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# X - AUXILIARY SYSTEMS

## 1.0 SUMMARY DESCRIPTION

This chapter describes the safety and power generation considerations, design, and inspection and testing criteria for various station auxiliary structures, systems, and components (SSCs). A topical discussion is also provided of fuel handling equipment and operations, the control of heavy loads at the station, and Main Control Room habitability. The following SSCs and topics are described in this chapter:

- 2.0 New Fuel Storage
- 3.0 Spent Fuel Storage
- 4.0 Fuel Handling and Movement of Heavy Loads
- 5.0 Fuel Pool Cooling and Demineralizer System
- 6.0 Reactor Equipment Cooling System
- 7.0 Turbine Equipment Cooling System
- 8.0 Service Water and RHR Service Water Booster System
- 9.0 Fire Protection System
- 10.0 Heating, Ventilating and Air-Conditioning Systems
- 11.0 Makeup Water Treatment System
- 12.0 Instrument and Service Air Systems
- 13.0 Potable and Sanitary Water Systems
- 14.0 Equipment and Floor Drainage Systems
- 15.0 Process Sampling and Post-Accident Sampling Systems
- 16.0 Communications Systems
- 17.0 Station Lighting System
- 18.0 Optimum Water Chemistry (OWC) System

## 2.0 NEW FUEL STORAGE

The new fuel storage vault was designed to provide a Class I repository for new fuel. The spacing of the new fuel racks was designed to assure that acceptable subcriticality margins would exist in cases of the vault being dry or flooded. However, it was not established that these margins would be maintained if aqueous foam were present.[111] Accordingly, the CNS Technical Specifications prohibit the storage of new fuel in the new fuel storage vault. Following onsite receipt, inspection and channeling, new fuel is stored in the Spent Fuel Pool for use during future refuelings. The criticality and structural support discussion in USAR Section X-3 is bounding for the storage of new fuel in the Spent Fuel Pool. Further details on the receipt and handling of new fuel are provided in USAR Section X-4.

3.0 SPENT FUEL STORAGE

3.1 Safety Objective

The safety objective of the spent fuel pool and storage racks is to allow for the storage of highly radioactive spent fuel in such a manner that the fuel will be kept in a safe, subcritical configuration during normal and abnormal operation, and during design basis events.

3.2 Safety Design Basis

1. The high density spent fuel storage racks are designed to maintain spent fuel assemblies in a subcritical configuration having a $k_{eff} \leq 0.95$ for all normal and abnormal configurations, as defined in USAR Section X-3.6.

2. The fuel storage pool and concrete structures provide a sufficient depth of water and sufficient concrete thicknesses to adequately shield station personnel from radiation emitted by a full load of spent fuel assemblies.

3. The fully loaded spent fuel storage racks, supports, and pool concrete structures are designed to Class I standards.

3.3 Power Generation Objective

The power generation objective of the spent fuel storage racks and the spent fuel pool is to provide specially designed underwater storage space for the spent fuel assemblies which require shielding during storage and handling.

3.4 Power Generation Design Basis

1. The authorized spent fuel pool capacity at Cooper Nuclear Station is for up to 2651 fuel assemblies. The high density fuel storage racks provide storage capacity for almost five cores.

2. The spent fuel storage racks and the spent fuel pool are designed to allow efficient handling of the fuel assemblies during refueling operations.

3.5 Description

3.5.1 General

The amount of reactor fuel which can be received, used, and possessed is limited by the onsite fuel storage capacity and the requirements for reactor operation which have been previously approved by the NRC staff. The Independent Spent Fuel Storage Installation (ISFSI) augments the Spent Fuel Pool as a means for storage of spent fuel, pursuant to 10 CFR 72.210.

Non-fuel irradiated components are stored in the spent fuel pool for radioactive decay until such time as they can be shipped offsite. An inventory of these items is maintained.

The spent fuel storage racks provide storage at the bottom of the fuel pool for the spent fuel received from the reactor vessel and for new fuel received on site (see Automation Industries Drawings 80E1148 and 80E1143 and Figures X-3-1 and X-3-2). There are 13 Nuclear Energy Services (NES) storage racks which were installed in the fuel pool in 1978. Two new Holtec racks were added to increase the fuel pool capacity in 2007. One or both of the two new racks may be installed in the shipping cask storage area in the northwest corner of the fuel pool. The second rack is used as a contingency and is installed in the cask set down area only if required for a full core offload. The racks are full-length top-entry and designed to maintain the spent fuel in a configuration which prevents criticality under normal and abnormal configurations.

Normal configurations are considered to be those which can result from allowed tolerances in spacing or thickness of rack components, tolerances in fuel assembly manufacture, tolerances in poison content, and from the positioning of fuel assemblies within storage locations.

Abnormal conditions are those conditions resulting from accident or malfunctions such as a fuel assembly drop onto the rack, a seismic event, an increase in fuel pool temperature due to loss of cooling, etc.

Each high density NES spent fuel rack is 93 3/4 inches long, 87 3/16 inches wide, 169 1/4 inches high, and stores 182 fuel assemblies with 6.56 x 6.56 inches center-to-center separation. There are 13 such racks to provide storage for 2366 elements. The storage location consists of a square aluminum box, 5.875 inches in I.D., with 0.125 inch thick walls. Each aluminum box is 158 inches tall so that it encloses the maximum 150 inch active fuel length of the fuel assembly completely.

The NES storage rack design consists of upper and lower "egg crate" grid structures, which retain the square aluminum cells and the nonstructural Boral poison curtains. The latter are positioned between rows of cells in one direction only. Exterior structure and cross-bracing are provided to hold the upper and lower grids together. Aluminum plates of one inch thickness with a single four inch orifice per cell location are welded to the lower grid and serve to support cells and fuel assemblies which add lateral rigidity to the lower grid structure. All storage rack structural components are fabricated from aluminum alloys (6061-T6 aluminum and 6063-T5 aluminum).

Between boxes in the NES storage racks is a 0.4375 inch thick gap which is filled with water when the rack is located in the spent fuel pool. Aluminum spacer grids at the top and bottom of the rack maintain the center-to-center spacing and the gap width.

Between the rows of 13 boxes are located 13 sheets of 1/8-inch Boral, 85 inches wide by 150 inches high. No Boral sheets are located on the outside of the rack; the spacing between adjacent racks of approximately 7 inches is sufficient for criticality control.[1]

The 13 NES storage racks sit on and are horizontally braced against a sub-base structure designed to clear existing hold-down bolts attached to the floor of the spent fuel pool. The sub-base is made of stainless steel box beams and sit approximately one inch above the pool floor on adjustable leveling and support pads.

Horizontal movement of the NES fuel storage racks and sub-base is limited by means of stainless steel seismic braces in close proximity to the pool walls at the upper grid and sub-base levels, and by inter-rack bumpers on the upper grid. Thermal expansion of the storage rack and sub-base is accommodated by small lateral clearances between individual racks and between racks and pool walls. The cumulative clearance in any direction is less than one inch. The overturning of the spent fuel storage racks during a seismic event is precluded by the presence of the seismic bracing between the racks and pool walls.

Structural material is provided between NES racks and at the upper grid of the peripheral storage racks to preclude the inadvertent positioning of a fuel assembly too close to stored fuel assemblies during fuel handling. The structure ensures that the fuel center-to-center spacing for such incidents will be in excess of 12 inches wherever required.

The two new Holtec fuel storage racks are freestanding racks supported by platforms. The Holtec racks are not physically restrained from horizontal movement but are positioned to prevent contact with the spent fuel pool walls or the surrounding seismic restraint structure for the existing NES rack modules during a seismic event. The Holtec racks are also designed to prevent overturning during a seismic event.

All of the racks are designed to withstand a pull-up force equal to 4000 pounds (necessary in the event that a fuel assembly or grappling device binds during removal). However, the fuel handling bridge fuel hoist has a load-limit cell set at a weight no more than 1,230 pounds (see USAR Subsection VII-6.3).

The NES spent fuel storage racks are designed such that it is not possible to insert a fuel bundle, either deliberately or by accidental drop, in any position not intended as a fuel storage position. Around the outside of the rack adjacent to the pool wall is located a six inch thick support beam which prevents this type of fuel handling incident in this location. Structural material and inter-rack bracing is placed between the racks, where necessary, to prevent inadvertent insertion of a fuel assembly.

Each fully loaded spent fuel storage rack is designed as a Class I structure.

Stress in a fully loaded NES rack will not exceed applicable AISC or ASCE specification requirements when subjected to a horizontal earthquake load of 0.75g applied in any direction. The results from a large number of seismic simulations performed on the Holtec rack modules under seismic conditions established that the freestanding rack modules possess a large margin of safety against impacting any proximate structures and an even larger margin of safety against overturning. Furthermore, because the modules have shear pad supports, the maximum rack structure stress factor under faulted conditions was shown to meet upset condition stress limits with large margins of safety. For the stored fuel, there is a maximum deceleration load sustained by the fuel which occurs as a result of its rattling in the storage cell during a seismic event. The maximum fuel mass-to-cell wall impact load was determined to be 1009 lbs within the new racks. The maximum calculated impact load represents less than one-tenth the impact load a fuel assembly can safely withstand. Therefore, the fuel-to-rack wall impact loads that may occur during the postulated earthquake events are acceptable.

A redundant hoist system, as described in USAR Subection X-4.4.1 has been installed to make the probability of a fuel cask drop accident into the spent fuel area acceptably low.

The results of the fuel assembly drop analysis[2] using energy balance methods show that for a straight drop of the fuel assembly on top of the NES storage rack, the maximum stress in the fuel storage cell is equal to the yield stress for aluminum, thus indicating that the fuel storage cell and the Boral plate will undergo some local deformation. However, the cell and the Boral plates will not collapse during such an event. The maximum stresses in the rack base and sub-base structures stay within the allowable stress values. This analysis also indicated that if a straight drop of a fuel assembly were to occur in the near vicinity of any rack support leg, the concrete bearing stress under the bearing plate of the impacted leg exceeds the allowable bearing stress for no damage. This could result in local crumbling of concrete, however, the leak tight integrity of the 1/4 inch liner plate will be maintained.

