6.4 Habitability Systems

The habitability systems are a set of individual systems that collectively provide the habitability functions for the plant. The systems that make up the habitability systems are the:

- Nuclear island nonradioactive ventilation system (VBS)
- Main control room emergency habitability system (VES)
- Radiation monitoring system (RMS)
- Plant lighting system (ELS)
- Fire Protection System (FPS)

When a source of ac power is available, the nuclear island nonradioactive ventilation system (VBS) provides normal and abnormal HVAC service to the main control room (MCR), control support area (CSA), instrumentation and control rooms, dc equipment rooms, battery rooms, and the nuclear island nonradioactive ventilation system equipment room as described in subsection 9.4.1.

If ac power is unavailable for more than 10 minutes or if “high-high” particulate or iodine radioactivity is detected in the main control room supply air duct, which would lead to exceeding General Design Criteria 19 operator dose limits, the protection and safety monitoring system automatically isolates the main control room and operator habitability requirements are then met by the main control room emergency habitability system (VES). The main control room emergency habitability system is capable of providing emergency ventilation and pressurization for the main control room. The main control room emergency habitability system also provides emergency passive heat sinks for the main control room, instrumentation and control rooms, and dc equipment rooms.

Radiation monitoring of the main control room environment is provided by the radiation monitoring system. Smoke detection is provided in the VBS system. Emergency lighting is provided by the plant lighting system. Storage capacity is provided in the main control room for personnel support equipment. Manual hose stations outside the MCR and portable fire extinguishers are provided to fight MCR fires.

6.4.1 Safety Design Basis

The safety design bases discussed here apply only to the portion of the individual system providing the specified function. The range of applicability is discussed in subsection 6.4.4.

6.4.1.1 Main Control Room Design Basis

The habitability systems provide coverage for the main control room pressure boundary as defined in subsection 6.4.2.1. The following discussion summarizes the safety design bases with respect to the main control room:

- The habitability systems are capable of maintaining the main control room environment suitable for prolonged occupancy throughout the duration of the postulated accidents discussed in Chapter 15 that require protection from the release of radioactivity. Refer to

Section 3.1 and subsections 6.4.4 and 15.6.5.3 for a discussion on conformance with General Design Criterion 19 and to Section 1.9 for a discussion on conformance with Generic Issue B-66.

- The main control room is designed to withstand the effects of an SSE and a design-basis tornado.

- A maximum main control room occupancy of up to 11 persons can be accommodated.

- The radiation exposure of main control room personnel throughout the duration of the postulated limiting faults discussed in Chapter 15 does not exceed the limits set by General Design Criterion 19.

- The emergency habitability system maintains CO_2 concentration to less than 0.5 percent for up to 11 main control room occupants.

- The habitability systems provide the capability to detect and protect main control room personnel from external fire, smoke, and airborne radioactivity.

- Automatic actuation of the individual systems that perform a habitability systems function is provided. Smoke detectors, radiation detectors, and associated control equipment are installed at various plant locations as necessary to provide the appropriate operation of the systems.

- The habitability system provides the capability to provide passive air filtration for the main control room during VES operation. The filtration portion of the systems meets the intent of Regulatory Guide 1.52 (Reference 10).

6.4.1.2 Instrumentation and Control Room/DC Equipment Rooms Design Basis

The habitability systems are also designed to service the instrumentation and control rooms and dc equipment rooms. The habitability systems are capable of maintaining the temperature in the instrumentation and control rooms and dc equipment rooms below the equipment qualification temperature limit throughout the duration of the postulated accidents discussed in Chapter 15, an SSE, or design-basis tornado.

6.4.2 System Description

Only the main control room emergency habitability system is discussed in this subsection. The remaining systems are described only as necessary to define their functions in meeting the safety-related design bases of the habitability systems. Descriptions of the nuclear island nonradioactive ventilation system, fire protection system, plant lighting system, and radiation monitoring system are found in subsections 9.4.1, 9.5.1, 9.5.3, and Section 11.5, respectively.

6.4.2.1 Definition of the Main Control Room Pressure Boundary

The main control room pressure boundary is located on elevation 117′-6″ in the auxiliary building, on the nuclear island. As shown in Figure 6.4-1, the pressure boundary encompasses the main control area, operations work area, operations break room, shift supervisor's office, kitchen, and toilet facilities. The pressure boundary is represented by the line around the periphery of the boundary in the figure. The stairwell leading down to elevation 100′ and the area within the vestibule are specifically excluded from the boundary.

The areas, equipment, and materials to which the main control room operator requires access during a postulated accident are shown in Figure 6.4-1. This figure is a subset of Figure 1.2-8. Areas adjacent to the main control room are shown in Figures 1.2-25 and 1.2-31. The layout, size, and ergonomics of the operator workstations and wall panel information system depicted in Figure 6.4-1 do not reflect the results of the design process described in Chapter 18. The actual size, shape, ergonomics, and layout of the operator workstations and wall panel information system is an output of the design process in Chapter 18.

6.4.2.2 General Description

The main control room emergency habitability system air storage tanks are sized to deliver the required air flow to the main control room and induce sufficient air flow through the passive filtration line to meet the ventilation and pressurization requirements for 72 hours based on the performance requirements of subsection 6.4.1.1. Normal system makeup is provided by a connection to the breathable quality air compressor in the compressed and instrument air system (CAS). See subsection 9.3.1 for a description of the CAS. A connection for refilling operation is provided in the CAS.

Flow from the air storage tanks induces a filtration flow of at least 600 cfm. Testing was conducted to validate that the passive filtration line is capable of inducing a filtration flow of at least 600 cfm greater than the design flow rate from the VES emergency air storage tanks. The testing is documented in TR-SEE-III-09-03 (Reference 12). The filtration flow passes through a series of silencers to maintain acceptable main control room noise levels. The passive filtration portion of the system includes a HEPA filter, a charcoal adsorber, and a downstream postfilter. The filters are configured to satisfy the guidelines of Regulatory Guide 1.52 (Reference 10). The air intake to the passive filtration ductwork is located near the operations work area. The ductwork is routed behind the main control area through the operations break room to reduce the overall noise level in the main control area. The filtered air supply is then distributed to three supply locations that are sufficiently separated from the air intake to avoid short circuiting of the air flow. Two of the supply locations are located inside the main control area. Flow dampers ensure the filtered air is properly distributed throughout the main control room envelope.

