9.5 Other Auxiliary Systems

9.5.1 Fire Protection System

See Subsection 9.5.13.9 for COL licence information pertaining to areas of the plant to be included in its fire protection program.

The ABWR Fire Protection Program follows the recommendations of BTP CMEB 9.5-1 except in the following cases:

(1) The capacity of each of the 3 Diesel Day Tanks is 12.1 m^3 (3200 gallons). This is enough fuel for 8 hours of operation of the diesel at the maximum LOCA load demand. The BTP recommends that the day tanks be limited to a capacity of 1100 gallons (BTP CMEB, Section 7j).

Justification: The day tanks are located in the reactor building outside secondary containment in a dedicated 3-hour fire rated compartment of masonry construction. There is no other safety-related equipment located in the day tank rooms. The day tank rooms are located in the Emergency Diesel Generator compartments and are positioned such that the 3-hour fire rated walls, ceiling, and floor of the day tank room are not shared by any other division. The day tank rooms are protected by a foam water sprinkler system that can deliver foam to the room for a minimum of 30 minutes without operator intervention.

The day tank is seismically designed and supported. In the unlikely event the day tank were to fail the entire contents of the day tank can be contained in the sunken volume of the room. Potential ignition sources inside the day tank rooms with enough energy to ignite diesel fuel are limited. Furthermore the supply of fresh air to support combustion is limited. In the event of a fire the pre-action automatic foam sprinkler system is designed to extinguish a fire in this room in 10 minutes. The sunken volume of this room can contain the day tank contents and 30 minutes worth of foam. The additional foam capacity beyond 10 minutes provides added assurance that a postulated fire will be extinguished. In the unlikely event the fire can not be extinguished the room can be closed off and the fire allowed to burn out on its own without spreading to other areas.

In the event that the fuel oil transfer line from the day tank to the emergency diesel generator (EDG) were to fail the sunken floor around the diesel can accommodate the contents of the day tank plus 10 minutes worth of foam applied by the automatic sprinkler. The automatic sprinkler system is designed to extinguish a fire in this room in 10 minutes. In the unlikely event the fire was not extinguished the room can be closed off and the fire allowed to burn out on its own without spreading to other areas. Alternatively, if the fire brigade is required to fight the fire manually the elevated entries into the room can accommodate approximately 30 minutes of additional

water/foam application from 2 hand held lines (0.47m^3/min per hose) before reaching the lowest door opening. The lowest door opening to these rooms are the exterior equipment doors which could be opened if fire fighting activities necessitate so that any overflow from the sump area of the room excess water, foam, or diesel fuel would spill outside the building and not spread to other parts of the reactor building. Therefore any overflow from the sump area of the room will not affect any safe shutdown equipment or equipment needed for support of safe shutdown equipment.

(2) The Control Room Complex has a raised floor with a subfloor area which is used for routing of cables from the Control Room cabinets, panels, and the divisional electrical rooms. Divisional separation of the subfloor cabling is maintained per the requirements of IEEE 384. The subfloor area will include fire detection capability. The subfloor area will not contain a fire suppression system as recommended by the BTP (BTP CMEB 9.5-1, Section 7b).

Justification: Fire Hazard Analysis section 9A.4.2.4.1, item 12 describes why the subfloor area is considered to be low risk fire area. In addition, the effectiveness of a permanently installed fire suppression system in the subfloor area is limited due to the small vertical space and the physical separation between the subfloor and the Control Room. Since the Control Room is continuously manned, manual fire suppression activities can be started quickly once it has been determined that there is a fire in the subfloor area. There are no transient combustibles stored in this area during normal activities to increase the severity of a possible fire. The characteristics of the subfloor cables are such that the probability of a fire ignition are very low and any fire that were to occur would be self-extinguishing or very slow to spread. Since fire resistant cables are required the amount of water needed to extinguish fire in the subfloor is relatively small. Any water that is introduced into the subfloor area can be removed by floor drains in the subfloor area or through the use of temporary portable sump pumps. Accumulation of water in the subfloor area is limited in depth to less than the raised floor and will not adversely effect water sensitive safety-related equipment which is installed above the floor. In the event that a fire in the Control Room were to require evacuation, the Division I and II Remote Shutdown Panels enable the operators to bring the plant to a safe shutdown.

(3) The office spaces contained in the Control Room Complex do not have automatic fire suppression systems installed. BTP CMEB 9.5-1, Section 7b recommends that these spaces have automatic suppression.

Justification: The Control Room Complex is continuously manned so that any fire will be quickly detected and manual suppression will be commenced without delay. The amount of combustibles is limited. Papers within the Complex are stored in file cabinets, book cases, or other storage locations except when in use.

Should manual fire fighting in the Control Room Complex be necessary, the accumulation and/or drainage of fire water will not affect the ability to safely shutdown the reactor. Using 2 hand held hoses at 0.57 m^3/m each (1.14 m^3/m total) the subfloor area in the Control Room will accommodate a minimum of 1 hour accumulation of water with no drainage without affecting safety-related equipment. If the fire water is assumed to transport immediately to the basement of the control building, the resulting accumulation of water will not affect safety-related equipment located in the basement. In either case the fire fighting activities will not prevent the reactor from being safely shutdown.

(4) Consoles and cabinets in the Control Room Complex do not have fire detectors installed inside them. BTP CMEB 9.5-1, Section 7b recommends that fire detectors be installed in these consoles and cabinets.

Justification: The Control Room Complex is continuously manned so that any fire will be quickly detected and manual suppression will be commenced without delay. The cabinets and consoles contain limited combustibles and are air cooled so that smoke from a cabinet fire will exhaust to the Control Room Complex. A fire in any single cabinet or console will not disable the capability to safely shut down the plant.

(5) The automatic sprinkler system in the emergency diesel generator room is installed to extinguish any fire in that room and does not replace restrictions on the positioning and direction of the application of the fire suppressant. BTP CMEB 9.5-1, Section 7b recommends that the sprinkler system be designed to permit the diesel generator to continue to run while the sprinkler system is operating.

Justification: The automatic sprinkler systems used in the emergency diesel generator rooms are designed to prevent the inadvertent actuation utilizing pre-action automatic sprinkler type. Actuation of these sprinklers requires the detection of a fire by infra-red and/or rate of heat detectors, and the opening of the fusible link sprinklers. Furthermore, each division has its own dedicated detection and actuation equipment for the control of the fire sprinklers in that divisional area. Two actuation signals are required to initiate the fire suppression system, the first of which will annunciate an alarm to alert the operator to any potential problems.

The ABWR design includes three independent and physically separated safety-related divisions, any of which is capable of bringing the plant to a safe shutdown in the event of a fire. For design purposes it is assumed that a fire anywhere in a division results in the immediate loss of function of all equipment associated with that division. Even with this conservative assumption, the two remaining independent safety-related divisions are available for full utilization by the operator.

9.5.1.1 Plant Features Enhancing Fire Tolerance

The basic layout of the plant and the choice of systems is such as to enhance the tolerance of the ABWR plant to fire. The systems are designed such that there are three independent safety-related divisions, any one of which is capable of providing safe shutdown of the reactor. In addition, there are non-safety-related systems such as the condensate and feedwater systems which can be used to achieve safe shutdown. The plant arrangement is such that points of possible common cause failure between these non-safety-related systems and the safety-related systems have been minimized.

Fire protection requirements beyond those for past designs were placed on future designs by Policy Issue SECY-89-013 (Reference 9.5-1). The Policy Issue requirements and the methods by which they have been met in the ABWR design are:

Requirement
"Therefore, the designers of standard plants have been informed that they must demonstrate that safe shutdown of their designs can be achieved, assuming that all equipment in any one fire area has been rendered inoperable by fire and that reentry to the fire area for repairs and for operator actions is not possible. The control room should be excluded from this approach, subject to the need for an independent alternate shutdown capability that is physically and electrically independent of the control room."

Compliance
Three divisions of safety-related safe shutdown equipment are provided. Each division has the capacity for safe shutdown of the plant. Exterior to the primary containment and the control room complex each division is separated from its two redundant counterparts by rated three hour fire barriers. The primary containment is inerted during operation, has the divisions separated as far as possible and does not contain anything other than check valves and piping which is required to operate for safe shutdown. A Remote Shutdown System provides safe shutdown capability which is independent physically and electrically from the control room.

Requirement
"Fire protection for redundant shutdown systems in the reactor containment building should ensure, to as great an extent as possible, that one shutdown division will be free of fire damage."

Compliance
The Fire Barrier System assures that two safe shutdown divisions will be free of fire damage.

Requirement
"Consideration should be given for safety-grade provisions for the fire protection systems to ensure that the remaining shutdown capabilities are protected."

Compliance

Fire protection piping systems, the failure of which could affect safe shutdown systems, are seismically designed. The fire barrier system for safety-related areas of buildings is Seismic Category I.

Requirement

"In addition, it should be demonstrated that smoke, hot gases, or the fire suppressant will not migrate into other fire areas to the extent that safe shutdown capabilities, including operator actions, could be adversely affected."

Compliance

The Fire Barrier System confines smoke, hot gases, fire suppressant to the division of the fire. The smoke control system maintains the areas for the two redundant divisions at a positive pressure with respect to the area of the division experiencing the fire. Any leakage through the fire barrier system is to the fire.

In order to meet the stated requirements, the design objectives have been to assure that independence of the redundant systems required or available for safe shutdown is not compromised by fire, the consequences of fire or the failure of fire protection equipment or systems. This design priority was met by implementing a coordinated overall design including fire considerations for the following plant features:

(1) Plant arrangement

(2) Divisional separation

(3) Fire containment system

(4) Combustible loading

(5) HVAC systems

(6) Smoke control system

(7) Spurious control actions

(8) Support systems

(9) Fire alarm system

(10) Fire suppression system

(11) Personnel access routes

(12) Manual fire suppression activities

The manner in which each of the above plant features is influenced by, and in turn affects the fire protection design considerations, is summarized as follows.

9.5.1.1.1 Plant Arrangement

The plant is laid out with the Control Building between the Reactor and Turbine Buildings so that power and control signals from the Reactor and Turbine Buildings enter the Control Building on opposite sides of the Control Building. There are no safety-related services provided from or through the Turbine Buildings. Occurrences in the Turbine Building which may disable the Turbine Building non-safety-related systems which are capable of providing safe shutdown do not disable Reactor Building safety-related equipment which provides safe shutdown. Interactions between reactor and turbine building systems are minimized.

Normal and alternate preferred power is supplied through the Turbine Building to the Reactor Building for the safety-related loads. These non-safety-related power sources are backed up by the safety-related diesel generators. The diesel generators are not affected by events in the Turbine Building. For this reason, events in the Turbine Building can only cause a transfer to the diesel generators for the safety-related reactor building loads.

Normal safe shutdown functions of feedwater supply and steam flow to the condenser are provided through the steam tunnel. Overpressure in the Reactor Building is vented to atmosphere by blowout panels in the walls of the reactor building operating floor. Therefore, failures in the reactor building which could possibly affect the RCIC, RHR, HPCF or MSIV Systems would not affect the normal shutdown systems in the steam tunnel or turbine building.

The buildings are laid out internally so that fire areas of like divisions are grouped together in block form as much as possible. This grouping is coordinated from building to building so that the divisional fire areas line up adjacent of each other at the interface between the Reactor and Control Buildings. An arrangement of this fashion naturally groups piping, HVAC ducts and cable trays together in divisional arrangements and does not require routing of services of one division across space allotted to another division.

9.5.1.1.2 Divisional Separation

As stated above, there are three complete divisions of safety-related cooling systems. Any one division is capable of safe or emergency shutdown of the plant so that a division may be out for maintenance, a single random failure occurs and the remaining functional division would still be able to provide safe plant shutdown.

In general, systems are grouped together by safety division so that, with the exceptions of the primary containment, the control room and the remote shutdown room (when operating from the remote shutdown panels), there is only one division of safe shutdown equipment in a fire area. Complete burnout of any fire area without recovery will not prevent safe shutdown of the plant; therefore, complete burnout of a fire area is acceptable.

The separation exception in the primary containment is made because it is not practical to divide the primary containment into three fire areas. The design is deemed acceptable because:

(1) Primary containment is inerted during plant operation; therefore, a fire is not possible.

(2) Sprinkler coverage is provided by the Containment Spray System.

(3) Only check valves and ADS/SRV valves are required to operate within containment to provide safe shutdown. A fire could not prevent the operation of a check valve nor would it prevent a safety valve from being lifted on its spring by pressure. The high-pressure pumps are capable of providing sufficient head to lift the SRV valves against their spring settings so that a fire could not prevent injection of water to and relief of steam from the reactor vessel.

(4) In addition, maximum separation is maintained between the divisional equipment within primary containment.

All divisions are present in the control room and this cannot be avoided. It is the purpose of the remote shutdown panel to provide redundant control of the safe shutdown function from outside of the control room. The controls on the remote shutdown panel are hard wired to the field devices and power supplies. The signals between the remote shutdown panel and the control room are communicated such that there are no power supply interactions between the control room and the remote shutdown panel.

During normal plant operation the remote shutdown room is divided into two rooms by a closed sliding fire door. A fire in one divisional section will not affect the other divisional section. When the operator puts the remote shutdown panel into operation, the sliding door is manually slid open so that there is one remote shutdown room with two divisional sections of panels.

There are areas where there is equipment from more than one safety division in a fire area. Each of these cases is examined on an individual basis to determine that the encroachment is required and that failure in the worst conceivable fashion is acceptable. This analysis is documented in Subsection 9A.5.5.

Electrical Divisions 1, 2 and 3 supplies, Reactor Building cooling water pumps and heat exchangers, emergency chillers and emergency HVAC systems are located in the Control Building. Since these systems are required for safe shutdown of the plant if the function of the control room is lost, they are separated from the control room complex and its HVAC System by rated fire barriers. A fire resulting in the loss of function of the control room will not affect the operation of the remote shutdown or remote shutdown support systems.

With the existing separation and the tolerance to spurious signals (Subsection 9.5.1.1.7) that the plant systems have, evaluation of the impact of fire on safe shutdown is greatly simplified. The specific location of a fire within a fire area, fire growth rate and intensity is unimportant as long

as the integrated intensity of the fire remains within the capability of the three-hour fire barrier system.

9.5.1.1.3 Fire Containment System

The Fire Containment System is the structural system and appurtenances that work together to confine the direct effects of a fire to the fire area in which the fire originates. The Fire Containment System is required to contain a fire with a maximum severity as defined by the time-temperature curve defined in ASTM E119 for a fire with a duration of three hours. For this condition, the temperature in the room at the end of three hours would be 1052°C. In addition, all structural walls, floors, ceilings, penetration seals, and hatches in the Reactor Building which are three hour fire barriers are required to withstand a 5 psid pressure differential. The Fire Containment System is comprised of the following elements:

(1) Concrete fire barrier floors, ceilings and walls which must be at least six inches thick (Reference 9.5-2, Figure 7-8T, NFPA Handbook) if made from carbonate and siliceous aggregates. Other aggregates and thicknesses are acceptable if the type of construction has been tested and bears a UL (or equal) label for a three-hour rating.

(2) Fire barrier walls which are of the special construction described in Subsection 9A.3.6 or of other approved construction types bearing a UL (or equal) label for a three-hour rating.

(3) Fire doors, which are required to have a UL (or equal) label certifying that they have been tested for a three hour-rating per ASTM E152, including a hose stream test.

(4) Both ends of all electrical and piping penetrations between the divisions and between a division and a non-division should be qualified to the same standard and tested to ASTM E119.

(5) Not Used

(6) Fire dampers, which are required for any HVAC duct penetrating a fire barrier, must have a rating of three hours. The plant arrangement minimizes fire dampers.

(7) Columns and support beams, which are required to be of reinforced concrete construction or enclosed or coated to provide a three-hour rating if of steel construction.

(8) Backup of the fire barrier penetration seals by the HVAC Systems when the HVAC Systems are operating in the smoke removal mode. This backup feature is accomplished in the Reactor and Control Buildings by maintaining a positive static pressure for the redundant divisional fire areas with respect to the fire area with the

fire. Leakage is into the fire impacted area under sufficient static pressure to confine smoke and heat to the fire area experiencing the fire, even if there is a major mechanical failure of the penetration seal.

(9) AC independent water addition (ACIWA) can be connected to the reactor building fire protection system header. Sufficient Fire Water pressure and flow should be available to perform the intended function. Refer to Subsection 5.4.7.1.1.10, AC-Independent Water Addition.

9.5.1.1.4 Combustible Loading

Allowable combustible loadings for the plant were established as follows (see Appendix 9B, Subsection 9B.2.3 for additional details):

(1) 1454 MJ/m^2 of room area, maximum allowable average exposed combustible loading without an automatic fire suppression system. This is termed the normal combustible loading limit (NCLL).

(2) 2908 MJ/m^2 of room area, maximum average allowable exposed combustible loading (cable insulation) for electrical equipment rooms. This is termed the electrical room combustible loading limit (ECLL). Transient combustible loadings other than minor amounts required for maintenance of the equipment in the electrical equipment rooms are not allowed.

(3) Not Used

(4) Not Used

(5) Not Used

(6) Transient combustibles such as lubricating oils and grease, cleaning solvent, etc. in small quantities and in approved containers are permitted.

(7) Transient combustibles such as bags of protective clothing are permitted within the constraints of items (1) and (2). If it can be shown by analysis or testing that flames from the burning transient combustibles will not likely impinge directly on cables within trays or risers, the contribution from the cable insulation need not be considered in calculating the total combustibles in the area with the transient combustible load.

Combustible loading due to cable insulation has been minimized by locating the power sources adjacent to the loads served and transmitting the control signals to and from the control room. This has allowed the elimination of cable spreading rooms and most of the cables to and from the control room. Data communication is also used within the control room so that the cables between panels have been reduced to mostly power cables.

9.5.1.1.5 HVAC Systems

The HVAC Systems have been matched to the divisional areas which they serve. For example, there are three divisions of power supply outside of secondary containment in the Reactor Building. The divisions are in separate fire areas and each fire area is served by its corresponding division of the HVAC System. This same philosophy is carried into the Control Building, where there is a divisional HVAC System for each of the three divisions of core cooling systems and a fourth HVAC System for the control room complex which contains four divisions of control equipment.

Division 4 contains a battery as the source of power but there is not a Division 4 diesel generator. Division 4 loads are comprised of instrumentation and controls to provide two-out-of-four logic. Loss of Division 4 reverts the logic back to two-out-of-three, which is acceptable on a permanent basis from a safety standpoint. The main function served by the Division 4 control and logic is one of improving plant availability for power production. On this basis Division 4 is supplied cooling from Division 2 in both the reactor and control buildings.

A single non-safety-related HVAC System supplies normal cooling for secondary containment in the Reactor Building. Within the Reactor Building the system is branched into three separate systems with valves and fire dampers for each branch (Subsection 9.5.5). Required emergency cooling for safety-related systems is provided by room coolers on a divisional basis.

9.5.1.1.6 Smoke Control System

The smoke control system for the plant provides major features as follows:

(1) Venting of fire areas to prevent undue buildup of pressure due to a fire.

(2) Pressure control across the fire barriers to assure that any leakage is into the fire area experiencing the fire.

(3) Pressure control and purge air supply to prevent back-flow of smoke and hot gases when fire barrier doors are maintained open for access for manual fire suppression activities.

(4) Augmented and directed clean air supply to provide a clean air path to the fire for fire suppression personnel.

(5) Smoke control by fans and systems external to the fire area experiencing the fire.

(6) Removal of smoke and heat from the fire by exhaust fans and operating supply fans to provide clean, cool air.

(7) Manually reset position of fire dampers in the smoke removal path.

These features are provided by designing the HVAC Systems for the dual purpose of HVAC and smoke control. ASHRAE’s “Design of Smoke Control Systems for Buildings” and NFPA’s “Recommended Practice for Smoke Control Systems” (References 9.5-3 and 9.5-4) were used as the basis for the design of the smoke control features of the combined systems.

The normal operating modes of the HVAC Systems are shown in Figures 9.4-1 through 9.4-6. The pressure at the input of an air handling unit is held at atmospheric pressure by a ducted, direct supply from outside through a bag type filter.

The systems are designed so the division of the air flow to the rooms within an HVAC/fire area is determined by the supply and exhaust ducting and the adjustable volume dampers.

The HVAC Systems in the fire areas not experiencing a fire continue to operate in their normal fashion so that the pressure in the other fire areas remains at a positive value. This assures that air leakage through any openings in the fire barriers surrounding the fire is to the fire.

The magnitude of the differential pressure which must be maintaianed across a fire barrier to provide aedquate smoke control varies with the intensity of the fire and the room height. For this reason, it is a COL license information requirement (Subsection 9.5.13.10) that the required differential pressure value for each barrier be calculated during the detailed design phase, the HVAC Systems be designed to provide the required pressure, and that the capability be confirmed during pre-operational testing. Normally the differential pressure would not have to be more than about 6.4 mm of water, and it most likely would be less.

Entry to a fire is gained from an adjacent fire area which by design is at a positive pressure with respect to the area experiencing the fire. The pressure differential is sufficient to provide adequate velocity through the open door to carry the combustion products back into the zone of the fire. The flow through the open door into the area of the fire and out the area of the fire’s exhaust duct system is maintained by the positive pressure of the non-fire area and by operation of smoke removal mode in the fire area. It gives the fire fighting squad a tenable environment from which to work.

There are fire dampers in the HVAC penetrations of building internal walls between safety-related fire areas.

Upon manual initiation of the smoke removal mode, the recirculation damper is closed, the exhaust fans are stopped, and the smoke removal fan is started in conjunction with the supply fan for 100% outside air purging. In the Control Building, the recirculation damper is closed, the damper in the bypass duct around the air handling unit is opened and both exhaust fans are operated in conjunction with the supply fan for smoke removal.

In order to maintain the objective of smoke and heat removal during a fire situation, the HVAC supply and exhaust duct openings in the exterior walls of the Reactor building do not have fire dampers. The walls are designated as three-hour fire barriers and would normally require fire

dampers for HVAC duct penetrations. Fire dampers could close due to heat from an internal fire, however. Internal fires are a more serious threat to the plant than external fires.

Omission of the fire dampers in the supply ducts is deemed acceptable because:

(1) Each HVAC/fire area has a separate intake structure.

(2) The intake structures are dispersed around the perimeters of the buildings.

(3) Not Used

(4) Isolation valves are provided and could be manually closed should there be a challenge due to an external fire.