The drop of a fuel assembly on top of the Holtec racks will result in a cell wall deformation at the top of the rack, but there will be no permanent damage to the active fuel region of the racks.

For the case of the inclined drop of the fuel assembly on top of the storage rack, the maximum external kinetic energy (6.19 in-k) per storage cell is considerably less than the kinetic energy for the straight drop of a fuel assembly on top of the upper grid structure (16.37 in-k). Therefore, the damage to the storage rack and the liner plate from the inclined drop of a fuel assembly on the top of a storage rack will be less severe than that of the straight drop event.

The free fall of a fuel assembly through the storage cell from a height of 24 inches above the top of a NES storage rack and its impact on top of the cell base plate and rack lower grid structure was analyzed using collapse load-energy balance methods. The results indicate that the maximum deformation of the rack base structure would be in the order of 2.89 inches. Therefore, during a fuel drop accident of this type, the fuel assembly will collapse the cell base plate. The kinetic energy developed during the free fall will be absorbed by both the bending of the cell base plate and the shearing of the plate to support channel weld. Due to the presence of the support channel structure, however, the fuel assembly will not impact the pool liner plate.

Since for this fuel assembly drop case, the external energy is absorbed in the flexural deformation of the flexible cell base plate and rack base structure, the reaction load transmitted to the rack base structure, rack feet and pool floor is less than that for fuel assembly drop on top of the storage cell. Therefore, the damage to the pool floor will be less severe for the fuel assembly drop through the storage cell than that for the fuel assembly drop on top of the NES storage rack.

The drop of a fuel assembly into one of the empty cells of the Holtec racks will result in a maximum baseplate deflection of less than 3 inches and will not impact the SFP floor liner. The drop of a fuel assembly onto one of the Holtec racks will not result in failure of the rack shear pads, platforms, or the fuel pool floor.

It should be noted that the fuel assembly drop analyses for the NES racks have been performed by conservatively assuming that no energy will be absorbed by the fuel assembly itself. The energy absorbed in the deformation of the flexible fuel assembly should result in reduced damage to the storage rack and the pool liner plate than that predicted by the conservative analysis. The fuel assembly drop analysis for the Holtec rack assumes minimal fuel energy absorption only for the drop onto the top of the rack.

It has, therefore, been concluded that neither the straight nor inclined drop of the fuel assembly on top of the storage cell nor the straight drop of the fuel assembly through the storage cell and impact on the cell base plate will damage the storage rack and the pool liner plate sufficiently to adversely affect the value of $k_{eff}$ or the leak-tight integrity of the pool.[2] Cask loading operations or use of the cask loading mast within the spent fuel pool require that fuel be lifted higher than what is required to just clear the fuel storage racks. Additional fuel assembly drop analyses have been performed and evaluated to likewise conclude that there is no adverse impact on the value of $k_{eff}$ or the leak-tight integrity of the pool. This analysis assumes a maximum lift height of 40 inches for the NES racks, and 48 inches for the HOLTEC racks (with spent fuel assemblies removed). The analyses credit hydraulic drag to lessen the impact on the racks.[126]

Materials used in the construction of the NES racks were specified in accordance with the applicable ASTM specifications, and welds are in accordance with AWS Standards for materials, and have been liquid penetrant tested in accordance to SNT-TC-1A code. Materials selected are corrosion resistant or treated to provide the necessary corrosion resistance.

The choice of aluminum components for the NES spent fuel storage racks in the stainless steel lined storage pool is based upon the following considerations:[3]

1. The use of stainless steel fasteners in aluminum to avoid detrimental galvanic corrosion is a recommended practice and has been used successfully for many years by the aluminum industry.

2. Water in the pool has very low conductivity, therefore, galvanic corrosion should not occur.

3. The coupled potential between the selected aluminum and the 300 series stainless steel is very low. Thus, the susceptibility for inducing galvanic corrosion is also very low.

4. The inherent high corrosion resistance of aluminum makes it well suited for use in demineralized water.

5. Operating experience with the aluminum fuel storage racks in the Humboldt Plant stainless steel lined fuel pool has given no indication of electrochemical corrosion deterioration.

The spent fuel pool has been designed to withstand earthquake loading as a Class I structure. It is a reinforced concrete structure, completely lined with seam-welded, stainless steel plates welded to reinforcing members (channels, I-beams, etc.) embedded in concrete. Interconnected drainage channels are provided behind the liner welds. These channels are designed to 1) prevent pressure buildup behind the liner plate and 2) prevent the uncontrolled loss of contaminated pool water to other relatively cleaner locations within the secondary containment. These drainage channels are formed in the concrete behind the liner and are designed to permit free gravity drainage to one of the Reactor Building floor drain sumps. The passage between the spent fuel pool and the refueling cavity above the reactor vessel is provided with two double-sealed gates with a monitored drain between the gates. This arrangement permits monitoring of leaks and facilitates repair of a gate or seal, if necessary.

To avoid unintentional draining of the pool, there are no penetrations that would permit the pool to be drained below a safe storage level (approximately 10 feet above the top of the fuel). Lines extending below this level are equipped with check valves and siphon breaker holes (in the event of check valve failure)[79] to prevent siphon backflow. Two epoxy phenolic-lined carbon steel skimmer surge tanks are sized to take into account the placement of large items such as the spent fuel cask into the pool.

### 3.5.2 Spent Fuel Pool Level Indicators

Low water level alarms are provided locally and in the main control room in the event of water loss from either rupture of the spent fuel pool wall liner or the rupture of the reactor cavity refueling bellows. (The alarm from the reactor cavity is isolated during station operation.) As a backup, flow alarms are provided in the drain lines of the reactor vessel to drywell seal, drywell to concrete seal, and spent fuel pool gate to detect leakage.

In addition to the level alarms, there are also two channels of a guided wave radar system that provide continuous indication of spent fuel pool level. Both channels provide local indication at their signal processor units. The primary channel provides a readout on the RHR system temperature recorder in the control room. The backup channel provides a readout on an outdoor indicator located on the outer wall of the control building. This level indication system is intended to provide reliable SFP level indication during a beyond design basis event (refer to NRC Order EA-12-051).

3.6 Safety Evaluation

The high density spent fuel storage racks are authorized to provide storage locations for up to 2651 fuel assemblies and designed to maintain the stored fuel in a safe, coolable, and subcritical configuration during normal and abnormal conditions. The following subsections demonstrate that Safety Design Bases 1, 2, and 3, have been met.

3.6.1 Criticality Analysis – Boral-Poisoned

The spent fuel storage racks are designed to ensure $K_{eff}$ does not exceed 0.95 in unborated water during normal and abnormal conditions, and during design basis events. A criticality analysis has been performed that demonstrates this requirement is met with a confidence interval of 0.95 for fuel types with an average enrichment up to 4.9 wt% U-235[70]. This enrichment value is bounding for the fuel types that have been used at CNS and for future fuel types, since it is not expected that new BWR fuel designs will exceed this value. It is also bounding for unchanneled fuel. The spent fuel storage rack criticality analysis was performed using the CASMO-4 analytic model, and the results have been verified by use of KENO5a and MCNP codes. Calculation uncertainties, reactivity uncertainties, and manufacturing tolerances have also been considered.

3.6.1.1 Analysis Assumptions

The following conservative assumptions have been made to assure the true reactivity will always be less than the calculated maximum reactivity:

1. The spent fuel storage racks are assumed to contain the most reactive fuel authorized to be stored in the facility without any control rods or burnable poison, except gadolinia, as appropriate.

2. The moderator is assumed to be pure, unborated water at a temperature corresponding to the highest reactivity (39.2°F).

3. Criticality safety analyses are based upon the assumption of an infinite array of storage cells, i.e., no credit is taken for radial or axial neutron leakage. This assumption is relaxed for the analysis of peripherally loaded assemblies.

4. Neutron absorption in minor structural members is neglected, i.e., spacer grids are assumed to be replaced by water.

Additionally, in the analytical model the flow channel and the Boral cladding were homogenized with the immediately surrounding water.

3.6.1.2 Abnormal Conditions and Design Basis Events

Abnormal conditions and design basis events have been considered to assure safe operation under all credible conditions. The double contingency principle of ANSI N16.1-1975 has been used which precludes the necessity of considering the occurrence of more than a single unlikely and independent abnormal condition or design basis event concurrently for criticality safety. Using this principle, there are no credible occurrences or configurations that have been identified that might have an adverse effect on spent fuel storage rack criticality safety. A specific analysis has been performed for a dropped fuel assembly, a seismic event, and a fuel mislocation event.

A dropped fuel assembly will most likely come to rest horizontally on top of the spent fuel storage racks, separated by more than 12 inches from the top of the enriched fuel region of the fuel in storage. This separation distance is more than adequate to assure no appreciable increase in reactivity. Should the dropped fuel assembly be postulated to enter a filled storage cell vertically, it could potentially rest vertically on the lower assembly. However, the physical separation of the active fuel is more than adequate to preclude an increase in reactivity. In the unlikely event that the

dropped assembly crushes or distorts the lower assembly, the result could be a small compression of the stored bundle, which would reduce the water-to-fuel ratio and thereby reducing reactivity.

During a Safe Shutdown Earthquake, the maximum deflection of a storage cell with respect to its neighbor is about 0.01 inch. This small local change in pitch has a negligible effect on $k_{eff}$ of a spent fuel storage rack.

In the unlikely event that an accidental attempt was made to place a fuel assembly outside of a storage rack module, the presence of steel support beams on the outside of the racks would prevent the insertion or preclude the mislocated assembly from being positioned close to the fuel. Under these circumstances, the reactivity effect would be negligible.

For peripherally loaded assemblies with a k-infinity (standard cold core geometry) greater than 1.20 and less than 1.29, the analysis assumed a misloaded assembly in an adjacent interior location.