The function of providing passive heat sinks for the main control room, instrumentation and control rooms, and dc equipment rooms is part of the main control room emergency habitability system. The heat sinks for each room are designed to limit the temperature rise inside each room during the 72-hour period following a loss of nuclear island nonradioactive ventilation system operation. The heat sinks consist primarily of the thermal mass of the concrete that makes up the ceilings and walls of these rooms.

To enhance the heat-absorbing capability of the ceilings, a metal form is attached to the interior surface of the concrete at selected locations. Metallic plates are attached perpendicular to the form. These plates extend into the room and act as thermal fins to enhance the heat transfer from the room air to the concrete. The specifics of the fin construction for the main control room and I&C room ceilings are described in subsection 3.8.4.1.2.

The normal operating temperatures in the main control room, instrumentation and control rooms, dc equipment rooms, and adjacent rooms are kept within a specified range by the nuclear island nonradioactive ventilation system in order to maintain a design basis initial heat sink capacity of each room. See subsection 9.4.1 for a description of the nuclear island nonradioactive ventilation system.

In the unlikely event that power to the nuclear island nonradioactive ventilation system is unavailable for more than 72 hours, MCR habitability is maintained by operating one of the two MCR ancillary fans to supply outside air to the MCR. See subsection 9.4.1 for a description of this cooling mode of operation. Doors and ducts may be opened to provide a supply pathway and an exhaust pathway. Likewise, outside air is supplied to division B and C instrumentation and control rooms in order to maintain the ambient temperature below the qualification temperature of the equipment.

The main control room emergency habitability system piping and instrumentation diagram is shown in Figure 6.4-2.

6.4.2.3 Component Description

The main control room emergency habitability system compressed air supply contains a set of storage tanks connected to a main and an alternate air delivery line. Components common to both lines include a manual isolation valve and a pressure regulating valve. Single active failure protection is provided by the use of redundant, remotely operated isolation valves, which are located within the MCR pressure boundary. In the event of insufficient or excessive flow in the main delivery line, the main delivery line is isolated and the alternate delivery line is manually actuated. The alternate delivery line contains the same components as the main delivery line with the exception of the remotely operated isolation valves, and thus is capable of supplying compressed air to the MCR pressure boundary at the required air flowrate. The VES piping and penetrations for the MCR envelope are designated as equipment Class C. Additional details on Class C designation are provided in subsection 3.2.2.5. The classification of VES components is provided in Table 3.2-3, as appropriate.

- Emergency Air Storage Tanks

  There are a total of 32 air storage tanks. The air storage tanks are constructed of forged, seamless pipe, with no welds, and conform to Section VIII and Appendix 22 of the ASME Code. The design pressure of the air storage tanks is 4000 psi. The storage tanks collectively contain a minimum storage capacity of 327,574 scf.

- Pressure Regulating Valve

  Each compressed air supply line contains a pressure regulating valve located downstream of the common header. The pressure at the outlet of the valve is controlled via a two-staged self-contained pressure control operator. A failure of either stage of the pressure regulating valve will not cause the valve to fail completely open. A failure of the second stage of the pressure regulating valve will increase flow from the emergency air storage tanks. There is adequate margin in the emergency air storage tanks such that an operator has time to isolate the line and manually actuate the alternate delivery line.

- Flow Metering Orifice

  The flow rate of air delivered to the main control room pressure boundary is limited by an orifice located downstream of the pressure regulating valve in the eductor and in the eductor bypass line. The orifice is sized to provide the required air flow rate to the main control room pressure boundary.

- Air Delivery Main Isolation Valve

  The pressure boundary of the compressed air storage tanks is maintained by normally closed remotely operated isolation valves in the main supply line. These valves are located within MCR pressure boundary downstream of the pressure regulating valve and automatically initiate air flow upon receipt of a signal to open (see subsection 6.4.3.2).

- Pressure Relief Isolation Valve

  To limit the pressure increase within the main control room, isolation valves are provided, one in each of redundant flowpaths, which open on a time delay after receipt of an emergency habitability system actuation signal. The valves provide a leak tight seal to protect the integrity of the main control room pressure boundary during normal operation, and are normally closed to prevent interference with the operation of the nonradioactive ventilation system.

- Main Air Flowpath Isolation Valve

  The main air flowpath contains a normally open, manually operated valve located within the MCR pressure boundary, downstream of the remotely operated air delivery main isolation valves. The valve is provided as a means of isolating and preserving the air storage tank's contents in the event of a pressure regulating valve malfunction.

- Air Delivery Alternate Isolation Valve

  The alternate air delivery flowpath contains a normally closed, manually operated valve, located within the MCR pressure boundary. The valve is provided as a means of manually activating the alternate air delivery flowpath in the event the main air delivery flowpath is inoperable.

- Pressure Relief Damper

  Pressure relief dampers are located downstream of the butterfly isolation valves, and are set to open on a differential pressure of at least 1/8-inch water gauge with respect to the surrounding areas. The differential pressure between the control room and the surrounding area location is monitored to ensure that a positive pressure is maintained in the control room with respect to its surroundings.

  The pressure relief dampers discharge through the MCR vestibule in order to reduce the amount of radioactivity that can be transported into the MCR when operators enter. Two vestibule discharge openings provide a purge flow path from the vestibule to the corridor.

- Eductor

  An eductor is connected to the discharge of the VES makeup line from the emergency air storage tanks and to ductwork located inside the main control room envelope that comprises the passive filtration portion of the VES. The eductor works by directing compressed air from the VES storage tanks through a specially designed nozzle to create a powerful vacuum that draws air from the main control room through the surrounding ductwork into the passive air filtration line. The eductor is designed to create a vacuum capable of drawing at least 600 scfm of flow into the passive air filtration system. This flow rate is based on a VES makeup flow of 65 ± 5 scfm at an approximate pressure of 50 psig at the discharge of the bottled air supply to the eductor. The eductor has no electrical power requirements, contains no moving parts, and requires no maintenance such as adjusting setpoints or lubricating bearings.

