6.4 HABITABILITY SYSTEMS

Habitability systems are designed to ensure habitability inside the control structure pressurization envelope during all normal and abnormal station operating conditions including the post LOCA requirements, in compliance with Design Criterion 19 of 10CFR50, Appendix A and 10CFR 50.67 for dose limits. Figures 6.4-1A, 6.4-1B, 6.4-1C, 6.4-1D and 6.4-1E show the control structure habitability zone. The areas covered include but not limited to the following rooms: Control Room, Technical Support Center (TSC), Operational Support Center (OSC), computer, relay, cable spreading, HVAC and battery rooms for both Units 1 and 2.

The habitability systems cover all the equipment, supplies, and procedures related to the control and auxiliary electrical equipment so that Control Room operators are safe against postulated releases of radioactive materials, noxious gases, smoke, and steam. Adequate water, sanitary facilities, and medical supplies are provided to meet the requirements of operating personnel during and after the accident. In addition, the environment of the Control Structure Envelope rooms are maintained to ensure the integrity of the contained safety related controls and equipment, during all the station operating conditions.

6.4.1 DESIGN BASES

The design bases of the habitability systems, upon which the functional design is established, are summarized as follows:

a) The control structure envelope is occupied continuously on a year-round basis. The occupancy of the operating personnel is ensured for a minimum of 5 days, after a design-basis accident (DBA).

b) HVAC systems for radiological habitability are designed to support personnel during normal and abnormal station operating conditions in the Control Structure Envelope.

c) Kitchen, sanitary facilities, and medical supplies for minor injuries are provided for the use of five Control Room personnel for five days during normal and accident conditions.

d) The radiological effects on the Control Structure Envelope that could exist as a consequence of any accident described in Chapter 15 will not exceed the guidelines set by 10CFR 50.67.

e) The design includes provisions to preclude the effects of smoke from inside or outside the plant from inhibiting the habitability of the Control Room, TSC and OSC.

f) Eye washes and emergency showers are located on the battery room floor. Respiratory and skin protection for emergencies are provided within the Control Room.

g) The habitability systems are designed to operate effectively during and after the DBA with the simultaneous loss of offsite power, Safe Shutdown Earthquake, and failure of any one of the HVAC system active components.

h) Radiation monitors, and smoke detectors continuously monitor the outside air at the control structure envelope outside air intakes. The detection of high radiation, smoke is alarmed in the Control Room and related protection functions are simultaneously initiated for high radiation. The operator may isolate the control structure on smoke alarm at his discretion.

i) In the event of a Control Room evacuation, an Alternate Control Structure HVAC Control Panel provides for manual operation of the required HVAC components from outside the Control Room.

6.4.2 SYSTEM DESIGN

6.4.2.1 Control Structure Envelope

Habitability system boundaries for Susquehanna SES is the control structure envelope.

a) An independent HVAC system is provided for the Control Room area. This includes: Control Room, TSC, OSC, kitchen, toilet and locker, office, conference room, document Control Room, electrical room, vestibule and storage space. All areas on plan floor EL 728'-0" and 741'-0" are served by this system. A detailed description of this redundant system is provided in Subsection 9.4.1.

b) Two independent HVAC systems are provided for the remaining areas. One system serves the computer room, lower relay rooms, computer maintenance room, office, and UPS rooms. The other system serves the lower cable spreading room, upper relay rooms, upper cable spreading rooms, electrician's office, battery rooms, cold instrument repair shop, equipment rooms, and HV equipment room. Each of these systems is described in Subsection 9.4.1.

There are eleven exterior doors in the control structure envelope. These doors are gasketed to minimize leakage and will be tested to 1/8" w.g. differential pressure to assure tightness.

Another leakage path across the ventilation barrier between the control structure envelope and outside environment is through the isolation damper blades. Isolation dampers are listed in Table 6.4-1.

Tests on the isolation dampers indicate a leakage rate as shown on Table 6.4-1 at test differential pressures ranging from 3 to 21 in. wg. The analysis for Control Room habitability given in Chapter 15 and Appendix 15B assumed a leakage of 10 cfm of outside air for ingress/egress and an additional 600 cfm of unidentified, unfiltered inleakage to the Control Structure Envelope. Note that for analyses that do not credit operation of the CRHE emergency ventilation system, 6901 cfm (5810 + 10% cfm + 10 cfm + 500 cfm) of unfiltered inleakage is assumed. Makeup air to the envelope is also filtered, so the makeup air to the Control Structure Envelope would not be at outside air concentrations.