(5) Each intake serves one fire area and, therefore, one division only except for the control room. The two redundant divisions are in separate fire areas. The control room fire area is separate from all other fire areas and the safe shutdown function is backed up by the remote shutdown panel.

Omission of the fire dampers in the exhaust ducts is deemed acceptable because:

(1) Each HVAC/fire area has a separate exhaust.

(2) Flow is normally out of the building so that external combustion products would not be drawn into the building.

(3) Isolation valves are provided and could be manually closed if it becomes necessary to shut a HVAC System down during an external fire situation.

(4) The run of metal duct from the exhaust structure to the isolation valves will contain stagnant air which will protect the isolation valves from high temperatures due to external fires if the valves are closed. The isolation valves will have far less leakage than normal fire dampers. It is an interface requirement that the exhaust duct between the exhaust structure and the isolation valves be insulated for high temperatures.

    The combination of these three things assures that the equivalent of a three-hour fire damper is provided.

(5) It is extremely important to be able to vent internal fires without interruption from a fire damper that has closed due to the temperature of the exhaust gases.

The HVAC/smoke control system for the Reactor Building secondary containment differs slightly from the other systems in the Reactor and Control Buildings, since because a common supply and exhaust system is used for all three divisional areas within secondary containment. The systems for each division are branched from the common system. A dual purpose isolation/fire damper valve is provided for each supply and exhaust branch. A two-position

motor-operated volume damper is also provided in each exhaust branch. Upon detection of a fire, a normally non operating exhaust fan is started to increase the negative pressure of the exhaust system. The motor-operated dampers in the exhaust ducts for the divisional HVAC/fire areas without the fire reposition to their predetermined fire settings to maintain normal negative pressure in their zones. The pressure in the HVAC/fire area experiencing the fire moves negative with the change in exhaust pressure. This establishes a pressure differential to the adjacent fire areas to provide smoke control by the differential pressure across the fire barriers surrounding the fire.

See Subsection 9.4.4 for a description of the smoke control system for the Turbine Building.

9.5.1.1.7 Spurious Control Actions

As stated above, the systems are separated by fire areas on a divisional basis. The ESF Logic and Control System (ELCS) utilizes redundant fiber optic links to communicate ESF system level actuation status to the Remote Digital Logic Controllers (RDLCs), which control the remote input/output functions and the actuation of the electromechanical components. The RDLC utilizes diagnostics to verify the validity of each redundant message. The redundant messages received by the RDLC must match for component actuation to occur. The probability of spurious messages occurring on each of the redundant links that both pass the communication diagnostics and that also match between the two redundant links is essentially zero.

The significance of the redundant fiber optic design is that, if the ability to operate from the control room is lost, equipment will continue to run until manually shutdown in the field by the operators. Equipment may also be manually started at the switchgear or motor control centers during a control room fire situation without fear that failures in the control room would cause the equipment to be shutdown. The feature of being able to start equipment locally without fear of it being shut down by spurious signals from the control room makes it possible to utilize non-safety-related systems such as the feedwater and condensate pumps in the Turbine Building as backups to the safety-related safe shutdown system, if desired.

The interlocks which prevent damage of equipment may be accomplished directly and by hard wiring in the field. For example, the protective relaying for the switchgear is located in the switchgear and the interlocks accomplished in switchgear. Signals for operational logic are communicated to the control room, but protective actions are not dependent on conditions in the control room.

Because of the nature of the design, there is no unacceptable failure that can occur due to fire induced failures within a division. This is independent of time or timing. This has been confirmed by the analysis performed as part of the plant evaluation for tolerance to sabotage. The sabotage analysis was done with no time constraints on actions precipitated within a division.

The evaluation of single and multiple spurious operations that could adversely impact post-fire safe shutdown will be performed in a manner that is consistent with the methodology of NEI 00-01, Revision 2 as modified by the guidance of RG 1.189 Revision 2 as it applies to Single and Multiple Spurious Operation Analysis.

9.5.1.1.8 Support Systems

Support systems such as HVAC and Reactor Building Closed Cooling Water Systems are designated as safety-related if they support safety-related systems. They are given divisional assignments and separated by fire barriers in the same fashion as the safety-related primary systems.

9.5.1.1.9 Fire Alarm Systems

Fire alarm systems which control equipment which could affect the operation of safety-related systems are designated as safety-related. It is a requirement that fire alarm systems be zoned by division according to the divisional assignment of the area which each zone covers.

9.5.1.1.10 Fire Suppression System

Automatically initiated fire suppression systems are initiated on a divisional basis so that there are no interactions between divisions. In general, fixed automatic suppression is provided in areas where the allowable limits of combustible loading, for no fixed suppression, as defined in Subsection 9.5.1.1.4, are exceeded. See Table 9.5-5 for a complete listing of automatic fire suppression systems.

9.5.1.1.11 Personnel Access Routes

The personnel access routes for fire suppression activities have been reviewed to see that access compatible with the design of the fire barriers, HVAC and smoke control systems has been provided. A source of clean cool air is provided for access routes to fire areas. The air supply is by fans out of the fire area experiencing the fire.

9.5.1.1.12 Manual Fire Suppression Activities

The plant is designed such that the divisional area in which a fire is occurring will be apparent to the operators at the time the fire is discovered. If the fire is significant, the operator can transfer operations to one of the two unaffected divisions and shut down the equipment in the affected division. All power supplies in the affected division can be deenergized and manual fire suppression activities commenced immediately without fear of damaging equipment in either of the two remaining operating divisions. Since the ventilation fans within the divisional fire area experiencing the fire aid in smoke removal, they should not be shut down unless necessary.

9.5.1.2 Design Bases

The program's intent is to provide a "defense-in-depth" design resulting in an adequate balance in:

(1) Preventing fires from starting.

(2) Quickly detecting and extinguishing fires that occur, thus limiting fire damage.

(3) Designing safety-related systems so that a fire that starts in spite of the fire prevention program and burns out of control for a considerable length of time will not prevent safe shutdown.

In addition, fire protection systems are designed so that their inadvertent operation or the occurrence of a single failure in any of these systems will not prevent plant safe shutdown.

Possible fires that could affect safety-related systems and significant combustible loadings are presented in Appendix 9A on a room-by-room basis. Fire barriers and fire protection systems are discussed for each safety and non-safety-related area. Each room is also analyzed for its potential radioactive release due to a postulated fire. Noncombustible or smoke-evolved and fuel-contributed index of 25 or less are used wherever practicable.

SRP Acceptance Criterion II.2.a of SRP Section 9.5.1 requires adherence to BTP CMEB 9.5.1. Paragraph C.5.f of the SRP requires that the means by which smoke will be removed from the plant be established early in the plant design. The ABWR meets this requirement, in that it is planned that smoke will be removed by normal HVAC System. In the Reactor Building, the normal supply and exhaust fans are located external to the building. Every room of the Reactor Building secondary containment receives supply air from and exhausts to the building normal HVAC. The emergency ventilation systems for the electrical equipment and diesel generator rooms provide additional smoke removal capability for those rooms.

There is a containment vent and supply system. Neither the supply or exhaust ducts are equipped with fire dampers. The isolation valves on these ducts are normally closed and would remain closed during plant operation so as to maintain the containment in an inerted condition. If a fire occurred in containment during a plant outage, when the valves were open and the containment not inerted, the drywell or wetwell spray would be initiated to protect the containment at a temperature well below the threshold of damage to the ventilation duct. For these reasons, the ABWR design for the containment ventilation is considered proper and adequate. (Further discussed in Subsection 9.5.1.3.12).

The water suppression systems are designed on the basis that, following a safe shutdown earthquake, there will be two manual hose streams available in any area containing equipment required for safe shutdown and that there will be no uncontrolled release of fire suppression water in the areas.

Transformers located within fire areas containing safety-related equipment will be of the drytype only. For those areas utilizing liquid insulated transformers, the COL applicant shall provide features to prevent the insulating liquid from becoming an unacceptable health hazard to employees in the event of release of the material to the building environment.

The quality assurance (QA) program, in accordance with CMEB 9.5.1 for the design of fire protection systems, is presented in Chapter 17.

The consequences of inadvertent operation of a suppression system and of moderate energy line cracks are discussed in Appendix 9A.

Except for fuel and lubricating oil located in the diesel-generator rooms, there are no storage areas in the Reactor or Control Buildings for flammable liquids, oxidizing agents, flammable compressed gases, corrosive material or explosive or highly flammable materials. Nonflammable compressed gases (e.g., air, nitrogen) do not represent a fire hazard.

Small quantities of chemicals may be stored in listed or approved cabinets and containers for immediate use. The CRD maintenance area is an example where such storage is permitted. Identification of the type and location of these materials is a requirement of SRP Section 13.2.2, which is the responsibility of the COL applicant.

9.5.1.3 System Descriptions

9.5.1.3.1 General Description

The Fire Protection System consists of:

(1) Standpipe

(2) Hose stations

(3) Sprinklers

(4) AFFF sprinkler systems

(5) Automatic foam sprinkling systems

(6) Smoke detectors

(7) Alarms

(8) Fire barriers

(9) Fire stops

(10) Portable fire extinguishers

(11) Portable breathing apparatus

(12) Smoke and heat ventilation systems

(13) Associated controls and appurtenances

The suppression systems for the buildings and the plant yard are shown in the following figures:

Area	Figures
Reactor Building	9A.4-1 thru 9A.4-10
Control Building	9A.4-11 thru 9A.4-16
Turbine Building	9A.4-17 thru 9A.4-21, 9A.4-33 and 9A.4-34
Service Building	9A.4-22 thru 9A.4-27
Radwaste Building	9A.4-28 thru 9A.4-32
Plant Yard	9.5-5

9.5.1.3.2 Fire Suppression System Requirements

The two firewater supply system pumps provide 5678 L/min flow from each pump at a differential pressure of 863 kPa. This requirement will meet the needs of NFPA 13 wet standpipe flow demand of 1893 L/min at a residual pressure of 448.2 kPa at the most hydraulically remote hose connection in plant buildings. The standpipe and sprinkler system are designed to meet the requirements of NFPA 13 and 14. In addition, the sprinkler systems and the portions of the wet standpipe system within the Control and Reactor Buildings and one train of the fire suppression water supply system analyzed to remain functional following a safe shutdown earthquake. They are also designed to meet the requirements of ANSI B31.1, Power Piping. The remainder of the fire suppression systems are designed to the appropriate fire protection codes as listed.

An automatic foam sprinkling system is provided for the diesel generator and day tank rooms.

9.5.1.3.3 Codes and Standards

The following listed documents, codes, standards and guidelines are referred to in the Fire Protection System designs:

29CRD1910	Occupational Safety and Health Standards
29CRD1926	Safety and Health Regulations for Construction
10CFR50	Licensing of Production and Equipment
UL	Underwriters Laboratories Approved Equipment
FM	Factory Mutual Approved Materials and Equipment List
ANI	Basic Fire Protection for Nuclear Power Plants, March 1976
ANSI B31.1	Power Piping
ASTM D992-56	Classification of Flammability Standards
ASTM E84	Method of Test of Surface Burning Characteristics of Building Materials
NFPA 10	Portable Fire Extinguishers—Installation
NFPA 10A	Portable Fire Extinguishers—Maintenance and Use
NFPA 11	Foam Extinguishing System
NFPA 13	Sprinkler System
NFPA 14	Standpipe and Hose Systems
NFPA 15	Standard for Water Spray Fixed Systems
NFPA 16	Deluge Foam-Water Sprinkler Systems
NFPA 16A	Closed Head Foam-Water Sprinkler Systems
NFPA 20	Standard for the Installation of Centrifugal Fire Pumps
NFPA 24	Outside Protection
NFPA 26	Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection
NFPA 37	Stationary Combustion Engines and Gas Turbines

NFPA 70	National Electric Code
NFPA 72	Protective Signaling Systems
NFPA 78	Lightning Protection
NFPA 80	Fire Doors and Windows
NFPA 80A	Protection from Exposure Fires
NFPA 90A	Air Conditioning and Ventilation Systems
NFPA 91	Blower and Exhaust Systems
NFPA92A	Smoke Control System
NFPA 101	Life Safety Code
NFPA 1963	Screw Threads and Gaskets for Fire Hose Connections
NFPA 1961	Fire Hose
NFPA 251	Fire Test, Building Construction and Materials
NFPA 252	Fire Tests of Door Assemblies
NFPA 255	Surface Burning Characteristics of Building Materials
NFPA 321	Classification of Flammable Liquids
NFPA 801	Facilities Handling Radioactive Materials
NFPA 802	Nuclear Reactors
NFPA 803	File Protection for Light Water Nuclear Power Plants.
NRC Regulatory Guide 1.39	Housekeeping Requirements for Water Cooled Nuclear Plants
BTP-CMEB 9.5-1 Appendix A	Guidelines for Fire Protection for Nuclear Power Plants
IEEE-384	IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits

9.5.1.3.4 Protection of Operating Units

The protection of operating units during construction of additional units is out of the scope of the COL applicant.

9.5.1.3.5 General Description of Fire Protection System

The sprinkler systems in the Reactor Building and the wet standpipe systems in the Reactor and Control Buildings are designed in compliance with ANSI B31.1 and analyzed to remain functional following a safe shutdown earthquake. A portion of the water supply system, including a tank, a pump and part of the yard supply main, is designed to these requirements also. The remainder of the water systems are designed to the appropriate fire protection standards. During normal operation, the seismically designed and non-seismically designed systems are separated by normally closed valves and a check valve such that a break in the non-seismically analyzed portion of the system cannot impair the operation of the seismically designed portion of the system. See the system requirements drawings (Figures 9.5-4 and 9.5-5) for more detailed requirements and information for these systems.

The water supply system is required to be a fresh water system, filtered if necessary, to remove silt and debris. Two sources with a minimum capacity of 1140 m^3 for each source is provided. If the primary source is a volume limited supply such as a tank, a minimum of 456 m^3 must be passively reserved for use by the seismically designed portion of the suppression system. This reserve will supply two manual hose reels for two hours. The equivalent of one 100% capacity motor driven pump and one 100% capacity diesel driven pump shall be provided. The equivalent capacity of each type may be comprised of multiple pumps of that type. A diesel driven pump is in the train designed to remain functional following the safe shutdown earthquake. A jockey pump to keep the system pressurized is provided.

The Turbine Building is provided with standpipes, hose reels and ABC portable extinguishers throughout the building. In addition, the following fire suppression systems provide primary fire suppression capability to the following areas:

(1) Automatic closed head sprinkler systems are provided throughout the Turbine Building except in higher hazard areas that are protected as described below.

(2) Deluge foam-water sprinkler systems are provided in the combustion turbine generator areas, hydrogen seal oil unit room, turbine lube oil storage tank room, EHC hydraulic control unit room, lube oil conditioning area and the lube oil reservoir area.

The Turbine Building fire suppression systems receive water from the portion of the supply system which is not required to be seismically analyzed for safe shutdown earthquake. They comply with the appropriate fire protection standard listed in Subsection 9.5.1.3.3.

The main power, unit auxiliary and reserve transformers are provided with deluge water spray suppression systems. The systems are automatically actuated by flame or temperature detectors.

An oil and water collection pit is provided beneath each transformer. Drains away from buildings and transformers are provided for each pit. Shadow type fire barrier walls are provided between adjacent transformers.

Alarm systems, both manual and automatic, are provided in all areas of the plant as passive systems. They alarm without controlling an extinguishing function.

9.5.1.3.6 Protection and Extinguishing Equipment for Safety-Related Equipment

Primary suppression coverage for all buildings is provided by wet standpipes and hose reels designed to meet the requirements of NFPA 14, "Standpipe, Hose Systems." Water fog electrically safe nozzles are provided. Secondary coverage is provided by portable ABC extinguishers.

9.5.1.3.7 Design Features of Fire Detection and Suppression Systems

Fire detection for all areas, except the diesel-generator rooms, is provided by the ionization-type product of combustion (POC) systems reporting to satellite panels, which, in turn, report to the master panel located in the control equipment room of the Control Building. Trouble and alarm signals are retransmitted to the control room. POC systems are designed to NFPA 72 Class A and NFPA 70 Class 1 requirements. Class A provides that the detector function with an open wire or a short to ground. These detection systems are not seismically qualified, as they are passive and have no control function.

The diesel-generator room fire detection systems utilize a cross-zoned combination rate of rise, rate-compensated heat detectors and infrared detectors to initiate an automatic foam sprinkler extinguishing system. This detection system is seismically qualified to protect against inadvertent actuation.

Fire detection and suppression alarm systems have four-hr battery packs located at each satellite panel and the control room panel and are also provided with power from an uninterruptible power supply.

Standpipe and hose reel systems are designed to meet the requirements of NFPA 14 and ANSI B31.1 (Power Piping Code). A 1.27 to 3.8 cm reducer is utilized on the 6.35 cm hose valve. The hose stations are equipped with 30.5-m neoprene-lined hose. Water fog electrically safe nozzles are supplied. The standpipe system is designed to remain functional following a safe shutdown earthquake. One train of the water supply system is designed to remain functional following a safe shutdown earthquake; therefore, an alternate water supply is not required.

Automatic wet pipe sprinkler systems piping is designed to meet the requirements of ANSI B31.1 and NFPA 13 (Sprinkler Systems). For pendant and upright sprinklers, the distance between the branch lines and between sprinklers on the branch lines does not exceed 3.7 m and the protection area per sprinkler does not exceed 12.1 m^2. For sidewall sprinklers, the distance

between sprinklers does not exceed 3m and the protection area per sprinkler does not exceed 9.3 m^2. Water density is 6.1 lpm/m^2 of floor area.

Automatic foam extinguishing systems are designed to meet the requirements of NFPA 11 (Foam Extinguishing Systems). The allocation rate is a minimum of 6.51 lpm/m^2. The duration of foam discharge shall be a minimum of 10 minutes. Audible and visual alarms are provided.

Portable fire extinguishers are provided throughout the buildings. Extinguishers are Class ABC multipurpose, 20-A, 80-B:C UL rated.

Distance from a hose reel and extinguishers is no more than 31.5 m from any location and, in most cases, is much less. Manual fire alarm stations are provided for each hose reel. Hose reels are located to provide double coverage for most areas of the plant.

All devices and equipment are for a make and type listed or approved by UL or FM. Where required, seismically qualified equipment is specified in lieu of nonqualified, listed or approved equipment.

9.5.1.3.8 Smoke Control

Smoke, heat toxic gas removal systems are discussed in Sections 6.4, 9.4 and 9.5.1.1.6.

9.5.1.3.9 Fire Alarm System

The fire alarm system is passive and it does not control the suppression systems. The thermal and infrared cross-zoned detection system are utilized in the emergency diesel-generator rooms. The automatic sprinkler systems used in these rooms require two actuation signals to initiate the fire suppression system. The first actuation signal will annunciate an alarm to alert the operator to any potential problems. Fire detection and alarm systems are supplied with power from a non-Class 1E uninterruptible power supply.

Detection, utilizing the ionization product of combustion detectors, is provided in all areas of the plant. The detectors report to satellite panels, which, in turn, report to the main control room in the Control Building.

Detector location is selected to cover a maximum 46.5 m^2.

Standpipe water/foam, sprinkler water flow, and manual alarm devices are integrated into the general alarm system.

Horns, flashing or rotating lights and bells are provided to alarm personnel in the fire zone. Signals are unique and distinctive so as not be confused with other alarm systems.

9.5.1.3.10 Electrical Cable Fire Protection

Electrical cables are specified to meet the requirements of IEEE-383. Cable tray penetrations are designed to meet the fire-resistive ratings of the barriers they penetrate. Fire barriers and separation for electrical cable trays are discussed in Section 8.3.

9.5.1.3.11 Fire Separation for Safe Shutdown

The ABWR standard plant design systems, whose primary functions are to provide core cooling, to bring the plant to a safe shutdown condition, have three independent mechanical and electrical safety-related divisions (mechanical divisions A, B, C) and (electrical divisions 1, 2, 3). Each division is capable of bringing the plant to a safe shutdown condition whether the system is initiated manually or automatically. The plant layout and design is such that the redundant portions of safety-related systems are located in different fire areas; therefore, if one division becomes disabled due to a fire (complete burnout without recovery is acceptable), there are still two independent redundant divisions available to provide core cooling. The system initiation logic is located in the control room, and is made up of four divisional logic; but if one division becomes disabled (e.g., due to a fire), the system initiation logic reverts to two-out-of-three logic. Safe shutdown following a fire is assured due to the fact the systems in any one of the three safety divisions are capable of accomplishing safe shutdown, and with the below listed exceptions, the safety divisions are separated by three-hour fire rated barriers.

(1) Main Control Room (MCR)

All four safety divisions of instrumentation and control are present in the main control room. Alternate safe shutdown capability is provided from the remote shutdown panel, which is located in a fire zone different from the MCR fire zone.

(2) Primary Containment

All four safety divisions are present in the primary containment. Primary containment is inerted during operation so that a fire in containment is not possible. In spite of this, separation within containment is maintained by as much distance as possible. Also, there is no combination of active components within containment which could fail due to a fire and prevent safe shutdown.

(3) Special Cases

There are some instances where equipment from more than one safety division is purposely mounted in the same fire area. For example, in order to provide redundancy for leak detection initiation, leak detection thermocouples for two or more divisions are mounted in the same room to control the single division of equipment contained in the room. The acceptability of each of these cases is analyzed and reported in Subsection 9A.5.

Even with these limited exceptions for separation by fire barriers, the plant design is such that complete burnout of a given fire area may occur and there will still be two divisions of functionally available equipment (including cables), either division of which is capable of accomplishing plant shutdown. Compliance of the design to this objective is confirmed by the Fire Hazard Analysis. Item 8 of the Fire Hazard Analysis of each individual room points out that, for each related or safe shutdown equipment located in the room, redundant safety-related equipment is available in a different fire area to accomplish the function of the equipment assumed to be involved in the fire or fire suppression activities. An item-by-item listing of this equipment is given in Table 9A.6-1. In addition, major safety-related equipment which may be used to accomplish safe shutdown is summarized in Table 9A.2-1.

Since the operator will always have two divisions of safe shutdown equipment available for use, he may use either the normal or emergency operating procedures as he sees fit to safely shut the plant down. These procedures would probably lead him to use one of the multiple non-safety-related systems that would normally be available to him as the first choice for achieving safe shutdown, but no credit is taken in the analysis for the non-safety-related systems.

9.5.1.3.12 Shutdown Risk to Fire in Containment

During normal operation the containment is protected from fire by nitrogen inerting. When the plant is shutdown, the containment is de-inerted to permit access by plant personnel for maintenance activities. During these periods the following design features minimize the risk and adverse consequences if a fire in containment.

