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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 236 Related to ESBWR Design Certification Application - Auxiliary Systems - RAI Number 9.4-29 S02**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission Request for Additional Information (RAI) sent by NRC Letter 236, dated August 5, 2008 (Reference 1). The GEH response to RAI Number 9.4-29 S02 is addressed in Enclosure 1. The GEH response to RAI 9.4-29 S01 was submitted via Reference 2 in response to Reference 3. The original response was submitted via Reference 4 in response to Reference 5.

Should you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

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References:

1. MFN 08-625, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 236 Related To ESBWR Design Certification Application*, dated August 5, 2008.
2. MFN 08-348, Response to Portion of NRC Request for Additional Information Letter No. 158 Related to ESBWR Design Certification Application - Auxiliary Systems - RAI Numbers 9.4-29 S01 and 9.4-30 S01.
3. MFN 08-209, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 158 Related To ESBWR Design Certification Application*, dated February 29, 2008.
4. MFN 07-687, Response to Portion of NRC Request for Additional Information Letter No. 103 Related to ESBWR Design Certification Application – Control Room Habitability – RAI Numbers 6.4-11, 6.4-12, 6.4-15, 6.4-17, 9.4-29, 9.4-30, 9.4-36, 9.4-37, 9.4-49, 14.3-152, and 14.3-153.
5. MFN 07-414, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 103 Related To ESBWR Design Certification Application*, dated July 23, 2007.

Enclosure:

1. MFN 08-858, Response to Portion of NRC Request for Additional Information Letter No. 236 Related to ESBWR Design Certification Application - Auxiliary Systems - RAI Number 9.4-29 S02

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH (with enclosures)
	RE Brown	GEH (with enclosures)
	eDRF	0000-0089-7048

Enclosure 1

MFN 08-858

Response to Portion of NRC Request for

Additional Information Letter No. 236

Related to ESBWR Design Certification Application

Auxiliary Systems

RAI Number 9.4-29 S02

For historical purposes, the original text of RAI 9.4-29 and RAI 9.4-29S01 with the applicable GEH responses are included. The DCD mark-up provided with the original responses is not included.

NRC RAI 9.4-29

In DCD, Tier 2, Revision 3, Section 9.4.1, the Emergency Filter Unit (EFU) flow rate was established at 424 cfm. This was stated to be the minimum outdoor supply air required to maintain breathable air quality in the control room based on American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 62.

Please provide the assumptions used in this determination. Show how the control room compares to the type of facility selected from the ASHRAE 62 tables in terms of use, equipment, and air circulation features. Are there monitors that would warn operators of oxygen or carbon dioxide levels? Is there a capability to increase filtered outdoor air flow if more fresh air is needed. Considering the control room as an isolated facility with very minimal air circulation, what is the maximum carbon dioxide level and how does it compare with the toxic limits for carbon dioxide in the 72 hours after an accident?

GEH Response

The Control Room Habitability Area (CRHA) is considered as an office setting. The area has desks, computers, offices and the activities mimic what would typically occur in an office setting. There is no specific category in ASHRAE 62 for industrial or power plant control rooms. Therefore, the amount of outside air used in the ESBWR CRHA is 9.5 l/s/person (20 cfm/person) for up to 21 people (See DCD Table 9.4-1). Establishing EFU flow rate at 424 cfm is consistent with ASHRAE Standard 62 to maintain breathable air quality.

There are no monitors that would warn operators of oxygen or carbon dioxide levels; the 200 l/s (424 cfm) is supplied by the safety-related EFU and is sufficient to insure a safe environment.

After an accident, the Control Room Habitability Area (CRHA) envelope air outlet connections are isolated to ensure control room pressurization with a minimum flow of 200 l/s (424 cfm) supplied by the Emergency Filter Unit (EFU). In order to ensure this minimum flow rate, a controlled leak path from the CRHA envelope will be provided. This leak path will maintain a 31Pa (1/8"wg) positive pressure and the minimum flow rate. Locating the leak path under the raised floor of the control room removed from the air supply location will provide a flow path for the incoming filtered fresh air to assure that the operator breathable zone is refreshed and maintain carbon dioxide levels well below 5000 ppm threshold value limit. This leak path will assure carbon dioxide mixing and meets the intent of ASHRAE 62.

