6.4 Habitability Systems

The Control Room Habitability Area (CRHA) HVAC System is provided to ensure that the main control room operators can remain in the main control area envelope and take actions to operate the plant safely under normal conditions and to maintain it in a safe condition under accident conditions.

The habitability systems include missile protection, radiation shielding, radiation monitoring, air filtration and ventilation systems, lighting, personnel and administrative support, and fire protection.

Detailed descriptions of the various habitability systems and provisions are discussed in the following sections:

Conformance with NRC General Design Criteria	Section 3.1
Wind and Typhoon Loadings	Section 3.3
Water Level (Flood) Design	Section 3.4
Missile protection	Section 3.5
Protection Against Dynamic Effects Associated with the Postulated Rupture of Piping	Section 3.6
Qualification of Seismic Category I Instrumentation and Electrical Equipment	Section 3.10
Environmental Design of Safety-Related Mechanical and Electrical Equipment	Section 3.11
Radiation Protection Design Features	Section 12.3 (Also Chapter 15)
Control Room Habitability Area HVAC System	Subsection 9.4.1
Fire Protection Systems	Subsection 9.5.1
Lighting Systems	Subsection 9.5.3
Electric Power Systems	Chapter 8
Radiation Instrumentation and Monitoring	Subsection 7.6.1.2 (Also Subsection 12.3.4 and Section 11.5)

Equipment and systems are discussed in this section only as necessary to describe their connection with main control area envelope habitability. References to other sections are made where appropriate.

The term “main control area envelope” includes the main control room, areas adjacent to the main control room containing plant information and equipment necessary to normal and emergency operations, and kitchen and sanitary facilities. These areas include the rooms which comply with the requirements of SRP Section 6.4 for “Control Room Emergency Zone.” It also includes the zone serviced by the control room habitability area HVAC System. “Emergency conditions” include such postulated releases as radioactive materials, toxic gases, smoke and steam.

The “systems” include the following:

(1) Control Building shielding and area radiation monitoring

(2) Control room habitability area heating, ventilating and air conditioning

(3) Provision for emergency food, water storage and air supply system

(4) Emergency kitchen and sanitary facilities are provided in the emergency facilities in the CRHA.

(5) Provision for protection from, and removal of airborne radioactive contaminants

(6) Removal of smoke and toxic gases

6.4.1 Design Basis

Criteria for the selection of design bases are found in Subsection 1.2.1.2.

Protection of the habitability systems of the Control Building from wind and typhoon effects is discussed in Section 3.3, flood design in Section 3.4, missile protection in Section 3.5, protection against dynamic effects associated with the postulated rupture of piping in Section 3.6, seismic design of electrical components in Section 3.10, and environmental design in Section 3.11.

6.4.1.1 Safety Design Basis

(1) The main control area envelope, or pressure boundary, includes all instrumentation and controls necessary for safe shutdown of the plant and is limited to those areas requiring continuous operator access during and after a design basis accident (DBA).

(2) Food, sleeping accommodations, medical supplies and sanitary facilities are provided to sustain an emergency team of five persons for a period of 5 days.

(3) The CRHA HVAC System during emergency mode maintains a suitable environment for sustained occupancy of 12 persons.

(4) The radiation exposure of Control Room personnel through the duration of any one of the postulated DBAs discussed in Chapter 15 does not exceed the guidelines set by 10CFR50 Appendix A, General Design Criterion 19.

(5) The habitability systems provide the capability to detect and limit the introduction of radioactive material and smoke into the main control room.

(6) Self-contained breathing apparatus and other protection such as may be required for eye and skin will be provided for emergency use within the Control Building.

(7) The main control area envelope ventilation system maintains the main control room atmosphere at temperatures suitable for prolonged occupancy throughout the duration of any one of the postulated DBAs discussed in Chapter 15.

(8) The main control area envelope ventilation system is capable of automatic transfer from its normal operation mode to its emergency or isolation modes upon detection of conditions which could result in accidental exposure of main control room personnel to a high level of airborne radioactivity.

(9) The habitability system and components are contained in a Seismic Category I structure that is typhoon-missile, pressure and flood protected.

(10) Nonseismic pipe, ductwork for the kitchen and sanitary facilities in the Control Building are designed to ensure that their physical collapse during a SSE will not adversely affect safety-related components.

(11) The CRHA HVAC System is designed with sufficient redundancy to ensure operation under emergency conditions assuming the single failure of any one active component.

(12) The CRHA HVAC ducting is ESF designed and the hangers are designed to Seismic Category I requirements.