(1) The large volume of the containment allows for spatial separation of the redundant divisional components. The redundant equipment for core cooling is separated to as large a degree as practically possible.

(2) Once a flow path for RHR shutdown cooling is established a fire in the drywell will not result in the loss of the ability to remove decay heat from the reactor.

(3) Removal of decay heat from the reactor can still be achieved even in the highly unlikely that a fire disables all of the active components inside the containment through a combination of high head injection systems (HPCF) and SRVs) and the suppression pool cooling mode of RHR.

(4) The containment purge fans can be operated in a smoke removal mode to prevent the spread of smoke outside the containment.

(5) The materials used inside the containment are non-flammable or flame resistant where ever practical resulting in low combustible loading.

(6) The drywell spray system can be used as a sprinkler system to suppress a fire in the containment either by itself or in conjunction with manual fire fighting activities.

In addition to the design features of the ABWR the COL applicants's fire protection program will contain elements that minimize the risk of fire including control of transient combustibles, ignition source permits, and fire watches. The design features and administrative control programs ensure that a fire in the containment during shutdown will not result in a loss of the ability to keep the core cool.

9.5.1.4 Safety Evaluation (Fire Hazard Analysis—Appendix 9A)

The Fire Hazard Analysis is performed on a room-by-room, system-by-system basis and includes a set of drawings which reflect pertinent details of construction, location of rooms and location of fire suppression equipment (Appendix 9A).

Past practices in performing a Fire Hazard Analysis were based on evaluation of essentially complete plant designs. The ABWR design has not been completed to that level; therefore, the approach for the analysis was to review the system piping and instrument diagrams (P&IDs), and to prepare a database which listed every device that could be adversely affected by fire.

If the reviewers knew or became aware of something that would eventually be in the plant design but did not appear on any drawing at that time, it also was added to the list and assigned a special MPL number. This got the device into the database for tracking. If possible, each device was given an electrical safety division assignment and the assigned division was entered into the database.

If a device appeared on the building arrangement drawings, its actual location by row, column and elevation was entered into the database. For all other identified devices, an estimate of location by row, column and elevation, based on experience and the known location of nearby devices, was entered into the database. The validity of the location information for each item was indicated as being determined by reference to a drawing or by estimation.

The Fire Hazards Analysis was then performed on the verified or assumed plant design as documented by the database. This made it possible for a Fire Hazards Analysis to be performed on a specific plant configuration. It makes a record of the configuration analyzed available for use as a guide in completing the plant design. Also, at some time near the end of the design phase, the assumed information in the database may be compared to the actual design to confirm that the original Fire Hazard Analysis conclusions are still valid for final plant design. Any discrepancies may be analyzed and resolved at that time.

A compliance review will be conducted of the as-built design against the assumptions and requirements stated in the Fire Hazard Analysis as documented in Appendix 9B. This as-built reconciliation will include a comparison with Table 9A.6-1 (database) and Table 9A.5-2 (special cases). In addition, it will demonstrated that multiple high impedance faults of those circuits described in Table 9A.5-2 resulting from a fire within any one fire area will not negatively impact other equipment fed from the same power source. Any non-compliance shall be documented in a Fire Hazards Report as being required and acceptable on the basis of the

Fire Hazard Analysis (Appendix 9A) and the Fire Protection Probabilistic Risk Assessment (Appendix 19M). The Fire Hazards Analyses (Appendix 9A) will be updated to include the as-built information. Any non-compliance must be documented as being required and acceptable.

The basis of the overall plant design with respect to the effects of fire is to assume that all functions are lost for equipment, including electrical cables, located within a fire area experiencing a fire. Redundant equipment is provided in other fire areas. A fire area by fire area treatment for the Fire Hazard Analysis evaluates the compliance of the design to this requirement for redundancy. Compliance was confirmed or the need for corrective action was identified and initiated to achieve compliance to the overall plant design basis. Therefore, the most serious consequence of a fire is that it may incapacitate one safety or safe shutdown division. This is consistent with the single failure design criteria used throughout the plant. Regardless of the location of a fire, sufficient operable equipment is assured for use in safely shutting the plant down.

The Fire Hazard Analysis assumes that the function of a piece of equipment may be lost if the equipment is either involved in fire fighting activities or subjected to fire suppression agents and confirms that redundant equipment out of the fire area is available. This redundant equipment is capable of performing the required safety or shutdown function. The basis of the design is not to assume a questionable limit on damage within a given fire area but to provide redundant equipment elsewhere.

As described in Appendix 9A, the fire detection systems are Class A and, therefore, are tolerant of single failures. The fire suppression systems are designed such that there are two suppression systems available to any given area. Areas covered by sprinklers or foam systems are also covered by the manual hose system. Areas covered by manual hose systems only may be reached from at least two hose stations. Standpipes are fed from two directions.

9.5.1.5 Inspection and Testing Requirements

Preoperational inspection and testing requirements will be prepared for each fire protection system as described in Subsection 14.2.12.

9.5.1.6 Personnel Qualifications and Training

9.5.1.6.1 Fire Protection Engineer

The qualification requirements of the fire protection engineer are as follows:

(1) A graduate of an engineering curriculum of accepted standing.

(2) Shall have completed not less than eight years of engineering practice of progressive importance indicative of growth in engineering competency and achievement, three of which shall have been in responsible charge of fire protection engineering work.

(3) If not such a graduate, shall have completed not less than 12 years of engineering practice of progressive importance indicative of growth in engineering competency and achievement, three of which shall have been in responsible charge of fire protection engineering work.

9.5.1.6.2 Quality Assurance (QA) Program

Quality assurance policies and procedures are described in Chapter 17. They provide compliance with the criteria of 10CFR50 Appendix B. The program defines the requirements and controls for activities affecting quality of structures, systems and components to an extent consistent with their importance to safety.

9.5.1.6.3 Emergency Response Plan

Out of ABWR Standard Plant scope.

9.5.1.6.4 Administrative Controls

The description of administrative controls that will be established to govern various details of operations of the plant will conform to guidelines of BTP APCSB 9.5-1. However, a detailed review and acceptance of the administrative controls by the NRC will be performed during the plant-specific licensing. Items of interest under the administrative controls review will include but not be limited to:

(1) Control of combustible materials such as combustible/flammable liquids and gases, fire retardant treated wood, plastic materials, and dry ion exchange resins

(2) Transient combustible materials and general housekeeping, including health physics materials

(3) Open-flame and hot-work permits and cutting and welding operations

(4) Quality assurance with respect to fire protection systems components, installation, maintenance, and operation

(5) Qualification of fire protection engineering personnel, fire brigade members, and fire protection systems maintenance and testing personnel

(6) Instruction, training, and drills provided to fire brigade members

The COL applicant shall provide the description of these administrative controls to the NRC for review. See Subsection 9.5.13.18 for COL license information.

9.5.2 Communication Systems

The ABWR Standard Plant design provides a telephonic communication system consisting of a power-actuated paging facility and a separate network of cables and jacks to facilitate use of sound-powered telephones for maintenance, repair, and emergency conditions.

See Subsection 9.5.13.11 for COL applicant information pertaining to criteria for the design of the plant security system.

9.5.2.1 Design Bases

9.5.2.1.1 Power-Actuated Paging System

The paging system is designed to provide facilities for mutual communication and simultaneous broadcasting in the related buildings of the plant.

9.5.2.1.2 Sound-Powered Telephone System

The design basis for the sound-powered telephone system is to provide communication primarily for fuel transfer, testing, calibration, maintenance and emergency conditions.

9.5.2.2 Description

9.5.2.2.1 Paging Facilities

This system provides communication means such as mutual telephonic communication and simultaneous broadcasting in various select buildings and areas, including outdoor locations of a nuclear power plant unit. The system also permits merging with paging facilities of other units of the nuclear power station. The system is a fixed-type (as opposed to wireless communication) and primarily used for intraplant communications during plant operations, testing, calibration, startup and limited emergencies.

The paging system is a non-safety system and, therefore, does not have seismic mounting requirements. Mounting of system components is such that it will not cause damage to safety-related equipment.

The paging facilities consist of handsets, speakers, branch boxes, main distribution board, a control board, amplifiers, amplifier boards, 48V battery, battery chargers, DC distribution board, cables-wiring materials, junction boxes and jacks. The system is a 3-channel, 3-branch split type design with a separate set of amplifiers and a distribution board for each branch. A general outline of the system is shown in Figure 9.5-2.

Handsets and speakers are installed in places which are important for plant operation and necessary for personnel safety including the rooms described below:

(1) Main control room

(2) Electrical equipment room

(3) Fuel replacement area

(4) Turbine operation area

(5) Periphery of control rods hydraulic units

(6) Feedwater pump room

(7) Elevators

(8) Exteriors of plant buildings

Each handset station can be used to communicate with any other handset station within the unit or the central station of another unit at the same nuclear station.

One circuit of the handset station is connected to a telephone line, thereby permitting a simultaneous broadcasting from a security telephone unit.

The system is operated from a 48V battery source with a normal and a spare battery charger. The chargers are fed from 3ø, 480 VAC station power supply, and a separate 1ø, 120VAC power source is used for panel lights and convenience receptacles.

Due to its importance to plant operation and safety, the paging equipment will have an exclusive DC power supply with a dedicated battery. The battery has capacity for 10 hours of operation following the loss of AC power. The charger is sized to recharge the battery from a fully discharged condition in 10 hours while supplying the normal DC loads.

A handset is located at the same relative position on each floor, at a conspicuous location in the patrol route, at uniform intervals in corridors and large rooms, close to panels where possible and at a location least affected by radioactivity within one area.

Paging equipment for outdoor facilities is designed to automatically limit the sound volume at night to a level manually set from the operator’s desk. The manual volume settings can be 10, 20, 30 or 40 dB.

The paging equipment produces an emergency signal (siren sound) upon actuation of an emergency signal pushbutton.

Speakers and handsets are installed at the best practical distance from noise sources. However, in rooms where noise level increases during equipment operation (such as feed water pump room, diesel generator room etc.), handsets are enclosed within a sound-proof booth.

The speakers are of two different types as described below. Their sound-to-noise (S/N) ratio is approximately 3 to 6 dB.

S = Output sound pressure of speaker.

N = Noise level at a place where the speaker is installed.

(1) Horn-shaped (Trumpet shaped): Output of 5 to 15W

(2) Cone-shaped (box-type): Output of 3W. Box-type speakers are installed in small rooms where reverberations make hearing difficult.

Junction boxes installed outdoors are made of stainless plate in accordance with the outdoor specifications. Junction boxes installed within the building are constructed to prevent water damage from above.

The interconnecting cables consist of a standard pair of conductors with cross-linked polyethylene insulation, a static electricity shield and an overall flame and heat-resistant sheath.

The circuits from the main paging equipment to each junction box are wired by separate routes. Wiring is routed in existing cable trays for control cables. Containment penetrations X-102 A and B are used for communication cables which are routed to the communication circuits within containment.

9.5.2.2.2 Sound-Powered Telephone System for Plant Maintenance and Repair

A separate communication system using portable sound-powered telephone units will be provided.

The communication facilities for use during plant maintenance and emergency conditions such as operation from RSS consists of local communication stations containing terminal jacks and boxes and a main patch panel with storage for patch cords. The patch panel is located outside the MCR. The portable sound-powered telephones themselves to be provided by the COL applicant. See Subsection 9.5.13.17 for COL license information.

The system provides communication capability between boards in the main control room, RSS and field station(s), or from field station to field stations.

An outline of the system is shown in Figure 9.5-2.

The communication between stations is by means of portable telephone units and patch cords at the main patch panel.

Terminal jacks are attached to the communication station at control panels and to local panels and racks where communication links are frequently required for testing, calibration, maintenance, and for operation from RSS.

The cable for the sound-powered communication facility is unshielded with a flame and heat resistant sheath and cross-linked polyethylene insulation. The cables are routed in existing control voltage level cable trays where available.

9.5.2.3 System Operation

The telephonic communication systems are designed to assist the plant personnel during preoperational, startup, testing, maintenance and emergency conditions. The system provides easily accessible means of communications between various intraplant locations and simultaneous broadcasting in those locations.

The various equipment involved in system operation is designed to function in the environment where it is located. The power supply for the paging system is derived from the dedicated batteries, thus providing a reliable source of power and the communication system for up to 10 hours in the event of a loss of plant power supply. The sound-powered telephone system does not require any electrical power source to operate the system.

9.5.2.4 Safety Evaluation

The communication system has no safety-related function as discussed in Section 3.2. However, see Subsection 9.5.13.2 for COL license information pertaining to use of the system in emergencies.

9.5.2.5 Inspection and testing Requirements

The communication systems are conventional and have a history of successful operation. Routine use of parts of the system during normal operation ensures availability. Measurements or tests required to guard against long-term deterioration shall be performed on a periodic basis. See Subsection 9.5.13.3 for COL license information pertaining to communication equipment maintenance and testing procedures.

9.5.2.6 Portable and Fixed Emergency Communication Systems

9.5.2.6.1 Design Basis

The design basis for the portable and fixed emergency voice communication systems is to provide communication facilities for normal and emergency plant operations and for plant security.

9.5.2.6.2 System Description

A fixed emergency communication system shall provide reliable communications between operating areas in the plant and to offsite locations. The system shall be independent of the other communication systems and shall include, but not be limited to commercial telephone, emergency alarms, and/or private branch exchange (PBX) system. The system shall be compatible with the plant paging facilities (Subsection 9.5.2.2.1) such that it will permit a simultaneous broadcasting from a security telephone unit.

A portable communications system such as hand-held portable radio or equivalent shall be furnished independent of other communications systems, and be available for use by plant operations and security personnel during plant normal and emergency conditions.

Design of fixed emergency communication and portable communication systems shall comply with BTP CMEB 9.5.1, position C.5.g(3) and (4).

9.5.2.6.3 System Operation

The system operation is the same as listed in Subsection 9.5.2.3 except for the discussion on the power supply requirements. The design and power supply requirements for these systems shall be specified by the COL applicant.

9.5.2.6.4 Safety Evaluation

The system safety evaluation is same as listed in Subsection 9.5.2.4.

9.5.2.6.5 Inspection and Testing Requirements

The system inspection and testing requirements are same as listed in Subsection 9.5.2.5.

9.5.3 Lighting and Servicing Power Supply System

The plant lighting is comprised of four independent lighting systems: (1) normal AC lighting system, (2) standby AC lighting system, (3) emergency DC lighting system, and (4) guide lamp lighting system. The normal lighting system is non-Class 1E. The other three lighting systems are comprised of Class 1E (guide lamps only), associated, and Non-Class 1E subsystems.

All yard lighting (i.e., external to the buildings) except fixtures mounted on the buildings themselves are within the COL applicant’s scope.

All lighting systems are designed to provide intensities consistent with the lighting needs of the areas in which they are located, and with their intended purpose. The lighting design considers the effects of glare and shadows on control panels, video display devices, and other equipment, and the mirror effects on glass and pools. Lighting and other equipment maintenance, in addition to the safety of personnel, plant equipment, and plant operation, is considered in the design. Areas containing flammable materials (e.g., battery rooms, fuel tanks) have explosion proof lighting systems. Areas subject to high moisture have water-proof installations (e.g., drywell, washdown areas). Plant AC lighting systems are generally of the fluorescent type, with High Pressure Sodium (HPS) lamps (or equivalent) provided for high ceilings. Incandescent lamps are used for DC lighting systems and above the reactor and fuel pool.

Lighting systems and their distribution panels and cables are identified according to their essentiality and type. Associated and Class 1E lighting systems are located in Seismic Category I structures, and are electrically independent and physically separated in accordance with assigned divisions. Cables are routed in their respective divisional raceways. Normal lighting

is separated from standby lighting. DC lighting cables are not routed with any other cables and are distinguished by “DCL” markings superimposed on the color markings at the same intervals.

Plant service buses supply power and heavy duty service outlets to equipment not generally used during normal plant power operation (e.g. Turbine Building and refueling floor cranes, welding equipment). Service outlets have grounded connections and the outlets in wet or moist areas are supplied from breakers with ground current detection.

9.5.3.1 Design Bases

9.5.3.1.1 General Design Bases

The general design bases for the Nuclear Island portion of the lighting systems are as follows:

(1) The lighting guidelines shall be based on Illuminating Engineering Society (IES) recommended intensities. These shall be inservice values as shown on Table 9.5-1, Illumination Levels. Reflected glare will be minimized.

(2) Control room lighting is designed with respect to reduction of glare and shadows on the control boards.

(3) Lighting systems and components are in conformity with the electrical standards of NFPA and OSHA as applicable for safety of personnel, plant and equipment. Light fixtures in safety areas are seismically supported, and are designed with appropriate grids or diffusers, such that broken material will be contained and will not become a hazard to personnel or safety equipment during or following a seismic event.

(4) Each of the normal, standby or emergency lighting systems has the following arrangement criteria:

    (a) Areas without doors and hatches (where access is impossible) have no lighting.

    (b) Rooms with normal (non-safety-related) lighting shall have on/off switches if the rooms are also used as passageways (e.g., patrol routes).

    (c) For high radiation areas, the on/off switches and lamps shall be arranged to facilitate maintenance and to obtain maximum service life from the lamps.

    (d) The switches shall be located at the entrance to the rooms, or the side of the passageway.

    (e) Normal lighting power for the small rooms with on/off switches shall be supplied from one power bus.

    NOTE: A small room means a room with three or less lighting fixtures, except for instrument rack rooms and electrical panel rooms.

(f) DC emergency lighting and associated lighting have no switch on their power supply lines.

(g) Standby lighting shall have no switch on power supply lines, as a rule. However, lighting for conference rooms etc., will have on/off switches.

(h) Power of inner panel lighting and outlets are supplied from one power bus.

(i) Each part of the 120V, 240V and 120/ 240V buses in lighting distribution panels shall have two or three spare circuits.

(j) Installation of fixtures on a high ceiling shall be avoided as far as possible to minimize lamp replacement work.

(k) The fixtures shall be located with due consideration of maintenance and inspection for the equipment in the rooms (such as tank rooms) where a well balanced arrangement is difficult.

(l) Not Used

(m) The standard installation interval of service power supply boxes should be 45.7 - 61.0 m.

(n) The standard installation interval of outlets should be 15.2 - 30.5 m; however, outlets shall be arranged around instrument racks. The outlet installation level in hazard control areas shall be above the top of dikes.

(o) As a rule, normal lighting power shall be supplied with two power buses. However, a power supply with one power bus can be used for areas with high illumination lighting by standby lighting and in small rooms.

(p) Lighting shall be designed with due consideration of reflection on the CRT screens where CRTs are installed.

(q) Lighting fixtures in rooms with glass windows shall be arranged with due consideration of the mirror effect to keep the window clear.

(r) Power for staircase and passage lighting is from the standby system and shall be supplied from two power buses in the staircases and passages to prevent a total lighting loss. Each bus supplies power to 50% of the standby lighting of the passages and staircases. The two power buses for safety-related area passages and staircases shall consist of the following:

    (i) One Class 1E bus (the same division as the safety-related equipment in the area), which is backed by its respective divisional diesel generator. A non-Class 1E bus, which is backed by the combustion turbine generator.

(ii) Under annual inspection of the power supplies, 50% lighting is secured with one lighting power bus. The 50% lighting level shall be sufficient for access and egress of personnel to and from the areas.

(5) Lighting fixtures shall be selected in accordance with the following criteria:

(a) Lighting fixtures inside the plant shall be the following type of fixtures:

(i) **Fluorescent lamps**—As a rule, fluorescent lamps shall be selected as fixtures for the general area.

(ii) **HPS lamps**—HPS lamps (or equivalent) shall be selected as fixtures for high ceiling areas.

(iii) **Incandescent lamps**—Incandescent lamps shall be selected as fixtures for DC emergency lighting and as fixtures above the reactors and fuel pool in R/B operating floor.

(b) Standby lighting shall be the rapid start type.

(c) Incandescent lamps shall have waterproof guards inside drywell.

(d) The fixtures can be a general industry type; however, the fixtures for the part of service area in S/B and control rooms shall match the interior finish of the area.

(e) Lighting fixtures above operator consoles, benchboards and RW operator consoles shall be dark green embedded louver lighting to reduce the reflection of fixtures on CRT screens. Illumination levels around the operator console and benchboards shall be adjustable.

(f) Non-Class 1E battery pack lamps shall be self contained units suitable for the environment in which they are located.

(g) The light fixtures for Class 1E battery packs may be located remote from the battery if the environment at the lamp is not within the qualified range of the battery. Alternatively, lamps powered from the station batteries may be provided.

(h) Outlets shall have grounded connections and should be 120V-15A type or 240V-15A type.

(i) Standard service power boxes shall be 3-phase 480V-100A type.

(j) Lighting around the reactor and fuel pool on the R/B operating floor shall be designed with due consideration of the reflection on the water surface to keep from impeding pool work. Lamps located where they may drop in the reactor or fuel pool, shall have guards.

(k) Outdoor lamps shall have automatic on/off switches.

(l) Associated lighting equipment shall be selected for the following areas. Wiring shall be an explosion-proof type.

(i) Batch oil tank room such as turbine oil tank room and lubrication oil tank room
(ii) EHC equipments room
(iii) Battery rooms
(iv) Diesel generator rooms
(v) Day tank rooms
(vi) Hydrogen related panels and seal oil equipment area

(m) Lighting inside the cask cleaning pit shall be an embedded waterproof type fixture

(n) Feeder circuits for the lighting fixtures and outlets in the following areas shall have circuit breakers with ground current detection:

(i) Decontamination pans
(ii) Decontamination rooms
(iii) Inside drywell (outlets)
(iv) R/B operating floor (service power supply boxes)
(v) Service power supply boxes

(6) Fixture installation levels shall be as follows with consideration for the arrangement of trays, HVAC ducts and equipment lifting space:

Equipment	2.4m (from floor surface)
Distribution panels	2m to the top of the panels
Suspended fixture	2.4m to bottom of the fixtures
Wall mounted fixtures	2.4m to bottom of the fixtures

Detailed installation levels will be coordinated at the construction site.

(7) Wiring Criteria

(a) Wiring from power buses to distribution panels shall be done with conduit or cable trays. Wiring from the distribution panels shall be done with conduits.

(b) Normal non-Class 1E lighting power supply lines from the distribution panels with dual power bus configuration can share the same conduit.