DCD Impact

DCD Tier 2, Figure 6.4-1, Figure 9.4-1, Figure 9.4-2 and DCD Tier 1, Figure 2.16.2-4 will be revised as shown in attached markup to reflect the controlled leakage path. DCD Tier 2 subsection 9.4.1.2 will also be revised as shown in attached markup to include this controlled leakage path design feature.

NRC RAI 9.4-29 S01

In the response to RAI 9.4-29 (letter number MFN 07-687) the addition of a discharge path from the CRHA partially addresses the concern but does not necessarily guarantee adequate mixing of air in the CRHA or that the fresh air will reach the operator breathing areas. The supply and return registers in the ceiling and floor plenums were designed to distribute 11,000 cfm from the recirculation air handling units. In addition to the MCR area, the shift supervisor office and other rooms draw air from this plenum. Please provide additional information on how the 424 cfm emergency air filtration unit supply will be distributed in the absence of the air handling unit operation. Specifically, will most of the flow go through the first few registers leaving other areas in the MCR and offices with little or no fresh air flow, or is there some mechanism which will evenly distribute the flow or proportion the flow to the most needed areas?

GEH Response

The ESBWR Control Room Habitability Area (CRHA) ventilation design allows for the elimination of ductwork internal to the control room, utilizing the raised floor volume and drop ceiling volume as duct-plenums to distribute air flow. This method of room air distribution is standard design for state of the art industrial computer/control rooms. Air balance is maintained through the use of open floor and ceiling panels "registers" to direct and distribute the airflow throughout the space. This design also allows for direct air flow through the MCR control cabinets to directly cool the electrical equipment, eliminating virtually all duct and supports in the Seismic Class I CRHA. The CRHA EFU airflow will be optimized during detailed design with several methods available to ensure adequate mixing and air delivery throughout the space. EFU air distribution will be enhanced by extending the EFU ductwork, attached to flexible air trunks above the ceiling, towards the center of the control room and terminating with ceiling diffusers. The diffusers can be located as required so that airflow enters adjoining rooms and spaces as well. The diffusers will be selected for appropriate velocity, throw, and spread that will ensure adequate mixing.

DCD Impact

No DCD changes will be made in response to this RAI.

NRC RAI 9.4-29S02

In order to support the safety evaluation with reference to the adequacy of the emergency filter unit (EFU) air supply and circulation in the control room, the staff needs additional information and clarification on the response to the RAI and needs to have the key information summarized in the DCD. The GEH response to RAI 9.4-29 states that "EFU air flow will be optimized during detailed design with several methods available to ensure adequate mixing. EFU air distribution will be enhanced by extending the EFU ductwork, attached to flexible air trunks above the ceiling towards the center of the control room and terminating with ceiling diffusers."

A. The staff does not have sufficient information as to how mixing of air occurs. Mixing affects both passive cooling and the freshness of the air that the operator breathes. Based on an 88,000 cubic foot control room with 15-foot ceilings, the floor area of the control room would be about 6000 square feet. One EFU ceiling register per 1000 square feet would deliver about 70 cfm if equally balanced. With 1/8 inch w.g. discharge pressure, the velocity of discharge would be very low and not effective at promoting mixing. If it were a hot day (117 def F max design temperature) thermal stratification and flow upward into the ceiling plenum would be probable. Although air is being removed by a leakage path in the floor plenum and leakage paths around the access doors, it is not clear that the leakage path facilitates mixing. ASHRAE 62-1989 based on the figure provided in the standard applies to a well mixed HVAC system which has a portion of the air being recirculated. The ESBWR has no recirculation in the first 72 hours. It is also not clear if the bathroom, kitchen, shift supervisors office or other areas are being provided with supply air from the EFU system. Please provide in the DCD sufficient design details to provide reasonable assurance that the air would mix uniformly by the EFU distribution to support the conclusion that the operators would have sufficient fresh air and that the assumption used in passive cooling analysis for uniform temperature in the control room is reasonable. A process flow diagram which shows EFU operation, flow rates, mixing of air capability and key controls would enhance the understanding in the DCD.