(13) The safety-related components of the CRHA HVAC System are operable during loss of offsite power using divisional onsite power from the emergency diesel generators and safety-related batteries.

(14) The main control area envelope defining the confines of the main control room and auxiliary spaces is sufficiently leaktight so that a positive pressure can be maintained.

6.4.1.2 Power Generation Design Bases

(1) The CRHA HVAC System is designed to provide and maintain an environment with controlled temperature and humidity to ensure both comfort and safety of the operators and the integrity of the main control room components.

(2) Provisions for periodic inspection, testing and maintenance of the principal components shall be a part of the design requirements.

6.4.2 System Design

Figure 9.4-1 provides the flow diagrams describing the CRHA HVAC System. Heating, cooling and pressurizing the main control area envelope, and filtering the air therein, are described in Section 9.4.1, wherein function is discussed and equipment is listed.

6.4.2.1 Main Control Area Envelope

The Control Building spaces within the envelope supplied by the control room habitability area HVAC System include:

(1) Main control Room proper

(2) Visitor Viewing Room

(3) Operators Area

(4) Instrument Maintenance Room

(5) Shift Supervisor's Office, Shift Supervisor's Conference Room, Shift Clerk's Office, Switching and Tagging Office

(6) North and South Control Panel Rooms

(7) Operators Area, Kitchen, Bathroom

(8) Process Computer Room

(9) Adjoining Corridors and Passages

The following supplemental facilities are provided in the Access Control Building outside the CRHA HVAC area:

(1) Kitchen and lunch rooms

(2) Men's lavatory

The main control room area envelope is maintained at a positive pressure of 31 Pa at all times with respect to the adjacent areas. Pressure control damper at the inlet of the exhaust fans maintain these pressures. These spaces constitute the operation, living and environmental control areas and can be isolated for an extended period if such is required by the existence of a LOCA or high radiation condition.

6.4.2.2 Control Room Habitability Area HVAC System Design

The design, construction and operation of the CRHA HVAC System are described in detail in Subsection 9.4.1. Figure 9.4-1 is a diagram of the control room habitability area HVAC System, showing major components, seismic classifications and instrumentation.

A description of the charcoal filters is given in Subsection 9.4.1.

A description of main control room instrumentation for monitoring of radioactivity is given in Subsections 11.5.2 and 12.3.4.

A description of the smoke detectors is in Subsection 9.5.1.

6.4.2.2.1 Control Room Drawings

Layout drawings of the main control room and the remainder of the Control Building are given in Section 1.2.

6.4.2.2.2 Release Points

Release points are shown in Figure (To be provided in FSAR) (plan view). The air intakes are well above grade. Elevation of other structures is seen in Figures 1.2-9 and 1.2-10.

6.4.2.3 Leaktightness

The main control room area envelope boundary walls are designed with low leakage construction. All boundary penetrations are sealed. The access doors are designed with self-closing devices which close and latch the doors automatically following the passage of personnel.

6.4.2.4 Interaction with Other Zones and Pressure-Containing Equipment

The main control area envelope is heated, cooled, ventilated and pressurized by a recirculating air system using filtered outdoor air for ventilation and pressurization purposes. Recirculated air and outdoor air are mixed and drawn through filters, a cooling coil and electric heating coils.

There are two intakes on the top floor side walls of the Control Building, one on each end. Radiation monitoring sensors located in each outdoor air intake duct warn the operating personnel (by means of readouts and alarms in the main control room) of the presence of airborne contamination. Also, the signal automatically closes down the contaminated air intake valves and normal vent dampers, opens the emergency vent dampers, and turns on the primary emergency filter unit fans on reduced flow. If both air intakes are contaminated, the main control room operator can manually override the system to open either air intake to draw makeup air when necessary. This makeup air is routed through HEPA and charcoal filtering system for cleanup before being used for pressurization.

The main control area envelope is maintained at positive pressure with respect to atmosphere. In an emergency, the pressure differential will eliminate infiltration of airborne contamination. The doors are of the double vestibule type to increase pressure differential between rooms, thereby eliminating infiltration when the doors are opened.

The main control area envelope must remain habitable during emergency conditions. To make this possible, potential sources of danger such as steamlines, pressure vessels, CO2 fire fighting containers, etc. are located outside of the main control area envelope and the compartments containing Control Building life support systems.

A tabulation of moving components in the CRHA HVAC System, along with the respective failure mode and effects, is shown in Table 6.4-1.