- High-Efficiency Particulate (HEPA) Filter, Charcoal Adsorber, and Postfilter

  The main control room passive filtration flowpath contains a HEPA filter in series with a charcoal adsorber and a postfilter. They work to remove particulate and iodine from the air to reduce potential control room dose during VES operation.

  HEPA filters are constructed, qualified, and tested in accordance with UL-586 (Reference 9) and ASME AG-1 (Reference 7), Section FC. Each HEPA filter cell is individually shop tested to verify an efficiency of at least 99.97 percent using a monodisperse 0.3-μm aerosol in accordance with ASME AG-1 (Reference 7), Section TA.

  The charcoal adsorber is designed, constructed, qualified, and tested in accordance with ASME AG-1 (Reference 7), Section FD; and Regulatory Guide 1.52. Each charcoal adsorber is an assembly with 2-inch deep Type II adsorber cells, conforming to IE Bulletin 80-03 (Reference 8).

  Postfilters downstream of the charcoal filters have a minimum DOP efficiency of 95 percent. The filters meet UL 900 (Reference 11) Class I construction criteria.

- Silencers

  Two silencers are located in the passive air filtration line. One silencer is located downstream of the eductor, and the other silencer is located upstream of the eductor. The silencers are designed to reduce the noise created by the passive air filtration line.

- Control Room Access Doors

  Two sets of doors, with a vestibule between, are provided at the access to the main control room.

- Breathing Apparatus

  Self-contained portable breathing equipment with air bottles is stored inside the main control room pressure boundary. The amount of stored air is sufficient to provide a 6-hour supply of breathable air for up to 11 main control room occupants. This is backup protection to the permanently installed habitability systems.

6.4.2.4 Leaktightness

The main control room pressure boundary is designed for low leakage. It consists of cast-in-place reinforced concrete walls and slabs, and is constructed to minimize leakage through construction joints and penetrations. The following features are applied as needed in order to achieve this objective:

- The outside surface of penetrations sleeves in contact with concrete are sealed with epoxy crack sealer. The piping and electrical cable penetrations are sealed with qualified pressure-resistant material compatible with penetration materials and/or cable jacketing.

- The interior or exterior surfaces of the main control room envelope (walls, floor, and ceiling) are coated with low permeability paint/epoxy sealant.

- Inside surfaces of penetrations and sleeves in contact with commodities (i.e., pipes and conduits, etc.) are sealed. Main control room pressure boundary HVAC isolation valves are qualified to shut tight against control room pressure.

- Penetration sealing materials are designed to withstand at least 1/4-inch water gauge pressure differential in an air pressure barrier. Penetration sealing material is a silicone-based material or equivalent.

- There is no HVAC duct that penetrates the main control room pressure boundary. The portions of the nuclear island nonradioactive ventilation system (VBS) that penetrate the main control room pressure boundary are safety-related piping that include redundant safety-related seismic Category I isolation valves that are physically located within the main control room envelope.

The piping, conduits, and electrical cable trays penetrating through any combination of main control room pressure boundary are sealed with seal assembly compatible with the materials of penetration commodities. Penetration sealing materials are selected to meet barrier design requirements and are designed to withstand specific area environmental design requirements and remain functional and undamaged during and following an SSE. There are no adverse environmental effects on the MCR sealant materials resulting from postulated spent fuel pool boiling events.

The main control room pressure boundary main entrance is designed with a double-door vestibule, which is purged by the pressure relief damper discharge flow during main control room emergency habitability system operation. The emergency exit door (stairs to elevation 100′) is normally closed, and remains closed under design basis source term conditions. Administrative controls prohibit the emergency exit door to the remote shutdown workstation from being used for normal ingress and egress during VES operation.

When the main control room pressure boundary is isolated in an accident situation, there is no direct communication with the outside atmosphere, nor is there communication with the normal ventilation system. Leakage from the main control room pressure boundary is the result of an internal pressure of at least 1/8-inch water gauge provided by emergency habitability system operation.

The exfiltration and infiltration analysis for nuclear island nonradioactive ventilation system operation is discussed in subsection 9.4.1.

6.4.2.5 Interaction with Other Zones and Pressurized Equipment

The main control room emergency habitability system is a self-contained system. There is no interaction between other zones and pressurized equipment.

For a discussion of the nuclear island nonradioactive ventilation system, refer to subsection 9.4.1.

6.4.2.6 Shielding Design

The design basis loss-of-coolant accident (LOCA) dictates the shielding requirements for the main control room. Main control room shielding design bases are discussed in Section 12.3. Descriptions of the design basis LOCA source terms, main control room shielding parameters, and evaluation of doses to main control room personnel are presented in Section 15.6.

The main control room and its location in the plant are shown in Figure 12.3-1.

6.4.3 System Operation

This subsection discusses the operation of the main control room emergency habitability system.

6.4.3.1 Normal Mode

The main control room emergency habitability system is not required to operate during normal conditions. The nuclear island nonradioactive ventilation system maintains the air temperature of a number of rooms within a predetermined temperature range. The rooms with this requirement include the rooms with a main control room emergency habitability system passive heat sink design and their adjacent rooms.

6.4.3.2 Emergency Mode

Operation of the main control room emergency habitability system is automatically initiated by either of the following conditions:

- “High-high” particulate or iodine radioactivity in the main control room supply air duct
- Loss of ac power for more than 10 minutes

Operation can also be initiated by manual actuation.

The nuclear island nonradioactive ventilation system is isolated from the main control room pressure boundary by automatic closure of the isolation devices located in the nuclear island nonradioactive ventilation system ductwork if radiation levels in the main control room supply air duct exceed the “high-high” setpoint or if ac power is lost for more than 10 minutes. At the same time, the main control room emergency habitability system begins to deliver air from the emergency air storage tanks to the main control room by automatically opening the isolation valves located in the supply line. The relief damper isolation valves also open allowing the pressure relief dampers to function and discharge the damper flow to purge the vestibule.