B. The staff is concerned that the reverse of the air flow in EFU operation which occurs because there is no recirculation AHU operation and the great reduction in flow from 11,000 cfm being recirculated from the floor up to 424 cfm being supplied from the ceiling down with unconditioned (potentially hot) air will not provide adequate cooling for electrical cabinets and components and that the temperatures inside the cabinets will increase. Please provide information on the temperature response inside CR safety related cabinets and assurance that it will not cause spurious or erratic operation or failure. Please make an appropriate statement in the DCD.

C. The RAI response identifies a carbon dioxide 5000 ppm threshold value limit. Five thousand (5000) ppm of carbon dioxide has not been established as a limit for the conditions of a control room which does not have substantial mixing or carbon dioxide monitoring. The principal source of carbon dioxide is breath being exhaled by personnel in the room which also carries with it other aromatic and biological effluents. The staff notes that ASHRAE 62- 1989 suggest a limit of 1000 ppm as a comfort level beyond which individuals may start feeling sick or have headaches. Considering the fact that control room temperatures could and probably would be rising and the stress level caused by a design basis accident would be high, operator performance might better be assured if the ASHRAE 62-1989 guidance limit was used. Please clarify how operator performance is assured in the enclosed confines of the CRHA with the limited fresh air supply being proposed. What defense in- depth measures are available to increase fresh air supply in the event that the air becomes stale and lacking in freshness?

GEH Response

A. The staff does not have sufficient information as to how mixing of air occurs. Mixing affects both passive cooling and the freshness of the air that the operator breathes. Based on an 88,000 cubic foot control room with 15-foot ceilings, the floor area of the control room would be about 6000 square feet. One EFU ceiling register per 1000 square feet would deliver about 70 cfm if equally balanced. With 1/8 inch w.g. discharge pressure, the velocity of discharge would be very low and not effective at promoting mixing. If it were a hot day (117 def F max design temperature) thermal stratification and flow upward into the ceiling plenum would be probable.

A. Providing ducted registers in the central Main Control Room (MCR) section (Room 3275 of DCD Tier 2, Figure 3H-1, Control Room Habitability Area El – 2000/-1400) will result in sufficient flow velocity to promote mixing, prevent upward airflow and thermal stratification under design temperature conditions (117 °F). As illustrated in Figure 1 and Figure 2 attached, emergency air from the EFU trains is distributed through a ceiling plenum located in the central MCR section and discharges through the variable orifice relief device located under the raised floor. This results in a down flow ventilation design common in semiconductor manufacturing plant control rooms. The region of the CRHA containing the ventilation ducting consists of a floor area of approximately 164 m^2 (1763 ft^2) and volume of 1090 m^3 (42,000 ft^3). Assuming that the actual free area / volume is in the order of 80% of this area due to furniture and equipment, the available floor area is 131 m^2 (1410 ft^2) and volume of 872 m^3 (33,600 ft^3). The four (4) registers would allow over 100 cfm airflow per register. For the louvered airfoil register detailed in the current design, a face velocity of approximately 80 fps would be achieved. This is sufficient to develop the required "throw" and promote air motion throughout the occupied zone to support uniform temperature gradients and velocities.

A. Although air is being removed by a leakage path in the floor plenum and leakage paths around the access doors, it is not clear that the leakage path facilitates mixing. ASHRAE 62-1989 based on the figure provided in the standard applies to a well mixed HVAC system which has a portion of the air being recirculated. The ESBWR has no recirculation in the first 72 hours. It is also not clear if the bathroom, kitchen, shift supervisors office or other areas are being provided with supply air from the EFU system.

A. Mixing of air in the central MCR section is facilitated by ceiling-mounted outlets. The supply air projects across the ceiling and uses the surface effect to transport supply air in the unoccupied zone. The variable orifice relief device located under the raised floor will also promote mixing as fresh air discharging from the EFU displaces air removed from the CRHA through the variable orifice relief device. The EFU does not supply air to the bathroom, kitchen, shift supervisors office and other areas not continuously occupied during emergency conditions. During emergency operations, all areas in the CRHA would not be continuously occupied. Minimal lighting and instrumentation available during emergency conditions would limit continuous occupancy to selected work stations in the main operation areas as recommended by NUREG 0700. Adequate airflow to all other areas will be assured using guidance provided in ASHRE-62.1-2007 Section 6.2.2.1. Detailed CRHA complex HVAC design will include door or wall louvers or undercut areas of doors, as appropriate.