The environment of the Control Structure Envelope is maintained to ensure the integrity of the contained safety related controls and equipment during all operating conditions. Technical Specification 3.7.3 discusses maintaining a positive pressure of >0.125 inches water gauge relative to the outside atmosphere during the pressurization mode of operation.

6.4.2.2 Ventilation System Design

The detailed HVAC system design is presented in Subsection 9.4.1. These systems are shown on Dwgs. M-178, Sh. 1, M-178, Sh. 2, VC-178 Sh. 1, VC-178, Sh. 2, and VC-178, Sh. 3. Design parameters are listed in Table 9.4-2. A list of isolation dampers with their leakage characteristics and closure times is shown in Table 6.4-1.

All the components are designed to function during and after a SSE except for the outside air intake electric heating controls and humidification equipment, Control Room relief fan, reheat coils and their controls, which are supported to stay in position even though they may not function.

Components are protected from internally and externally generated missiles. See Section 3.5 for details. Layout diagrams of the control structure, showing doors, corridors, stairways, shield walls, equipment layout, and the Control Structure Envelope are shown on Figures 6.4-1A, 6.4-1B, 6.4-1C, 6.4-1D and 6.4-1E.

The description of controls, instruments, and radiation monitors for the control structure HVAC system is included in Subsections 9.4.1 and 7.3.1. The locations of outside air intakes and potential sources of radioactive and toxic gas releases are indicated on Figure 6.4-2.

A detailed description of the emergency makeup air filter trains is presented in Subsection 6.5.1.2.

6.4.2.3 Leaktightness

The entire Control Structure Envelope is of leaktight construction. The free air space volume is approximately 110,000 cubic feet in the Control Room floor, 80,000 cubic feet in the battery room floor, and 328,000 cubic feet in the remaining spaces of the envelope. All cable tray and duct penetrations are sealed. Approximately 5810 cfm of outside air is introduced in the pressurization emergency mode through charcoal filters into the envelope, to maintain approximately 1/8 in. w.g. positive pressure over atmosphere; this includes 3500 cfm to the battery rooms as make-up air. The battery rooms are exhausted through the SGTS exhaust vent. The air intake rates are the same for normal operation and for pressurization emergency modes radiation release. As discussed in FSAR Section 9.4.1, during normal operation, the control structure habitability envelope is maintained at a positive pressure over the outside air pressure.

6.4.2.4 Interaction with Other Zones and Pressure-Containing Equipment

The Control Structure Envelope is surrounded by the turbine building, reactor building, and central access control area. Each of these areas is separated from the control structure by shield walls and floors and served by independent HVAC systems.

All penetrations for conduits, pipes and ductwork penetrating the Control Structure Envelope will be completely sealed; all air outlet openings which continue to areas outside of the envelope will be isolated by a set of redundant isolation dampers (except for the smoke removal system) which has one normally closed isolation damper and one normally closed fire protection damper. The ductwork penetration is of welded construction.

The Control Structure Envelope is surrounded by the Turbine Building and Reactor Building. These areas are served by independent HVAC systems described in Section 9.4. The control structure is isolated by the ventilation barrier between the control structure and the other areas consisting of concrete wall and floor slab construction and leaktight doors.

Upper and lower cable spreading room floor drain discharge piping have rupture discs installed at their termination locations in the Turbine Building. These rupture discs support the Control Structure HVAC system in maintaining positive air pressure above atmosphere. In addition, these components provide a drainage path for firefighting water when a predetermined water head in the drain piping is reached based on actuation of automatic fire sprinkler systems or use of fire hoses in the cable spreading areas.

Except for fire protection halon bottles, fire extinguishers and self-containing breathing apparatus, there are no pressure-containing tanks in the Control Room area. Steam piping is excluded from the control structure.

6.4.2.5 Shielding Design

The Control Structure radiation shielding design is discussed in Section 12.3 which describes control structure shield wall thicknesses, the location of associated plant structures relative to the control structure, and provision to reduce radiation from external sources. A description of radiation sources used to design control structure shielding is presented in Section 12.2 and in Subsection 18.1.20 and includes source strength, geometry, and attenuation parameters.