After the main control room emergency habitability system isolation valves are opened, the air supply pressure is regulated by a self-contained regulating valve. This valve maintains a constant downstream pressure regardless of the upstream pressure. A constant air flow rate is maintained by the flow metering orifice downstream of the pressure regulating valve. This flow rate is sufficient to maintain the main control room pressure boundary at least 1/8-inch water gauge positive differential pressure with respect to the surroundings and induce a flow rate of at least 600 cfm into the passive air filtration line. The main control room emergency habitability system air flow rate is also sufficient to maintain the carbon dioxide levels below 0.5 percent concentration for 11 occupants and to maintain air quality within the guidelines of Table 1 and Appendix C, Table C-1, of Reference 1.

The emergency air storage tanks are sized to provide the required air flow to the main control room pressure boundary for 72 hours. After 72 hours, the main control room is cooled by drawing in outside air and circulating it through the room, as discussed in subsection 6.4.2.2.

The temperature and humidity in the main control room pressure boundary following a loss of the nuclear island nonradioactive ventilation system remain within limits for reliable human performance (References 2 and 3) over a 72-hour period. The initial values of temperature/relative humidity in the MCR are 75°F/60 percent. At 3 hours, when the non-1E battery heat loads are exhausted, the conditions are 87.2°F/41 percent. At 24 hours, when the 24 hour battery heat loads are terminated, the conditions are 84.4°F/45 percent. At 72 hours, the conditions are 85.8°F/39 percent.

Sufficient thermal mass is provided in the walls and ceiling of the main control room to absorb the heat generated by the equipment, lights, and occupants. The temperature in the instrumentation and control rooms and dc equipment rooms following a loss of the nuclear island nonradioactive ventilation system remains below acceptable limits as discussed in subsection 6.4.4. As in the main control room, sufficient thermal mass is provided surrounding these rooms to absorb the heat generated by the equipment. After 72 hours, the instrumentation and control rooms will be cooled by drawing in outside air and circulating it through the room, as discussed in subsection 6.4.2.2.

In the event of a loss of ac power, the nuclear island nonradioactive ventilation system isolation valves automatically close and the main control room emergency habitability system isolation valves automatically open. These actions protect the main control room occupants from a potential radiation release. In instances in which there is no radiological source term present, the compressed air storage tanks are refilled via a connection to the breathable quality air compressor in the compressed and instrument air system (CAS). The compressed air storage tanks can also be refilled from portable supplies by an installed connection in the CAS.

6.4.4 System Safety Evaluation

In the event of an accident involving the release of radioactivity to the environment, the nuclear island nonradioactive ventilation system (VBS) is expected to switch from the normal operating mode to the supplemental air filtration mode to protect the main control room personnel. Although the VBS is not a safety-related system, it is expected to be available to provide the necessary protection for realistic events. However, the design basis accident doses reported in Chapter 15 utilize conservative assumptions, and the main control room doses are calculated based on operation of the safety-related emergency habitability system (VES) since this is the system that is relied upon to limit the amount of activity the personnel are exposed to. The analyses assume that the VBS is initially in operation, but fails to enter the supplemental air filtration mode on a High-1 radioactivity indication in the main control room atmosphere. VES operation is then assumed to be initiated once the High-2 level for control room atmosphere activity is reached.

Doses are also calculated assuming that the VBS does operate in the supplemental air filtration mode as designed, but with no switchover to VES operation. This VBS operating case demonstrates the defense-in-depth that is provided by the system and also shows that, in the event of an accident with realistic assumptions, the VBS is adequate to protect the control room operators without depending on VES operation.

Doses were determined for the following design basis:

	VES Operating	VBS Operating
Large Break LOCA	4.41 rem TEDE	4.73 rem TEDE
Fuel Handling Accident	2.5 rem TEDE	1.6 rem TEDE
Steam Generator Tube Rupture		
(Pre-existing iodine spike)	4.3 rem TEDE	3.1 rem TEDE
(Accident-initiated iodine spike)	1.2 rem TEDE	1.7 rem TEDE

Steam Line Break		
(Pre-existing iodine spike)	3.9 rem TEDE	2.1 rem TEDE
(Accident-initiated iodine spike)	4.0 rem TEDE	4.9 rem TEDE
Rod Ejection Accident	1.8 rem TEDE	2.2 rem TEDE
Locked Rotor Accident		
(Accident without feedwater available)	0.7 rem TEDE	0.5 rem TEDE
(Accident with feedwater available)	0.5 rem TEDE	1.5 rem TEDE
Small Line Break Outside Containment	0.8 rem TEDE	0.3 rem TEDE

For all events the doses are within the dose acceptance limit of 5.0 rem TEDE. The details of analysis assumptions for modeling the doses to the main control room personnel are delineated in the LOCA dose analysis discussion in subsection 15.6.5.3 for VES operating cases. The analysis assumptions are provided in subsection 9.4.1.2.3.1 for the VBS operating case.

No radioactive materials are stored or transported near the main control room pressure boundary.

As discussed and evaluated in subsection 9.5.1, the use of noncombustible construction and heat and flame resistant materials throughout the plant reduces the likelihood of fire and consequential impact on the main control room atmosphere. Operation of the nuclear island nonradioactive ventilation system in the event of a fire is discussed in subsection 9.4.1.

The exhaust stacks of the onsite standby power diesel generators are located in excess of 150 feet away from the fresh air intakes of the main control room. The onsite standby power system fuel oil storage tanks are located in excess of 300 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.

The protection of the operators in the main control room from offsite toxic gas releases is discussed in Section 2.2. The sources of onsite chemicals are described in Table 6.4-1, and their locations are shown on Figure 1.2-2. Analysis of these sources is in accordance with Regulatory Guide 1.78 (Reference 5) and the methodology in NUREG-0570, "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release" (Reference 6), and the analysis shows that these sources do not represent a toxic or flammability hazard to control room personnel.

A supply of protective clothing, respirators, and self-contained breathing apparatus adequate for 11 persons is stored within the main control room pressure boundary.