A. Please provide in the DCD sufficient design details to provide reasonable assurance that the air would mix uniformly by the EFU distribution to support the conclusion that the operators would have sufficient fresh air and that the assumption used in passive cooling analysis for uniform temperature in the control room is reasonable. A process flow diagram that shows EFU operation, flow rates, mixing of air capability and key controls would enhance the understanding in the DCD.

A. GEH believes that the DCD contains sufficient design details to provide reasonable assurance that the air would mix uniformly by the EFU to ensure that the operators would have sufficient fresh air and support the assumption used in passive cooling analysis for uniform temperature in the control room. As discussed in question C of this RAI response, considerable margin is available in the ESBWR CRHA design to prevent physical effects impacting control room operator performance and ensure the uniform temperature assumed for the passive cooling analysis. Carbon dioxide is the major concern with air stagnation and stratification. Carbon dioxide vapor is heavier than air and will accumulate in low areas. Therefore, the variable orifice relief device located under the raised floor will be effective removing this contaminant. During emergency operations, all areas in the CRHA would not be continuously occupied. Minimal lighting and instrumentation available during emergency conditions would limit continuous occupancy to selected work stations in the main operation areas as recommended by NUREG 0700.

While a detailed process flow diagram is not available at this point in the system design process, Figure 3, EFU Air Distribution- Conceptual, attached to this RAI response, illustrates the duct and register layout visualizing the EFU air flow in the CRHA.

B. The staff is concerned that the reverse of the air flow in EFU operation which occurs because there is no recirculation AHU operation and the great reduction in flow from 11,000 cfm being recirculated from the floor up to 424 cfm being supplied from the ceiling down with unconditioned (potentially hot) air will not provide adequate cooling for electrical cabinets and components and that the temperatures inside the cabinets will increase.

B. Safety-related electrical and mechanical equipment located in the CRHA are listed in DCD, Revision 5, Tier 2,Thermodynamic Environment Conditions Inside Control Building for Accident Conditions, and included in the Equipment Qualification (EQ) program (Ref. DCD, Revision 5, Tier 2, section 3.11). The CRHA is an EQ mild environment. EQ demonstrates performance to worse case temperature conditions with margin. The maximum qualification temperature is at least 10°C higher than the maximum temperature to which the equipment is exposed for the worst-case anticipated operational occurrences (AOO) or normal, accident and post accident environments, while the equipment is under its maximum loading, to comply with margin requirements. The minimum qualification temperature is at least 10°C lower than the minimum temperature to which the equipment is exposed for the worst-case AOO. EQ performance is demonstrated with maximum heat rise from collocated and adjacent heat sources.

B. Please provide information on the temperature response inside CR safety related cabinets and assurance that it will not cause spurious or erratic operation or failure. Please make an appropriate statement in the DCD.

B. The Control Building Environmental Equipment Qualification Temperature Analysis, including the CRHA, was provided to the staff for review. This analysis models the emergency airflow with the EFU in operation and 424 cfm being supplied from the ceiling down with unconditioned (potentially hot) air supplied to electrical cabinets and components in the CRHA. As stated in response to RAI 9.4-33S01 (MFN 08-064 dated June 9, 2008), Item 1, the temperature in the cabinets is expected to be slightly higher than the bulk air temperature. However, the bulk air temperature, which is the incoming temperature to safety-related cabinets, of 92°F is well below the mild environment equipment qualification temperature of 122°F (Ref. DCD, Revision 5, Tier 2, Table 3H-10). Therefore, the EQ equipment located in the CRHA are demonstrated to perform its intended safety function with no spurious or erratic operation with adequate margin. DCD Revision 5, Tier 2, subsection 3.11.3, Environmental Conditions, describes that EQ equipment is qualified for the worst-case temperatures with margin per the requirements of IEEE 323 assuming no HVAC cooling with worst case highest ambient temperature caused by lack of HVAC, maximum outside temperature, and maximum heat rise from collocated and adjacent heat sources.