3.6.2 Criticality Analysis – Metamic-Poisoned

The criticality analysis for the Metamic-poisoned racks demonstrates that the limit on k-effective of 0.95 is met. This analysis was performed using Monte Carlo methods. CASMO4 was used for some evaluations. Abnormal and accident conditions were evaluated.

3.6.2.1 Analysis Assumptions

1. An average uniform enrichment of 4.9% wt% U-235 was used for the GNF2 fuel type.

2. The GNF2 fuel type was used for the analysis as it exhibits a reactivity that bounds all other fuel types in use or in storage at CNS.

3. The fuel rack design has storage cell lattice spacing sufficient to permit installing and removing fuel assemblies with Metamic neutron absorber plates.

4. Tolerances for cell box ID, box wall thickness, fuel density, fuel enrichment, and Metamic areal density were included in the analysis.

5. Uncertainties included in the analysis were uncertainty in the determination of the calculational bias in the benchmark calculations, statistical uncertainty in the Monte Carlo calculation, and uncertainty in the depletion calculations.

6. Temperature of maximum reactivity of 4 degrees Centigrade.

7. Gadolinia credit was taken for fuel with enrichments greater than 3.27 wt% U-235 and burnups less than 12.7 MWD/KgU.

8. Partially rodded fuel array was assumed to extend over the entire core during operation in order to obtain a conservative estimate on burnup for assemblies with the highest assumed enrichment of 4.9%.

9. Due to distances between racks compared with the mean free path of neutrons in steel and water, no calculations of interface configuration were performed and poison panels on the peripheral rack locations were not necessary.

3.6.2.2 Abnormal and Accident Conditions

1. Eccentric assembly positioning (4 assemblies at closest approach) calculations result in a small reduction in reactivity.

2. Calculations on the removal of the flow channel shows a reduction in reactivity.

3. Temperature and void coefficients of reactivity were confirmed to be negative. Temperature of highest reactivity was confirmed to be 4 degrees Centigrade.

4. Calculations were made for misloaded assembly in which the assembly is placed outside and immediately adjacent to the rack. These calculations demonstrate that reactivity addition is negligible.

5. Seismic displacement of the rack module was examined for reactivity impact; no adverse reactivity consequence was found.

3.6.2.3 Limiting Criteria for Acceptable Storage

Fuel stored in the Metamic racks must meet one of the limiting criteria for acceptable storage:

1. Uniform average enrichment of 3.27% U-235 or less.

2. K-infinity (standard cold core geometry) of 1.33 or less, corresponding to a minimum discharge fuel burnup of 12.7 MWD/KgU.

3. Minimum of 3 wt% $Gd_2O_3$ in at least 7 fuel rods. Applicable to fuel assemblies with burnup less than 12.7 MWD/KgU and a uniform average enrichment greater than 3.27% U-235.

3.6.3 Water Level

Fuel in the spent fuel pool is covered with sufficient water for radiation shielding. As discussed in Subsection X-3.5.2, excessive leakage or low water level alarms in the Main Control Room. An adequate fuel pool water level is maintained even in the unlikely event of a pipe break between the skimmer surge tanks and the fuel pool cooling system pumps since fuel pool discharge to the skimmer surge tanks is by overflow only. Thus, a pipe break would drain the skimmer surge tank but not reduce the fuel pool level. Check valves and siphon breaker holes prevent siphon backflow through the fuel pool cooling system discharge pipes.

The spent fuel pool concrete structure, metal liner, and spent fuel storage racks are designed as Class I. The spent fuel pool make-up is normally supplied from the Class II Seismic condensate transfer system. Alternate Class II Seismic sources of makeup include the following[8]:

1. The RHR system can deliver water to the fuel pool diffusers via the RHR-Fuel Pool Cooling intertie. The water supply for the RHR system can come from the the suppression pool (1000 gpm for 11 hours), the condensate storage tank (1000 gpm for 5 hrs), or the RHR service water booster system (see Burns and Roe Drawings 2040, Sheet 2, 2030, Sheet 1, 2006, Sheet 4, and 2036, Sheet 1).

2. The spent fuel pool can be supplied with water from fire hoses using hose valves. See Burns and Roe Drawing 2016, Sheet 1C.

In the event that the Class II Seismic makeup sources are out of service due to a seismic occurrence, Service Water can be supplied to the fuel pool through hoses attached to the reactor building Service Water drain connections on the RHR heat exchangers for long term makeup (120 gpm via two 1 1/2" hoses[101]). The following sequence is used, as available, for alternate makeup water sources to the Spent Fuel Pool: 1) Condensate Storage

Tank, 2) Service Water through the RHR cross tie, 3) Service Water using hoses from the RHR Heat Exchanger, and 4) Suppression Pool.

After a safe shutdown earthquake (SSE) following a complete core off-load, the temperature of the pool would increase to boiling. Since the spent fuel pool temperature will initially be less than 150°F, the decay heat will take at least 4 hours to heat the spent fuel pool water to 212°F. Four hours is sufficient time to establish adequate makeup to the spent fuel pool prior to the onset of bulk boiling. Also, under bulk boiling conditions, the temperature of the fuel will not exceed 350°F. This is an acceptable temperature from the standpoint of fuel rod integrity and surface corrosion.

3.6.4 Dropped Control Blade in the Spent Fuel Pool

Secondary containment and CREFS must be maintained, as required, during plant shutdowns if non-fuel loads which could potentially damage irradiated fuel are being moved in the secondary containment (see Section V-3.4 and X-10.4.6.4).

An analysis was performed on the drop of a control blade in the spent fuel pool. The analysis concluded that 11 fuel rod failures are predicted to result from dropping a control blade onto the spent fuel storage pool. The analysis assumes that the control blade will be moved directly over spent fuel bundles. Two impacts on the fuel were evaluated. First the control blade, fuel support piece, and two-in-one blade handling tool fall vertically on the top of the rack and then tip over to a horizontal position. The bundles investigated were GE12, GE13, and GE14. Other fuel types currently stored in the spent fuel pool have cladding that can withstand greater amounts of energy than the bundles considered in the analysis.[86]

3.6.5 Dropped Fuel Bundle in the Spent Fuel Pool

The drop of a fuel bundle in the fuel pool was evaluated for dose consequence purposes. The drop of a channeled bundle in the spent fuel pool is bounded by the design basis fuel handling accident dose consequences. The drop of an unchanneled bundle was evaluated generically and it was determined that the drop of an unchanneled bundle is bounded by the design basis fuel handling accident as long as it has a decay period of 45 days or greater.

3.7 Inspection and Testing

Leak detection drainage channels are provided on the concrete side of the spent fuel pool liner. These drainage channels are routed to the Reactor Building Sump "C". Any liner leakage would be noticeable by a higher rate of "C" sump discharge as well as lowering level in the skimmer surge tanks.

A surveillance assembly containing three types of sample coupons is installed in the fuel pool to simulate the condition of the spent fuel racks. One coupon is inspected for stainless steel to aluminum galvanic corrosion; two are inspected for edge weld failure or core degradation of the Boral plates.[4] A surveillance assembly is also installed in the fuel pool for monitoring of the Metamic material; one type of sample coupon is used on the Metamic assembly.

The spent fuel pool is in scope for License Renewal per 10 CFR 54.4(a)(1) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Neutron Absorber Monitoring (see USAR Section K-2.1.23) and Water Chemistry Control - BWR (see USAR Section K-2.1.39). There are no Time-Limited Aging Analyses that are applicable.

## 4.0 FUEL HANDLING AND MOVEMENT OF HEAVY LOADS

### 4.1 Introduction

The fuel handling equipment and operational controls provide a safe and effective means for transporting and handling fuel from the time it reaches the plant as new fuel until the time it leaves the plant as irradiated spent fuel. This section additionally describes the equipment and controls used to move non-fuel heavy loads so as to avoid damage to safety-related equipment.

### 4.2 Fuel Servicing Equipment

Two fuel preparation machines are used for loading new fuel assemblies into the Spent Fuel Pool. They can also be used for dechanneling and rechanneling irradiated fuel assemblies for inspection and maintenance. These machines are designed to be removed from the pool for servicing. Due to concerns about the effects of channel bowing and as a requirement for the use of NSF channels, CNS does not reuse channels for new fuel.

A new fuel inspection stand is used to restrain the fuel assembly in the vertical position for inspection and channeling of new fuel. The inspection stand can hold two assemblies.

A channel-handling boom with spring-loaded takeup reel can be used to assist the operator in supporting the weight of a channel after the channel has been removed from the fuel assembly during dechanneling operations involving irradiated fuel. The boom is set between the two fuel preparation machines. With the channel-handling tool attached to the reel, the channel may be conveniently moved between the fuel preparation machines.

Various optical aids are provided to assist with fuel handling and servicing. General area underwater lights are provided with a suitable reflector for general downward illumination.[5] Local area underwater lights provide additional downward illumination. Drop lights can be used for intense radial illumination where needed. These lights are small enough in diameter to fit into fuel channels or control blade guide tubes. A portable underwater television camera can transmit images for viewing on the refueling platform or in the main control room, and the images can be recorded on videotape. A general purpose, clear plastic viewing aid that will float may be used to break the water surface for better visibility.

### 4.3 Refueling Equipment

The refueling platform is used as the principal means of transporting fuel assemblies back and forth between the reactor well and the storage pool. The platform travels on tracks extending along each side of the reactor well and fuel pool. The platform supports the refueling grapple and auxiliary hoists. The grapple is suspended from a trolley system that can traverse the width of the platform. Platform operations are controlled from operator station on the trolley. The platform contains a position-indicating system that indicates the position of the fuel grapple over the core.

A single operator is capable of controlling all the motions of the platform required to handle the fuel assemblies during refueling. The Operator is given indication that the grapple is properly engaged when the sensor switches of the redundant grapple hooks have changed state on full closure. This reduces the likelihood of dropped fuel bundles attributable to incomplete closure of the hook engaging the handle of the fuel assembly.[6] The refueling interlocks are described and evaluated in USAR Section VII-6.