The main control room emergency habitability system components discussed in subsection 6.4.2.3 are arranged as shown in Figure 6.4-2. The location of components and piping within the main control room pressure boundary provides the required supply of compressed air to the main control room pressure boundary, as shown in Figure 6.4-1.

During emergency operation, the main control room emergency habitability system passive heat sinks are designed to limit the temperature inside the main control room to remain within limits for reliable human performance (References 2 and 3) over 72 hours. The passive heat sinks limit the air temperature inside the instrumentation and control rooms to 120°F and dc equipment rooms to 120°F. The walls and ceilings that act as the passive heat sinks contain sufficient thermal mass to accommodate the heat sources from equipment, personnel, and lighting for 72 hours.

The main control room emergency habitability system nominally provides 65 scfm of ventilation air to the main control room from the compressed air storage tanks. Sixty scfm of supplied ventilation flow is sufficient to induce a filtration flow of at least 600 cfm into the passive air filtration line located inside the main control room envelope. This ventilation flow is also sufficient to pressurize the control room to at least positive 1/8-inch water gauge differential pressure with respect to the surrounding areas in addition to limiting the carbon dioxide concentration below one-half percent by volume for a maximum occupancy of 11 persons and maintaining air quality within the guidelines of Table 1 and Appendix C, Table C-1, of Reference 1.

Automatic transfer of habitability system functions from the main control room/control support area HVAC subsystem of the nuclear island nonradioactive ventilation system to the main control room emergency habitability system is initiated by either the following conditions:

- “High-high” particulate or iodine radioactivity in MCR air supply duct
- Loss of ac power for more than 10 minutes

The airborne fission product source term in the reactor containment following the postulated LOCA is assumed to leak from the containment and airborne fission products are assumed to result from spent fuel pool steaming. The concentration of radioactivity, which is assumed to surround the main control room, after the postulated accident, 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 main control room takes into consideration the radiological decay of fission products and the infiltration/exfiltration rates to and from the main control room pressure boundary.

A single active failure of a component of the main control room emergency habitability system or nuclear island nonradioactive ventilation system does not impair the capability of the systems to accomplish their intended functions. The Class 1E components of the main control room emergency habitability system are connected to independent Class 1E power supplies. Both the main control room emergency habitability system and the portions of the nuclear island nonradioactive ventilation system which isolates the main control room are designed to remain functional during an SSE or design-basis tornado.

In accordance with SECY-77-439 (Reference 13), a single passive failure of a component in the passive filtration line in the main control room emergency habitability system does not impair the capability of the system to accomplish its intended function. There is no source that could create line blockage in the VES line from the air bottles to the eductor. Thus potential blockage in the filtration line does not preclude breathable air from the emergency air storage tanks from being delivered to the main control room envelope for 72 hours during VES operation. Passive filtration using the main control room habitability system is not required to maintain operator dose rates below the acceptance limit of 5.0 rem TEDE 24 hours after the initiation of a design basis event. The dose rates for the following limiting cases were determined to demonstrate that passive filtration is not required 24 hours after the initiation of a design basis event. The following cases are evaluated since they involve releases that extend beyond 24 hours after the initiation of the event:

Large Break LOCA	4.5 rem TEDE
Steam Line Break	
(Pre-existing iodine spike)	4.0 rem TEDE
(Accident-initiated iodine spike)	4.5 rem TEDE

For all events, the doses are within the dose acceptance limit of 5.0 rem TEDE. The details of analysis assumptions for modeling the doses to the main control room personnel are the same as those delineated in the LOCA dose analysis discussion in subsection 15.6.5.3 assuming a passive failure disables the passive filtration flow path after 24 hours. Potential blockage in the filtration line does not preclude breathable air from the emergency air storage tanks from being delivered to the main control room envelope for 72 hours during VES operation. An eductor bypass line with a flow control orifice provides the operators with the ability to ensure that the breathable air from the emergency air storage tanks is delivered to the MCR.

6.4.5 Inservice Inspection/Inservice Testing

A program of preoperational and inservice testing requirements is implemented to confirm initial and continued system capability. The VES system is tested and inspected at appropriate intervals, as defined by the technical specifications. Emphasis is placed on tests and inspections of the safety-related portions of the habitability systems.

6.4.5.1 Preoperational Inspection and Testing

Preoperational testing of the main control room emergency habitability system is performed to verify that the air flow rate of 65 ± 5 scfm is sufficient to induce a flow rate of at least 600 cfm into the passive air filtration line and maintain pressurization of the main control room envelope of at least 1/8-inch water gauge with respect to the adjacent areas. 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 preoperational testing also verifies that the VES pressure regulating valves are capable of maintaining the VES flow rate of 65 ± 5 scfm over the operating range of expected valve inlet pressures. The pressurization of the control room limits the ingress of radioactivity, and the recirculation through the passive air filtration line maintains operator dose limits below regulatory limits. Air quality within the MCR environment is confirmed to be within the guidelines of Table 1 and Appendix C, Table C-1, of Reference 1 by analyzing air samples taken during the pressurization test.

The storage capacity of the compressed air storage tanks is verified to be in excess of 327,574 scf of compressed air. This amount of compressed air will assure 72 hours of air supply to the main control room.

An inspection will verify that the heat loads within the rooms identified in Table 6.4-3 are less than the specified values.

Preoperational testing of the main control room isolation valves in the nuclear island nonradioactive ventilation system is performed to verify the leaktightness of the valves.

Preoperational testing for main control room envelope habitability during VES operation will be conducted in accordance with ASTM E741 (Reference 4). Where possible, inleakage testing is performed in conjunction with the VES system level operability testing since the VES must be in operation to perform the inleakage testing. See Note 7 of Table 3.9-17 for additional information on the VES system level operability test.

Testing and inspection of the radiation monitors is discussed in Section 11.5. The other tests noted above are discussed in Chapter 14.

6.4.5.2 Inservice Testing

Inservice testing of the main control room emergency habitability system and nuclear island nonradioactive ventilation system is conducted in accordance with the surveillance requirements specified in the technical specifications in Chapter 16.