(c) Standby lighting circuits shall not share raceways with normal lighting circuits.

(d) To enhance lighting reliability, emergency DC lighting circuits shall not share raceways with any other circuits.

(e) Physical identification of the safety-related equipment and cables is addressed in Subsection 8.3.1.3.

(8) Wires and Cables

(a) Wire size shall be 2.1mm, or larger as required.

(b) The size of the neutral line shall be the same as the branched circuits.

(9) Conduits

(a) Generally, embedded conduits shall be thick wall type, and exposed conduits may be thin wall type.

Exposed conduits in the drywell, the yard and the area where safety type fixtures or pressure resistant explosion-proof fixtures are required shall be thick wall type.

9.5.3.1.2 Safety-Related Design Bases

Nuclear safety-related design bases for ABWR Standard Plant lighting systems are as follows:

(1) Not Used

(2) Adequate lighting for any safety-related areas, such as areas used during emergencies or reactor safe shutdown, including those along the appropriate access or exit routes, are provided from three different lighting circuits (standby AC; emergency 125VDC, or self-contained battery fixtures).

See Table 9.5-2 for the lighting subsystems and their normal and backup power sources and the switching sequence. This table shows that the lighting is provided from normal AC power and standby AC power, and is backed up by emergency DC power during normal operation. On the loss of normal and standby AC power, the lighting is provided by emergency DC powered lighting facilities or self-contained battery fixtures.

9.5.3.2 System Description

Plant lighting is divided into four subsystems:

(1) Normal lighting (AC)

(2) Standby lighting (AC)

(a) Associated

(b) Non-Class 1E

(3) Emergency lighting (DC)

(a) Associated

(b) Non-Class 1E

(4) Guide lamps

(a) Class 1E

(b) Non-Class 1E

9.5.3.2.1 Normal (Non-Class 1E) Lighting

The normal lighting system is AC and non-Class 1E and provides up to 50% of the lighting needed for operation, inspection, and repairs during normal plant operation and is installed throughout the plant in non-safety-related equipment areas, except for the passageways and stairwells. Normal lighting is generally supplied from the non-safety-related power generation (PG) buses. In the non-safety-related equipment areas, the normal lighting is supplemented (a minimum of 50%) by the non-Class 1E lighting system. Lighting from a single load group is acceptable for localized high intensity lighting and lighting in small rooms where only a limited number of fixtures are needed. Non-Class 1E service outlets and internal lighting for panels is provided by the normal lighting system. In passageways and stairwells leading to non-safety-related equipment areas, the lighting is supplied from two different load groups of the non-Class 1E lighting system. With this configuration, non-safety-related equipment areas receive 100% of their lighting from two different power sources.

9.5.3.2.2 Standby Lighting

Standby lighting is provided for the operation and maintenance of equipment during the loss of normal power and is installed over the entire plant area. The AC lighting configuration permits retaining approximately 50% of the lighting illumination in all passageways, stairwells and safety-related equipment areas during lighting maintenance or loss of a load group. Illumination from 50% of the lighting is adequate to observe equipment and support personnel movement.

The standby lighting system is made of two subsystems: associated and non-Class 1E. The associated lighting subsystem serves the safety-related areas, and their associated passageways. The non-Class 1E lighting subsystem serves the non-safety-related areas and their associated passageways.

9.5.3.2.2.1 Associated Standby Lighting Subsystem (SSLS)

The associated AC Standby Lighting System is comprised of lighting from three Class 1E divisions. Each of the three Class 1E divisions is supplied power from the Class 1E divisional bus, which is connectable to the Class 1E standby power supply (emergency diesel generator

(DG)) in its respective division. Each associated standby lighting system supplies a minimum of 50% of the lighting needs of the safety-related equipment areas in its respective division and of the passageways and stairwells leading to its respective equipment areas. The associated lighting in the battery room and other instrument and control areas of Division IV is supplied from the Division II associated standby lighting system. The main control room lighting is supplied from Division II and III associated standby lighting systems. The remainder of the lighting (up to 50%) in the safety-related equipment areas and the passageways and stairwells leading to them is supplied from the non-Class 1E standby lighting system in the same load group as the associated lighting system. With this configuration, essential equipment areas receive 100% of their lighting needs from two different standby lighting power supplies.

The associated standby lighting subsystem is fed from Class 1E buses through separate lighting panels. Fixtures are provided for all safety-related areas, areas where Division 1, 2, 3, and 4 systems equipment is located, and their associated access areas. The fixtures provide a reduced lighting level adequate to support personnel movement and observation of equipment after interruption of the normal lighting system. In the event of a LOPP, the SSLS is automatically fed from the diesel generator sets.

The lighting circuits are associated. The lighting fixtures themselves are not seismically qualified, but are seismically supported. This is acceptable to the Class 1E power supply because of overcurrent protective device coordination. The bulbs cannot be seismically qualified. However, the bulbs can only fail open and therefore do not represent a hazard to the Class 1E power sources.

9.5.3.2.2.2 Non-Class 1E Standby Lighting Subsystems (NSLS)

The non-Class 1E AC Standby Lighting System (NSLS) is comprised of lighting from three non-Class 1E load groups. Each load group is supplied from a different plant investment protection (PIP) bus which is connectable to the non-Class 1E standby power supply (combustion turbine generator (CTG)). The NSLS supplies a minimum of 50% of the lighting needs of the non-safety-related equipment areas and 100% of the lighting in passageways and stairwells leading to non-safety-related equipment areas (as described above). In addition, the NSLS supplies up to 50% of the lighting needs in safety-related equipment areas and in passageways and stairwells leading to safety-related equipment areas. The remainder of the lighting (a minimum of 50%) in the safety-related equipment areas and in passageways and stairwells leading to them is supplied from the SSLS.

The NSLS is fed from non-Class 1E buses through separate lighting panels. Fixtures are provided for all non-safety-related areas (areas where non-divisional equipment is located), and their associated passageways. The fixtures provide a reduced lighting level adequate to support personnel movement and observation of equipment after interruption of the normal lighting system. In the event of a LOPP, the NSLS is automatically fed from the combustion turbine generator. The NSLS transformers and their associated panels are non-Class 1E and are routed in non-Class 1E raceways. The illumination levels and power sources are shown on Table 9.5-3.

9.5.3.2.3 DC Emergency Lighting

The DC Emergency Lighting System consists of two subsystems: associated and non-Class 1E. The associated subsystem serves the following safety-related areas:

- Main control room
- Safety-related electric equipment rooms
- Diesel generator areas and associated control rooms
- DC electric equipment rooms (battery rooms are included)
- Remote shutdown control rooms

The non-Class 1E subsystem serves the non-safety-related radwaste control room.

The DC Emergency Lighting System provides backup illumination for periods after the loss of preferred power, until the combustion turbine generator energizes the standby lighting system, as well as in the event of loss of all the AC lighting sources.

The illumination levels and power sources of the DC Emergency Lighting System is shown in Table 9.5-4.

9.5.3.2.3.1 Associated Emergency Lighting Subsystem (SELS)

The Associated Emergency Lighting System (SELS) provides the emergency lighting needs to the main control room, the remote shutdown panel room, the emergency diesel generator areas and control rooms, and the safety-related electrical equipment rooms (both AC and DC). Lighting power for the identified safety-related areas is supplied from the 125 VDC battery in the same divisions as the area. The lighting power to the main control room is supplied from Divisions 2 and 3 125 VDC batteries.

The power for the DC emergency lighting subsystem is fed from the Class 1E station DC power supply system through Class 1E distribution panels for the above safety-related areas. Fixtures are provided for all safety-related areas. The circuits are treated as Class 1E. The SELS circuits up to the lighting fixture are classified as associated and are routed in Seismic Category I raceways. This is acceptable to the Class 1E power supply because of overcurrent protective device coordination. The bulbs are not seismically qualified. However, the bulbs can only fail open and therefore do not represent a hazard to the Class 1E power sources.

9.5.3.2.3.2 Non-Class 1E Emergency Lighting Subsystem (NELS)

The Non-Class 1E Emergency Lighting System (NELS) provides the emergency lighting needs to the Radwaste Building (RW/B) control room, the combustion turbine generator (CTG) area and control room, and the non-safety-related electrical equipment areas (both AC and DC).

Lighting power for the RW/B control room is supplied from a Non-Class 1E battery. Lighting power for the non-safety-related electrical equipment rooms is supplied from the 125 VDC battery in the same non-safety-related load group as the equipment in the room. Lighting power for the non-Class 1E CTG is supplied from one of the non-Class 1E 125 VDC batteries.

The power for the NELS is fed from the non-Class 1E station DC power supply system through the non-Class 1E distribution panel for the radwaste control room. The lighting panel and wiring are non-Class 1E and non-seismic. The circuits are classified as non-Class 1E and are routed in non-seismic raceways.

9.5.3.2.4 Guide Lamps With Self-Contained Battery Packs

DC emergency guide lamp lighting fixtures are installed for stairways, exit routes and major control areas such as the main control room and remote shutdown panel areas. Each of the emergency lighting fixtures has two incandescent sealed-beam lamps, with an 8-hr minimum self-contained battery charger and an initiating switch which energizes the fixture from the battery in the event of loss of the AC power supply, and de-energizes the fixture upon return of AC power to the standby light, following a time delay of 15 minutes (Table 9.5-2). The power supply AC source is fed from the standby lighting system in the same area. The passageways are illuminated to a level of 1 foot candle on the floor per the Life Safety Code.

The self-contained emergency lighting sets are Class 1E qualified in safety-related areas. Class 1E equipment is classified as Seismic Category I.

9.5.3.2.5 Emergency Operation Failure Analysis

Because of the redundancy provided by the systems described above, the complete loss of lighting in any of the critical areas is not credible. The standby lighting system on loss of the normal lighting system and the emergency lighting systems provide totally independent low level illumination in areas vital to safe shutdown of the reactor and evacuation or access by personnel should the need occur. This is specifically demonstrated by Tables 9.5-1 and 9.5-2. Also, the safety-related control systems will automatically bring the plant to safe shutdown if lighting is not available.

9.5.3.3 Inspection and Testing Requirements

Since the normal standby and emergency lighting circuits are energized and maintained continuously, they require no periodic testing. However, periodic inspection and bulb replacement will be performed (Subsection 8.3.4.25). The guide lamps are capable of being tested and will be inspected and tested periodically to ensure operability of lights and switching circuits.

9.5.4 Diesel-Generator Fuel Oil Storage and Transfer System

9.5.4.1 Design Bases

9.5.4.1.1 Safety Design Bases

(1) Each engine is supplied by a separate safety-related diesel-generator fuel oil storage and transfer system. All fuel oil transfer equipment is designed, fabricated and qualified to Seismic Category I requirements. Failure of any one component could result in loss of fuel supply to only one diesel-generator.

(2) Minimum onsite storage capacity of the system is sufficient for operating each diesel-generator for a minimum of seven days while supplying post-LOCA maximum load demands.

(3) Design and construction of the diesel-generator fuel oil storage and transfer system and the connection for the diesel generator system piping from the day tank up to the first connection on the engine skid conforms to the IEEE Criteria for Class 1E Power Systems for Nuclear Power Generating Stations (IEEE-308); and ASME Code, Section III, Class 3, Quality Group C. Miscellaneous equipment conforms to applicable standards of NEMA, DEMA, ASTM, IEEE, ANSI, API, NFPA. ANSI Standard N195 “Fuel Oil Systems for Standby Diesel Generators” is applied.

(4) The diesel-generator fuel oil storage and transfer system is of Seismic Category I design. In addition, the storage tanks are separately located underground in vaults, designed for stick gauge access and are protected from damage by flying missiles carried by tornados and hurricanes, from external floods, and other environmental factors. The fill connection is located at grade elevation. The sample connection is located a little above the grade elevation. The fill and sample lines are capped and locked to prevent entry of moisture. The fill and sample lines are also provided with locked-closed isolation valves. The vent is located above the maximum flood level. Each vent is of fireproof goose-necked line with fine mesh screen to prevent access of debris.

    Damage to these lines would have no adverse safety consequences, since they are not part of the fuel path from the storage tank to the diesel. In addition, each diesel has its own day tank, which is located inside the Reactor Building. This provides another level of protected fuel supply for each diesel generator. Also, there are three independent diesel-generator systems. Missile damage of such lines for more than one division is highly unlikely because each division is located in separated areas of the plant.

(5) System components are selected to be corrosion resistant.

(6) System design also considers positive protection from damage caused by turbine missiles.

9.5.4.1.2 Power Generation Design Bases

The diesel-generator systems are standby power supply systems. The diesel fuel oil storage and transfer systems are capable of supporting the instant start requirements of the diesel-generators.

9.5.4.2 System Description

Although specific suppliers may differ in the final design, a typical P&ID is provided as Figure 9.5-6. See Subsection 9.5.13.5 for COL license information.

There are three diesel-generators (DG-A, DG-B and DG-C), each one housed in its separate, respective divisional area within the Reactor Building. The units are identical and are held in reserve to furnish standby AC power in case of an emergency.

The Diesel-Generators DG-A and DG-C are located on one side of the Reactor Building, but are separated from each other. The diesel-generator DG-B is located in the opposite side of the Reactor Building.

Electrical and mechanical components of the fuel oil storage and transfer system in the Reactor Building are located in their respective divisional areas.

The diesel-generator fuel oil storage and transfer system for each engine consists of a yard 7-day storage tank, a fuel oil day tank, two fuel oil transfer pumps located inside the storage tank, suction strainer, duplex filter, instrumentation and controls, and the necessary interconnecting pipe and fittings. A bleed line returns excess fuel oil from the day tank for recirculation to the yard storage tank. A gravity drain is supplied from the bottom of each of the yard storage tanks. These drains periodically remove any water accumulation and sediment from the tanks. The suction of the fuel oil transfer pumps is elevated two to three inches above the tank low points to allow some tank volume for settling of any water. Day tank elevation is such that the engine fuel oil pump operates with flooded suction. The bottom of the day tank will never be lower than the pump suction centerline.

Each diesel-generator set has its own day tank, which holds a capacity of fuel oil sufficient to operate its corresponding diesel-generator set for a minimum of eight hours while supplying its maximum LOCA load demand. Fuel oil is supplied by transfer pumps to each day tank from the yard storage system.

The diesel-generator fuel oil storage and transfer system is capable of transferring fuel oil from the storage tank to the day tank at a rate which exceeds the engine consumption rate while supplying its post-accident load requirements. Fuel oil transfer will not degrade diesel-generator operation.

Electrical power requirements for the fuel transfer system components is provided from the Class 1E electrical system in the same safety-related division.

A set of transfer pumps may be operated with manual control switches from the main control room and locally. However, they are normally operated automatically by level switches on the day tanks. A “low” level switch starts the first transfer pump, a “low-low” level switch starts the standby transfer pump and a “high” level switch stops both pumps.

Capability analyses will be performed in accordance with acceptable industry practice to assure the seven day and eight hour storage and day tank capacities, respectively.

An engine-driven fuel oil pump increases the fuel pressure to the diesel engine fuel manifold. Fuel oil transfer system piping is ASME Code Section III, Class 3, Seismic Category I. A motor driven fuel oil booster pump is also provided for priming purpose, and for added reliability.

9.5.4.3 Safety Evaluation

The overall diesel-generator fuel oil storage and transfer system is designed so that failure of any one component may result in the loss of fuel supply to only one diesel-generator. The loss of one diesel-generator does not preclude adequate core cooling under accident conditions.

Day tank fuel oil feed to the fuel pump is by gravity. There are no powered components to fail. A duplex suction strainer prevents foreign matter from entering the pump and causing malfunction. The system is safety-related and all piping and components up to the engine skid connection are designed and constructed in accordance with the ASME Code Section III, Class 3, and Seismic Category I requirements.

The diesel-generator fuel oil storage and transfer system is designed to withstand the adverse loadings imposed by earthquakes, tornadoes and winds. Earthquake protection is provided by the Seismic Category I construction. Tornado and wind protection is provided by locating system components either underground or within the reactor building. All underground piping is covered with protective coating and wrapping to guard against corrosion. The Seismic Category I portions of diesel-generator fuel oil piping are routed in tunnels between the storage tanks and the Reactor Building. The system is provided with a protection against external and internal corrosion. The storage tanks, located in vaults, are provided with waterproof protective coating.

All storage and day tanks are located at a sufficient distance away from the plant control room to preclude any danger to control room personnel or equipment resulting from an oil tank explosion and/or fire. The fuel oil day tank is located in a separate room with 3-hr fire rated concrete walls. The quality of the fuel oil used for diesel engine will be ensured per Appendix B, of ANSI N195. The fuel oil stored will meet the requirements of the ASTM D975 “standard specification for diesel fuel oils” and the requirements of the diesel engine manufacturer. Fuel oil not meeting these requirements will be replaced within a one-week period.

9.5.4.4 Tests and Inspections

The diesel-generator fuel oil storage and transfer system is designed in accordance with Regulatory Guide 1.137, and to permit periodic testing and inspection. (See Responses 430.274 through 430.276 in Subsection 20.3.16.)

Diesel-generator fuel oil storage and transfer system operability is demonstrated during the regularly scheduled operational tests of the diesel generators (test frequency is given in Chapter 16). Periodic testing of instruments, controls, sensors and alarms is necessary to assure reliable operation.

ASTM standard fuel sample tests are conducted at regular intervals to ensure compliance with fuel composition limits recommended by the diesel engine manufacturer. The “Standard Specification for Diesel Fuel Oils ANSI/ASTM D975” is the governing specification.

Fuel oil may be stored a minimum of six months without deterioration.

Each fuel oil storage tank will be emptied and accumulated sediments be removed every 10 years to perform the ASME Section XI, Article IWD-2000 examination requirements.

New fuel oil will be tested for specific gravity, cloud point and viscosity and visually inspected for appearance prior to addition to ensure that the limits of ASTM D975 are not exceeded. Analysis of other properties of the fuel oil will be completed within two weeks of the fuel transfer.

9.5.4.5 Instrumentation Application

Fuel supply level in the storage and day tanks is indicated both locally and in the main control room. Also, alarms on the local diesel-generator panel annunciate low level and high level in the day tanks. The setting of the low level alarm shall provide fuel at least 60 minutes of DG operation at 100% load with 10% margin between the alarm and the suction line inlet. A group repeat trouble alarm is also provided in the main control room. Level switches in the day tank signal automatic start and stop of the fuel oil transfer pump.

9.5.5 Diesel-Generator Jacket Cooling Water System

9.5.5.1 Design Bases

All essential components of the diesel-generator cooling water system shall be qualified to Seismic Category I requirements and to 10CFR50 Appendix B. All engine-skid mounted pumps, valves, tanks, piping and heat exchangers shall be designed in accordance with ASME Code, Section III, Class 3, Quality Group C. Failure of the cooling system in any one engine shall not affect the readiness or operability of any other engine. Each cooling system rejects its heat to the Reactor Building Cooling Water (RCW) System of the corresponding division. Diesel-generators DG-A, DG-B and DG-C are located in Seismic Category I structures,

protected from tornado-generated missiles and flood waters. The jacket water cooling system shall be able to operate at full load for seven days without any makeup.

The diesel engine shall be capable of operating for two minutes without secondary cooling to ensure that the engine can operate at full load in excess of the time required to restore cooling water (RCW and RSW), which are sequenced onto the Class 1E power supply within one minute following a loss of preferred power (see Table 8.3-4).

9.5.5.2 System Description

Although specific suppliers may differ in the final design, a typical P&ID is provided as Figure 9.5-7. See Subsection 9.5.13.5 for COL license information.

Each diesel-generator unit is supplied with a complete closed loop cooling system mounted integrally with the engine generator package. Included in each cooling package are a jacket water heater and keep-warm pump, temperature-regulating valve, lube oil cooler, motor and/or engine-driven jacket water pumps, jacketed manifold and a jacket water cooler, which is furnished with RCW from the essential portion of the system. RCW supply is from the same division as that of the diesel generator served.

The jacket cooling water passes through a three-way temperature control valve which modulates the flow of water through or around the jacket water heat exchangers (coolers), as necessary, to maintain required water temperature. Jacket water cools the turbocharger, the governor, the air cooler, the exhaust manifold and the lube oil cooler. The three-way valve, whose service is crucial, is designed and qualified as stated in Subsection 9.5.5.1.

An electric heater is installed in each system for the purpose of keeping the engine jacket water at a temperature near the normal operating level during plant normal operation. The heater water is circulated (via the keep-warm pump) through the engine to assure temperature uniformity in the engine while in standby. Two jacket water circulating pumps are provided to circulate the cooling water through the system during diesel-generator operation. During the standby mode, the jacket water temperature is maintained at 48.9°C based on 15.6°C normal ambient temperature.

The system is vented by an expansion tank vent line. The physical mounting of the piping and pumps is lower than the tank elevation; thus a static head will keep the pumps and piping filled with water.

To prevent long-term deterioration of the system internal surfaces, the system is filled with high quality treated water from the Makeup Water Purified System. The RCW side of the system is designed with the appropriate corrosion allowances of piping, and a fouling factor of 0.002 for heat exchanger tubes. A long interval periodic cleaning of the heat exchanger tubes may be necessary to restore the heat transfer capacity of the system in case of excessive fouling rates.

The RCW System for the DG jacket cooling water system is designed for a total heat removal rate based on the maximum permissible overload output of each diesel generator. Prudent margins are incorporated into the design to assure reliable system operation. See Subsection 9.5.13.6 for COL license information pertaining to cooling water system flow and heat removal requirements.

9.5.5.3 Safety Evaluation

Each diesel-generator cooling water system is independent. Failure of the diesel-generator cooling water system does not affect the other diesel-generator cooling systems or their diesel-generators. The engine jacket cooling water heat exchanger is furnished in accordance with ASME Boiler and Pressure Vessel Code, Section III, Class 3. Components of the diesel-generator cooling water systems are designed to Seismic Category I requirements. Procurement of components is governed by the requirements of 10CFR50 Appendix B to ensure quality assurance in all places of manufacture and installation.

9.5.5.4 Tests and Inspection

To ensure the availability of the diesel-generator cooling water system, scheduled inspection and testing of the equipment is performed in accordance with Regulatory Guide 1.9, as part of the overall engine performance checks. Instrumentation is provided to monitor cooling water temperatures, pressure and head tank level. Instruments receive periodic calibration and inspection to verify their accuracy. During standby periods, the keep-warm feature of the engine water jacket cooling closed-loop system is checked at scheduled intervals to ensure that the water jackets are warm. This system facilitates quick starting of the engine; however, the engines are required to be capable of a cold start in 20 seconds. The cooling water in the engine water jacket cooling closed-loop system is analyzed at regular intervals and is treated, as necessary, to maintain the desired quality.

