these sources. In the event the loss of normal AC power duration extends beyond two hours, the reduced CRHA heat load is passively cooled by the CRHA heat sink. The CRHA heat sinks