ASTM E741 testing of the main control room pressure boundary is conducted in accordance with the frequency specified in the technical specifications.

6.4.5.3 Air Quality Testing

Connections are provided for sampling the air supplied from the compressed and instrument air system and for periodic sampling of the air stored in the storage tanks. Air samples of the compressed air storage tanks are taken quarterly and analyzed for acceptable air quality within the guidelines of Table 1 and Appendix C, Table C-1, of Reference 1.

6.4.5.4 Main Control Room Envelope Habitability

Testing for main control room envelope habitability during VES operation will be conducted in accordance with ASTM E741 (Reference 4).

The main control room envelope must undergo an analysis of inleakage into the control room envelope to determine the integrity of the control room envelope boundary during a design basis accident, hazardous chemical release, or smoke event. Baseline control room envelope habitability testing will be performed as discussed in subsection 6.4.5.1, followed by a self-assessment at three (3) years after successful baseline testing, and a periodic test at six (6) years in conjunction with other ASME inservice testing requirements. The self-assessment of the ability to maintain main control room habitability includes a review of procedures, boundaries, design changes, maintenance activities, safety analyses, and other related determinations.

If periodic testing is successful, then the assessment/testing cycle continues with a self-assessment three (3) years later and periodic testing three (3) years after the self-assessment. If a periodic testing is unsuccessful, then a periodic test is required three (3) years after repair and successful re-testing, following the unsuccessful periodic testing, to ensure there is no accelerated degradation of the main control room boundary or discrepancies in control of the main control room habitability.

In addition to periodic tests, control room envelope testing will also be performed when changes are made to structures, systems, and components that could impact control room envelope integrity, including systems internal and external to the control room envelope. The tests must be commensurate with the types and degrees of modifications and repairs and the potential impact upon integrity. Additional control room envelope testing will also be performed if a new limiting condition or alignment arises for which no inleakage data is available. Test failure is considered to be inleakage in excess of the licensing basis value for the particular challenge to control room envelope integrity.

Where possible, inleakage testing is performed in conjunction with the VES system level operability testing since the VES must be in operation to perform the inleakage testing. See Note 7 of Table 3.9-17 for additional information on the VES system level operability test.

6.4.6 Instrumentation Requirements

The indications in the main control room used to monitor the main control room emergency habitability system and nuclear island nonradioactive ventilation system are listed in Table 6.4-2.

Instrumentation required for actuation of the main control room emergency habitability system and nuclear island nonradioactive ventilation system are discussed in subsection 7.3.1.

Details of the radiation monitors used to provide the main control room indication of actuation of the nuclear island nonradioactive ventilation system supplemental filtration mode of operation and actuation of main control room emergency habitability system operation are given in Section 11.5.

A description of initiating circuits, logic, periodic testing requirements, and redundancy of instrumentation relating to the habitability systems is provided in Section 7.3.

6.4.7 Combined License Information

Combined License applicants referencing the AP1000 certified design are responsible for the amount and location of possible sources of hazardous chemicals in or near the plant and for seismic Category I Class 1E hazardous chemical monitoring, as required. Regulatory Guide 1.78 (Reference 5) addresses control room protection for hazardous chemicals and evaluation of offsite hazardous chemical releases (including the potential for hazardous chemical releases beyond 72 hours) in order to meet the requirements of TMI Action Plan Item III.D.3.4 and GDC 19.

Combined License applicants referencing the AP1000 certified design are responsible for verifying that procedures and training for control room envelope habitability are consistent with the intent of Generic Issue 83 (see Section 1.9).

The Combined License applicant testing frequency for the main control room envelope habitability is discussed in subsection 6.4.5.4.

6.4.8 References

1. "Ventilation for Acceptable Indoor Air Quality," ASHRAE Standard 62 - 1989.

2. "Human Engineering Design Guidelines," MIL-HDBK-759C, 31 July 1995.

3. "Human Engineering," MIL-STD-1472E, 31 October 1996.

4. "Standard Test Methods for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution," ASTM E741, 2000.

5. "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Regulatory Guide 1.78, Revision 1, December 2001.

6. NUREG-0570, "Toxic Vapor Concentrations in the Control Room Following a Postulated Accidental Release," June 1979.

7. "Code on Nuclear Air and Gas Treatment," ASME/ANSI AG-1-1997.

8. "Loss of Charcoal Adsorber Cells," IE Bulletin 80-03, 1980.

9. "High-Efficiency, Particular, Air-Filter Units," UL-586, 1996.

10. "Design, Testing, and Maintenance Criteria for Post Accident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants," Regulatory Guide 1.52, Revision 3, 2001.

11. "Test Performance of Air-Filter Units," UL-900, 1994.

12. "AP1000 VES Air Filtration System Test Report," TR-SEE-III-09-03.

13. "Single Failure Criterion," SECY-77-439.

Table 6.4-1

ONSITE CHEMICALS

Material	State	Location
Hydrogen	Liquid/Gas	Gas storage/Yard at Turbine Building
Nitrogen	Liquid	Gas storage
CO_2	Liquid	Gas storage
Oxygen Scavenger	Liquid	Turbine building
pH Addition	Liquid	Turbine building, CWS area[(a)]
Sulfuric Acid	Liquid	Turbine building, CWS area[(a)]
Sodium Hydroxide	Liquid	Turbine building, CWS area[(a)]
Dispersant[(a)]	Liquid	Turbine building, CWS area[(a)]
Fuel Oil	Liquid	DG fuel oil storage tank/DG building/Annex building
Corrosion Inhibitor	Liquid	Turbine building, CWS area[(a)]
Scale Inhibitor	Liquid	Turbine building, CWS area[(a)]
Biocide/Disinfectant	Liquid	Turbine building, CWS area[(a)]
Algaecide	Liquid	Turbine building, CWS area[(a)]

Note:
a. Site-specific

Table 6.4-2

MAIN CONTROL ROOM HABITABILITY INDICATIONS AND ALARMS

VES emergency air storage tank pressure (indication and low and low-low alarms)
VES MCR pressure boundary differential pressure (indication and high and low alarms)
VES air delivery line flowrate (indication and high and low alarms)
VES passive filtration flow rate (indication and high and low alarms)
VBS main control room supply air radiation level (high-high alarms)
VBS outside air intake smoke level (high alarm)
VBS isolation valve position
VBS MCR pressure boundary differential pressure