Mounted on both the reactor well side of the refueling platform and on the platform trolley monorail are one-half-ton auxiliary hoists. These hoists normally can be used with appropriate grapples to handle control rods, incore detectors, sources, and other internals of the core. The auxiliary hoist can also serve as a means of shuffling fuel elements and other equipment within the pool.

4.4 Reactor Building Crane

The Reactor Building crane is an electric motor driven overhead crane with a 108 ton rated capacity and is controlled from a traversing cab or remote radio controller. The crane is controlled either in the Normal or Restricted modes. In the Restricted mode, interlocks and hoist adjustable frequency drive limit crane speed to 18.5 feet per minute and a position Programmable Logic Controller restricts the path of travel (see USAR Subsection X−4.6.2). The crane spans the east/west walls of the Reactor Building and has two hoisting systems, the main hoist and the auxiliary hoist.

The main hoist is rated for 108 tons and is principally used for:

1. Transporting, positioning, and removing heavy components for a refueling outage, such as concrete shielding plugs, the reactor vessel and drywell heads, the steam separator and dryer assemblies, the spent fuel pool and dryer/separator storage pit gates.

2. Transporting spent fuel casks between the cask storage area in the spent fuel pool and the Transport Trailer located on the first floor of the Reactor Building.

The auxiliary hoist, having a 5 ton rated capacity, is used for moving smaller items such as new fuel and new fuel shipping containers. The auxiliary hoist hook and hoist cable are made from stainless steel and are suitable for underwater operations.

The Reactor Building Crane is designed to meet or exceed the criteria established by CMAA Specification #70 with the exception of two components when handling a 108 ton load. The trolley and rails (girder rails) are overstressed by 5% when compared to the CMAA #70 bending criteria, but meet AISC allowable of 24,000 psi. Additionally, the bridge girders full depth diaphragms are overstressed by 10% when compared to the CMAA #70 bearing criteria, but meet AISC allowable of 32,400 psi. It is also compatible with the requirements of the Occupational Safety and Health Act of 1970, and as amended in 1971, as well as with ANSI B30.2.0., 1967. The bridge girders will withstand the combined vertical and horizontal loads of the Reactor Building Crane loaded to 108 tons coincident with a Safe Shutdown Earthquake.

The general purpose grapple can be attached to the reactor building auxiliary hoist, the jib crane, or the auxiliary hoists on the refueling platform. The general purpose grapple is used to remove new fuel from its shipping container in the metal shipping container vertical support area, place it in the inspection stand, and transfer it to the fuel pool. It also can be used to shuffle fuel in the pool and to handle fuel during channeling.

4.4.1 Single Failure Considerations

The Reactor Building crane has been designed to prevent dropping or losing control of the heaviest load to be handled assuming a single failure. The crane was licensed in comparison to the criteria provided in Branch Technical Position APCSB 9-1. The main hoist consists of a dual load path through the hoist gear train, the reeving system, and the hoist load block along with restraints at critical points to provide load retention and minimization of uncontrolled motions of the load in the event of failure of any single hoist component. The

hoist includes two complete gear trains connecting the hoist motor to the single hoist drum. Redundancy has also been designed into the hoist and trolley brakes, the load lifting devices, and the crane control components.

While the hoist system design is predicated upon a dual load path, some items within the path cannot be made redundant. Where full redundant features are not feasible or are impractical or impossible within the mechanical load path, increased design safety factors are used. Single element components have been designed to a minimum factor of safety of 8.2 based on the ultimate strength of the material. "Two blocking" (which could be caused by a fused contactor in the main hoist control circuit) is prevented by a mechanically operated power limit switch in the main hoist motor power circuit. The power limits switch interrupts power to the main hoist motor and causes the holding brakes to set prior to "two blocking." The crane reeving system does not meet the BTP APCSB 9-1 recommended criteria for fleet angles. To preclude the possibility of an accelerated rate of wire rope wear, a wire rope inspection and replacement requirement is prescribed in the TRM.

There are two strongbacks used to transport the vessel head and the drywell head. The head strongback is used for lifting the drywell head and is also capable of lifting the vessel head. The RPV head stud tensioner carousel strongback is designed to lift the vessel head and provide a support and transport arrangement for stud tensioning equipment, RPV closure nuts and washers. Both strongbacks are designed to keep the head level during lifting and transport. Both strongbacks are cruciform in shape, with four equally spaced lifting points, and are designed so that no single component failure would cause the load to drop or to swing uncontrollably.

#### 4.4.2 Inspection and Testing

A preventive maintenance program for the reactor building crane has been established based upon the crane manufacturer's recommendations. Records of all work performed are maintained and indicate the dates and types of maintenance performed, names of personnel performing work, and quality control.

Inspections prior to use of the crane and handling equipment are in accordance with the manufacturer's recommendations and ANSI B30.2.0 - 1976. Additional inspections and testing of the Reactor Building Crane is described in the Technical Requirements Manual.

### 4.5 Fuel Handling Operations

This subsection describes important elements in the receipt and handling of new fuel, and the conduct of refueling operations. The placement of spent fuel in shipping casks in preparation for removal offsite is described in USAR Subsection X-4.6.2.

#### 4.5.1 Receipt and Transfer of New Fuel

When new fuel arrives on site, it is offloaded and the outer lid of the wooden shipping container is removed. At the Reactor Building 903’ elevation the Reactor Building crane lifts the inner metal shipping container to the Reactor Building refueling floor where it is set down in an area designated for new fuel storage.

Each fuel bundle is individually removed from the metal shipping container via the Reactor Building Crane auxiliary hoist using the general purpose grapple which is attached to the fuel bundle bail handle. The bundle is moved to the new fuel inspection stand where it is secured in place. A detailed inspection is performed for cleanliness, foreign materials, and physical damage. The fuel bundles that are satisfactorily inspected are then channeled in the new fuel inspection stand.

After channeling, the new fuel assemblies are transferred to the fuel preparation machine in its full up position using the auxiliary hoist with the general purpose grapple attached to the fuel assembly bail handle. The fuel preparation machine is lowered to its lowest position and the fuel is transferred to its designated location in the Spent Fuel Pool by the Refueling Bridge using the telescoping mast.

#### 4.5.1.1 New Fuel and Non-Fuel Special Nuclear Material Criticality Controls

CNS follows the requirements of 10CFR50.68(b), "Criticality Accident Requirements":

1. Plant procedures prohibit the handling and storage at any one time of more fuel assemblies than have been determined to be safely subcritical under the most adverse moderation conditions feasible by unborated water.

2. The quantity of special nuclear material, other than nuclear fuel stored onsite, is less than the quantity necessary for a critical mass.

3. Radiation monitors are provided in storage and associated handling area when fuel is present to detect excessive radiation levels and to initiate appropriate safety actions.

4. The maximum nominal U-235 enrichment of fresh fuel assemblies is limited to five percent by weight.

### 4.5.2 Refueling Operations

#### 4.5.2.1 General Prerequisites

Following reactor shutdown and cooldown to a depressurized state, RPV disassembly and reactor cavity floodup is performed in preparation for refueling operations. The RPV head and drywell head are stored in designated areas on the refueling floor. The dryer and separator are stored in the dryer/separator storage pit. The storage pit is separated from the reactor cavity by removable concrete blocks that serve as a shield when the dryer and separator are stored and the water level is lowered. Because of the relatively low neutron activation dose rates and low crud dose rates, a dry transfer of the dryer is normally possible, although a wet transfer can be made. To minimize operator exposure during dry transfer of the dryer assembly, the storage pit canal is deep enough so the top of the dryer can be kept below the operating floor level during transfer. The storage pit is deep enough below the canal so that, with the reactor cavity drained, a minimum of 6 inches of water shielding can be maintained above the separator plenum dome. Ventilation exhaust ducts embedded in the storage pit walls effectively preclude contamination out leakage to secondary containment during reactor cavity draindown.

Plant conditions and equipment availability that are Technical Specification refueling prerequisites are established prior to the movement of irradiated fuel. This includes: a) placing the Reactor Mode Switch in the REFUEL position, b) testing the refueling interlocks and other equipment associated with refueling operations, c) flooding up the reactor cavity, and d) establishing the operability of other systems required during the movement of irradiated fuel.

A minimum of 24 hours is allowed to elapse after reactor shutdown prior to offloading any fuel. This is the decay period assumed in the Fuel Handling Accident and ensures that Secondary Containment Integrity is not required to mitigate dose consequences. However, the Secondary Containment breach control strategy is put in place prior to moving irradiated fuel (see Section V-3.4). A minimum of 67 hours after shutdown is needed to reduce the decay heat from the fuel being transferred to be within the heat removal capability of the Fuel Pool Cooling System such that the Spent Fuel Pool design temperatures are not exceeded. A cycle-specific determination of this time criteria is performed which takes into account:

1. The number of fuel assemblies being transferred from the reactor to the spent fuel pool.

2. The Reactor Equipment Cooling System supply temperature.

3. The fuel pool cooling pump and heat exchanger combinations that will be established.

4. The highest Spent Fuel Pool temperature that is desired.

This determination takes credit for the effectiveness of the Fuel Pool Cooling System alone without reliance on the RHR Fuel Pool Cooling assist mode of operation (whose availability is separately controlled). This assures satisfactory Spent Fuel Pool cooling capability if there is a failure of Fuel Pool Cooling System equipment during refueling operations.

4.5.2.2 Conduct of Refueling Operations

Fuel movements are performed by a refueling platform operator under the direct supervision of a senior licensed operator who has no concurrent duties in accordance with 10CFR50.54(m)(2)(iv). Continuous communications are maintained with the main control room through an open microphone on the refueling platform.