Core Spray piping is located in the reactor building close to the reactor building/control structure wall. For the DBA LOCA dose consequence analysis (Chapter 15.6), the core spray piping is assumed to be filled with radioactive suppression pool water. For the DBA LOCA dose consequence analysis, the core spray piping creates a significant shine dose to the STA Office (C-401), Operational Support Center (C-402), Electrical Equipment Room (C-413) and NRC Conference Room (C-414) (although these rooms are not assumed to be continuously occupied following a DBA LOCA). To reduce the dose from this source, ¾" steel plate was installed on portions of the core spray pipe and control structure wall.

6.4.3 SYSTEM OPERATIONAL PROCEDURES

During normal plant operation, the mixture of recirculated air and outside air for the control structure HVAC systems is filtered through UL Class 1 particulate filters with a rated efficiency of 90 percent by ASHRAE Standard 52-68 atmospheric dust spot method. The control structure HVAC systems are started through remote hand switches that are located in the Control Room HVAC control panel. The operation of the Control Room HVAC system is described in Subsection 9.4.1.2.1.

To remove any noxious gases and odors from the Control Room, the operator can manually isolate the Control Room HVAC system and place the emergency outside filter train in recirculating operation.

To remove smoke from the Control Room, the operator can manually operate the smoke exhaust fan and fire protection control damper from the fire protection control panel in the Control Room. Smoke will be exhausted by the fans, through the duct system to the turbine building exhaust vent.

In the event of high radiation at the outside air intake of the control structure HVAC systems, the radiation monitoring system automatically shuts off normal outside air supply to the systems. The outside air is automatically routed through the emergency outside air filter train before entering the HVAC system.

In the event of a Reactor Building HVAC/Secondary Containment isolation signal, the control structure HVAC system will automatically transfer to the emergency outside air filter train as described in the high radiation mode.

Two emergency outside air filter trains and fans are provided. Each train consists of an electric heater, prefilter, upstream HEPA filter, charcoal adsorber, and downstream HEPA filter. The system is designed to handle the requirements of outside air for the HVAC systems. Each train is sized to process 6000 cfm ±10% (note that the fan is operationed at a flow rate ≤5810 cfm during surveillance test) of outside air, providing 500 cfm ±10% to the Control Room HVAC system, 400 cfm ±10% to the computer room HVAC system, and 5100 cfm ±10% to the control structure HVAC system. The emergency outside air filter train system is described in detail in Section 6.5.

In the event of an evacuation of the Control Room, operation of the control structure HVAC system can be manually controlled by an operator at the Alternate Control Structure HVAC Control Panel.

6.4.4 DESIGN EVALUATIONS

The control structure HVAC systems are designed to maintain a suitable environment for personnel and equipment in the control structure under all the station operating conditions. The systems are provided with redundant equipment to meet the single failure criteria. The redundant equipment is supplied with separate Class 1E power sources and is operable during loss of offsite power. The power supply and control and instrumentation meet IEEE-279 and IEEE-308 criteria. All the HVAC equipment, except the normal outside air intake heating, humidification, Control Room relief fan, reheat coils and their controls, and surrounding structure, are designed for Seismic Category I.

For the condition of a fire, as defined by 10CFR50, Appendix R, the need for the Control Structure HVAC system to provide cooling for the 72-hour coping period was evaluated. This evaluation concluded that the Control Structure HVAC system is not required to support safe shutdown.

The likelihood of an equipment fire affecting control structure habitability is minimized because early ionization detection is anticipated, fire fighting apparatus is available, and filtration and purging capabilities are provided. Refer to Subsection 9.5.1 for further description of the Fire Protection System.

The following provisions are made to minimize fire and smoke hazards inside the control structure and damage to nuclear safety related circuits:

a) Most electrical wiring and equipment are surrounded by, or mounted in, metal enclosures.

b) The nuclear safety related circuits for redundant divisions (including wiring) are physically segregated.

c) Cables used throughout the control structure are flame retardant.

d) Structural floors and interior walls are of reinforced concrete. Interior partitions are constructed of metal, masonry, or gypsum dry walls on metal joists. The Control Room ceiling is suspended type with non-combustible (maximum flame spread index, 25) acoustic tile, the door frames, and doors are metallic. Wood trim is not used.