Table 6.4-3

LOSS OF AC POWER HEAT LOAD LIMITS

Room Name	**Room Numbers**	**Heat Load 0 to 24 Hours (Btu/sec)**	**Heat Load 24 to 72 Hours (Btu/sec)**
MCR Envelope	12401	12.823 (Hour 0 through 3) 5.133 (Hour 4 through 24)	3.928
I&C Rooms	12301, 12305	8.854	0
I&C Rooms	12302, 12304	13.07	4.22
dc Equipment Rooms	12201, 12205	3.792 (Hour 0 through 1) 2.465 (Hour 2 through 24)	0
dc Equipment Rooms	12203, 12207	5.84 (Hour 0 through 1) 4.51 (Hour 2 through 24)	2.05

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Figure 6.4-1

Main Control Room Envelope

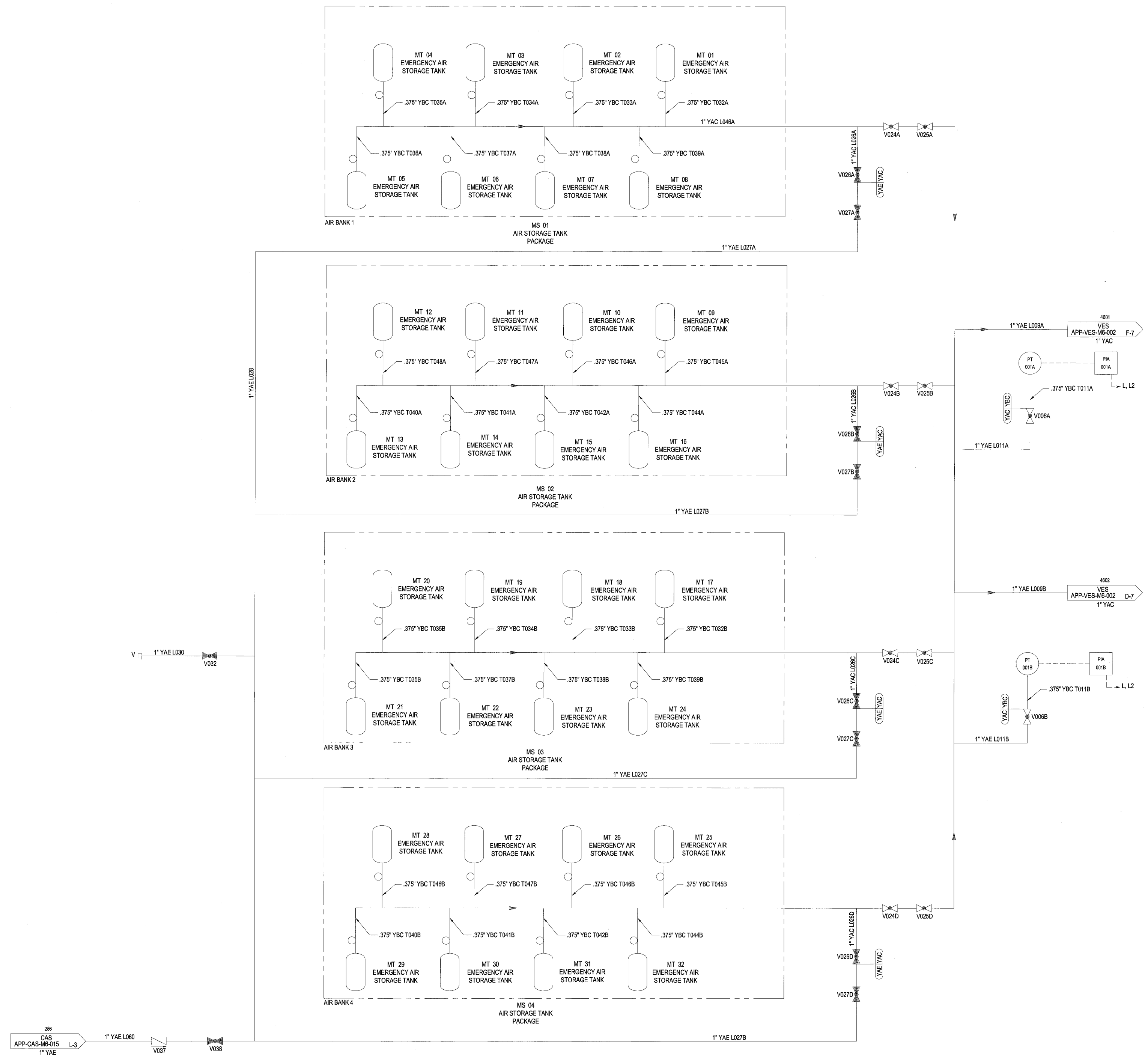
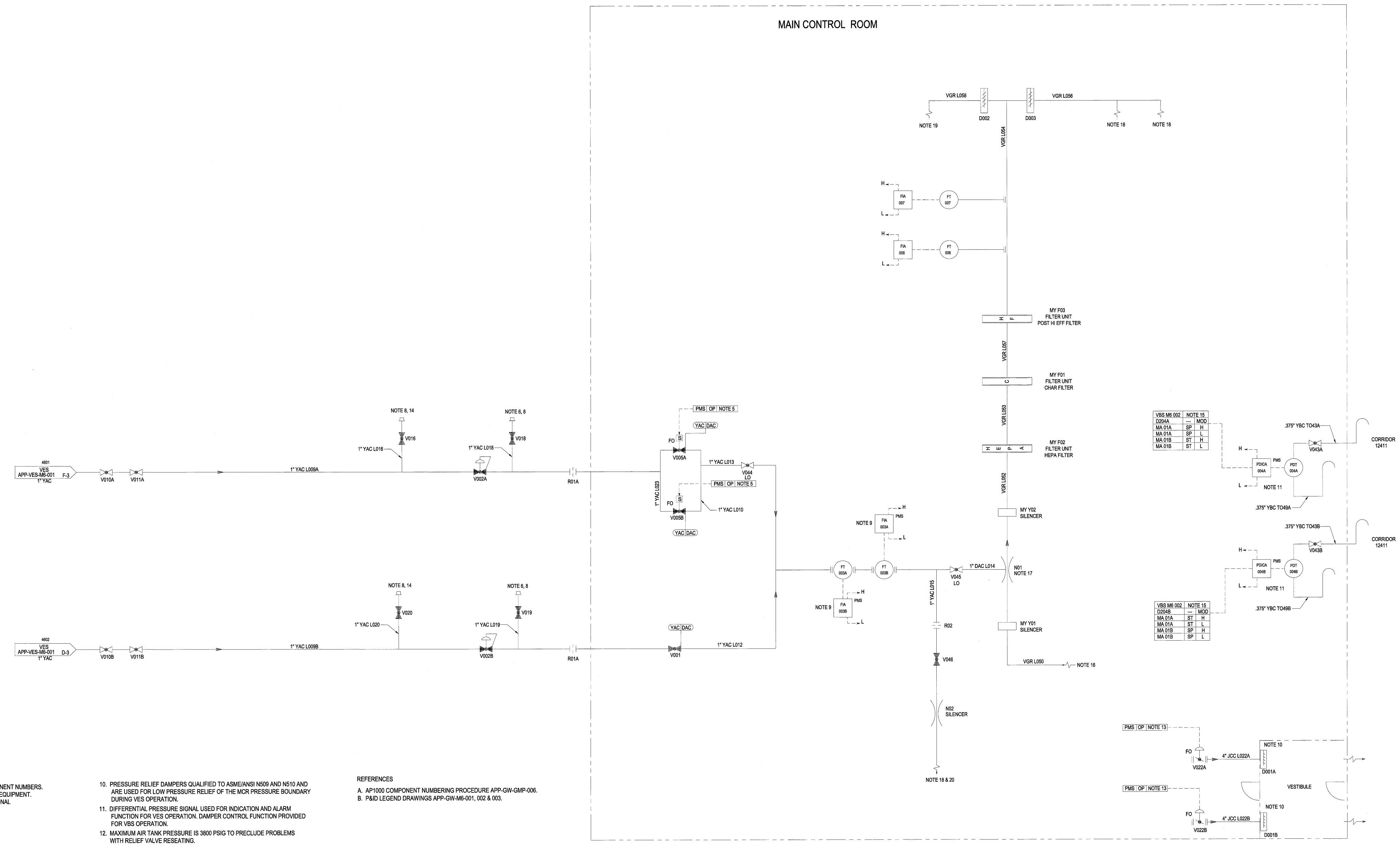