Two basic types of irradiated and unirradiated fuel movements can be performed: a) fuel shuffle, and b) full core offload/onload. A fuel shuffle includes:

1. Movement of fuel from one location in the core to another core location to optimize fuel burnup and core performance.

2. Partial transfer of fuel between the core and the Spent Fuel Pool. In this type of fuel shuffle, some irradiated fuel remains in the core.

A full core offload transfers all the fuel in the core load to the Spent Fuel Pool. A full core onload refuels the empty core after a full core offload. A full core offload/onload can be performed during a typical refueling outage to maximize operational flexibility, or to allow certain kinds of in-vessel work.

The individual sequence of movements of fuel between specific core locations and Spent Fuel Pool storage rack locations, including fuel orientations, are pre-established and followed during refueling operations. The fuel movement sequence takes into account the reactivity of individual fuel assemblies and their location in the core to ensure that Technical Specification requirements for shutdown margin and a visible source range monitor count rate

will be met. The methods available to visually verify proper fuel orientation are described in USAR Subsection III-2.5.

4.6 Control of Heavy Loads

In response to Generic letter 80-113, NPPD addressed NRC concerns for controlling heavy loads that could damage irradiated fuel or safe shutdown equipment[113]. The measures taken by CNS to control heavy loads have the following objectives:

1. Reduce the potential for a load drop to a very small probability, or

2. Assure the criteria below are satisfied.

When evaluating control of heavy loads (i.e., loads greater than the weight of a single fuel bundle) that do not meet the conditions of 1. above the following criteria apply:

1. The release of radioactive material resulting from damage to spent fuel caused by dropping a heavy load is limited to a small fraction of the 10CFR100 limits.

2. Damage to spent fuel and spent fuel racks caused by dropping a heavy load does not result in a configuration that will result in a $K_{eff}$ greater than 0.95.

3. Damage to the reactor vessel and spent fuel pool caused by the drop of a heavy load does not result in uncovering irradiated fuel.

4. Damage to equipment in redundant or dual safe shutdown paths is limited so as not to result in the loss of required safe shutdown functions.

4.6.1 Cranes, Trolleys, Monorails, and Hoists

The reactor building crane is discussed in USAR Subsection X-4.4. Additionally, it meets the criteria of ANSI N14.6-1978, "Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 pounds(4500 kg) or More for Nuclear Materials." Non-destructive testing (NDE) of load bearing welds is performed through a program to verify strongback continued compliance with ANSI N14.6-1978. All load bearing welds are examined over a normal inservice inspection interval of 10 years. The crane is also in conformance with ANSI B30.9-1971, "Slings." However, slings used to lift the reactor cavity concrete shield plugs and dryer-separator storage pool shield plugs are selected to conform with ANSI B30.9-2006.[127] The reactor building crane moves heavy loads to designated laydown areas via established safe load paths.

The intake structure crane lifts the service water pump and motor parts out of individual hatches above the service water pump room when maintenance is required. Removal through the hatches is considered a safe load path since one pump will not be lifted above another. Procedural controls prevent lifting service water pump or motor parts where a load drop could result in damage to the other service water pumps or other safety-related equipment. The intake structure crane is in conformance with ANSI B30.9-1971, "Slings." It is also in conformance with Chapters 2-1 and 2-2 of ANSI B30.2-1976, "Overhead and Gantry Cranes", as well as the ANSI B30.2-1976 criteria for crane operator training, qualification, and conduct. The intake structure crane also conforms with CMAA Specification 70.

A monorail system is installed in the diesel generator rooms above diesel generators 1A and 1B. The lifting would occur over only one diesel generator unit at a time while the unit is shut down so the monorail system is considered a safe load path.

A monorail is installed in the control room basement above the RHR service water booster pumps. Servicing the pump and motor parts occurs around each individual pump so the safe load path is established. No parts of significant weight are lifted over the pumps. Procedural controls prevent lifting RHRSW booster pump or motor parts over other RHRSW booster pumps or associated safety-related equipment. The monorail is in conformance with ANSI B30.9-1971, "Slings."

The monorails in the Reactor Building are considered to have safe load paths since the loads handled would not be lifted over any safety-related equipment. Monorails located over the recirculation pumps cannot be used unless the plant is shutdown thus making them safe load paths.

The two 4 ½ ton hoists and one 7 ½ ton hoist installed for the Mark I containment project are located over the northwest hatch above the torus. The hoist is used during shutdown for movement of material into and out of the torus and the path through the hatch is considered a safe load path.

The hoist in the Reactor Building used for valve and equipment removal cannot be used unless the plant is shutdown, making the hoist's path a safe load path during plant operation.

Monorail systems located above RHR heat exchangers 1A and 1B are used only when working on the heat exchangers while the plant is shutdown and are therefore considered to have safe load paths.

A jib crane and trolley located in the Reactor Building are used to move control rod drives when maintenance is required during an outage. The jib crane[82] is used to raise and lower the drives between the 903' and 958' elevation. The trolley is used to move the drives for repair on the 958' elevation. Neither is used to lift loads over safety-related equipment and are considered to have safe load paths.

A monorail used for work on the RWCU filter demineralizers is isolated from other safety-related plant equipment. The monorail is therefore considered to have a safe load path.

4.6.2 Spent Fuel Cask Movements

NPPD has implemented a General License to store spent fuel on the CNS Independent Spent Fuel Storage Installation (ISFSI) in accordance with 10 CFR 72.210. This General License utilizes a Transnuclear, Inc. NUHOMS® cask handling system, which is described in NUH-003, "Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," and in the 10 CFR 72.212 Report.

The spent fuel Transfer Cask (TC)/Dry Shielded Canister (DSC) weight when loaded with spent fuel, water, and attached to the lifting yoke, is a maximum of 106.2 tons, which is within the 108 ton rating of the Reactor Building crane.

The TC is connected to the Reactor Building crane, raised to a vertical position, load tested per CNS Technical Requirements Manual requirements, and placed in a designated location on the 903'6" level. The DSC (pre-staged on the 1001'0" level Refueling Floor) is then connected to the Reactor Building crane, lifted off the Refueling Floor, and lowered into the TC. Sections of handrail around the hatch are removed and the TC/DSC is lifted to the Refueling Floor. The TC/DSC is moved north in the controlled area (see Figure X-4-10) from point #1 to point #2 over the cask washdown area. The TC/DSC is kept from six to sixteen inches above the floor during these movements. At

point #2 the TC/DSC is set down and seismic restraints are installed to prevent possible seismic overturn.

Prior to moving from point #2 eastward across the floor to point #3, the TC/DSC annulus is filled with clean, demineralized water, and the annulus seal is inflated. The DSC cavity is then filled with demineralized water. The seismic restraints are removed, and the TC/DSC is then moved sequentially to point #3, thence southward to point #4 and eastward to point #5 which is directly over its lowering position in the spent fuel pool. The TC/DSC is then lowered into the pool onto a one inch thick stainless steel plate welded to the pool liner. The TC/DSC is then readied for fuel loading.

Following fuel loading the shield plug is installed on the TC/DSC. The procedure is reversed and the cask is returned to the cask washdown area, and the seismic restraints are re-installed. The water in the DSC is partially pumped down to the Spent Fuel Pool. The DSC inner top cover plate is installed and welded in place, and the DSC water is then fully pumped down to the Spent Fuel Pool while purging with helium. The DSC is then vacuum dried and a helium backfill is applied. The DSC outer top cover plate is installed and welded in place. The seismic restraints are removed, and the TC/DSC is moved over the Reactor Building equipment hatch and lowered onto the Transport Trailer located on the 903'6" elevation for transfer to the ISFSI.

Movement of the spent fuel TC/DSC on the 1001'-0" operating floor of the reactor building is limited to the controlled path as follows.

a. A key-locked selector switch is used for selection of the "normal" and "restricted" modes of crane operation such that the key must be inserted to change selection between modes, and with the key removable in the "restricted" mode only.

b. Additional circuitry provides the following functions when the selector switch is locked into the "restricted" mode.

    (1) Loss of horizontal motion capabilities if the main hook load has not been raised to the critical elevation as defined by the hoist limit switch.

    (2) Manually selectable control of horizontal functions of either bridge or trolley motions for any available direction of travel which will keep the vertical axis of the load within the controlled area.

    (3) Automatic loss of horizontal drive capability if the load is lowered beyond the reset point of the hoist limit switch at the washdown point or either normal landing point until the selector switch has been reset to "normal."

    (4) Loss of hoisting capability above the preset hoist limit elevation until the selector switch has been reset to the "normal" mode.

    (5) Loss of possibility of load motion if for any reason the position Programmable Logic Controller has been overdriven until the selector switch has been returned to "normal."

(6) Placement of the selector switch to "normal" will negate the functions of the controlled path system and return the functions of the crane to the "normal" operating mode.

### 4.6.3 Movements of Loads Related to RPV Disassembly

Section X-4.5.2 discusses the general method of RPV vessel disassembly. Analyses have been performed that demonstrate that the loads associated with this disassembly do not constitute loads that have the potential to damage irradiated fuel. The Reactor Building Crane is used to move the following loads:

1) Concrete shield plugs
2) Drywell head
3) RPV head insulation
4) RPV head
5) Bellows shield
6) RPV steam dryer
7) RPV main steam line plugs
8) RPV shroud head/steam separator assembly
9) Reactor Cavity Work Platform

It is assumed that the postulated load drops are caused by a failure of rigging components other than the Reactor Building Crane or its components (e.g., hook, cables, trolley, etc.) This is consistent with the single failure-proof design of the Reactor Building Crane as discussed in Section X-4.4.1.

#### 4.6.3.1 Concrete Shield Plug Drop Analysis

The concrete shield plugs are arranged in two layers, with each layer consisting of three segments/plugs. The largest single concrete shield plug weighs approximately 92 tons. Procedural controls ensure that the shield plugs are lifted only high enough to facilitate removal and transportation to the laydown area. The Reactor Building structure, including the refueling floor, is designed such that substantial margin exists to preclude damage from a drop of a concrete shield plug that would be of sufficient impact to cause enough damage to the reinforced concrete floor structure and consequently result in enough damage to RPV such that the fuel could be damaged. In addition to the dead load (which includes the concrete shield plug weight), the refueling floor is designed for a substantial live load and seismic load, most of which is not present or required to be considered during the lifting process. Properly designed reinforced concrete has substantial capability for absorbing kinetic energy since the steel reinforcement can inelastically deform prior to failure.