C. The RAI response identifies a carbon dioxide 5000 ppm threshold value limit. Five thousand (5000) ppm of carbon dioxide has not been established as a limit for the conditions of a control room which does not have substantial mixing or carbon dioxide monitoring. The principal source of carbon dioxide is breath being exhaled by personnel in the room which also carries with it other aromatic and biological effluents.

C: A $C0_2$ concentration of 5,000 ppm is the lower limit enforced by OSHA, and recommended by NIOSH and ACGIH for industry occupancy. ESBWR DCD Revision 5 is committed to ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality (Ref Table 1.9-22 and subsection 6.4.10). ASHRAE Standard 62.1-2007 includes Table B-1, Comparison of Regulations and Guidelines Pertinent to Indoor Environments. This Table provides a 5000 ppm OSHA $C0_2$ concentration as the enforcement or regulatory C02 concentration limit.

C. The staff notes that ASHRAE 62-1989 suggest a limit of 1000 ppm as a comfort level beyond which individuals may start feeling sick or have headaches. Considering the fact that control room temperatures could and probably would be rising and the stress level caused by a design basis accident would be high, operator performance might better be assured if the ASHRAE 62-1989 guidance limit was used. Please clarify how operator performance is assured in the enclosed confines of the CRHA with the limited fresh air supply being proposed.

C. ASHRAE 62-1989 states that comfort (odor) criteria are likely to be satisfied if the ventilation rate is set so that 1000 ppm $C0_2$ is not exceeded. ASTM D6245, Standard Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation, states: "The use of $C0_2$ concentrations as an indicator of human body odor is distinct from any health effects associated with the $C0_2$ itself. Adverse health effects from elevated $C0_2$ have not been observed until the concentration reaches a value of 7,000 ppm to 20,000 ppm and these studies involved continuous exposure for at least 30 days."

The calculated CO_2 concentration difference between the MCR and the outdoor air is as follows:

C_s-C_o=N/V_o (Ref. ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality, Appendix C, Formula C-1)

Where:

C_s	CO_2 concentration in the space, L/ per L of air
C_o	CO_2 concentration in outdoor air, L/ per L of air
N	CO_2 generation rate per person (0.31 L/min as sedentary persons)
V_o	outdoor airflow rate per person (40 L/s or 85 cfm)

C_s-C_o = 0.31/(40 x 60 s/min) = 0.000129 L of CO2 per L of air, approximate 130 ppm

With an outdoor air CO_2 concentration of 500 ppm, the ESBWR CRHA CO_2 concentration level will be less than 700 ppm (500+130). This level is well below the comfort or odor control value of 1,000 ppm recommended by ASHRAE 62.1-2007, Ventilation for Acceptable Indoor Air Quality. ASHRAE Standard 62.1-2007 Table 6-1, Minimum Ventilation Rates in Breathing Zone, also provides an estimated maximum occupancy of 5 occupants per 1000 ft^2 for office spaces. Considering the CRHA free area available, significantly more than five (5) occupants can be present in the ESBWR CRHA and meet this default occupant density requirement.

C. What defense in- depth measures are available to increase fresh air supply in the event that the air becomes stale and lacking in freshness?

C. Control Room Operator human performance will be ensured due to the margin provided by ESBWR CRHA design for $C0_2$ levels below those concentrations where human performance is impaired. Figure 3, CO_2 Buildup for Isolated MCR, illustrates that the CO_2 concentration in the ESBWR CRHA will not reach 5000 ppm for several days with five (5) CRHA occupants in a totally isolated control room, such as during an external fire or toxic gas event.

Additional defense in depth measures available with the ESBWR CRHA design include starting an additional EFU unit or EFUs in the other redundant train or restricting the number of occupants in the CRHA (4 CRHA occupants is minimal staffing Ref DCD Tier 2 Table 18.6-1). The CRHA Auxiliary Cooling Units will also be available and in operation with cooling and ventilation capacity post 72 hours after a DBA powered by the ancillary diesel generator.