Figure 6.4-2 (Sheet 1 of 2)

Main Control Room Habitability System
Piping and Instrumentation Diagram



NOTES:

1. THE SYSTEM LOCATOR CODE "APP-VES" HAS BEEN OMITTED FROM ALL COMPONENT NUMBERS. THE COMPONENT CODE HAS BEEN OMITTED FROM ALL COMPONENTS EXCEPT EQUIPMENT. REFER TO THE P&ID LEGEND DRAWING APP-GW-M6-001, 002 & 003 FOR ADDITIONAL INFORMATION REGARDING COMPONENT NUMBERING.
2. REFER TO SYSTEM DESCRIPTIONS FOR A DETAILED DESCRIPTION OF ALL INSTRUMENTATION AND CONTROLS.
3. SYSTEM IS FILLED AND REFILLED USING BREATHABLE QUALITY AIR SOURCE.
4. REFER TO DRAWING APP-VBS-M6-002 FOR NORMAL HVAC SYSTEM.
5. REFER TO APP-PMS-J1-113 FOR DESCRIPTION OF LOGIC.
6. TEMPORARY PRESSURE INSTRUMENT CONNECTION TO PERMIT ADJUSTMENT OF PRESSURE REGULATOR VALVES.
7. DELETED.
8. TUBING PLUG CLOSURES ARE NOW FITTED WITH AN INTERGRAL BLEED MECHANISM TO RELIEVE LINE PRESSURE.
9. LOW FLOW ALARM TO BE ACTIVATED ON TIME DELAY AFTER VES ACTUATION.
10. PRESSURE RELIEF DAMPERS QUALIFIED TO ASME/ANSI N509 AND N510 AND ARE USED FOR LOW PRESSURE RELIEF OF THE MCR PRESSURE BOUNDARY DURING VES OPERATION.
11. DIFFERENTIAL PRESSURE SIGNAL USED FOR INDICATION AND ALARM FUNCTION FOR VES OPERATION. DAMPER CONTROL FUNCTION PROVIDED FOR VBS OPERATION.
12. MAXIMUM AIR TANK PRESSURE IS 3800 PSIG TO PRECLUDE PROBLEMS WITH RELIEF VALVE RESEATING.
13. PRESSURE RELIEF ISOLATION VALVE TO BE ACTUATED ON TIME DELAY AFTER VES ACTUATION SIGNAL.
14. TEMPORARY PRESSURE INSTRUMENT CONNECTION.
15. VBS DAMPER CONTROL PROVIDED VIA PLS.
16. THE AIR INTAKE SHOULD BE LOCATED ABOVE THE INNER VESTIBULE DOOR. A 12/24 EGG CRATE GRILL MINIMUM IS REQUIRED.
17. N01 IS AN EDUCTOR / AIR AMPLIFIER.
18. DISCHARGES INTO MAIN CONTROL AREA.
19. DISCHARGES INTO SHIFT MANAGER'S OFFICE.
20. THE DISCHARGE OF THIS PIPING WILL CONTAIN A LINE SILENCER / MUFFLER (N02).

REFERENCES

A. AP1000 COMPONENT NUMBERING PROCEDURE APP-GW-GMP-006.
B. P&ID LEGEND DRAWINGS APP-GW-M6-001, 002 & 003.

Figure 6.4-2 (Sheet 2 of 2)

Main Control Room Habitability System
Piping and Instrumentation Diagram