When lifting the top layer of shield plugs, the bottom three plugs remain in place. A top layer plug is assumed to be dropped from approximately five feet onto the bottom layer plugs. The bottom layer plugs will absorb all of the kinetic energy from the dropped plug without causing damage to the steel drywell structure since the bottom plugs are approximately the same size, mass, and stiffness as the top plugs. At that height, there would be minimal rotation of the dropped plug, thereby permitting a significant distribution of the impact load to the bottom layer of plugs. The support structure for the plugs is the massive reinforced concrete biological shield structure which has substantial margin against failure. It is therefore concluded that a postulated drop of a top layer concrete shield plug will not damage any irradiated fuel.

When the bottom plugs are lifted, the weight of the top layer of plugs has been relocated to a designed laydown area and, therefore, the structure in the immediate area adjacent to the concrete plugs is no longer supporting the

full weight of the top layer of plugs. A bottom plug could be dropped from a maximum of approximately eight feet and could impact the drywell head. The drywell (including the drywell head) is a substantial structure that based on its shape and mass could absorb the majority of the kinetic energy resulting from a postulated drop of a bottom layer plug. However, even if the dropped plug were to penetrate the drywell head, the remaining kinetic energy of the plug would be bounded by the energy calculated for the RPV head drop analysis (see Section X-4.6.3.3). It is therefore concluded that a postulated drop of a bottom layer concrete shield plug will not damage any irradiated fuel.

4.6.3.2 Drywell Head Drop Analysis

The drywell head is lifted after both layers of concrete shield plugs are removed and relocated to designated laydown areas. Therefore, a postulated drop of the drywell head near the reactor cavity opening will not adversely affect the concrete structure. Since the RPV head is still installed while lifting the drywell head is occurring, a drop could impact the RPV head. The drywell head (43 tons) is approximately 17 tons lighter than the RPV head (60 tons) and its weight is distributed over a much larger volume. The RPV head is much denser and stiffer than the drywell head. Therefore, it is concluded that the damage due to a dropped drywell head is bounded by the results for the RPV head drop analysis (see Section X-4.6.3.3). It is therefore concluded that a postulated drop of the drywell head will not damage any irradiated fuel.

4.6.3.3 RPV Head Drop Analysis

A plant specific detailed non-linear dynamic finite element evaluation has been performed for the RPV head drop. The RPV head was assumed to drop from 29 feet above the vessel flange. The weight of the RPV head and strongback plus hook was assumed to be 82.5 tons. It was conservatively assumed that the head turns 180° from the horizontal position and that a point contact is made. This assumes that the entire weight and momentum of the head is applied at a point. Results of the RPV head evaluation indicate that local yielding occurs at the contact point (vessel flange). However, the remainder of the vessel and the vessel support skirt behave elastically. Buckling of the vessel support skirt was also evaluated and shown to not occur. In addition, the displacements observed due to the drop are minor. Based on these small deflections and only local yielding at the contact point, it is concluded that the fuel is not in danger of any damage.

4.6.3.4 RPV Shroud Head/Steam Separator Assembly Drop Analysis

Prior analyses have been performed for several BWRs with varying shroud geometries and shroud head/steam separator assembly weights. These analyses were used to predict the consequences of the Cooper loadings. Based on a comparison between these analyses and the Cooper drop condition, it has been determined that the Cooper drop condition is bounded. Therefore, the conclusions in the earlier analyses are applicable to the Cooper drop condition.

The weight assumed for the shroud head/steam separator assembly is 46 tons. The assembly is assumed to drop from a height such that the terminal velocity in water is attained. Results of the evaluation indicate that the kinetic energy for the Cooper condition is less than that used for the basis of the comparison. For the base case, deflections are small and yielding does not occur. Since the kinetic energy of the Cooper assembly is less than the base case, the results of the base case are conservative when applied to Cooper. Therefore, the conclusions for the base case are considered to be applicable and conservative for Cooper.

Based on these results, it is concluded that the accidental drop of the shroud head/steam separator assembly does not cause sufficient deflection or yielding to jeopardize the support of the fuel.

4.6.3.5 RPV Steam Dryer Drop Analysis

The steam dryer drop was compared to the shroud head/steam separator assembly drop. This comparison illustrates that the kinetic energy of the steam dryer is bounded by the shroud head/steam separator assembly. Therefore, the conclusions in Section X-4.6.3.4 are applicable and bounding for the steam dryer drop. Based on these results, it is concluded that the accidental drop of the steam dryer does not cause sufficient deflection or yielding to jeopardize the support of the fuel.

4.6.3.6 RPV Main Steam Line Plugs, Bellows Shield, and RPV Head Insulation Drop Analyses

As discussed in the previous sections, the drop analyses for the RPV head, the steam dryer, and the steam separator demonstrate that the structural integrity of the vessel and core support (shroud and shroud support) is maintained. Additionally, contact with the fuel is precluded by geometric constraints. By inspection, those analyses envelope load drops of the RPV head insulation and the main steam line plugs (as long as the steam separator remains in place while the plugs are being lifted). The RPV head insulation is considerably lighter than the RPV head itself and the main steam line plugs are negligible mass compared to the steam separator. It is therefore concluded that a postulated drop of the main steam line plug or the RPV head insulation will not damage any irradiated fuel. Additionally, it has been concluded that a bellows shield drop will also not damage irradiated fuel.

4.6.3.7 Reactor Cavity Work Platform (RCWP) Drop Analysis

Due to limited free laydown space on the Refueling Floor, the RCWP is required to be placed on top of the Concrete Shield Plugs after the shield plugs have been removed and located to their designated laydown area. The bounding lift height evaluated in the RCWP drop analysis is considered to be 7’-6" based on the load path of the RCWP atop the shield plugs to its installed location in the RPV cavity. The bounding load drop scenario is with RCWP entering the RPV cavity pool during a cascading failure of the lift points causing the RCWP to strike the pool at a 10° angle of incline. The kinetic energy is dissipated by the drag force at the interface between the RCWP and RPV cavity pool assuming the stated bounding conditions. The dissipation of the kinetic energy results in the RCWP penetrating the cavity pool by approximately 1’, resulting in no fuel damage.

# 5.0 FUEL POOL COOLING AND DEMINERALIZER SYSTEM

## 5.1 Power Generation Objective

The power generation objective of the fuel pool cooling and demineralizer system is to remove the decay heat released from the spent fuel assemblies. The system maintains a specified spent fuel pool water temperature, purity, water clarity, and water level.

## 5.2 Power Generation Design Bases

1. The fuel pool cooling and demineralizer system shall minimize corrosion product buildup and shall control water clarity, so that the fuel assemblies can be efficiently handled underwater.

2. The fuel pool cooling and demineralizer system shall minimize fission product concentration in the water which could be released from the pool to the reactor building environment.

3. The fuel pool cooling and demineralizer system shall monitor fuel pool water level and accommodate normal changes in water inventory in the Spent Fuel Pool.

## 5.3 Description

The fuel pool cooling and demineralizer system is shown in Burns and Roe Drawing 2030, Sheets 1 and 2. The system cools the fuel storage pool by transferring the spent fuel decay heat (see Table X-5-1) through a heat exchanger to the Reactor Equipment Cooling (REC) system. Water purity and clarity in the storage pool, reactor cavity, and dryer-separator storage pit are maintained by filtering and demineralizing the pool water through a filter-demineralizer.

The system consists of the original fuel pool cooling and demineralizer system and additional cooling capability from the Alternate Decay Heat Removal (ADHR) Subsystem. The original system consists of two parallel trains each consisting of a circulating pump, heat exchanger, filter-demineralizer, and the required piping, valves, and instrumentation. The system flow rate is designed to be larger than that required for two complete water changes per day of the spent fuel pool (42,280 $ft^3$) or one change per day of the fuel pool, reactor well and dryer-separator pit (91,256 $ft^3$) in order to maintain water quality. Each pump has a design capacity equal to the system design flow rate and is capable of simultaneous operation. Two filter-demineralizers are provided each with a design capacity equal to the design flow rate. The pumps circulate the pool water in a closed loop, taking suction from the skimmer surge tanks, circulating the water through the heat exchangers and filters, and discharging it through diffusers at the bottom of the fuel pool. This results in Spent Fuel Pool water overflow via the skimmer wells back to the skimmer surge tanks. During refueling operations, the fuel pool cooling system suction and discharge paths can be aligned to the reactor cavity.

The ADHR subsystem includes the third fuel pool cooling (FPC) heat exchanger and the third and fourth FPC pumps that tie in parallel with the two existing parallel FPC trains. The new ADHR subsystem is configured and operated similar to the original FPC system. Each ADHR pump has a design capacity flowrate equal to an original FPC pump. The ADHR heat exchanger is provided with a design capacity to enable heat removal without the RHR system earlier in the refueling outage (see Table X-5-1). The FPC system is suited to operate with all combinations of pumps and heat exchangers from one pump and one heat exchanger to four pumps with three heat exchangers.