DCD Impact

No DCD changes will be made in response to this RAI.

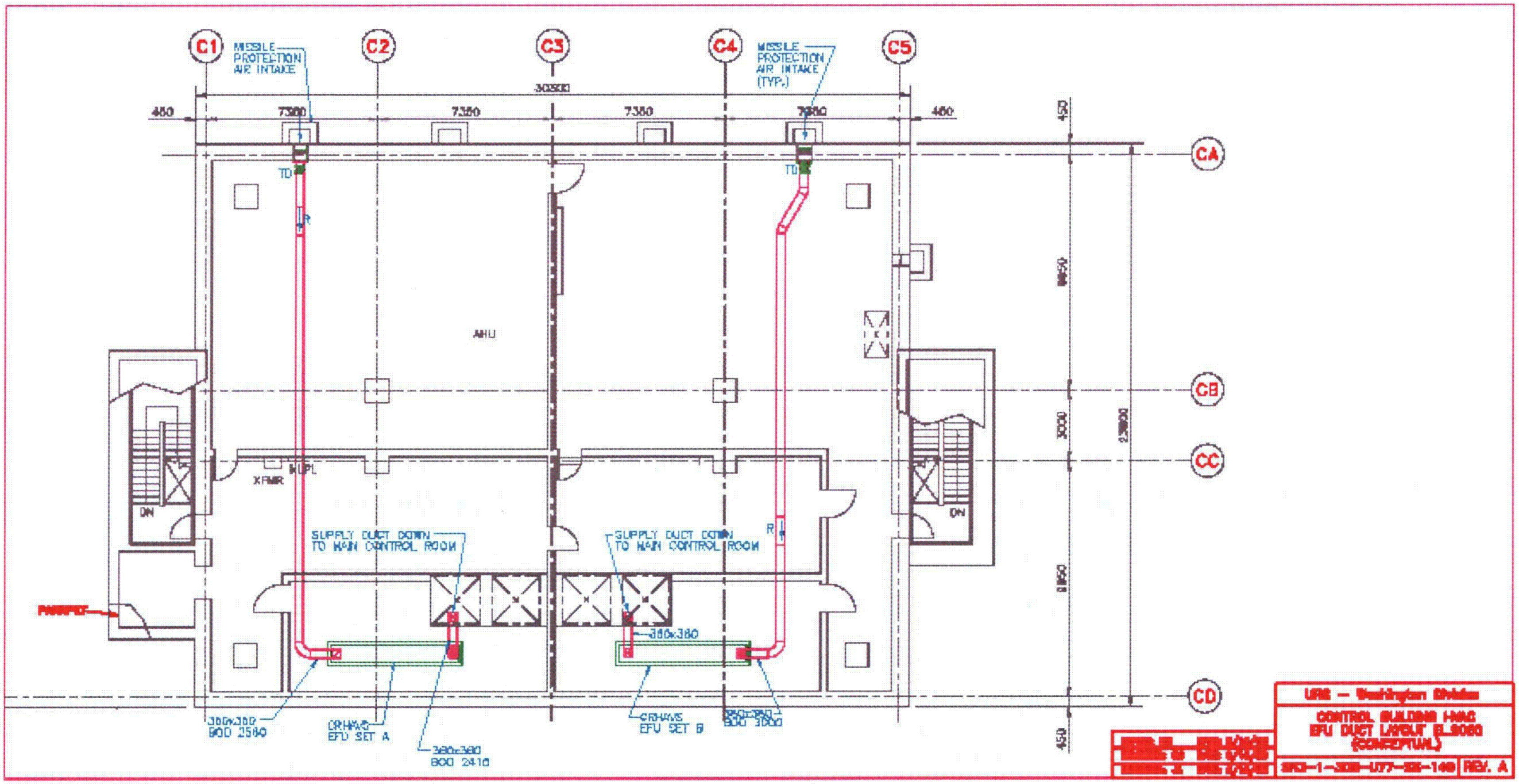

Figure 1, CRHA EFU AIR SUPPLY- CONCEPTIONAL

