6.4 Habitability Systems

The main control room (MCR) habitability systems are designed to allow control room operators to remain in the MCR to operate the plant safely under normal conditions and to maintain the plant in a safe state under accident conditions.

The habitability systems protect the control room operators from the effects of accidental releases of radioactive gases. The systems also provide the necessary support for the Technical Support Center (TSC) personnel in case of an accident or abnormal event. The TSC is contained within the control room envelope (CRE).

The term "habitability systems" refers to equipment, supplies, and procedures. The habitability equipment is defined in Section 6.4.2.1.

Control room habitability system objectives include:

- Missile protection and radiation shielding (Section 3.8).
- Air filtration (Section 6.5.1, Section 9.4.1).
- Pressurization and air conditioning (Section 9.4.1).
- Fire protection (Section 9.5.1).
- Radiation monitoring (Section 12.3.4).
- Detection of smoke (Section 9.4.1).
- Lighting (Section 9.5.3).
- Personnel support.

6.4.1 Design Basis

Control room habitability is provided, so that the plant can be operated safely under normal conditions, and maintained safely under accident conditions or abnormal events. These design bases relate to MCR habitability:

- Habitability systems are designed to accommodate the effects of environmental conditions associated with normal operation, maintenance, testing, and postulated accidents and are protected against dynamic effects that may result from equipment failures and from events and conditions outside the nuclear power unit (GDC 4).
- The MCR habitability systems are not shared among multiple nuclear power units (GDC 5).
- The CRE is protected from radiological releases and outside fire or smoke events to permit access and occupancy of the MCR.

- The MCR air conditioning system (CRACS) provides the capability to isolate the CRE from the surrounding areas, pressurize the CRE to prevent in-leakage, and filter supply air to remove radioactive halogens (10 CFR 50.34(f)(2)(xxviii)).

- The air intake structures are physically located away from potential radiological sources, (10 CFR 50.34(f) (2) (xxviii)).

- The TSC is designed in accordance with NUREG-0696 (Reference 6). A space of at least 1875 ft^2, within the integrated operations area, is allocated to the TSC. Therefore, the TSC is large enough to provide space for 25 personnel at 75 ft^2 per person.

- The CRE design permits periodic testing and in-service inspection to confirm integrity.

- The volume of the CRE is approximately 200,000 ft^3. With the CRE operating in a full recirculation alignment, the air inside the CRE can support five persons in the MCR and twenty-five persons in the TSC (Integrated Support Center) for at least one and one-half days.

The CRACS design bases are presented in Section 9.4.1.

The evaluation of potential toxic chemical accidents is addressed by the COL applicant in Section 2.2.3 and includes the identification of toxic chemicals. A COL applicant that references the U.S. EPR design certification will evaluate the results of the toxic chemical accidents from Section 2.2.3, address their impact on control room habitability in accordance with RG 1.78, and if necessary, identify the types of sensors and automatic control functions required for control room operator protection.

6.4.2 System Design

6.4.2.1 Definition of Control Room Envelope

The MCR contains the equipment necessary to monitor and control the plant during all operating conditions and to bring the plant to a safe shutdown state.

The CRE comprises these areas:

- Main control room.

- Shift supervisor’s office.

- Integrated operations area including:

  – Technical support center.

  – NRC office area.

  – Break area.

- Restroom facilities.
- Instrumentation and controls (I&C) service center.
- Service corridors.
- Computer rooms.
- Equipment rooms that contain MCR ventilation supply, filtration, and air conditioning systems.

The CRE is housed within Safeguard Buildings 2 and 3. The CRE is shown in Figure 6.4-1—Control Room Envelope Plan View 1, Figure 6.4-2—Control Room Envelope Plan View 2, and Figure 6.4-3—Control Room Envelope Elevation View. The total free-air volume of the CRE is approximately 200,000 ft^3.

These personnel support items are maintained within the confines of CRE in sufficient quantities for required operational personnel:

- Non-perishable food supply and drinking water.
- Emergency medical supply kits.
- SCBA units, air supply equipment and protective clothing for protection from smoke in accordance with RG 1.189.

Food, water, and medical needs of the control room personnel are met using the site emergency preparedness process for providing these services to emergency centers, following the guidance of NUREG-0654 (Reference 1). Emergency planning is addressed in Section 13.3.

6.4.2.2 Ventilation System Design

The CRACS design is described in Section 9.4.1, which identifies and describes major components, design parameters and classifications, instrumentation and controls, and provides a system schematic. Figure 15.0-4 presents airflows through the system for post-accident filtration. Section 6.5.1 describes the engineered safety features (ESF) filter systems and fission product removal capability for the CRACS.

Section 3.8.4 contains elevation and plan views of the Safeguard Buildings. Figure 2.3-1 provides the relative locations of potential radiological release points and the CRACS air intakes. Figure 6.4-1 through Figure 6.4-3 illustrate the CRE layout, including surrounding corridors, doors, stairwells and shielded walls.