The Control Room raised floor consists of steel plates and supports covered with carpet with a flame spread of less than 25.

A system is provided to detect high radiation at the outside air intake. These monitors alarm the Control Room upon detection of high radiation conditions. The emergency outside air filter trains, designed to remove radioactive particulates and adsorb radioactive iodine from the HVAC system outside air supply, are automatically started upon high radiation signals.

The emergency outside air filter trains and Control Room shielding are designed to limit the occupational dose levels required by 10CFR 50.67.

The introduction of sufficient outside air to maintain the Control Structure Envelope at a positive pressure with respect to surroundings, precludes infiltration of unfiltered air into the control structure at all the station operating conditions except when the system is in the recirculation mode.

<u>6.4.4.1 Radiological Protection</u>

The Control Room air purification system and shielding designs are based on the most limiting design basis assumptions, those of Regulatory Guide 1.183.

The CRHE radiation shielding is designed to reduce gamma radiation shine from both normal and post-accident radiation sources to levels consistent with the requirements of 10CFR20 or 10CFR50.67.

Under accident conditions, radiation doses to control room personnel may result from several sources. While in the control room, personnel are exposed to beta and gamma radiation from gaseous fission products that enter after an accident via the ventilation system or from unfiltered air entering the control structure habitability envelope (CSHE). In addition, personnel may be subject to gamma shine dose from fission products in the containment and reactor building, from contained system sources and from fission products in the atmosphere outside the CSHE.

To evaluate the capability of the control room ventilation system and radiation shielding to keep doses within the specified criteria, control room doses are evaluated for each of these dose contributors. This analysis includes control room doses from the following radiation sources:

- Contamination of the control room atmosphere by the pressurization of air flow or infiltration of the radioactive material contained in the radioactive plume released from the facility,

- Radiation shine from the external radioactive plume released from the facility,

- Radiation shine from radioactive material in buildings adjacent to the control structure; includes containment, reactor building and turbine building,

- Radiation shine from radioactive material in systems and components inside or external to the control room envelope, e.g., piping, components and radioactive material buildup in HVAC filters.

The concentration of radioactivity, which is postulated to surround the Control Room after the postulated accident, is dependent on, the containment leak rate, and the meteorology for each period of interest. The assessment of the amount of radioactivity within the Control Room considers the flow rate through the Control Room outside air intake, the effectiveness of the Control Room air purification system, the radiological decay of fission products, and the exfiltration rate from the Control Room.

The Control Room emergency filtration train draws the incoming air through an electric heating coil, moderate efficiency filter, HEPA filters, and a carbon adsorber to minimize the exposure of Control Room personnel to airborne radioactivity. In order to increase the effectiveness of the carbon adsorbers, incoming air is warmed by the heating coil to decrease its relative humidity. Air within the Control Room, TSC and OSC is recirculated continuously through the air handling unit, which controls room temperature 75°F ± 5°F and humidity 50% ± 5%.

The resulting calculated doses to personnel inside the control room for a postulated LOCA, taking into account the effects of control structure ingess and egress and occupancy of personnel on a rotating shift basis, are less then 5 rem TEDE. The doses are within the dose limits specified in 10CFR 50.67. A detailed discussion of the dose calculation model for control structure operators is discussed in Subsection 15.B.2.

Control structure shielding design, based on the most limiting design basis LOCA fission product release, is discussed in Section 12.3 and is evaluated in Subsection 15.B.2. The evaluations in Chapter 15 demonstrate that radiation exposures to control structure personnel originate from containment shine, external cloud shine, and containment airborne radioactivity sources. Total exposures resulting from design basis accidents are below the dose limits specified by 10CFR 50.67; the portion contributed by containment shine and external cloud shine is reduced to a small fraction of the total by means of shielding. Access control may also be used in areas of the Control Room Envelope that do not support critical safety functions, to maintain doses less than 10CFR 50.67 limits.

6.4.4.2 Toxic Gas Protection

The control structure HVAC systems are designed to satisfy the recommendation of revision 1 of Regulatory Guide 1.78. The HVAC systems are described in Subsection 9.4.1.

A detailed discussion of the toxic gas protection is in Subsection 2.2.3.