9.5.5.5 Instrument Application

Pressure, temperature and level instrumentation is provided for monitoring of important system operating parameters. Alarms provide warning in case of system low or high water temperature, low pressure, or low water inventory. Except for post-LOCA operation, the diesel generators will trip on high-high cooling water temperature. See Subsection 8.3.1.1.8.5 for complete alarms.

9.5.6 Diesel-Generator Starting Air System

9.5.6.1 Design Bases

The Diesel-Generator Starting Air System provides a supply of compressed air for starting the emergency generator diesel engines without external power. In order to meet the single-failure criterion, each diesel-generator set is provided with two complete, redundant starting air systems. Each starting air system has enough air storage capacity for five consecutive starts of the engine, and performs its starting function in such a way that the time interval between signal

to start and "ready to load" status will not exceed 20 sec. The air storage tanks, valves and piping between tank and up to first connection on the engine skid are designed to Seismic Category I requirements, and in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Class 3. The system is located in a Seismic Category I structure, protected against tornado, external missiles and flood waters.

9.5.6.2 System Description

Although specific suppliers may differ in the final design, a typical P&ID is provided as Figure 9.5-8 (see Subsection 9.5.13.5 for COL license information).

The diesel-generator starting air system provides a separate and independent starting facility for each of the diesel-generating units. Each facility includes two 100% capacity sections, each section consisting of an air compressor, after cooler, air dryer and air receiver. Two redundant starting air admission valves in each of two engine starting air manifolds are provided for each engine. Failure of an one starting system in no way affects the ability of any other system to perform its required safety-related function. Normally, the compressors are fully automatic in operation, controlled by pressure switches located on their respective air receivers. The pressure switches signal the start and stop of the compressors, as necessary to maintain the required system pressure. Manual override of the automatic sequence is provided for emergency situations.

To avoid depleting air start capability, following unsuccessful automatic starting of the diesel generator with and without AC external power, each diesel generator's air receiver tanks will have sufficient air remaining for three more successful starts without recharging (i.e., a total of five starts). Each motor-driven compressor has sufficient capacity to recharge the storage system in 30 min, after five starts of the diesel engine. The compressors are electric motor-driven, and receive power from the Class 1E bus within the same division.

Each air receiver is also provided with a blowdown connection. A connection at the receiver bottom will be used to blow down any water accumulated in the tank. The starting air admission valves are operated by solenoids supplied with uninterruptible DC power from 125 VDC. Solenoids and power feeds are in the same division.

The diesel-generator air start system is provided with an air dryer to ensure clean dry air to engine starting. The dryer will be capable of controlling the dew point as recommended by the diesel engine manufacturer. The dryer will be equipped with pre- and after-filters to remove oil, waste, dust and any pipe scale from the air stream. (See Response 430.285 in Subsection 20.3.16.)

9.5.6.3 Safety Evaluation

The standby diesel-generator starting air system tanks are designed in accordance with the requirements of Section III of the ASME Boiler and Pressure Vessel Code. The system is classified Safety Class 3 and Seismic Category I. Starting air facilities for each of the diesel

engines are completely redundant, with each redundant section capable of supplying enough air for a minimum of five normal engine starts. Because of the redundancy incorporated in the system design, the diesel-generator starting system provides its minimum required safety function under the following conditions.

(1) Design basis loss of coolant condition with loss-of-offsite power, by putting into operation the standby diesel generator.

(2) Maintenance, outage of failure of one of the two air starting systems associated with the diesel engine.

Components of the diesel generator starting system are designed to Seismic Category I requirements. Procurement of components is governed by the requirements of 10CFR50 Appendix B to ensure quality assurance in all phases of manufacture and installation. The diesel generator support systems meet the NUREG/CR-0660 recommendations 2.a, 2.b, 2.d and 5 with regard to protection of these systems from the adverse effects of dust and dirt (Subsection 9.5.13.8).Filters just upstream of the starting air distributor protect the air injectors from airborne contaminants. Each independent starting system has two redundant solenoid air valves. Therefore, system capability is maintained in the unlikely event of blockage of one air valve.

9.5.6.4 Tests and Inspection

Periodic tests and inspections are performed on the following:

(1) System pressure control pressure switches for proper and reliable function.

(2) Low pressure alarm signals for low receiver pressure and low pressure to the engine.

(3) Engine air admission valves and the admission line vent to ensure proper function in response to engine start signal.

(4) Pressure gauges on the receivers to verify calibration.

(5) Air receivers to clear accumulated moisture using the blowdown connection.

9.5.6.5 Instrument Application

An air receiver low pressure alarm is provided to alert the control room operator in case of loss of starting air pressure. See Section 8.3.1.1.8.5 for complete alarms.

9.5.7 Diesel Generator Lubrication System

9.5.7.1 Design Bases

The Diesel Generator Lubrication System is a self-contained system designed to supply clean, filtered oil to the engine and generator bearing surfaces at controlled pressure and temperature.

Built-in capability ensures adequate lubrication of wearing surfaces, and cooling as necessary. An electric heater and a keep-warm circulating pump maintain sufficient circulation of warm oil to help keep the engine in standby readiness. The keep-warm pump also serves as a priming pump to provide prelubrication of engine components. (See Response 430.293 in Subsection 20.3.16.) The pumps, valves, tanks and heat exchangers shall be designed in accordance with ASME Code, Section III, Class 3, Quality Group C.

The system is located in a Seismic Category I structure providing protection from tornado-generated missiles and flood waters, as well as the effects of pipe whip and jet impingement from high and moderate energy pipe failures.

9.5.7.2 System Description

Although specific suppliers may differ in the final design, a typical P&ID is provided as Figure 9.5-9. See Subsection 9.5.13.5 for COL license information.

All components herein described are supplied as part of the diesel-generator package by the diesel-generator supplier. All three systems are nuclear safety-related except for the keep-warm heaters and pumps. In the event of the LOPP or other emergency requiring diesel generator operation, the lube oil keep-warm system is shut down.

Each of the three diesel-generator lubrication systems consists of an oil sump in the engine frame, an engine-driven positive displacement pump, an oil cooler, a main header, and oil strainer and a filter. The main engine-driven lube oil pump takes oil from the sump, passes it through the lube oil cooler and lube oil filter, through a strainer, through the main header and back to the sump. A second feed line from the strainer supplies oil to the turbos via the rocker lube system. Constant oil pressure to the main header is maintained by pressure-regulating valves, which bypasses excess oil back to the sump.

Each of the three lube oil coolers are shell and tube type, built to TEMA Class C, and conform in all respects to ASME Code, Section III, Class 3. Cooling water for the coolers comes from the jacket cooling water (Subsection 9.5.5).

The diesel-generator sets have lube oil heating systems to keep the oil warm during standby. An electric lube oil heater heats the oil, which is circulated through the main header by a keep-warm oil circulating pump. The keep-warm circuit circulates oil through a filter to ensure oil cleanliness. The engine lube oil sump can be replenished by a lube oil supply pump actuated by the low level in the engine sump. The lube oil supply pump transfers lube oil from the lube oil supply tank to the engine sump. The supply tank is filled via pipe feed from a delivery tanker truck. The lube oil may be added to the engine oil sump during engine operation. The lube oil system is capable of operating for seven days at full load. All tanks, pumps, piping, and valves are built to ASME Section III, Class 3, Quality Group C or ANSI B31.1 and Seismic Category I.

9.5.7.3 Safety Evaluation

Each diesel-generator lubrication system is an integral part of the diesel generator. The system is not required to meet the single-failure criterion because a failure does not prevent the other two divisions of the emergency power system from providing adequate power to safely shut down the plant or to mitigate the consequences of any of the postulated accidents.

9.5.7.4 Tests and Inspection

The operating ability of the Diesel-Generator Lubrication System is tested and inspected during scheduled testing of the overall engine. Instrumentation is provided to monitor the lube oil temperature, pressure and sump level, ensuring proper operation of the system. During standby periods, the keep-warm feature of the system is checked at scheduled intervals to ensure that the oil is warm. Warm oil assists quick starting of the engine. Periodic sampling and analyzing of the lube oil is required to ensure good quality of oil in the system.

Local gauge board-mounted alarms signal low oil pressure, high oil temperature and low oil level. A remote combine alarm, one for each division, located in the main control room, annunciates on signal of diesel generator trouble from any alarm source on the local panel. Instruments receive periodic calibration and tests to verify their accuracy.

The lubrication systems are located in locked, controlled diesel-generator rooms, thus precluding unauthorized personnel from interfering with system operation. Also, any contamination of the lubricating oil by deleterious material is thereby prevented.

9.5.8 Diesel-Generator Combustion Air Intake and Exhaust System

9.5.8.1 Design Bases

All components of the Diesel-Generator Combustion Air Intake and Exhaust System shall be designed and qualified to Seismic Category I requirements. All piping shall be designed in accordance with ASME Code, Section Ill, Class 3, Quality Group C. Failure of the intake and exhaust system in any one diesel generator shall not compromise the readiness or operability of any other diesel generator. Except for the exhaust silencers, the system shall be housed in a Seismic Category I and tornado-generated missile-protected structure. The system shall also be protected from flooding and the effects of pipe breaks.

The exhaust silencers for the diesel generators shall be seismically mounted and bolted down in the horizontal position such that the likelihood of their sustaining significant damage, or becoming missiles during a tornado or hurricane event is extremely remote. However, the probability of the silencers themselves being damaged due to externally generated missiles is acceptable. This is because the silencer can be lost without affecting the operation of the diesel unless debris from the damaged silencer clogs the exhaust pipe. In this highly unlikely scenario, the diesel would be assumed lost and the plant shutdown could still be accomplished with either of the remaining two diesels.

The design basis for the Diesel Generator Combustion Air Intake and Exhaust System, regarding protection from the effects of contaminating substances related to the facility site, systems, and equipment is as follows:

(1) There are no contaminating substances available within the ABWR buildings to the combustion air intake in quantities which could degrade the diesel engine performance.

(2) Restriction or contaminating substances from the plant site, which may be available to the combustion air intake is COL license information requirement (Subsection 9.5.13.1).

(3) The diesel engine exhaust system is capable of exhausting the products of combustion to the atmosphere.

9.5.8.2 System Description

Although specific suppliers may differ in the final design, a typical P&ID is provided as the center portion of Figure 9.5-6. See Subsection 9.5.13.5 for COL license information.

Each engine DG-A, DG-B and DG-C takes combustion air from its own inlet air cubical above the diesel generator room. The air is filtered as it enters the cubical through the outside wall above. See Section 9.4.5.5 for a description of the diesel-generator HVAC system.

Engine exhaust gases are ducted out of the building. The exhaust is ducted up through the Reactor Building to the roof where the silencers are mounted. Each engine has its own exhaust system.

In order to protect the crank case from accumulation of fumes and possible consequent fire and explosion, the crank case is kept at negative pressure by vacuum blowers. The gases are exhausted to an outside vent via a 150 A pipe which passes through the Reactor Building wall (see Figure 9.5-6). Pressure sensors will detect unacceptable high pressure conditions in the crank case, and will annunciate this condition to the operator (Figure 9.5-6). This signal will also shut down the diesel unless a LOCA signal is present (Table 8.3-5).

9.5.8.3 Safety Evaluation

Both the intake and exhaust system components of all three engines are completely separate and independent. Failure in any one system has no effect on the readiness and/or operability of either of the others.

For all systems, the air intake is through the wall of the Reactor Building at approximately 11.5m above grade, while the exhaust gases are released to the atmosphere on the Reactor Building roof at approximately 26m above grade. Therefore, the possibility of products of combustion diluting the oxygen content of the intake air is essentially nil. Also, other gases will

not be stored close enough to the diesel air intake that their release to the atmosphere would dilute the intake air and affect the performance of the diesel generators.

See the Reactor Building arrangement drawings in Section 1.2 for intake and exhaust locations, Subsection 3.8.4 for design of the Reactor Building, Section 3.4 for flood protection and Section 3.6 for pipe failure protection.

The combustion air intakes are protected by grills through which the air passes vertically upward. This minimizes plugging of the filters by gross debris picked up by events such as a tornado or a hurricane. Particulate matter small enough to pass through the grill can cause plugging of the inlet filters. To monitor this condition, a differential pressure gauge is installed across each filter (see Figure 9.5-6).

The effect of a local decrease in barometric pressure (e.g., due to a tornado or hurricane) is largely negated by the engine turbochargers.

All intake and exhaust ducting, as well as the ducting hangers, are designed and qualified to Seismic Category I requirements. The ducting also conforms to ASME Section III, Class 3, Quality Group C requirements.

9.5.8.4 Inspection and Testing Requirements

Visual inspection of the diesel-generator combustion air intake and exhaust system may be carried out concurrently with regularly scheduled diesel-generator testing and inspection. Integrity of the ducting and joints, filter condition, intake and exhaust silencer condition inspection are included in the diesel-generator inspection procedure.

9.5.9 Suppression Pool Cleanup System

9.5.9.1 Power Generation Design Bases

The primary function of the Suppression Pool Cleanup (SPCU) System is to provide a continuous purifying water treatment of the suppression pool. During normal plant operation, the SPCU is designed to recirculate approximately 250 m^3/hr of suppression pool water through a Fuel Pool Cooling and Cleanup System filter-demineralizer.

The SPCU System also fills the upper pools from the suppression pool during a refueling outage.

9.5.9.2 System Description

Except for the primary containment penetrations, the SPCU is a non-safety-related system designed to provide a continuous purifying water treatment of the suppression pool. The system removes various impurities by filtration, adsorption, and ion exchange processes. The system maintains the water quality in the suppression pool at a quality equal to that of the fuel and equipment pools. Water quality limits for these upper pools are specified in Subsection 9.1.3.2.

The SPCU System can provide makeup to the fuel pool and the surge tanks of the RCW System as a backup to normal makeup supplied by the condensate system.

The SPCU System also provides water from the suppression pool to the upper pools before a refueling outage.

The system draws water from the suppression pool through a single 250 m^3/hr pump, and directs flow to either the fuel pool seismic makeup line or to a connection to the filter demineralizer that is part of the FPC System. Water is returned from the filter-demineralizer and directed to the suppression pool or the upper pools via the dryer/separator (D/S) pit.

In the event of a LOCA, the SPCU System function is automatically terminated to accomplish containment isolation. Containment isolation valves are provided with Class 1E power.

The SPCU System, consisting of piping, valves, and instrumentation, is shown in Figure 9.5-1. The system has no unique major components.

9.5.9.3 Safety Evaluation

The SPCU System has no safety-related function, except for the primary containment isolation, as previously defined. Failure of the system does not compromise any safety-related system or component and does not prevent safe reactor shutdown.

However, the system does incorporate some features that assure reliable operations over the full range of normal plant operations. These features consist primarily of instrumentation that monitors and/or controls SPCU operation and performance.

Portions of the SPCU System that penetrate the containment are provided with isolation valves which are automatically closed by an isolation signal from leak detection system.

The containment isolation signal logic receives reactor low water-level signals and drywell high-pressure signals. These inputs isolate the SPCU System to prevent containment bypass leakage.

9.5.9.4 Tests and Inspections

All systems piping and components shall be hydrostatically tested prior to plant startup. Non-destructive testing shall be performed in accordance with ASME Section III, Class 2 and 3 requirements, where applicable. The system is designed to permit periodic inservice inspection of all system components to ensure the integrity and capability of the system.

The SPCU System is designed for periodic pressure and functional testing to assure.

(1) Its structural and leaktight integrity, by visual inspection of its components.

(2) The operability and the performance of the active components of the system.

(3) The operability of the system as a whole.

Motor-operated isolation valves shall be tested periodically to assure that they are capable of opening or closing by manual switches in the control room and to confirm by observation that the valve position lights on the control panel correctly indicate valve position.

9.5.9.5 Instrumentation Requirements

Operation of the SPCU System is controlled by the plant operator, who may select either of the operational modes of the system or turn it off from the control room.

The containment isolation valves are supplied with position indication in the control room and remote-manual as well as automatic operation.

9.5.10 Motor-Generator Set

9.5.10.1 Design Bases

The primary function of the motor-generator (M-G) set equipment is to provide additional energy storage capacity for extending the coastdown time of the connected reactor internal pumps (RIPs) during a complete loss of AC power bus incident. In normal operation, the MG set converts the incoming electrical power to mechanical energy, then back to electrical power before using it to source the connected loads. By properly sizing the amount of inertia in the MG set for mechanical energy storage, the generator's output can be made less sensitive to large fluctuations in the input power bus voltage. The design bases of the equipment are the following performance criteria:

(1) Following a complete loss of AC power bus input, the operating speed of the connected RIPs shall be maintained, up to the rated speed, for at least one second.

(2) The subsequent speed reduction in the connected RIPs shall not be greater than –10% per second for a minimum period of two seconds.

In addition to meeting the above equipment performance criteria, the MG set is designed to tolerate certain ranges of normal voltage and/or frequency variations in input power source with negligible effect on generator output. These ranges include the normal, continuous variations in bus voltage up to ±10% of rated and in frequency of up to ±5% of rated. Also, fluctuations in bus voltage as caused by the starting or tripping of other large AC machines connecting to the same bus shall be tolerated.

9.5.10.2 System Description

Two MG sets are provided; each is connected to an independent 13.8 kV power bus. The individual power buses are separated from one another by unit auxiliary transformers and circuit breakers. Each MG set is designed to provide constant voltage and constant frequency power to three adjustable speed drives (ASDs). These ASDs are the static converter devices

which generate the appropriate variable voltage, variable frequency power to the connected RIPs.

Each MG set consists of the following components:

(1) An induction motor.

(2) A generator and excitation system. The exciter design is of brushless type.

(3) A flywheel of appropriate moment of inertia to satisfy the pump speed coastdown requirements as specified in Subsection 9.5.10.1.

(4) Control and protective circuits. The control circuit is designed to maintain generator output at a fixed voltage-to-frequency (V/f) ratio for optimum RIP speed modulation. Protective logic and circuits, monitoring instrument, annunciators, indicators, etc. are provided to protect the MG set components from being damaged by consequences of abnormal equipment operation.

The MG set does not interface directly with the ASD/RIP loads; it interfaces with the loads through three vacuum circuit breakers (VCBs) and three ASD input transformers. Each VCB provides for automatic or manual disconnection of the associated ASD input transformer and ASD/RIP motor load from the generator power output. The ASD input transformers provide two functions in the RIP power supply systems. They step down the MG set voltage output to the level compatible with the rectifier circuitry in the ASD. Also, by phase-shifting the output of the three transformers by ±20 degrees among one another, a majority of the harmonic currents produced by the 6-pulse ASD converter are canceled, thus preventing most of the negative-phase-sequence current from flowing back into the generator.

The MG set will be started with no load. This is accomplished by first leaving all connected ASD loads in their shutdown or tripped status. The MG set motor is started by a control switch in the main control room, and accelerates directly to the rated speed. The connected ASD loads are then sequentially placed online by the control room operator through issuance of proper mode switch commands. The MG set output varies from no load to full load in accordance with the variable operating speed of the RIPs. Shutdown of the MG sets is the exact reverse of the startup.

9.5.10.3 Safety Evaluation

The MG set equipment performs no safety-related function. Failure of the MG set equipment does not compromise any safety-related system or component and does not prevent safe reactor shutdown.

However, the equipment does include some inherent passive design features which help to alleviate the consequence of a complete loss of AC power bus or momentary voltage drop

event. This feature involves automatic extension of electrical coastdown power to the connected RIPs during a bus failure event.

In normal operation, the consequence of having one MG set failure is no worse than that of a three-RIP trip event.

9.5.10.4 Tests and Inspection

Each major component of the MG set, including the motor, generator, flywheel and control panel, will be tested in the vendor’s facility for verification of design and functional conformance. The motor and generator components will be measured for moment of inertia and inspected for mechanical integrity. The electrical properties and load characteristics of the individual motor and generator components will also be tested.

The complete, assembled MG set will be tested in the factory for control panel function, as well as for normal and transient performance response. The normal performance test will be repeated in the site during plant startup.

The MG set equipment is always in service during plant operation, hence its operability is continuously demonstrated. Its extended coastdown performance is a result of its inherent design that does not require special demonstration by periodic testing.

9.5.10.5 Instrumentation Requirements

The operation of the MG set equipment is monitored by instrumentation for early detection of abnormal behavior. The motor input voltage, generator output voltage, current and speed signals are available for display in the control room. In addition, protective relays are supplied with the equipment for automatic detection and alarm annunciation of control panel malfunction, unbalanced loads, breaker trip, and open or short circuit conditions.

9.5.11 Combustion Turbine/Generator

9.5.11.1 Design Basis

The primary functions of the combustion turbine generator (CTG) are:

(1) The alternative AC (AAC) power source during the station blackout (SBO) event as defined in Regulatory Guide 1.155 (see Appendix 1C).

(2) A standby non-safety-related power source located on the site to energize non-safety-related plant investment protection (PIP) loads during loss-of-preferred-power (LOPP) events.

(3) A standby power source during shutdown operations.

The design bases of the equipment shall meet the following performance criteria:

(1) The CTG unit shall automatically start, accelerate to required speed, reach nominal voltage and frequency, and begin accepting load within ten minutes of receipt of its start signal.

(2) The CTG shall be capable of being manually connected to SBO shutdown loads (via any one of the Class 1E diesel generator buses) from the main control room within ten minutes from the beginning of the event. The CTG shall also be capable of being manually connected to the remaining Class 1E buses. However, the CTG shall not be normally connected to plant safety buses nor require any external AC power to operate. There shall be two circuit breakers (one Class 1E and one non-class 1E) in series between the bus automatically connected to the CTG and each Class 1E bus.

(3) The reliability of the CTG unit, based on successful starts and successful load runs, shall be $\geq$ 0.95, as calculated by methods defined in NSAC 108, The Reliability of Emergency Diesel Generators at US Nuclear Power Plants.

(4) The CTG shall have an ISO rating (continuous rating at site conditions) of at least 20 MW, with nominal output voltage of 13.8 kV at 60 Hz.

(5) The generator output shall have a steady-state voltage regulation within ±1% of required voltage when the load is varied from no load to rated load and all transients have decayed to zero. As a minimum, the CTG shall have sufficient capacity to energize required shutdown loads.