One outside air intake for the CRACS is located in Safeguard Building 2 and the other is located at a separate location on Safeguard Building 3, to prevent intrusion of radiological contamination.

The CRACS intakes are located on the roof of Safeguard Buildings 2 and 3. The two intakes are physically separated and are removed from potential radiological release points, including the main steam relief exhaust, the Safeguard Building depressurization shafts, and the vent stack, in both lateral and vertical directions. Section 15.0.3 identifies the bounding atmospheric release point used in the radiological analyses.

Radiation monitors (R-29 and R-30, Table 11.5-1) in the CRACS supply air duct continuously measure the concentration of radioactive materials in the supply air. The control room airborne radioactivity monitoring system is addressed in Section 12.3.4 and Section 11.5.3.1.11.

The main features related to control room habitability of the CRACS design are:

- Under normal operating conditions:
  - The ventilation system operates in the recycling mode with fresh air makeup.
  - The air makeup rate corresponds to the exhausts from the kitchen and restrooms and leakage out of the area.
  - The ventilation system maintains a positive pressure greater than or equal to 0.01 inches water gauge within the CRE areas with respect to the adjacent environmental zones.
- The ventilation system maintains an ambient condition for comfort and safety of control room occupants and to support operability of the MCR components during normal operation, anticipated operational occurrences (AOO), and design bases accidents (DBA).
- The ventilation system maintains a positive pressure of greater than or equal to 0.01 inches water gauge under normal operation, and greater than or equal to 0.125 inches water gauge under accident conditions within the CRE areas with respect to adjacent environmental zones to prevent uncontrolled, unfiltered in-leakage during normal and accident conditions. The filtered outside air supply rate during accident conditions corresponds to 0.3 volume changes per hour.
- During a site radiological contamination event, the air intake is redirected through the ESF filter system trains.
- The ventilation system can be operated in full recirculation mode without outside air makeup during DBAs. The recirculated airflow rate is 3,000 cfm to the CREF unit.
- The ventilation system provides adequate capacity for proper temperature within the CRE.
  - Redundancy for air cooling and filtration is provided by having two independent trains for critical functions.

– Redundancy is provided for proper operation of the system when one active component is out of service.

– Power supplies of the active components are backed up with emergency power so that they function in case of a loss of offsite power.

– Each CRACS train has the capability to remove the design heat load. Each CRACS coiling coil (30SAB01AC001, 30SAB02AC001, 30SAB03AC001, and 30SAB04AC001) has a total cooling capacity of 470,000 Btu/hr and is designed in accordance with ASME AG-1 (Reference 2).

6.4.2.3 Leak-tightness

The CRACS is maintained in a manner that minimizes the unfiltered in-leakage across the CRE boundary. Adequate leak-tightness for air sealing components supports control room operator habitability within the CRE boundary during normal operation, AOOs and DBAs.

Leak-tightness provisions for pressure boundary components are:

- Pipe penetrations are sealed and tested for air leakage after initial construction.
- Cable penetrations are sealed and tested for air leakage after initial construction.
- Doors used for personnel or equipment access are sealed and remain substantially air-tight to maintain pressurization of the CRE area. Doors are arranged to allow access by necessary operational personnel and maintain pressurization of the CRE area. Two access doors are arranged in series to form a configuration similar to an air lock, minimizing in-leakage from surrounding areas.
- Open ended drain lines are provided with water seals.
- Building joints within the CRE boundary are sealed.

The CRACS maintains a positive pressure of greater than or equal to 0.125 inches water gauge within the CRE boundary during accident conditions, which limits unfiltered in-leakage through walls, ceiling, doors, pipes and cable penetrations.

The CRE boundary limits leakage from adjacent environmental zones to a maximum of 40 cfm unfiltered in-leakage plus 10 cfm for CRE ingress and egress, in accordance with RG 1.197 (Reference 7). The system design requirements are provided in Section 9.4.1 and testing requirements are specified in the control room envelope habitability program in Technical Specifications Section 5.5.17.

6.4.2.4 Interaction with Other Zones and Pressure-Containing Equipment

The CRACS does not supply air to areas other than the CRE. The air supply filtration and air conditioning systems are within the pressure boundary, thus minimizing the potential in-leakage of contaminated air into the MCR through fan shafts or ductwork connections.

The CRE area is isolated in the event of an outside fire or smoke.

Upon detection of a smoke alarm from the smoke detector located in the outside air inlet ducts for the CRACS, the operator in the MCR will close the outside inlet isolation dampers at the location of the alarm and place both CREF (iodine filtration) trains in the filtered alignment.

Fire barriers with a three hour fire rating enclose the MCR. Openings penetrating the fire barrier are furnished with both fire doors and fire dampers or approved fire rate seals meeting the associated barrier fire duration rating. In case of a fire within the CRE area, the room supply and exhaust are isolated by fire dampers and monitoring and control of the plant can be performed from the remote shutdown station (RSS). The RSS is located in a different fire zone and is on a different elevation than the MCR, and is not contained within the CRE boundary. The RSS is described in Section 7.4.