6.4.5 TESTING AND INSPECTION

The control structure HVAC systems and their components are thoroughly tested in a program consisting of the following:

a) Factory and component qualification tests (see Table 9.4-1)

b) Onsite preoperational testing (see Chapter 14)

c) Onsite subsequent periodic testing (see Chapter 16)

6.4.6 INSTRUMENTATION REQUIREMENTS

All safety-related instruments and controls for the control structure HVAC systems are electric or electronic, except for isolation damper actuators which are pneumatically operated. These dampers are designed to fail safe on loss of compressed air. The compressed air system is not safety-related.

a) Separate local HVAC panels are provided for redundant HVAC systems. Controls for the ‘A’ train of the HVAC systems are provided on ‘OC877A’ panel and the controls for the redundant ‘B’ train of the HVAC systems are provided on ‘OC877B’ panel. Important operating functions are controlled and monitored from the Control Room HVAC panel.

b) Instrumentation is provided to monitor important variables associated with normal operations. Instruments are provided to alarm in the Control Room if abnormal conditions are detected.

c) A radiation detection system (measurement range of .01 to 100 mR/hr.) is provided to monitor the radiation levels at the system outside air intakes. A high radiation signal is alarmed on the main control board.

d) Fire detection capability is provided in the outside air intake plenum. Fire detection is annunciated on the main control board via the fire protection control panel.

e) The control room and control structure HVAC systems are designed to provide automatic control of the environmental parameters such as temperature (normal and emergency plant operation) and humidity (normal plant operation only). These systems can be operated in manual or auto modes. The chilled water system can be started in manual or auto (standby) mode by placing the chilled water pump OP162A/B switch in start or auto mode.

f) A fire protection water spray system is provided for each charcoal adsorber bed in the emergency outside air filter train.

g) The emergency outside air filter train airflow rate and upstream HEPA filter differential pressure are recorded on the main control room HVAC panel. The upstream HEPA filter differential pressure high (indicated by CS EMERG OA HEPA FILTER DP HI), and the air flow low (indicated by CS EMERG OA SUP FAN FAILED) conditions are alarmed on this panel.

h) The control structure HVAC system Train A is designed for manual operation at the Alternate Control Structure HVAC Control Panel. Train A of the control structure chilled water system can also be manually operated at this panel. These systems have been evaluated for their need in supporting Appendix R safe shutdown in the event of a Control Room fire. The result of this evaluation is that these systems are not required to support Appendix R safe shutdown.

Table Rev. 51

TABLE 6.4-1 CONTROL STRUCTURE ISOLATION DAMPER CLOSURE TIMES				
DAMPER NO.	NOMINAL FLOW cfm	LEAKAGE cfm (Note)	CLOSURE TIME SECONDS (Note)	SIZE INCHES
HDO7802A/B	5810	5.05	3	26 x 28
HD07814A/B	5810	5.05	3	26 x 28
HD07812A/B	5810	5.05	3	28 x 26
HD07813A/B	5810	5.05	3	26 x 28
HD07833A/B	300	1.80	3	16 x 16
HD07824A1/B1	535	2.22	3	20 x 16
HD07871A1/A2	3500	2.80	3	20 x 20
HD07871B1/B2	3500	2.80	3	20 x 20
HD07872A/B	125	3.3	3	10 x 10
HD07873A/B	200	3.1	3	8 x 8

Note: Manufacturer's Suggested Operating Data

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
CONTROL STRUCTURE ELEVATION
FIGURE 6.4-1A

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
CONTROL STRUCTURE ENVELOPE PLAN EL. 697'-0" & 714'-0" FIGURE 6.4-1B

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
CONTROL STRUCTURE ENVELOPE CONTROL ROOM FLOOR PLAN EL. 729'-0" TECHNICAL SUPPORT CENTER EL. 741'-1" FIGURE 6.4-1C

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

CONTROL STRUCTURE
ENVELOPE PLAN
EL. 753'-0" & 771'-0"

FIGURE 6.4-1D

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
CONTROL STRUCTURE ENVELOPE PLAN EL. 783'-0" FIGURE 6.4-1E

Security-Related Information
Figure Withheld Under 10 CFR 2.390

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 FINAL SAFETY ANALYSIS REPORT
CONTROL ROOM LOCATION INTAKE & EXHAUST LOCATION FIGURE 6.4-2