(6) The transient response of the generator shall be capable of assuming sudden application of up to 20% of the generator NEMA rating when the generator, exciter, and regulator are operating at no load, with required voltage and frequency resulting in less than 25% excursion from required voltage. Recovery shall be within 5% of required voltage, with no more than one undershoot or one overshoot within one second.

(7) With the generator initially operating at required voltage, and with a constant load between 0 and 100% at rated power factor, the change in the regulated output shall not exceed 1% of required voltage for any 30-minute period at a constant ambient temperature.

(8) The bus tie arrangement, and the capacity and capability of the CTG, is designed such that the time to place the CTG on line to supply any one load group of safe shutdown loads (i.e., includes manual connection to any one Class 1E bus) shall be within 10 minutes.

(9) The non-Class 1E CTG shall be physically and electrically independent from the Class 1E diesel generators such that weather-related failures, common cause failure, or single-point vulnerabilities are minimized or precluded.

(10) The CTG shall be capable of being periodically inspected, tested and maintained (see Subsection 9.5.13.19 for COL license information).

9.5.11.2 System Description

The interconnections for the CTG are shown on the power distribution system single line diagram (SLD), Figure 8.3-1.

The CTG is designed to supply standby power to selected loads on any two of the three turbine building (Non-Class 1E) 4.16 kV buses which carry the plant investment protection (PIP) loads during LOPP events. The CTG automatically starts on detection of a voltage of ≤70% on its preselected PIP buses. When the CTG is ready to load, if the voltage level is still deficient, power is automatically transferred to the CTG.

The CTG fuel oil and transfer system is separate from those of the diesel generators.

Manually controlled breakers also provide the capability of connecting the combustion turbine generator to any of the 4.16 kV Class 1E buses if all other power sources are lost. The reconfiguration necessary to shed PIP and connect the CTG to a preselected bus for emergency shutdown loads can be accomplished from the main control room within 10 minutes of the onset of a postulated station blackout event. Thus, the CTG meets the requirements for alternate AC (AAC) source (per Regulatory Guide 1.155) such that a station blackout coping analysis is not required. The additional connection capability for the remaining Class 1E buses enable the operator to start and operate redundant shutdown loads and other equipment loads if necessary.

The CTG is provided with a fuel supply that is separate from the fuel supply from the Class 1E onsite AC power system. The fuel shall be sampled and analyzed to maintain quality consistent with standards recommended by the CTG manufacturer.

The CTG is completely independent, and located in a separate building, from the Class 1E AC power sources. Thus, no single-point vulnerability exists between them.

The CTG consists of a completely-packaged, fully-assembled and tested, skid-mounted unit with the following components:

(1) A gas turbine with diesel hydraulic start system (i.e., capable of black start). The unit shall be operated with liquid fuel.

(2) A generator with brushless excitation system and terminal box.

(3) Not Used

(4) Lubrication system.

(5) An oil cooling system.

(6) Accessory gearbox.

(7) Air intake and exhaust equipment.

(8) Microprocessor-based control system with control and protective circuits.

(9) Panels, junction boxes and other accessories as required.

See Appendix 1C for requirements for the CTG oil storage and transfer.

9.5.11.3 Safety Evaluations

The CTG is non-safety-related and its failure will not affect safe shutdown of the plant. The unit is not required for safe shutdown of the plant, but is provided as an alternative AC (ACC) source to mitigate the consequences of a station blackout (SBO) event. The CTG does not supply power to nuclear safety-related equipment except on condition of complete failure of the emergency diesel generators and all offsite power (SBO event). Under this condition, the CTG can provide emergency backup power through manually-actuated breakers in the same manner as the offsite power sources. This provides an alternate AC (AAC) power source in accordance with RG 1.155. Adequate protection of the CTG against sabotage is provided by locating the unit inside the security protected area.

Relative to its function as an AAC source, the CTG complies with References 9.5-7, 9.5-8, and 9.5-9.

For detailed assessment of the ABWR during station blackout, see Appendix 1C.

9.5.11.4 Tests and Inspections

The initial test qualification requirements described in IEEE-387, IEEE Standard Criteria for Diesel Units Applied as Standby Power Supplies for Nuclear Power Generating Stations, shall also be applied to the CTG in order to ensure adequate system reliability. However, the factory-test portion of this requirement may be waived if the identically designed unit has been shown capable of maintaining a reliability of 0.99 over a five-year period.

The reliability of the CTG shall meet or exceed 95% as determined in accordance with NSAC-108, or equivalent methodology.

Site acceptance testing, periodic surveillance testing and preventive maintenance, inspections, etc., shall be performed in accordance with the manufacturer’s recommendations, including time intervals for parts replacement, the plant maintenance program, and the operational reliability program (Subsection 9.5.13.19).

9.5.11.5 Instrumentation Requirements

The CTG is provided with local instrumentation and control systems suitable for manual startup and shutdown, and for monitoring and control during operation. Automatic startup and subsequent loading is controlled via the control console located in the main control room. Controls are also provided in the main control room for manual startup of the CTG, and to facilitate connections to the Class 1E buses, should a station blackout occur.

Control room displays are provided to monitor starting, lubricating and fuel supply systems, the combustion air intake and exhaust system, and the excitation, voltage regulation and synchronization systems. CTG start/stop capability is provided in the main control room.

Generator output voltage, current, kVA, power factor, Hz, etc., are also displayed in the control room. Annunciators and computer logs provide early detection of abnormal behavior.

9.5.12 Lower Drywell Flooder

9.5.12.1 Design Basis

The function of the lower drywell flooder (LDF) is to flood the lower drywell with water from the suppression pool in the unlikely event of a severe accident where the core melts and causes a subsequent vessel failure to occur.

The equipment shall meet the following performance criteria:

(1) The LDF shall provide a flow path from the suppression pool to the lower drywell when the drywell air space reaches a nominal temperature of 260°C.

(2) The LDF shall pass sufficient flow from the suppression pool to the lower drywell to quench all of the postulated corium, cover the corium, remove the corium decay heat, and provide an overlying pool of water in the lower drywell as confirmed by severe accident analysis (Subsection 19E.2.8.2).

(3) The LDF shall operate automatically in a passive manner.

(4) The LDF outlet shall be at least one meter above the lower drywell floor.

(5) The LDF inlet shall be located as far below the bottom of the first horizontal drywell-to-wetwell vent as possible while still meeting the requirements for the location of the LDF outlet.

(6) The LDF shall not become a flow path from the suppression pool to the lower drywell during design basis accidents (DBAs) such as loss-of-coolant accidents (LOCAs) or during normal plant operation.

(7) The LDF shall distribute flow around the circumference of the lower drywell.

9.5.12.2 System Description

The LDF, shown schematically in Figure 9.5-3, provides a flow path for suppression pool water into the lower drywell area during a severe accident scenario that leads to core meltdown, vessel failure, and deposition of molten corium on the lower drywell floor. Molten corium is a molten mixture of fuel, reactor internals, the vessel bottom head and control rod drive components. The flow path is opened when the lower drywell airspace temperature reaches 260°C.

The flow of suppression pool water to the lower drywell through the LDF forms a pool of water above the core debris. This pool cools the molten corium and subsequently removes the corium decay heat. This limits the drywell temperature to 260°C and avoids degradation of non-metallic penetration seals in the upper and lower drywell. Interaction between corium and the concrete floor is also stopped. This delays the time of fission product releases for the severe accident, which allows for more decay of fission products and results in lower release fractions. Any fission products released from the debris bed will be scrubbed by the overlying water pool.

The LDF consists of ten pipes that run from the vertical pedestal vents into the lower drywell. Each pipe has an isolation valve and a fusible plug valve connected to the end of the pipe that extends into the lower drywell. The fusible plug valves open when the drywell air space temperature reaches 260°C. When the fusible plug valves open, a minimum of 10.5 L/s of suppression pool water will be supplied through each flooder pipe (105 L/s total) to the lower drywell to quench the corium, flood the lower drywell and remove corium decay heat, which is estimated at 1% of rated thermal power. The flow rate is based on a minimum hydrostatic head of 200 mm above the flooder pipe inlet centerline and takes the frictional losses through the flooder pipe and fusible plug valve into account.

The minimum flow necessary to remove decay heat and the energy from zirconium reactions with the water and carbon dioxide released by concrete ablation is 18 L/s, which can be supplied by two of the ten lines. If nine lines are available (assuming single failure), the flow will be sufficient to fill the lower drywell within two hours.

The inlet centerlines of the drywell flooder pipes are located 10.2 meters below the bottom of the vessel, and the outlets of the fusible plug valves are located at least one meter above the lower drywell floor.

The fusible plug valves open fully, and stay open when the air surrounding the fusible plug valves reaches 260°C. Opening of the valves is triggered by a temperature sensitive fusible plug (or fusible link) that melts when the surrounding air in the lower drywell reaches the opening temperature of 260°C. The temperature sensitive fusible material is isolated from the thermal effects of the suppression pool water inside the fusible plugs as required, to assure consistent operation when the 260°C nominal opening temperature is reached. The fusible plug valves are not pressure relief valves. The pressure retaining portions of the fusible plug valves that contact the suppression pool water are made from stainless steel materials. The seals and gaskets used are compatible with suppression pool water at the design pressure and temperature listed in

Subsection 9.5.12.3.1. The fusible plug valves have zero leakage under all operating and accident conditions, until the surrounding air temperature reaches 260°C. The temperature sensitive fusible material is protected or isolated, as required, from the following: moisture and humidity in the lower drywell, contact with personnel or equipment in the lower drywell, or release of any toxic components to the lower drywell (except during heat-up to 260°C).

The fusible plug valve is mounted in the vertical position, with the fusible metal facing downward, to facilitate the opening of the valve when the fusible metal melting temperature is reached. The opening time for the valve is found to be less than 10 minutes from the time the lower drywell gas space reaches 260°C.

The drywell flooder pipes are welded to the stainless steel vertical vent pipes in the pedestal and to the steel liner in the lower drywell.

9.5.12.3 Safety Evaluation

9.5.12.3.1 General Evaluation

The LDF is a passive injection system and is maintained in an operable state whenever the reactor is critical. The system is never expected to be needed for safety reasons because of the extensive array of water injection systems available to maintain core cooling.

The LDF is safety-related because it is a structural extension of the blowdown vent system. The LDF is Seismic Category I. The quality control classification of the LDF components is the same as the pedestal and the blowdown vents. Therefore, it meets the same structural design, materials, welding, fabrication, thermal and structural analysis, and quality assurance requirements as the reactor pedestal.

The LDF has sufficient redundancy that the failure of one fusible plug to open does not degrade the ability of the system to flood the drywell and quench the corium.

The design pressure of the LDF components is 0.108 MPaD.

The design temperature of the LDF components is 171°C. This value is the primary containment design temperature and considers DBA events. If the LDF components lose pressure integrity at higher temperatures during a severe accident, then the LDF function (i.e., drywell flooding) is performed. Therefore, the design temperature does not need to be higher than the temperature based on DBA events.

The LDF components have zero leakage when subjected to design differential pressure of 0.108 MPa at a design temperature of 171°C.

The portions of the flooder pipe that extend from the steel liner in the lower drywell meet the requirements of ASME Class 2 piping components.

An ANSI B16.5 stainless steel weld-neck flange (or equivalent) is used at the interface between the flooder pipe and the fusible plug valve. The flooder pipe is made of the same material as the blowdown vent pipe or of a stainless steel material that is compatible for welding to the blowdown vent pipe.

The fusible plugs are passive, safety-related components whose design function is to remain closed to maintain the suppression pool boundary during all operating conditions, including a Design Basis Accident. They are non-ASME Code components due to their application and function to open during a Beyond Design Basis Accident at a set temperature of 260°C.

The fusible plug is required to open fully when the air surrounding the valve reaches 260°C during a severe accident and to pass a minimum of 10.5 L/s with 375 mm of water above the valve inlet flange.

A plastic cover on the valve outlet seals the valve from the intrusion of moisture that could cause corrosion of the fusible metal material. The plastic cover has a melting point below 130°C and greater than 70°C and is required to melt completely or offer minimal resistance to valve opening when the opening temperature is reached.

9.5.12.3.2 Consequences of One Flooder Line Opening First

Core debris that enters the lower drywell will be distributed fairly uniformly. The lower drywell floor was designed so that debris spreading would not be hindered. The temperature of the lower drywell air space and structures should be even more uniform because of convective and radiative heat transfer from debris material. Cooler regions will tend to absorb more heat than warmer ones resulting in temperature equalization.

However, if highly non-uniform debris dispersal occurs, it has been postulated that one flooder line could open and its operation could delay or even prevent the other lines from activating. In the worst physical case, the initiation of one flooder line causes crust formation without completely quenching the debris. The crust limits heat transfer from the surface of the debris bed. Core-concrete interaction (CCI) will occur if surface heat transfer is reduced enough.

CCI results in large quantities of gases being formed under the surface of the crust. The gases will increase in pressure due to continued generation until the crust ruptures or they escape from the edges of the bed. In either case, the gases will pass from the debris bed into the lower drywell airspace. The passage either will be unobstructed with gasses exiting the debris above the water elevation or through an overlying layer of water. Since only one flooder line is presumed active, the water layer, if it exists, will be thin and no significant amount of heat will be transferred from the gas to the liquid.

Concrete has an ablation temperature of approximately 1500 K. The released gases from core concrete interaction will be at least at this temperature. Higher temperatures may be reached by the gases as they interact with debris material in their exit. Thus, gases enter the lower drywell

air space at very high temperature. The CCI gases will increase the temperature of the lower drywell air space. More flooder lines will become active as the lower drywell temperature increases. For this reason, the activation of a single flooder line is transient condition at worst and is not expected to adversely affect the operation of the other lines.

9.5.12.3.3 Estimation of Net Risk

In order to assess the net risk of the lower drywell flooder system, a sensitivity study was performed in Subsection 19E.2.8.2.7 using three failure probabilities for the lower drywell flooder. In these cases, the failure probability of the lower drywell flooder was increased from its base case value to 1.0.

The overall performance of the ABWR design is not sensitive to the LDF failure probability. Failure of the LDF leads to an increase in the probability of Dry CCI. Thus, the probability of Dry CCI increases by one, two and three orders of magnitude, respectively for the three sensitivity cases. However, the base case results for Dry CCI are so small that a three order of magnitude increase does not impact other results significantly.

The principal conclusions of the sensitivity studies are:

(1) Pedestal failure does not increase since it is dominated by the sequences where core-concrete interaction persists even though the lower drywell is flooded.

(2) The only probabilistic output which shows any significant variation is drywell head seal overtemperature leakage which exhibits a two fold increase for a two orders of magnitude increase in the passive flooder failure probability, and a ten fold increase for a three order of magnitude increase. The change in seal leakage is much less than the change in passive flooder failure probability since high RPV pressure sequences with entrainment of debris to the upper drywell and failure of the upper drywell sprays dominate the seal leakage sequences in the base analysis.

(3) Even for the case where the passive flooder is assumed to be unavailable, the frequency associated with the Dry CCI is below the lower limit considered in the evaluation of offsite dose.

Thus, it is seen that the lower drywell flooder does not affect net risk for frequencies of interest. Therefore, the value of the lower drywell flooder system is not measured as a direct impact on risk. Rather, it should be viewed as a passive system which serves to limit the impact of uncertainty in operator actions and allows the ABWR design to mitigate a severe accident in a purely passive manner.

9.5.12.4 Testing and Inspection Requirements

The ability of the LDF to mitigate severe accidents by passing sufficient water to cover and quench the postulated corium in the drywell is confirmed by severe accident analysis (Appendix 19E).

No testing of the LDF system will be required during normal operation. During refueling outages, the following surveillance would be required:

(1) During each refueling outage, verify that there is no leakage from the fusible plug valve flange or outlet when the suppression pool is at its maximum level.

(2) Once every two refueling outages, two of the fusible plug valves are tested to demonstrate proper opening function and triggering of the opening at the proper temperature. These tests may be performed together or separately, and the two fusible plug valves tested (or temperature sensitive materials) will be replaced.

9.5.12.5 Instrumentation Requirements

The LDF operates automatically in a passive manner during a severe accident scenario that involves a core melt and vessel failure. No operator action is required; therefore, no instrumentation is placed upon the system. An inadvertent opening or leak would be detected by the lower drywell leak detection system and the suppression pool water level instrumentation which would result in plant shutdown.

During severe accidents, operation of the LDF is confirmed by other instrument readings in the containment. These instruments include those which would record the drywell temperature reduction and the lowering of suppression pool water level.

9.5.13 COL License Information

9.5.13.1 Contamination of the DG Combustion Air Intake

The COL applicant shall take measures to restrict contaminating substances from the plant site which may be available to the diesel generator air intakes (Subsection 9.5.8.1).

9.5.13.2 Use of Communication System in Emergencies

Procedure for use of the plant communication system in emergencies including operation from RSS in the event of a main control room fire shall be provided by the COL applicant (Subsection 9.5.2.4).

9.5.13.3 Maintenance and Testing Procedure for Communication Equipment

Maintenance and testing procedures for the plant communication systems shall be provided by the COL applicant (Subsection 9.5.2.5).

9.5.13.4 Use of Portable Hand Light In Emergency

The portable sealed-beam battery-powered hand light is used by the fire brigade and other personnel during an emergency to achieve a plant shutdown. The COL applicant's design shall comply with the BTP CMEB 9.5-1, Position C.5.g(l) and (2) per Subsection 9.5.1.2.3. The COL applicant shall supplement this subsection accordingly as applicable.

9.5.13.5 Vendor Specific Design of Diesel Generator Auxiliaries

The COL Applicant's vendor-specific diesel generator support systems (i.e., the D/G Fuel Oil System, the D/G Cooling Water System, the D/G Starting Air System, the D/G Lubrication System, the D/G Combustion Air Intake and Exhaust System) shall be reviewed for differences in design with those discussed in Subsections 9.5.4 through 9.5.8, respectively. A discussion of such differences shall be provided by the COL applicant.

Specific NRC requested information lists as follows:

(1) Not Used

(2) Provision for stick gauges on fuel storage tanks.

(3) Description of engine cranking devices.

(4) Duration of cranking cycle and number of engine revolutions per start attempt.

(5) Lubrication system design criteria (pump flows, operating pressure, temperature differentials, cooling system heat removal capabilities, electric heater characteristics).

(6) Selection of a combustion air flow capacity sufficient to assure complete combustion.

(7) Volume and design pressure of the air receivers (sufficient for 5 start cycles per receiver).

(8) Compressor size (sufficient discharge flow to recharge the system in 30 minutes or less).

See Subsections 9.5.4.2, 9.5.5.2, 9.5.6.2, 9.5.7.2 and 9.5.8.2.

9.5.13.6 Diesel Generator Cooling Water System Design Flow and Heat Removal Requirements

The COL applicant shall provide the table which identifies the design flow and heat removal requirements for the diesel generator cooling water system. It shall include the design heat removal capacities of all the coolers or heat exchangers in the system.

Specific NRC requested information lists as follows:

(1) Type of jacket water circulating pumps (i.e., motor-driven or others).

(2) Type of temperature sensors (use “Amot” brand or equal per NUREG.CR-0660, Page V-17, Recommendation under Item 4).

(3) Expansion tank capacity.

(4) NPSH of jacket water circulating pump.

(5) Cooling water loss estimates.

See Subsection 9.5.5.2.

9.5.13.7 Fire Rating for Penetration Seals

The COL applicant shall provide 3-hour fire rated penetration seals for all high energy piping or, as a minimum, state those conditions when such seals cannot be provided and what will be installed as a substitute. The detail design shall provide completely equivalent construction to tested wall assemblies or testing will be required (Subsection 9A.5.1).

9.5.13.8 Diesel Generator Requirements

(1) The diesel generator operating procedures for a particular diesel-engine make and model shall require loading of the engine up to a minimum of 40% of full load (or lower load per manufacturer’s recommendation) for 1 hour after up to 8 hours of continuous no-load or light load operation.

(2) Diesel generator selection shall include prudent component design with dust tight enclosures. Construction guidelines shall include provisions for minimizing accumulation of dust and dirt into equipment. These shall be in accordance with recommendations 2.a, 2.b, 2.d and 5 of NUREG/CR-0660 (Subsection 9.5.6.3).

(3) The diesel generator operating procedure shall include provisions to avoid as much as possible or otherwise restrict the no-load or low-load operation of the engine/generator for prolonged periods of time; or operate the engine at nearly full-load following every no-load or low-load (20% or less) operation lasting for a period of 30 minutes or more (Subsection 8.3.1.1.8).

9.5.13.9 Applicant Fire Protection Program

The following areas are out of the ABWR Standard Plant design scope for the fire protection program, and shall be included in the COL applicant’s fire protection program:

(1) Main transformer

(2) Equipment entry lock

(3) Fire protection pumphouse

(4) Ultimate heat sink

The COL applicant's fire protection program shall comply with the SRP Section 9.5.1, with ability to bring the plant to safe shutdown condition following a complete fire burnout of a fire area/division without a need for recovery (Subsection 9.5.1).

9.5.13.10 HVAC Pressure Calculations

The COL applicant shall provide pressure calculations and confirm capability during preoperational testing of the smoke control mode of the HVAC systems as described in Subsection 9.5.1.1.6.

9.5.13.11 Plant Security Systems Criteria

The COL applicant's design of the security system (Subsection 9.5.2) shall include an evaluation of its impact on plant operation, testing, and maintenance. This evaluation shall assure that the security restrictions for access to equipment and plant regions is compatible with required operator actions during all operating and emergency modes of operation (i.e., loss of offsite power, access for fire protection, health physics, maintenance, testing and local operator). In addition, this evaluation shall assure that:

(1) There are no areas within the Nuclear Island where communication with central and secondary alarm stations is not possible.

(2) Portable security radios will not interfere with plant monitoring equipment.

(3) Minimum isolation zone and protected area illumination capabilities cannot be defeated by sabotage actions outside of the protected area.

(4) Electromagnetic interference from plant equipment startups or power transfers will not create nuisance alarms or trip security access control systems.

9.5.13.12 Not Used

9.5.13.13 Diesel Fuel Refueling Procedures

The COL applicant shall establish procedures to verify that the day tank is full prior to refilling the storage tank. This minimizes the likelihood of sediment obstruction of fuel lines and any deleterious impacts on diesel generator operation.

9.5.13.14 Portable and Fixed Emergency Communication Systems

The COL applicant's design of the portable radio communication system and the fixed emergency communication system shall comply with BTP CMEB 9.5-1, position C.5.g(3) and (4). The COL applicant will supplement Subsection 9.5.2.6 accordingly, as applicable.