All dampers except the mixing dampers in the air conditioning units and the pressure control damper in the exhaust plenum are of the two position (open or closed) type.

6.4.2.5 Shielding Design

6.4.2.5.1 Design Basis

The Control Builidng shielding design is dominated by the shielding required for N-16 shine from the main steam lines which traverse the upper portions of the control building. The shielding required for these steam lines (see PSAR Subsection 12.3.2.3 (5) and (6)) combined with the fact that the primary occupied portions of the control building are underground make the control building inherently well shielded against radiation. The sources of radiation in a post-accident environment are:

(1) Fission products released from the reactor pressure vessel to the primary containment as well as fission products which leak from primary containment to the reactor building secondary containment can serve as a source of gamma shine to the control building.

(2) Additionally fission products released to the environment (see (3) below) and entrained into the electrical equipment rooms may also serve as a source of gamma shine.

(3) Fission products leaked from the primary containment into the reactor building secondary containment (via unspecified leakage paths) are treated by the SGTS prior to being released from the reactor building through the plant stack. These releases which consist of 100% of the treated noble gases and 1% of the treated iodine will form into a dispersive cloud of the plant site. Direct gamma shine from the dispersive cloud can then add to the shine dose rate on the control room. This source is,

however, minor due to the large amount of shielding required to shield against N-16 shine off the main steam lines. The worst case for shielding against gamma shine is the Loss of Coolant Accident which is described along with the assumptions, inventories, and enviornmental releases in Subsection 15.6.5.

(4) Of the fission products released to the environment from the various pathways in the LOCA case (worst shielding case), a small fraction are entrained in the Control Room HVAC filter system and collected in the charcoal filtration system. This concentration also serves as a minor source of gamma shine to the control room.

(5) Of the fission products entrained into the Control Room HVAC, 100% of the noble gases and 1% of the iodine are circulated into the occupied areas of the control room which results in airborne doses to personnel and the significant majority of the personnel dose under accident conditions. This dose calcualtion, it's assumptions, and results are given in Subsection 15.6.5.

6.4.3 System Operation Procedures

During normal operation, the control room habitability area HVAC System operates with mixed recirculated and outdoor air, which pressurizes the subject spaces. Emergency conditions such as a LOCA or high radiation cause an automatic changeover reducing outside air intake and to start charcoal filtering all outside air and a portion of the return air. This effectively isolates operating personnel from the environment and from airborne contamination. Protection from direct radiation is discussed in Subsection 6.4.2.5.

Radioactivity is monitored, and changeover to reduced circulation and charcoal filtering is automatic. Redundancy of instrumentation and air handling systems ensures against system failure due to single component failure.

The above operational description is brief. For a more detailed description of normal and emergency operation of the control room habitability systems, see Subsections 9.4.1, 9.5.1, 9.5.3, 12.3.4, 6.5.1, and Chapter 8.

6.4.4 Design Evaluations

6.4.4.1 Radiological Protection

The Chi/Qs used for evaluation of the main control room operator dose to meet General Design Criterion 19 are presented in Subsection 15.6.5.

6.4.4.2 Smoke and Toxic Gas Protection

As discussed and evaluated in Subsection 9.5.1, the use of non-combustible construction and heat- and flame-resistant materials throughout the plant minimizes the likelihood of fire and consequential fouling of the main control area envelope atmosphere with smoke or noxious vapor introduced in to the main control room air. In the smoke removal mode, the purge flow through the Control Building provides three air changes per hour in order to sweep atmospheric contaminants out of the area.

The main control area envelope is normally exhausted from the recirculation plenum by one of the exhaust fans. Upon detection of smoke in the CRHA, the operating division of the CRHA HVAC System is put into smoke removal mode by the main control room operators. For smoke removal both exhaust fans are started at high speed in conjunction with a supply fan, the recirculation damper is closed. Either division of the CRHA HVAC System can be used as a smoke removal system.

Transfer of the system to the isolation mode for exterior smoke may also be initiated manually from the main control room. Local, audible alarms warn the operators to shut the self-closing doors, if, for some reason, they are held open after the receipt of a transfer signal. Isolation mode makeup air flow, required after approximately 72 hours of isolation (based on the buildup of carbon dioxide to 1% by volume in the space due to the respiration of 12 persons), must be initiated manually by the operator after tests with portable air analyzers indicate the need to do so. However, the operator is allowed to manually initiate the isolation mode makeup airflow after 10 minutes of isolation mode.

Redundant components are provided, where necessary, to ensure that a single failure will not preclude adequate main control area envelope ventilation. A CRHA HVAC System failure analysis is presented in Table 6.4-2.