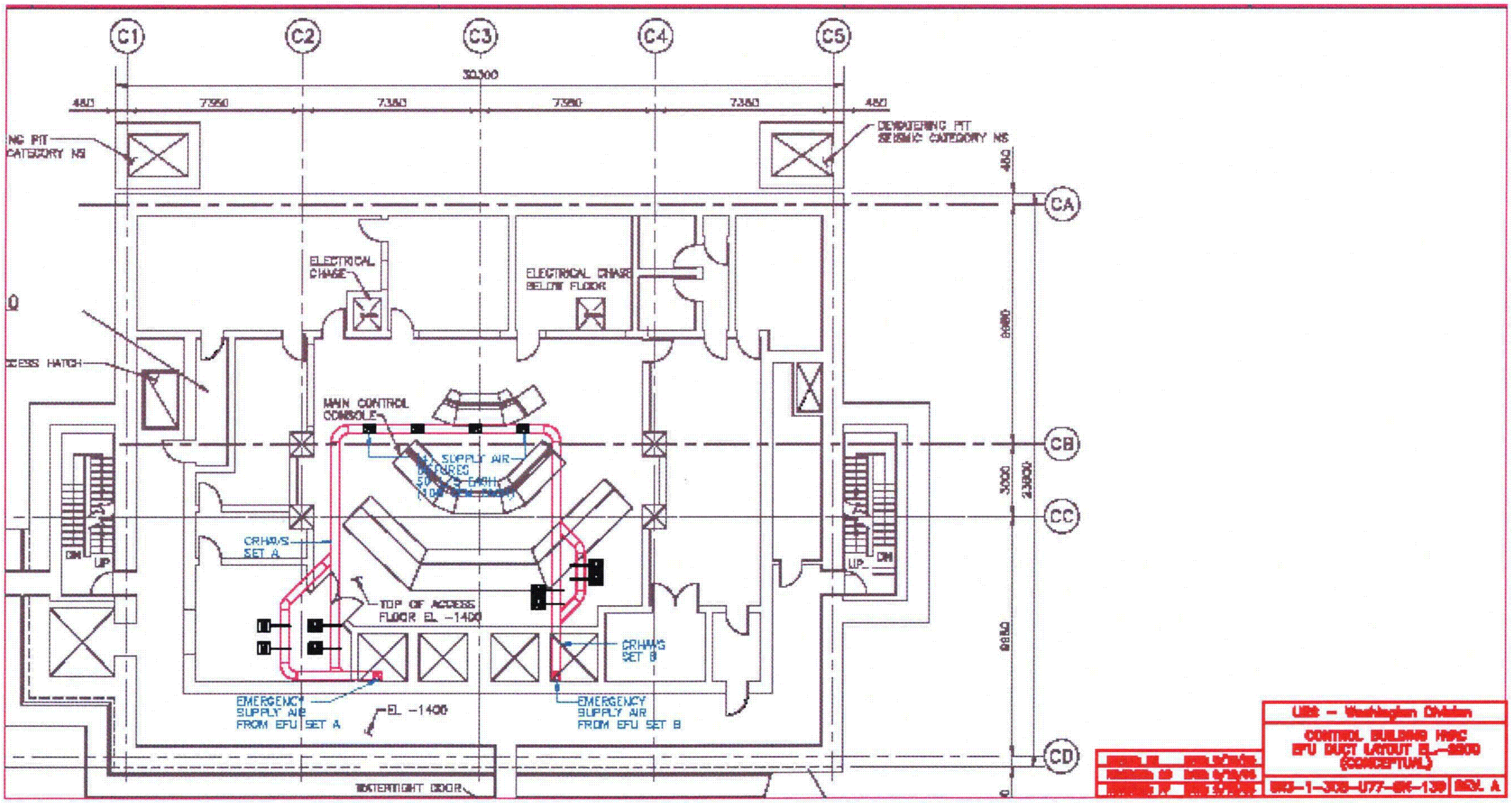

Figure 2, CRHA EFU AIR DISTRIBUTION- CONCEPTIONAL

Figure 3, CO_2 Buildup for Isolated MCR