TABLE X-5-1

FUEL POOL COOLING AND DEMINERALIZER SYSTEM -
SYSTEM PERFORMANCE

| System Function | System Specification |
|---|---|
| System design flow (1 pump) | 475 gpm |
| Maximum flow (4 pumps) | 2600 gpm |
| Pump characteristics | 475 gpm, 300 feet TDH, 25 ft NPSH |
| Filter-demineralizer | 240 sq. ft., 475 gpm, 20 psi max. $\Delta$p (dirty) |
| Heat Removal Capacity [119] | System Capability |
| 1 Pump/1 Fuel Pool Heat Exchanger (Maximum REC Temperature of 100°F) | $2.73 \times 10^6$ BTU/hr (Pool Temperature of 125°F) |
| 1 Pump/2 Fuel Pool Heat Exchangers (Maximum REC Temperature of 100°F) | $7.86 \times 10^6$ BTU/hr (Pool Temperature of 150°F) |
| 2 Pumps/2 Fuel Pool Heat Exchangers (Maximum REC Temperature of 100°F) | $11.07 \times 10^6$ BTU/hr (Pool Temperature of 150°F) |
| 4 Pumps/3 Fuel Pool Heat Exchangers (Maximum REC Temperature of 60°F) | $30 \times 10^6$ BTU/hr (Pool Temperature of 110°F) |
| RHR Fuel Pool Inter-tie (Service Water Temperature of 95°F) | $14.20 \times 10^6$ BTU/hr (Pool Temperature of 150°F) |

During Mode 5, RWCU can be cross-tied to the FPC return line (see Section IV-9.3.

The fuel pool cooling pumps and heat exchangers are located in the reactor building below the bottom of the spent fuel pool. The fuel pool filters, which collect radioactive corrosion products, are located in the radwaste building.

Fuel pool water is continuously recirculated except during the period when the reactor cavity and dryer-separator pit are being drained. Although the capability exists to drain down the reactor cavity and dryer-separator pit following refueling operations via the Fuel Pool Cooling System, this is not a normal operation, and is not expected to be used. The Fuel Pool Cooling System normally maintains the spent fuel pool temperature well below the normal operating temperature of 125°F. When a full-core unload of fuel is required, this temperature will rise due to the higher decay heat generation of the freshly discharged fuel. Depending on the amount of fuel discharged and the time since shutdown, the spent fuel pool temperature may rise to as much as 150°F. During refueling periods, the Spent Fuel Pool is normally connected to the Reactor Cavity with the fuel pool gates and slot plugs removed. During this time, the total decay heat load is shared by both the Fuel Pool Cooling System and RHR shutdown cooling until all reactor fuel has been transferred to the Spent Fuel Pool.

Pool water clarity and purity is maintained by a combination of filtering and ion exchange processes. The filter-demineralizer maintains total heavy element content (Cu, Ni, Fe, Hg, etc.) at 0.1 ppm or less, with a pH range of 6.0 to 7.5 for compatibility with aluminum fuel racks and other equipment. Particulate material is removed from the circulated water by the pressure precoat filter-demineralizer unit in which a finely divided disposable filter medium is supported on permanent filter elements. The filter medium is replaced when the pressure drop is excessive or the ion exchange resin is depleted. Backwashing and precoating operations are manually controlled from the radwaste building. The spent filter medium is flushed from the elements and transferred to the condensate phase separator tanks by backwashing with air and condensate. The new filter medium is mixed in a precoat tank and transferred as a slurry by a precoat pump to the filter where the solids deposit on the filter elements. The holding pump maintains circulation through the filter in the interval between the precoating operation and the return to normal system operation.

A post-strainer is provided in the effluent stream of the filter-demineralizer to limit the migration of the filter material. The filter holding element is capable of withstanding a differential pressure greater than the developed pump head for the system. The maximum pressure drop across the filter and associated process valves and piping at the time for filter media replacement should not exceed the value shown in Table X-5-1. A holding pump is connected to each filter-demineralizer. This pump starts automatically to maintain sufficient flow through the filter media to retain it on the filter elements during loss of system flow. The backwash system is used to completely remove resins and accumulated sludge from the filter demineralizers with a minimum volume of water. The backwashed slurry drains to a phase separator. The precoat system is designed to rapidly apply a uniform precoat of filter media to the holding elements of a filter-demineralizer. One centrifugal precoat pump and associated piping and valves are provided to precoat either filter-demineralizer and recirculate the water to the precoat tank or suction side of the precoat pump. The filter-demineralizer units are located separately in shielded rooms. Each room contains only the filter-demineralizer and piping. All inlet, outlet, recycle, vent, drain, and other valves are located on the outside of one shielding wall of the room, together with necessary piping and headers, instrument elements and controls.

Penetrations through shielding walls are located so as not to compromise radiation shielding requirements.

System instrumentation is provided for both automatic and remote manual operations. Instrumentation and controls are provided to detect, control and record skimmer surge tank level, pump operation, pool temperature and system flow.

Changes in Spent Fuel Pool water inventory are reflected in skimmer surge tank water level. Direct indication of Spent Fuel Pool level is provided as described in USAR Subsection X-3.5.2. Low skimmer surge tank level annunciates in the Main Control Room, alerting the operators to fill the tanks from the Condensate Storage and Transfer System via a manual valve crosstie. High skimmer surge tank level also alarms in the Main Control Room. Excess tank level can be discharged to the Condensate Storage Tank or the main condenser hotwell. The controls and position indication for the air-operated valve which discharges the skimmer surge tank water to the Condensate Storage Tank is located in the Radwaste Control Room. The controls and position indication for the air-operated valve used for discharging to the condenser hotwell is located in the Radwaste Control Room.

The fuel pool cooling pumps are controlled locally. The 1A and 1B pumps can also be controlled in the Radwaste Control Room. Pump low suction pressure or low-low skimmer surge tank level automatically trips the pumps. Low pump discharge pressure alarms in the Main Control Room and on a remote instrument rack.

The flow rate through each of the filter-demineralizers is indicated by a flow indicator on the pump room panel or on the flow indicating controller in the radwaste control room. When fuel pool cooling flow rates exceed the filter-demineralizer capability, the filter-demineralizer bypass valve is manually opened to set required flow as indicated by the total flow indicator on the pump area panel or on the flow indicating controller in the radwaste control room.

A high rate of leakage through the refueling bellows assembly, drywell to reactor seal, or the fuel pool gates is indicated by lights on a remote instrument rack and is alarmed in the main control room.

The filter-demineralizers are controlled from a local panel in the radwaste control room. Differential pressure and conductivity instrumentation are provided for each filter-demineralizer unit to indicate when backwash is required. Suitable alarms, differential pressure indicators, and flow indicators are provided to monitor the condition of the filter-demineralizers.

## 5.4 Power Generation Evaluation

The fuel assemblies are cooled by natural circulation flow through the fuel assemblies. The thermal-hydraulic calculations indicate that even with the most conservative assumptions, the natural circulation in the spent fuel pool is adequate to preclude local boiling by a substantial margin when the Fuel Pool Cooling system is operating to maintain the bulk fuel pool temperature below 150°F.[9] USAR Subsection X-3.6.2 discusses the effects of a complete loss of Fuel Pool Cooling on the Spent Fuel Pool during a Safe Shutdown Earthquake.

During normal refueling operations, the maximum expected spent fuel pool temperature of 150°F results from the decay heat of the full core load of fuel at the end of the fuel cycle plus the remaining decay heat of the spent fuel discharged at previous refuelings. Prior to the spent fuel pool reaching this temperature, the Residual Heat Removal system is manually

aligned to operate in conjunction with the fuel pool cooling and demineralizer system to reduce the spent fuel pool temperature and maintain it at or below 150°F (see USAR Subsection IV-8.5.5).

Another scenario that permits the fuel pool water temperature to rise to 150°F is while the system water flow is diverted from the pool to drain the reactor cavity and dryer separator pit. The limiting case is during refueling periods when the full core is off-loaded to the Spent Fuel Pool and in-vessel work is required. The Fuel Pool gates and slot plugs can be set in place and the drain down begun when the heat removal capability of the Fuel Pool Cooling System is sufficient to maintain Spent Fuel Pool temperature below 150°F.

## 5.5 Inspection and Testing

No special tests are required because at least one pump, heat exchanger, and filter-demineralizer are normally in operation while fuel is stored in the spent fuel pool. Redundant units are operated periodically to handle abnormal heat loads or to replace a unit for servicing. Routine visual inspection of the system components, instrumentation, and trouble alarms are adequate to verify system function.

The Fuel Pool Cooling and Demineralizer System is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Selective Leaching (see USAR Section K-2.1.34), Water Chemistry Control - BWR (see USAR Section K-2.1.39), and Water Chemistry Control - Closed Cooling Water (see USAR Section K-2.1.40). There are no Time-Limited Aging Analyses that are applicable.

## 6.0 REACTOR EQUIPMENT COOLING SYSTEM

### 6.1 Safety Objective

The safety objective of the Reactor Equipment Cooling (REC) System is to provide cooling to the Emergency Core Cooling Systems (ECCS) areas.

### 6.2 Safety Design Basis

1. The system shall be designed with sufficient redundancy so that no single, active system component failure can prevent the system from achieving its safety objective.

2. The system shall be designed to provide an adequate supply of cooling water to the ECCS areas under all accident and transient conditions.

3. The system shall receive power from a critical AC power source.

### 6.3 Power Generation Objective

The power generation objective of the REC System is to provide required cooling to equipment located in the Reactor Building, Drywell, Control Building, Radwaste Building, and Augmented Radwaste Building during normal planned station operations.

### 6.4 Power Generation Design Basis

1. The system shall be designed with sufficient redundancy and flexibility of components such that the system will be continuously able to perform its power generation objectives and to maintain a stable inlet temperature to equipment during planned operation.

2. The system supplies cooling to support the operation of safe shutdown systems in the event of a fire related event.

### 6.5 Description

The REC system was called the Reactor Building Closed Cooling Water system in the FSAR. See Burns and Roe Drawing 2031, Sheets 1, 2, and 3.