The CRHA HVAC System is designed in accordance with Seismic Category I requirements (Section 3.2). The failure of components (and supporting structures) of any system, equipment or structure which is not Seismic Category I will not result in loss of a required function of the CRHA HVAC System.

6.4.4.3 Life Support

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

Food storage space is provided as a part of the operator area adjacent to the main control room. Water and food storage adequate for 12 people for 5 days is stored in this area. The storage cabinets have a net volume of 0.7m3 usable for food storage. In addition, the refrigerator has a net volume of 0.28m3 available. Potable water is stored in sealed sanitary containers in the operator area.

All foodstuffs and water intended for emergency use must be so labeled and not be used for normal conditions, thus ensuring an adequate supply at all times for emergency use.

The sanitary facilities are located in the Access Control Building near the CRHA.

Individual respirators for personnel use in the event of toxic gas intrusion, which cannot for any reason be adequately removed by the smoke removal mode, are stored in the main control room ready for immediate use. Sufficient respirators are maintained for the full complement of personnel assigned to the main control room. As emergency safety life support equipment, these respirators are subject to operational test and inspection at regular intervals.

All personnel attached to the Control Building group and all others that may be exposed to smoke and/or toxic gases in the Control Building are trained in the use of the respirator. Initiation training is supplemented by refresher sessions at six-month intervals.

6.4.5 Testing and Inspection

The system is designed to permit periodic inspection of important components (e.g., fans, motors, coils, filters, ductwork, piping, dampers, control instrumentation and valves), to assure the integrity and efficiency of the system. Local display and indicating devices are provided for periodic inspection of vital parameters such as air temperature upstream and downstream of the heating and cooling coils, cooling water inlet temperatures, filter pressure drop, duct static pressures, and cooling water pressures at the inlet and outlet of coils.

Test connections are provided in the duct work and piping for periodic checking of air and water flows for conformance to design requirements. All features are periodically tested by initiating all dampers during normal operation. The operating system is proven operable by its performance during normal plant operations. The HEPA filters are periodically tested with DOP smoke per ANSI N510. The charcoal filters are periodically tested for adsorption efficiency. Inspection and sampling connections are provided for on site filter testing.

Filter pressure drop is to be routinely monitored and a high differential alarm alerts the operator to switch over to standby system for filter replacement.

The systems are to be tested periodically by initiating the changeover sequence during normal operation. All equipment is designed to facilitate the above discussed test and inspection functions.

Failure of any system or component to properly perform its assigned function during any test or inspection is grounds for repair or replacement.

6.4.6 Instrumentation Requirements

A complete description of the required instrumentation is given in Subsection 7.3.1.1.8, 7.6.1.2, 9.4.1 and 9.5.1.

Table 6.4-1 Identification of Failure/Effect in the Control Room Habitability Area HVAC System

Component Nomenclature	Mode	Failure Effect	Action
Main Outside Air	Open	Contaminated Air Penetration	RE Automatically Starts Emergency Unit
Emergency Outside Air Damper	Closed	Loss of Control Room Pressurization	Flow Switch Starts Redundant Unit
Emergency Outside Air Supply Fan	No Flow	Loss of Control Room Pressurization	Flow Switch Starts Redundant Unit
Main Control Area Envelope Supply Fan	No Flow	Loss of Control Room Cooling	Flow Switch Starts Standby Unit
Main Control Area Envelope Return Fan	No Rotation	Control Room Overpressurization	Flow Switch Starts Redundant Unit
Main Control Area Envelope Return Air Damper	Closed	Partial Loss of Control Room Cooling	Flow Switch Starts Redundant Unit

Note:

Failure mode and effect is indicated for each individual component in the system during an emergency operation. The postulation of more than a single failure in the system is not considered.

Table 6.4-2 Control Room Habitability Area HVAC System Failure Analysis

Component	Malfunction	Comments
Air-conditioning supply or return fan	Failure of a fan resulting in loss of duct pressure.	Should an operating fan fail, the resultant loss of duct pressure actuates an alarm, and transfers operation to the standby fan. Fans are powered from engineered safety features (ESF) buses.
Chiller (Refrigerator)	Failure of a chiller resulting in loss of cooling capacity.	Following the loss of a chiller, air temperature on discharge of A/C unit fan increases and actuates a high temperature alarm in the control room. The defective unit would shut down, and the standby A/C unit started. Chillers are powered from the ESF buses.
Main Control Area Envelope emergency filtration system	Failure resulting in high pressure differential across filter unit.	High pressure differential across filter unit will actuate an alarm in control room. Defective filter will isolate and standby system brought into service.
Outside air supply intake	Failure resulting in loss of outdoor air supply.	Two redundant and separate outdoor air supply sources have been provided.
Radiation monitor in outside air intake duct	Failure resulting in loss of radiation-monitoring capability.	Four channels of radiation monitors are provided in parallel.
Smoke detector	Failure or loss in smoke detection capability.	A minimum of two products of combustion detectors located in each safety-related air intake duct.