The CRACS does not interact with air conditioning equipment serving adjacent zones, minimizing the possibility of transferring radioactive gases into the CRE. Piping not connected or related to the equipment within the CRE boundary is routed outside the pressurized boundary of the CRE.

The MCR is not located near pressure-containing tanks, equipment, or piping, such as CO_2 tanks or steam lines, which upon failure could transfer dangerous or hazardous material to the CRE. However, portable self-contained breathing apparatus (SCBA) are available for use by the control room operators.

6.4.2.5 Shielding Design

Massive concrete structures separate the MCR from the reactor containment atmosphere and the external environment, as described in Section 3.8. The thick concrete walls prevent any significant direct radiation shine from outside the Safeguard Buildings. The MCR is protected against direct shine from the MCR charcoal filtration system by a 19 inch concrete floor. Radiation sources and shielding requirements are identified in Section 12.2 and Section 15.0.3. The MCR dose calculations that are presented in these sections identify the contribution from direct radiation shine and demonstrate that the total MCR dose under accident conditions is within regulatory limits.

6.4.3 System Operational Procedures

During normal plant operation, the CRACS maintains acceptable environmental conditions within the CRE boundary. Upon receipt of a high radiation signal in the air intakes or a primary containment isolation signal, the system is automatically switched so that the intake is routed through the CREF (iodine filtration) trains. The operating modes of the CRACS are described in Section 9.4.1.

Upon detection of a smoke alarm from the smoke detector located in the outside air inlet ducts for the CRACS, the operator in the MCR will close the outside inlet isolation dampers at the location of the alarm and place both CREF (iodine filtration) trains in the filtered alignment.

A COL applicant that references the U.S. EPR design certification will provide written emergency planning and procedures in the event of a radiological or a hazardous chemical release within or near the plant, and will provide training of control room personnel.

6.4.4 Design Evaluations

Section 9.4.1 contains the design evaluation of the CRACS. Fire protection inside and outside the CRE boundary is addressed in Section 9.5.1.

The total effective dose equivalent (TEDE) for the MCR occupants throughout the duration of any postulated DBA does not exceed the limits of GDC 19. The evaluation of radiological exposure to control room operators and the dose calculation model for the MCR is described in Section 15.0.3.

The CRE is designed, maintained and tested in accordance with RG 1.196 and RG 1.197. Habitability systems provide the capability to detect and protect personnel within the CRE boundaries from external fires, smoke, and airborne radioactivity.

A COL applicant that references the U.S. EPR design certification will confirm that the radiation exposure of MCR occupants resulting from a DBA at a nearby unit on a multi-unit site is bounded by the radiation exposure from the postulated design basis accidents analyzed for the U.S. EPR; or confirm that the limits of GDC 19 are met.

6.4.5 Testing and Inspection

Testing and inspection of the CRACS are described in Section 9.4.1. Refer to Section 14.2 (test abstract #082) for initial plant testing.

Periodic testing to confirm CRE integrity is performed using testing methods and at testing frequencies consistent with RG 1.197. The air in-leakage test (tracer gas test) of the CRE boundary is performed in accordance with ASTM E741 (Reference 3). Air quality testing is performed in accordance with ANSI/ASHRAE 52.2 (Reference 4) and ANSI/ASME N510 (Reference 5).

The control room envelope habitability program in Technical Specifications Section 5.5.17 defines testing requirements.

6.4.6 Instrumentation Requirements

The instrumentation and control features of the CRACS are described in Section 9.4.1. Radiation monitoring equipment for the CRE is described in Section 12.3.4, Section 11.5.3.1.11 and Table 11.5-1, Monitors R-29 and R-30.

6.4.7 References

1. NUREG-0654/FEMA-REP-1 Revision 1, “Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, November 1980.

2. ASME AG-1, “Code on Nuclear Air and Gas Treatment,” The American Society of Mechanical Engineers, 1997 (including the AG-1a-2000, “Housings” Addenda).

3. ASTM E741–2000, “Standard Test Methods for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution,” American Society for Testing and Materials, 2000.

4. ANSI/ASHRAE Standard 52.2-1999, “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size,” American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1999.

5. ANSI/ASME N510-1989, “Testing of Nuclear Air-Treatment Systems,” American National Standards Institute/The American Society of Mechanical Engineers, 1989.

6. NUREG-0696, “Functional Criteria for Emergency Response Facilities,” U.S. Nuclear Regulatory Commission, February 1981.

7. NRC Regulatory Guide 1.197, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," 2003.

Figure 6.4-1—Control Room Envelope Plan View 1

Figure 6.4-2—Control Room Envelope Plan View 2

Figure 6.4-3—Control Room Envelope Elevation View

Next File