

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 plant operators from the effects of accidental releases of toxic and 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 and protection from toxic gases and hazardous chemicals.
- 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 to permit access and occupancy of the MCR under accident conditions (GDC 19).

- The CRE is protected from hazardous chemical releases 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 separated and located away from potential radiological sources, (10 CFR 50.34(f) (2) (xxviii)).
- The CRE design permits periodic testing and in-service inspection to confirm integrity.

The CRACS design bases are presented in Section 9.4.1.

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.
- Sanitary 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 ft³.

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, and toxic or noxious gases.
 - SCBA units contain a minimum of six hours of air supply capacity, as specified by RG 1.78.

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. The evaluation of potential toxic chemical accidents is addressed in Section 2.2.3. Figure 6.4-1 through Figure 6.4-3 illustrate the CRE layout, including surrounding corridors, doors, stairwells and shielded walls.

The CRACS intakes are located on the roof of Safeguard Buildings 2 and 3, to prevent intrusion of toxic gases or radiological contamination. 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 stack, in both lateral and vertical directions. Section 15.0.3 identifies the bounding atmospheric release point used in the radiological analyses.

Radiation monitors 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.

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 sanitary rooms and leakage out of the area due to the controlled overpressure.
- 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 0.125 inches water gauge as a minimum 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.
- Control room operators are protected from chlorine releases and other toxic gases in accordance with RG 1.52, RG 1.78, and ASME AG-1 (Reference 2).
- The ventilation system can be operated in full recirculation mode without outside air makeup during DBAs or events involving toxic gas releases. The recirculated airflow rate is 17,000 cfm.
- The ventilation system provides adequate capacity for proper temperature within the CRE.
 - Redundancy for air cooling, filtration, and toxic gas protection 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.

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 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.
- All building joints within the CRE boundary are sealed.

The CRACS maintains a positive pressure of 0.125 inches water gauge as a minimum within the CRE boundary, 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 50 cfm unfiltered in-leakage. 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, external toxic gas release, smoke, and excessive concentrations of carbon monoxide or carbon dioxide. During these events, outside air is automatically isolated and CRACS operates in full recirculation mode. Upon detection of toxic gas or smoke, audible or visual alarms are actuated in the MCR. The CRACS and filter systems can be manually aligned from the MCR.

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 toxic or 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 CO₂ 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 emergency filtration system. The operating modes of the CRACS are described in Section 9.4.1.

Upon detection of any hazardous chemicals in the environment which have a potential for infiltration within the CRE boundary, the control room operator will take protective measures within a short period of time from the initiation of the toxic gas sensors and alarms. The operators are not subjected to prolonged exposures during this time. Storage provisions for SCBAs and procedures for their use allow operators to begin using the SCBAs within a short period of time after detection of a radiological event or a hazardous release.

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, toxic gases 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.

The evaluation of potential toxic chemical accidents is addressed by the 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 and address their impact on control room habitability in accordance with RG 1.78.

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 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.

Toxic chemicals whose release has the potential to affect control room operators are monitored by toxic gas sensors. A list of chemicals and their locations is provided in Section 2.2. A COL applicant that references the U.S. EPR design certification will identify the type(s) of Seismic Category I Class IE toxic gas sensors (i.e., the toxic chemical(s) of concern) necessary for control room operator protection.

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-1-2003, "Nuclear Air and Gas Treatment," The American Society of Mechanical Engineers, 2003.
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 52.2-1999, "Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size," American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1999.
5. ASME N510-1989 (R1995), "Testing of Nuclear Air-Treatment Systems," The American Society of Mechanical Engineers, 1989.

Figure 6.4-1—Control Room Envelope Plan View 1

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Figure 6.4-2—Control Room Envelope Plan View 2

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Figure 6.4-3—Control Room Envelope Elevation View

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