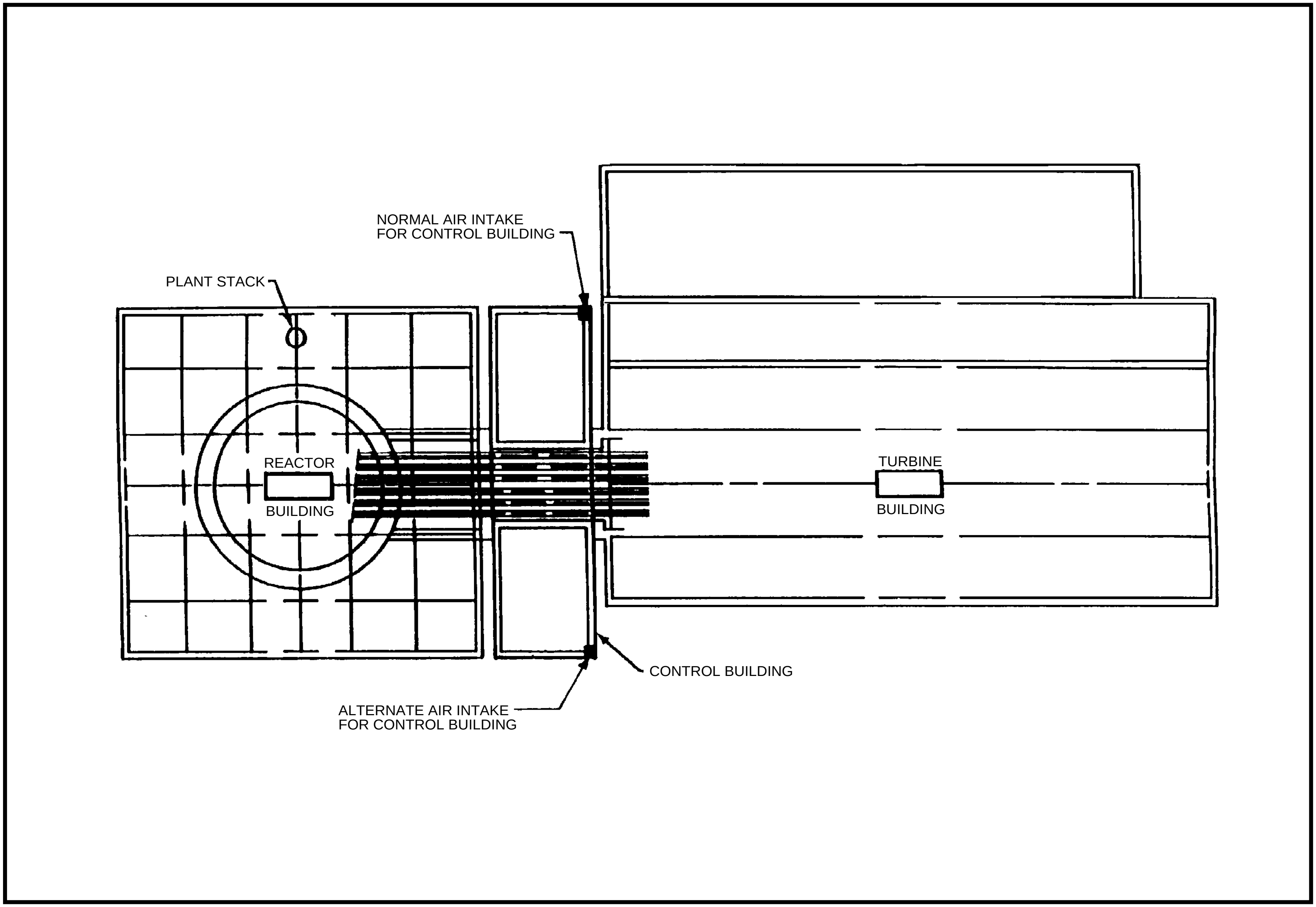

Figure 6.4-1 Plant Layout