9.5.13.15 Identification of Chemicals

The COL applicant shall provide protection features for liquid insulated transformers and will identify the type and location of chemicals as required by SRP Section 13.2.2 (Subsection 9.5.1.2).

9.5.13.16 NUREG/CR-0660 Diesel Generator Reliability Recommendations

Programs shall be developed to address NUREG/CR-0660 recommendations regarding training, preventive maintenance, and root-cause analysis of component and system failures.

9.5.13.17 Sound-Powered Telephone Units

The COL applicant shall provide the sound-powered telephone units to be used in conjunction with the system described in Subsection 9.5.2.2.2.

9.5.13.18 Fire-Related Administrative Controls

The COL applicant shall provide the description of the administrative controls outlined in Subsection 9.5.1.6.4.

9.5.13.19 Periodic Testing of Combustion Turbine Generator (CTG)

Appropriate plant operating procedures shall include periodic testing and/or analysis to verify the adequacy of the CTG to meet alternate AC (AAC) requirements for station blackout and to support its use in Section 3.8 of the Technical Specification. As a minimum, such procedures shall verify the following:

(1) For each 4.16 Kv emergency bus (staggered among the three buses at 18-month intervals), verify the CTG starts and energizes the bus within 10 minutes and energizes all required loads (as defined in the "LOCA-Loads" section of Table 8.3-4) within 15 minutes. The steady-state CTG voltage and frequency shall be 13.8 kV ± 10 % and 60 Hz ± 2 %. All CTG starts may be preceded by an engine prelube period.

(2) The operator can accomplish this from the main control room.

(3) One Class 1E circuit breaker and four non-Class 1E circuit breaker exist and are functional between each of the Class 1E diesel generator buses and the CTG. (Note that the Class 1E and non-Class 1E breakers, which provide the connection from the CTG bus to the diesel generator buses, are normally open and have no automatic function. The operator must manually align this connection.)

(4) Each 92 days, verify the combustion turbine generator (CTG) starts and achieves steady state voltage (13.8 kV ± 10 %), and frequency (60 Hz ± 2 %) in less than 10 minutes. Load the CTG to ≥90% and ≤100% of its continuous rating and operate it with this load for at least 60 minutes. All CTG starts may be preceded by an engine prelube period.

(5) The reliability of the CTG is at least 0.95 as calculated by methods defined in NSAC 108, The Reliability of Emergency Diesel Generators at US Nuclear Power Plants.

9.5.13.20 Operating Procedures for Station Blackout

Appropriate operating procedures and personnel training shall be developed to:

(1) Address the operation of the AAC-CTG during an SBO event

(2) Restore other plant offsite (preferred) and onsite emergency power sources as soon as possible

(3) Recover 4.16 HVAC Systems as soon as possible to limit heat rises

(4) Provide additional core, containment, and vital equipment makeup and cooling services, as necessary

(5) Establish orderly plant safe shutdown conditions

(6) Be consistent with severe weather guidelines in NUMARC 87-00, Section 4.2.3. Deviation may be authorized from NUMARC 87-00 criteria for grid conditions where a shutdown may increase the likelihood of a loss of offsite power.

9.5.13.21 Quality Assurance Requirements for CTG

Quality assurance standards and practices shall be developed to assure continued operational reliability of the CTG as an AAC power source for SBO events, in accordance with Regulatory Guide 1.155 and 10CFR50.63.

9.5.14 Alternate Feedwater Injection System

9.5.14.1 System Description

An alternate feedwater injection (AFI) system, capable of injecting into the Reactor Pressure Vessel (RPV) at operating pressure (≥800 g.p.m. at a pressure approximately at the lift setpoint of the first group of safety/relief valves) and located outside of the Reactor Building (R/B) is available. The system is capable of providing sufficient core cooling in the unlikely event that all normal and emergency core cooling systems are unavailable. It is comparable to the High Pressure Core Flooder (HPCF) system capacity and discharge pressure (at rated pressure). The AFI Pump House which contains this system as well as the water source for AFI are located a minimum of 300 feet from the nearest outside wall of each of the Reactor Building, Control

Building and Turbine Building. The interaction of the non-seismic AFI Pump House with Seismic Category I structures, systems and components will be evaluated in accordance with the existing process described in Section 3.7.2.8. This will ensure that a failure of the non-seismic Pump House will not render any Category I structure inoperable. A schematic of the AFI system is shown in Figure 9.5-10.

The system takes suction from an existing water source which is located near the AFI Pump House. There is a minimum of 300,000 gallons of useable water at the AFI Pump suction line while the AFI is in standby. The water supply source is required to be a fresh water source, filtered if necessary to remove silt and debris. If the primary source is a volume limited supply such as a tank, a minimum of 300,000 gallons must be reserved for the AFI system, and the source must be capable of being refilled. The AFI system discharges through three normally closed motor-operated valves (MOV). The system discharge piping is routed underground or is otherwise protected from physical impact. The injection is provided through the non-safety-related portion of the NB system downstream of the CUW system tie-in line to the feedwater piping. The tie-in is in the R/B portion of the Steam Tunnel. The system and power supplies are non-safety grade. The AFI Pump House and water source are separated by barriers from each of the Reactor Building, Turbine Building, and Control Building as described in Tier 1, Table 2.11.24.

The power supply for the pump and motor-operated valves is a non-safety-related power supply and independent of the emergency power supplies and meets the requirements of non-Class 1E power as described in Chapter 8. The power supply is physically separated from the emergency power supplies such that a simultaneous loss due to beyond design basis events is unlikely. In order to satisfy this separation requirement, the power supply is located at least 300 feet from the nearest outside wall of each of the Reactor Building, Control Building, and Turbine Building (Reference NEI 06-12 “B.5.b Phase 2 & 3 Submittal Guideline”, Rev. 2, December 2006, which was endorsed by the NRC by letter dated December 22, 2006). The power supply and associated power supply auxiliary support equipment such as switchgear and cables are separated by barriers from each of the Reactor Building, Turbine Building and Control Building as described in Tier 1, Table 2.11.24.

The AFI pump is a self-cooled pump that relies on the pumped fluid for cooling. At rated flow, pump cooling is provided by the fluid flowing to the RPV. As shown in Figure 9.5-10, a minimum flow bypass line is provided to return water to the pump suction source to prevent pump damage due to overheating when the injection valves on the main discharge lines are closed. Cooling of the AFI pump is consistent with the Pump Manufacturer’s recommendations.

Lubrication of the AFI pump is performed in accordance with the Pump Manufacturer’s recommendations and is included as part of the applicant’s maintenance procedures.

The system can be operated from the AFI Pump House. This will ensure that the injection can be initiated within 30 minutes after the loss of normal makeup systems to provide sufficient

core cooling. In addition, the operator is provided with the capability to control flow from the AFI Pump House by throttling a motor-operated valve located in the Pump House. The procedures for operation of the AFI system include provisions to throttle the flow at the start of the AFI pump, which minimizes the effects of water hammer. The AFI Pump House environment is compatible with the AFI equipment requirements as specified by the equipment manufacturer.

9.5.14.2 Safety Evaluation

This system does not degrade safety for normal operation and provides enhanced safety during and after beyond design basis events. The ability to maintain core cooling is improved by the addition of a separate and diverse means of providing cooling water to the core when all normal and emergency cooling systems are unavailable. The piping and components that interface with the NB system are the same quality as that system up to and including the second check valve.

In the event that fluid from the CUW system should leak past the two check valves and the first MOV, a leakoff line is included in the AFI design as shown in Figure 9.5-10 which directs any leakage back to the Reactor Building low conductivity sump. Consequently, any leakage of radioactive fluid into the AFI system is ultimately contained within the Reactor Building. The existing leak detection that exists for the Reactor Building low conductivity sump can then be used to monitor this leakage. Flooding from AFI pipe breaks during AFI operation, as well as from the AFI water source, is bounded by existing analyses in the DCD. The impact on risk assessment for internal flooding is minimal because the AFI system is only required to operate for beyond design basis events after all safety systems are already assumed to have failed.

The dynamic effects from an AFI system pipe break are not required to be postulated. The effects on plant safety systems are bounded by the Main Steam or Feedwater High Energy Line Breaks. Additionally, the safety systems are already assumed to have failed at the time the AFI System is required.

9.5.14.3 Testing and Inspection Requirements

Preoperational testing requirements for the AFI system are prepared as described in Subsection 14.2.12.

The AFI system components are periodically tested consistent with the Manufacturer's recommendations as part of the COL Applicant's maintenance program.

9.5.14.4 Instrumentation Requirements

The following indications are provided in the AFI Pump House:

- RPV water level
- RPV pressure

- Wetwell WR pressure
- Suppression pool water level

In addition, the following AFI-related instrumentation is provided in the AFI Pump House:

- AFI pump flow and discharge pressure
- Level indication of any dedicated water storage tanks

The AFI Transmitter Rack for RPV level, RPV pressure, and wetwell pressure is located in Room 314 of Floor B1F of the Reactor Building. The AFI Transmitter Rack for Suppression Pool Level is located in Room 111 of Floor B3F of the Reactor Building. Both instrument racks are located in rooms that are outside of the physical and fire damage footprints from beyond design basis events. The AFI Instrument Rack in Room 314 is shock-mounted.

The location of the AFI instrument lines is shown in Table 9.5-6. All AFI cabling and instrument lines are located outside of the physical damage footprint for beyond design basis events. Instrument lines are routed through rooms that are protected from fire exposure with the exception of Room 230 where the instrument lines are protected from fire by 3-hour rated fire wrap. The room protection is achieved by creating new fire areas protected by 3-hour fire rated doors or by 3-hour fire rated water-tight doors. Instrument cabling with at least 3 hour fire rating is used. The instrument lines to be used for monitoring the alternate feedwater injection are branched from the existing lines and are connected to new level and pressure transmitters. The safety classification of the instrumentation and associated piping for the AFI system is the same as that for the existing instrumentation to which it is connected as identified in Table 3.2-1. In the unlikely event of an instrument line break, the break flow is limited by the small size of the instrument line orifice and an excess flow check valve, and is accounted for in the specified capacity for the AFI pump.

9.5.15 Reference

9.5-1 Stello, Victor, Jr., “Design Requirements Related To The Light Water Reactors (ALWRS)”, Policy Issue, SECY-89-013, The Commissioners, United States Nuclear Regulatory Commission, January 19, 1989.

9.5-2 Cote, Arthur E., “NFPA Fire Protection Handbook”, National Fire Protection Association, Sixteenth Edition.

9.5-3 “Design of Smoke Control Systems for Buildings”, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., September 1983.

9.5-4 “Recommended Practice for Smoke Control Systems”, NFPA 92A, National Fire Protection Association, 1988.

9.5-5 Life Safety Code, NFPA 101, National Fire Protection Association.

9.5-6 “Reliability of Emergency Diesel Generators at U.S. Nuclear Power Plants”, Electric Power Research Institute, NSAC-108, September 1986.

9.5-7 Loss of All Alternating Current Power, 10CFR50.63.

9.5-8 Regulatory Guide 1.155—Station Blackout.

9.5-9 “Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors”, NUMARC-87-00.

Table 9.5-1 Normal and/or Standby Lighting (Non-Class 1E AC Power Supply)

	Location	Illumination Lux	Area
1.	(RW control room) Operation desk (console panel)	538.2	Working level
	Instrument on the perpendicular surface	538.2	Working level
	Others	538.2	Floor level
2.	Local control panels	538.2	Working Level
3.	Instrument rooms, maintenance rooms, hot laboratory	538.2	Working level
4.	Computer rooms, office, conference rooms, radiation administration rooms	322.9	Working level
5.	Check points, FMCRD RIP maintenance room	322.9	Working level
6.	Machining rooms, valve wrapping rooms	322.9	Working level
7.	R/B operating floor	322.9	Floor level
8.	Relay rooms, operator waiting room, dressing room, paging room	215.3	Working level
9.	Sampling rack rooms	215.3	Working level
10.	Electrical panel rooms, instrument rack rooms, diesel generator rooms	215.3	Working level
11.	General machine area	215.3	Floor level
12.	Equipment transfer area	107.6	Floor level
13.	Machine area under low radiation	107.6	Floor level
14.	Tank rooms	215.3	Floor level
15.	Battery rooms, passages and stair cases with frequent access	215.3	Floor level
16.	Inside drywell	107.6	Floor level
17.	Condenser area, SGTS rooms	107.6	Floor level
18.	HVAC rooms and elevator machine rooms	107.6	Floor level
19.	(RW filter rooms, enrichment rooms) MSIV room	107.6	Floor level
20.	Passages and staircases	53.8	Floor level
21.	Rooms isolated with hatches where access is restricted to annual inspection	53.8	Floor level
22.	Piping space	107.6	Floor level
23.	The rooms where the access is very difficult	0	Floor level

Table 9.5-2 Lighting and Power Sources

Lighting	Normal Operation	Loss of Preferred Power (LOPP)	LOPP Plus Loss of CTG	LOPP Plus Loss of CTG Plus Loss of DGs	Loss of All AC Plus Loss of Station Batteries
Normal Lighting	X	–	–	–	–
Standby Lighting					
Non-Class 1E	X	X	–	–	–
Class 1E Associated	X	X	X	–	–
Emergency Lighting					
Non-Class 1E	X*	X†	X	X	–
Class 1E Associated	X*	X†	X†	X	–
Guide Lamps					
Non-Class 1E	X*	X†	X	X	X
Class 1E Associated	X*	X†	X†	X	X

* Available, but off while AC power is available.

† On only during the time required to energize the standby bus from the standby power source

Table 9.5-3 Standby Lighting (Class 1E AC Power Supply)

Area	Illumination Lux Working Level	Division of Power
Main control room	538.2	Division II and III
Safety-related electric equipment room DG control room, DG room, RSS room	215.3	Division of power supply is the same as the equipment's power supply.
Safety equipment area	21.5-53.8	Division of power supply is the same as the equipment's power supply.
Other areas of buildings	5–10% of standard illumination level	Divisional (for safety-related passage ways)

Table 9.5-4 DC Emergency Lighting

Area	Illumination Lux Floor Level*	Division of Power
Main Control Room	75.4	Div. II, Ill DC power supply
Div. I essential electric equipment room (RB)	75.4	Div. I DC power supply
Div. II essential electric equipment room (RB)	75.4	Div. II DC power supply
Div. III essential electric equipment room (RB)	75.4	Div. Ill DC power supply
Div. I diesel generator area and associated control room (RB)	75.4	Div. I DC power supply
Div. II diesel generator area and associated control room (RB)	75.4	Div. II DC power supply
Div III diesel generator area and associated control room (RB)	75.4	Div. III DC power supply
Div. I DC electrical equipment room (CB)	75.4	Div. I DC power supply
Div. II DC electrical equipment room (CB)	75.4	Div. II DC power supply
Div. Ill DC electrical equipment room (CB)	75.4	Div. III DC power supply
Div. IV DC electrical equipment room (CB)	75.4	Div. IV DC power supply
Div. I Remote Shutdown System control area (RB)	75.4	Div. I DC power supply
Div. II Remote Shutdown System control area (RB)	75.4	Div. II DC power supply
Radwaste control room (RW/B)	75.4	Non-div. DC power supply
Non-essential electric equipment rooms	75.4	Non-div. DC power supply
CTG room	75.4	Non-div. DC power supply

* Working areas in front of Class 1E panels containing instruments or controls shall be a minimum of 107.6 Lux measured 1 meter up from the floor level.

Table 9.5-5 Summary of Automatic Fire Suppression Systems

Bldg.	Elev	Room No.	Fire Area	Area Name	Div	Combustible	Sprinkler System Type
PY	7350	N/A	N/A	Unit Auxiliary Transformer	ND	Oil	Deluge water
PY	7350	N/A	N/A	Main Transformer Area	ND	Oil	Deluge water
PY	7350	N/A	N/A	Reserve Transformer	ND	Oil	Deluge water
RB	–8200	133	F1300	CRD Pump Room	ND	Class III B lube oil & cables	Dry pipe, closed head
RB	12300	412	F4100	Diesel Generator A Room	D1	Fuel oil, Lube oil, & cables	Preaction foam-water
RB	12300	423	F4200	Diesel Generator B Room	D2	Fuel oil, Lube oil, & cables	Preaction foam-water
RB	12300	432	F4300	Diesel Generator C Room	D3	Fuel oil, Lube oil, & cables	Preaction foam-water
RB	23500	610	F6101	Diesel Generator Fuel Tank A Room	D1	Diesel fuel	Deluge foam-water
RB	23500	620	F6201	Diesel Generator Fuel Tank B Room	D2	Diesel fuel	Deluge foam-water
RB	23500	630	F6301	Diesel Generator Fuel Tank C Room	D3	Diesel fuel	Deluge foam-water
RW	12300	N/A	N/A	Dry Radioactive Waste Storage Area	ND	Radioactive material	Wet pipe sprinkler
TB	2300	N/A	FT1500	Beneath the Turbine surroundings	ND	Lubricants & cables	Wet pipe sprinkler
TB	6300	230	FT2500	Lube Oil Conditioning Area	ND	Class III B lube oil	Deluge foam-water
TB	6300	247	FT2503	House Boiler Area	ND	Lubricants and cables	Wet pipe sprinkler
TB	12300	317 & 2X8	FT3500	Gas Turbine Generator	ND	Diesel fuel & Class III B lube oil	Deluge foam-water
TB	19700	3X2	FT35X9	Hydrogen Seal Oil Skid Area	ND	Hydrogen seal oil	Deluge foam-water
TB	15350	321	FT1500	Beneath the Turbine Surroundings	ND	Lubricants, & cables	Wet pipe sprinkler
TB	15350	330	FT3501	Lube Oil Reservoir Area	ND	Class III B lube oil	Deluge foam-water

Table 9.5-5 Summary of Automatic Fire Suppression Systems (Continued)

Bldg.	Elev	Room No.	Fire Area	Area Name	Div	Combustible	Sprinkler System Type
TB	19700	330	FT3501	Lube Oil Reservoir Area	ND	Class III B lube oil	Deluge foam-water
TB		122	FT1503	Stairwell No. 2	ND		Wet pipe sprinkler
TB		249	FT2504	Stairwell No. 4	ND		Wet pipe sprinkler
TB		1X3	FT15X1	Stairwell No. 6	ND		Wet pipe sprinkler
TB		1X4	FT15X2	Stairwell No. 7	ND		Wet pipe sprinkler
TB	6300	N/A	FT1500	Beneath Turbine surroundings	ND	Lubricants & Cables	Wet pipe sprinkler
TB		114	FT1502	Stairwell No. 1	ND		Wet pipe sprinkler
TB		212	FT2502	Stairwell No. 3	ND		Wet pipe sprinkler
TB		1Y5	FT15Y1	Stairwell No. 8	ND		Wet pipe sprinkler
TB		250	FT15Y2	Elevator Shaft	ND	Lubricants & Cables	Wet pipe sprinkler
TB	6300	1Y1	FT15Y3	Lube Oil Storage Tank Area	ND	Class III B lube oil	Deluge foam water
TB	6300	232	FT1501	HNCW Chiller Area	ND	Lubricants & Cables	Wet pipe sprinkler
TB	6300	111	FT1501	Instrument & Service Air Equip.	ND	Lubricants & Cables	Wet pipe sprinkler
TB	6300	1Y2	FT1501	Breathing Air Equipment Area	ND	Lubricants & Cables	Wet pipe sprinkler
TB	6300	232	FT15Y4	EHC Hydraulic Power Unit Area	ND	Class III B hyd. fluid	Deluge foam water
TB	12300	N/A	FT1500	Beneath Turbine surroundings	ND	Lubricants & Cables	Wet pipe sprinkler
TB	12300	2X5	FT25X1	CTG Switchgear Area	ND	Electrical Cables	Wet pipe sprinkler
TB	12300	210	FT25X3	Switchgear Room 'A'	ND	Electrical Cables	Wet pipe sprinkler
TB	19700	N/A	FT1500	Beneath Turbine surroundings	ND	Lubricants & Cables	Wet pipe sprinkler
TB	19700	31X-2	FT35X1	LPCP Switchgear Room	ND	Electrical Cables	Wet pipe sprinkler
TB	19700	310	FT35X8	Switchgear Room 'B'	ND	Electrical Cables	Wet pipe sprinkler
TB	19700	3X9	FT35X7	Electrical Equipment Area	ND	Electrical Cables	Wet pipe sprinkler
TB	19700	3X4	FT35X3	250VDC Battery Room	ND	Electrical Cables	Wet pipe sprinkler

Table 9.5-5 Summary of Automatic Fire Suppression Systems (Continued)

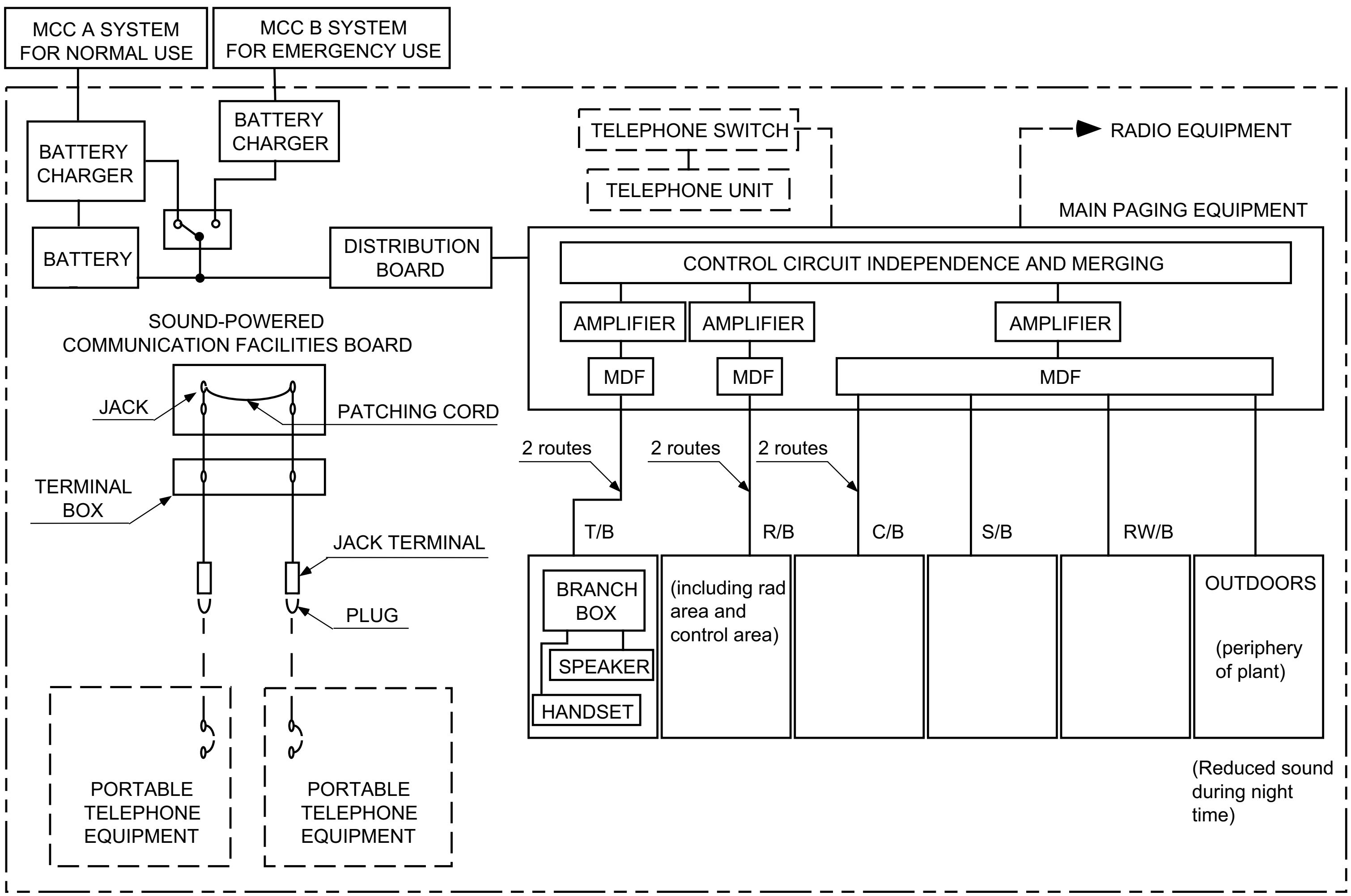
Bldg.	Elev	Room No.	Fire Area	Area Name	Div	Combustible	Sprinkler System Type
TB	19700	3X5	FT35X2	250VDC Battery Room	ND	Electrical Cables	Wet pipe sprinkler
TB	19700	3X6	FT35X4	125VDC Battery Room 'A'	ND	Electrical Cables	Wet pipe sprinkler
TB	19700	3X7	FT35X5	125VDC Battery Room 'B'	ND	Electrical Cables	Wet pipe sprinkler
TB	19700	3X8	FT35X6	125VDC Battery Room 'C'	ND	Electrical Cables	Wet pipe sprinkler
TB	27800	N/A	FT1500	Above Turbine surroundings	ND	Lubricants & Cables Wet pipe sprinkler	
TB	27800	N/A	FT1500	Turbine Generator Bearings	ND	Class III B lube oil	Closed head preaction spray
TB	27800	N/A	FT1500	Beneath Turbine skirt	ND	Class III B lube oil	Wet pipe sprinkler
TB		4X5	FT45X1	Stairwell No. 9	ND		Wet pipe sprinkler
TB	38300	N/A	FT1500	Above Turbine surroundings	ND	Lubricants & Cables	Wet pipe sprinkler
TB		5X1	FT55X1	Stairwell No. 10	ND		Wet pipe sprinkler

Table 9.5-6 AFI Instrument Line Locations

Name	Division	Penetration Location	Description	Room No.
RPV Pressure	1	X-142A RB G2F	Branch line from Original to AFI Inst. Panel at B1F	314, 411, 414, 511
RPV Level	1	X-142A RB G2F X-144A RB G1F	Branch lines from Original to AFI Inst. Panel at B1F	314, 411, 414, 511
S/P Water Level	1, 3	X-322E RB B2F X-323E RB B3F	Branch lines from Original to AFI Inst. Panel at B3F	110, 111, 112, 118, 212, 230
S/P Pressure	1, 3	X-321A RB B2F	Branch line from Original to AFI Inst. Panel at B1F	212, 230, 314

The following figure is located in Chapter 21:

Figure 9.5-1 Suppression Pool Cleanup System P&ID



(NOTES) 1. MDF : MAIN DISTRIBUTING FRAME
2. SOLID LINES INDICATE THE EXTENT OF ABWR STANDARD PLANT SCOPE

Figure 9.5-2 Outline — Telephonic Communication Systems

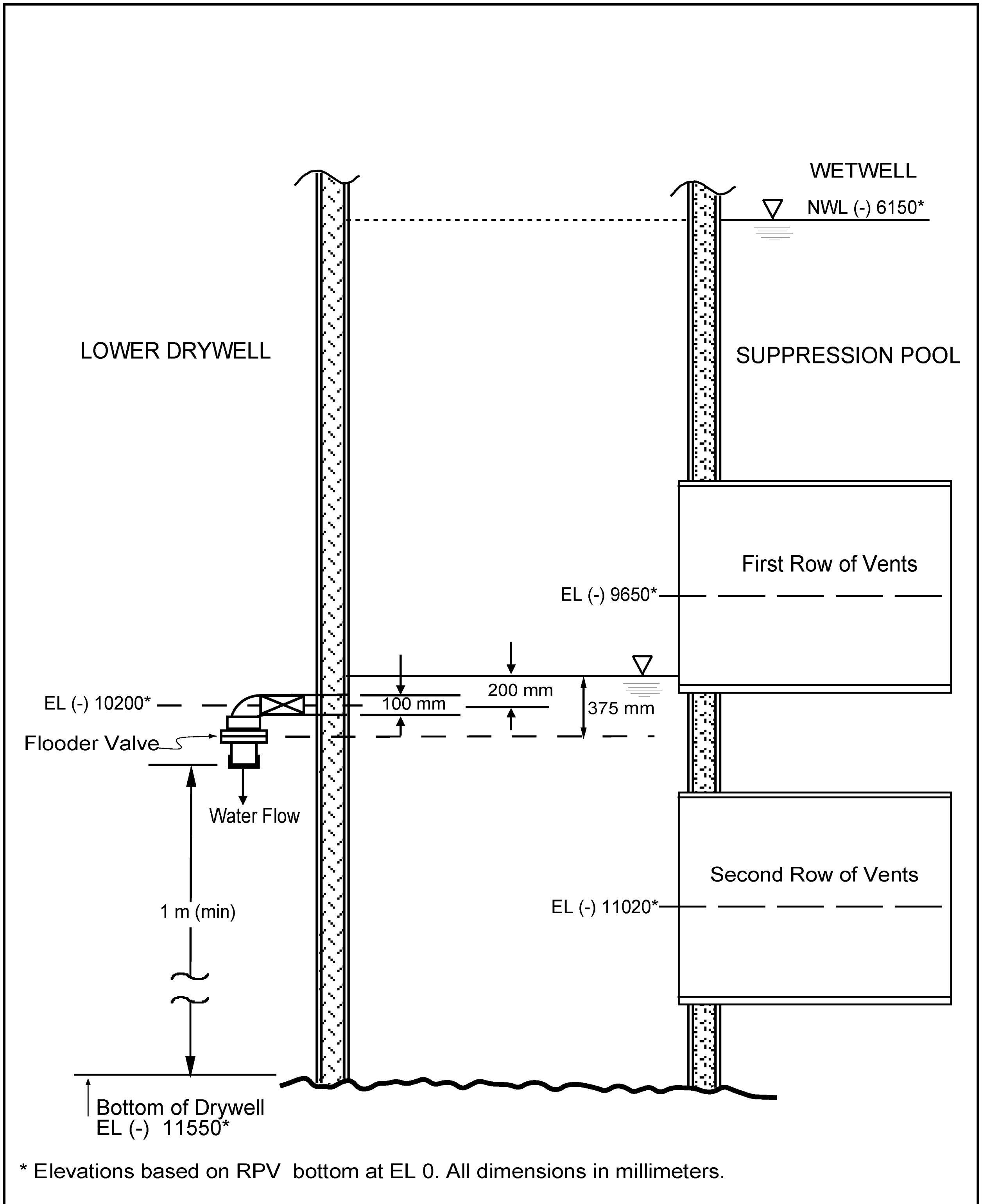


Figure 9.5-3 Lower Drywell Flooder System Arrangement/Configuration

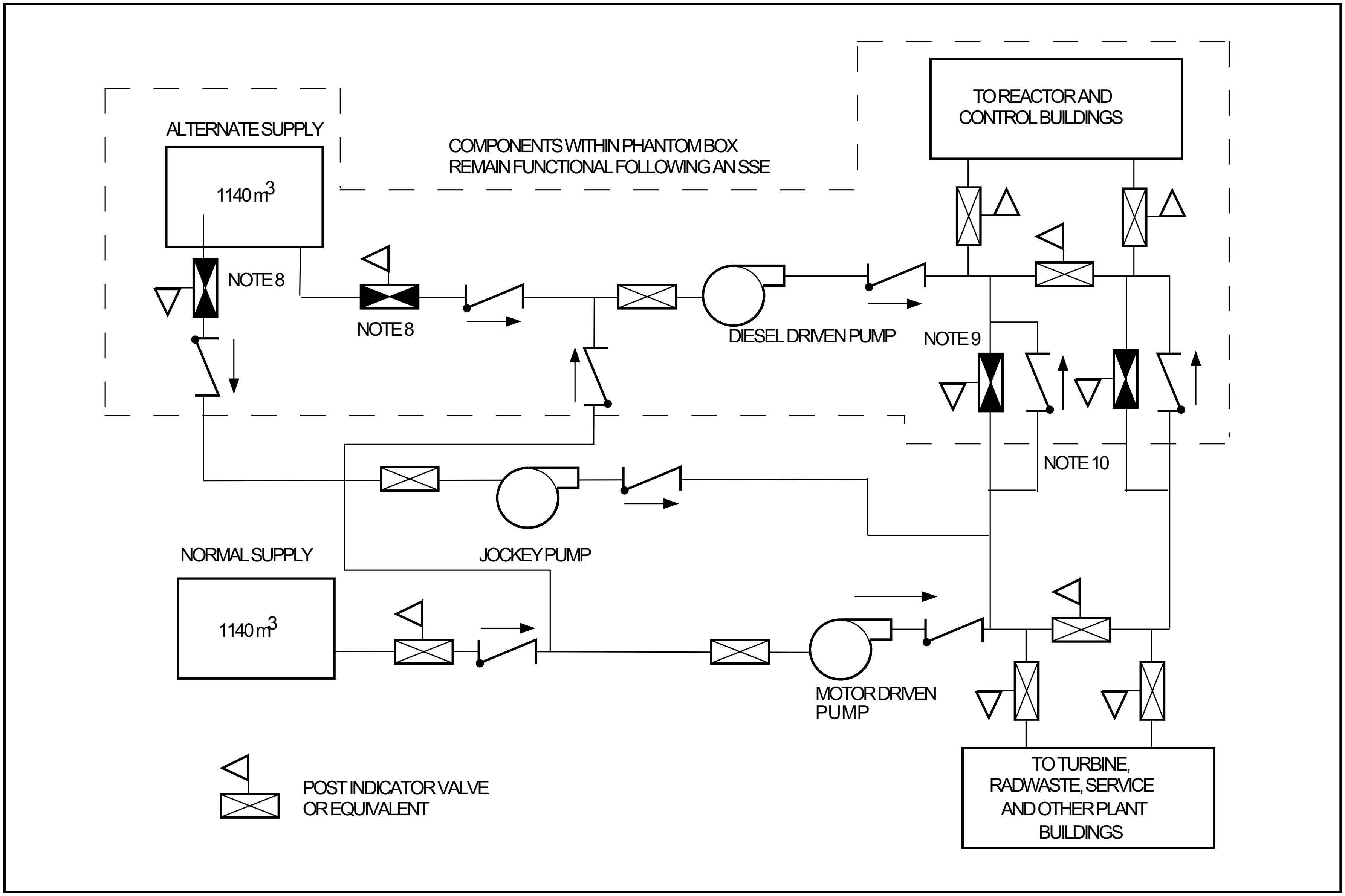


Figure 9.5-4 Fire Protection Water Supply System

Notes for Figure 9.5-4:

(1) The equivalent of one 100% capacity motor-driven pump and one 100% capacity diesel-driven pump shall be provided. the equivalent capacity of each type may be comprised of multiple pumps of that type.

(2) The motor-driven pumps shall be supplied power from the non-Class 1E busses.

(3) The following specific requirements apply to the components within the phantom box:

(a) They shall be designed to remain functional following a safe shutdown earthquake.

(b) The piping and valves as a minimum shall satisfy the requirements of ANSI B31.1.

(4) Each 100% capacity pumping unit and its controls shall be separated from the other pumping unit/units by a fire wall with a minimum rating of 3 hours.

(5) Alarms indicating pump running, driver availability, failure to start and low fire-main pressure shall be provided.

(6) The fire pump installation should conform to NFPA 20, “Standard for the Installation of Centrifugal Fire Pumps.”

(7) The water supply shall meet the following requirements:

(a) Fresh water free of silt and debris shall be used. Filters for makeup supply are acceptable.

(b) Each supply shall have a minimum storage volume of 1140m^3.

(c) If tanks or other limited volume storage means are used:

(i) There shall be two storage devices.

(ii) One storage device shall contain a passively dedicated volume of 456m^3 to supply two hose streams for two hours in areas required for safe shutdown.

(iii) The makeup supply shall be capable of providing 1140m^3 for either storage device in 8 hours.

(8) Normally closed valve, opened only to pump from the alternate supply.

(9) Normally closed valve, opened only when motor driven pump is out of service.

(10) Normally closed valve, opened only when a section of the piping connected to normal water supply is valved out for maintenance.

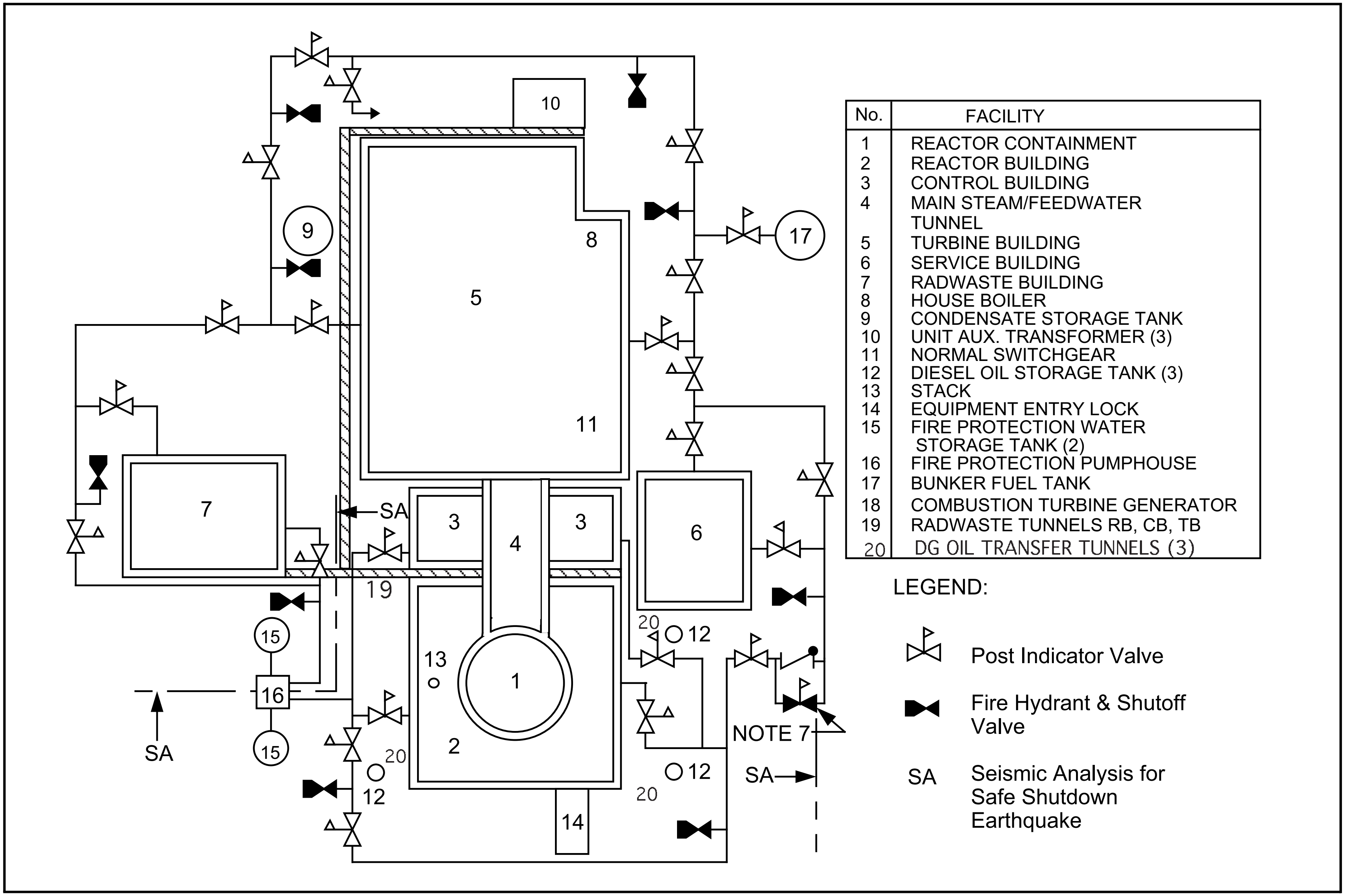


Figure 9.5-5 Fire Protection Yard Main Piping

Notes for Figure 9.5-5:

(1) NFPA 24. “Standard for Outside Protection,” shall be used as guidance in designing and installing the yard fire main loop.

(2) The main loop shall be sectionalized with post-indicator valves, or their equivalent, such that any single section may be taken out of service for maintenance without disrupting the supply to any safety-related building.

(3) An individual isolation valve shall be provided for each outside hydrant so that it may be taken out of service for maintenance without interrupting the supply to any other load.

(4) The maximum spacing between outside hydrants shall be 76m.

(5) Hose houses, if used, shall have a maximum spacing of 228m.

(6) Threads compatible with those used by the local fire department should be provided on all hydrants, hose couplings and standpipe risers.

(7) Normally closed valve, opened only when a section of the non-seismically analyzed yard main is valved out for maintenance.

(8) Siamese fire department connections and backflow check valves are required at each building supply but are not shown.

The following figures are located in Chapter 21:

Figure 9.5-6 Standby Diesel Generator Fuel Oil and Intake and Exhaust System

Figure 9.5-7 Standby Diesel Generator Jacket Cooling Water System

Figure 9.5-8 Standby Diesel Generator Starting Air System

Figure 9.5-9 Standby Diesel Generator Lubricating Oil System

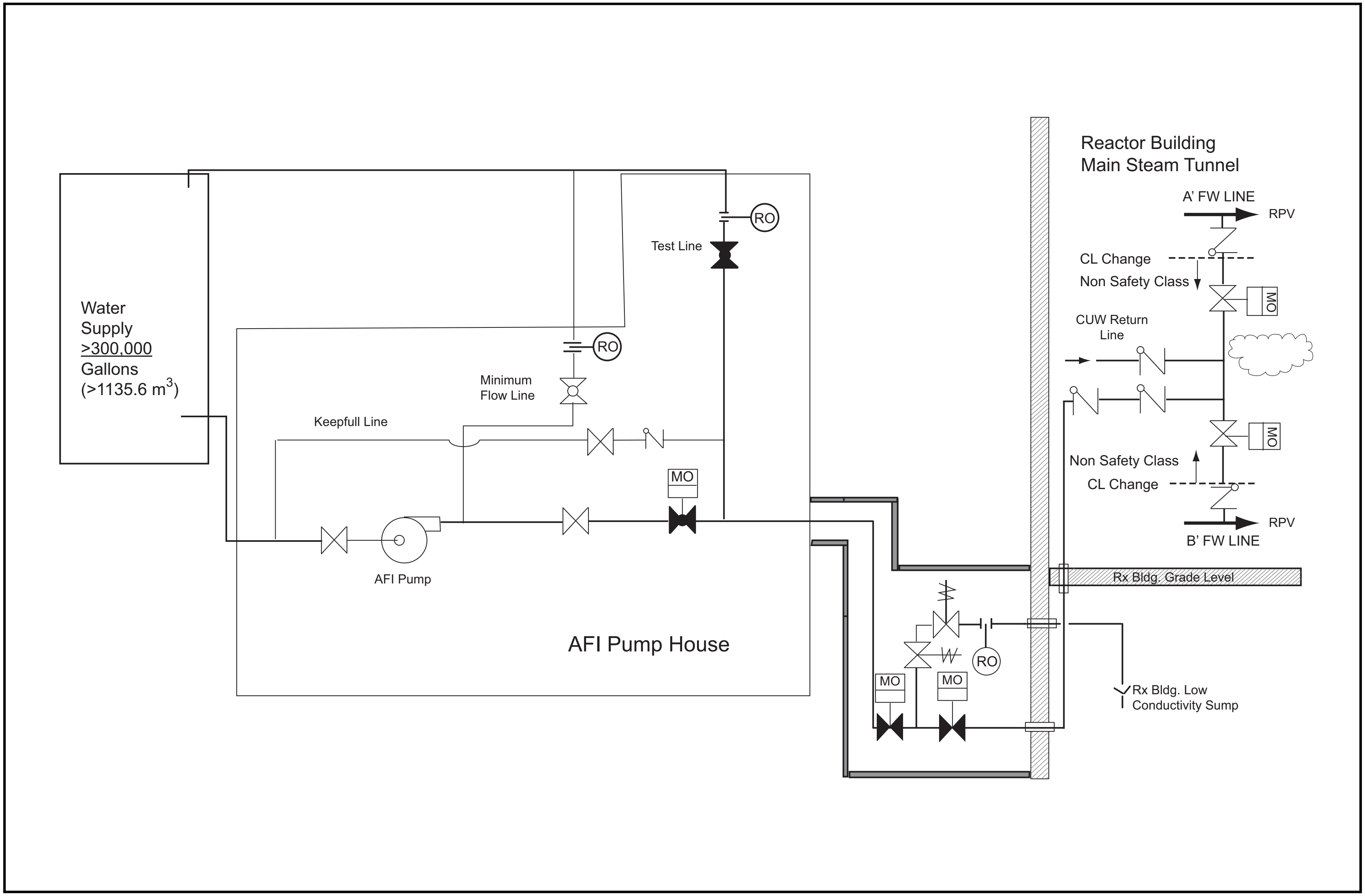


Figure 9.5-10 Alternate Feedwater Injection System Schematic