#### 6.5.1 System Components

The REC system consists of two subsystems that provide cooling for those components which must function during postulated accidents and transients (see USAR Chapter XIV). These subsystems are designed to Class I criteria (see USAR Chapter XII and Appendix C). The REC subsystems are designed with electrical division independence, such that with the loss of one electrical division, critical loads will receive adequate cooling with the available equipment. Non-critical equipment is provided with common supply and return headers, and motor operated valves are provided to isolate these non-critical cooling loads under accident conditions. Flexibility of system operation is provided with the interconnection of the two subsystems through crosstie lines equipped with normally open isolation valves. This assures the system will still function under a variety of degraded conditions. Remote manual switches are available to close the critical loop supply and return crosstie valves (REC-MOV-695MV and REC-MOV-694MV) for separation of the two critical loops for maintenance. However, these crosstie valves are

required to remain open during normal plant operation to meet REC single failure criterion.

Each REC subsystem has two centrifugal pumps discharging to one REC heat exchanger and capable of delivering demineralized water to the equipment listed in Table X-6-1. REC pump specifications and REC heat exchanger specifications are listed in Table X-6-2. Each REC pump has a control switch and a mode select switch. The control switch starts and stops the pump. When placed in the Standby position, the mode selector switch causes the REC pump to auto start following restoration of power to the associated critical bus.

TABLE X-6-1

EQUIPMENT SUPPLIED BY THE REC SYSTEM

Critical Cooling Services Header

SOUTH LOOP

Two RHR pump seal water coolers
One HPCI pump area cooling coil
One RHR pump area cooling coil
One Core Spray pump area cooling coil

NORTH LOOP

Two RHR pump seal water coolers
One RHR pump area cooling coil
One Core Spray pump area cooling coil

Non-Critical Cooling Services

Drywell Loop

One Equipment Drain sump heat exchanger
Four Drywell cooling coils
Two Reactor Recirculation pump seal water and motor bearing lube oil coolers

Non-Critical Services Loop

Two Reactor Recirculation Motor Generator set oil system heat exchangers
Three Reactor Building sample coolers
Two RWCU nonregenerative heat exchangers
Three Fuel Pool Cooling heat exchangers
One Reactor Building Equipment Drain sump heat exchanger
Two Control Rod Drive pumps oil and bearing coolers
Two Reactor Water Cleanup pumps bearing, stuffing box and seal water coolers
Six Condensate holding pumps coolers
Three station air compressor cylinder, intercooler, and aftercooler (one normal and two backup supply)
Three fan coil units (Augmented Liquid Radwaste Control Room, AOG Control Room, and ADHR Equipment Room)
Two sets of Glycol coolers (two coolers per set)
One Augmented Radwaste Building sample rack
One Concentrator Condenser

TABLE X-6-2

REC SYSTEM
EQUIPMENT DATA
NUMBER OF SUBSYSTEMS-2

REC Pumps

| | |
|---|---|
| Quantity per Subsystem | 2 |
| Type | Horizontal Centrifugal |
| Flow and Head | 1350 GPM at 150 ft. TDH |
| Material: | |
| Casing/Impeller/Shaft | Cast Iron/Bronze/Stainless Steel |
| Motor: Size | 75 HP |
| Voltage/Phase/Cycle | 460 Volt/3 Phase/60 Hertz |
| RPM | 1775 |

REC Heat Exchangers

| | |
|---|---|
| Quantity per Subsystem | 1 |
| Type | Horizontal, Shell and Tube, TEMA Type R |
| Heat Transfer Area | 8716 Sq. Ft.* |
| Heat Duty Rate | 33 x $10^6$ Btu/HR* |
| Shell Design: | |
| Pressure/Temperature | 150 psig/200°F |
| Material | Carbon Steel |
| Flow Medium | Demineralized Water |
| Tube Design: | |
| Pressure/Temperature | 150 psig/150°F |
| Materials: Tube | 304L A-249 |
| Tube Sheet | A516/304 Clad |
| Tube Joint | Rolled and Welded |
| Flow Medium | River Water |

* Spec sheet data only - actual heat duty rate and heat transfer area of the heat exchanger is a function of fouling and number of tubes plugged, which are both controlled by the applicable plant procedures and analyses.

The 550 gallon capacity surge tank, located at the highest point of the system, accommodates system volume changes, maintains static pressure in the REC subsystem, detects gross leaks in the REC system and provides a means for adding makeup water. Makeup water to the REC system from the non-essential demineralized water storage tank is supplied by a connection from the demineralized water transfer pump to the surge tank. Surge tank level is maintained automatically by means of level switches and a control valve. Should failure of automatic system occur, non-essential manual isolation and bypass is available for the level control valve.[52] The surge tank is readily accessible during reactor operation for level adjustment if desired. Venting of the tank is directed to the reactor building.

During normal plant power operation, water leakage from the REC system is monitored by station procedures to ensure that this leakage does not exceed the maximum allowable leakage.[120] The maximum allowable leakage is based on the criterion that the REC surge tank shall be capable of providing sufficient NPSH for the REC pumps in a post LOCA condition for at least 30 days without requiring any makeup during this 30 day period.

The common discharge header from the heat exchangers is monitored for low pressure and alarmed in the Control Room. A pressure test point is located at the inlet and outlet of each heat exchanger for pressure testing if desired. Pressure indicators are located on the suction and discharge of each pump and on the supply headers to the critical services. Local temperature elements are located on the inlet and outlet of the heat exchangers to indicate the temperature of the cooling water. One temperature indicator located on the common discharge header from the heat exchangers to the non-critical cooling loads indicates the REC system temperature in the main Control Room. A cooling water sampling point is located at the common discharge header from the REC heat exchangers. Samples are taken periodically to determine activity levels and quality of cooling water.

The following conditions will alarm in the main Control Room indicating a loss of system function or integrity:

1. Surge tank low level
2. Surge tank high level
3. Heat exchanger discharge header low pressure
4. High radiation level

The REC system has a "slip-stream" type demineralizer unit connected to the non-critical header. The demineralizer unit is normally utilized to maintain REC system water chemistry.[116][134]

The REC system is powered by the critical buses.

## 6.5.2 Planned Operations

During normal power operation, all four pumps and both heat exchangers may be placed into operation depending upon river water temperature. Cooling water can be provided to the equipment listed in Table X-6-1. The critical cooling services are not in operation at this time and are valved out of the system. The flow rate to each component in the REC System is established to maintain adequate heat transfer during normal operations. Flow alarms, temperature alarms, and local temperature and flow indicators are provided throughout the system for process monitoring. In addition, remote temperature indicators are provided to monitor drywell equipment. To support summer operations at CNS, the design maximum inlet water temperature to the equipment coolers and area cooling coils is 100°F. However, under LOCA conditions without a LOOP, the REC outlet temperature can increase above 100°F and still provide adequate cooling to the ECCS pump areas.[97]

REC and TEC supply normal and backup cooling water to the three plant air compressors. Air-operated isolation valves on the TEC and REC supply and return headers to each air compressor are controlled from common selector switches which prevent cross-connecting the systems. REC normally supplies one of the air compressors. On loss of power or instrument air, the isolation valves realign so that REC supplies both the A and B air compressors.

A radiation indicator-recorder is located in the system to monitor radioactivity level. On detection of a high radiation level an alarm will sound automatically in the Control Room.

### 6.5.3 Accident and Transient Operations

Either REC subsystem has sufficient capacity with one pump operating to transfer the critical services design cooling load during postulated transient or accident conditions for 30 days.[97] If service water backup is available, it may be used for long term cooling.

Low pressure in the common discharge header signals an alarm in the main Control Room and automatically closes the Division I motor-operated valves (REC-MOV-700MV, REC-MOV-702MV, and REC-MOV-1329MV) in the supply headers to the non-critical services. Drywell isolation valve (REC-MOV-702MV) can be manually reopened by remote manual switch override if necessary.[10] Low pressure in the 'A' or 'B' heat exchanger's outlet signals an alarm in the main Control Room and closes the associated Division II motor-operated valve in the supply line to the nonessential services. This action is initiated by a pressure switch in each heat exchanger's outlet which will send a signal to close REC-MOV-712MV if a low pressure condition is sensed in the 'A' heat exchanger outlet, and REC-MOV-713MV if a low pressure condition is sensed in the 'B' heat exchanger outlet. There is a 40 second time delay associated with automatic REC isolation valve closure to allow for REC system pressure recovery during operational transients so that the potential for unwanted auto isolations is minimized.[12]

The ECCS equipment coolers (for the RHR, Core Spray and HPCI pumps) are located in the basement of the reactor building in the following compartments:[11]

| Compartment | System | No. of Pumps |
|---|---|---|
| North-East | Core Spray | 1 |
| North-West | RHR | 2 |
| South-East | Core Spray | 1 |
| South-West | RHR | 2 |
| HPCI | HPCI | 1 |

In each RHR Quad, area cooling is provided by a single cooler, with the Northwest Quad's cooler energized from Division I and the Southwest Quad's cooler powered from Division II power source. The RHR pumps in each Quad are powered from separate divisional power sources. A CS injection leg break coincident with a divisional power failure would require the operation of both surviving RHR pumps, one in each Quad, to meet minimum ECCS requirements to assure adequate core cooling. This would result in a loss of area cooling for one of the surviving RHR pumps. The equipment hatch plugs at the 903'-6" & 881'-9" elevations in each RHR Quad are removed[26], allowing the continuous operation of a single RHR pump in each Quad via natural, convective cooling.[27,28] Forced area cooling is, however, still required for concurrent pump operation. For post-LOCA long-term operation, SW backup cooling to REC must be initiated within 1 hour if cooling is lost after the pumps have been operating for an extended time period and the room has reached equilibrium conditions with the fan coil unit operating.[29] Cooling to the critical loops is required to be restored within 1 hour to ensure postulated temperature limits are maintained.

SW-MOV-650MV and SW-MOV-651MV will receive an auto-open signal to open the valve to the approximate 10% open position, if they are not already open, 30 seconds after the Group VI Isolation signal is received and divisional power is restored. After SW-MOV-650MV and SW-MOV-651MV are approximately 10% open, REC-MOV-711MV and REC-MOV-714MV will receive auto-open signals commencing REC flow to the North and South Critical Loops. This will commence REC cooling to the Critical Loops within 30 seconds after the Group VI Isolation signal is received and Bus 1F and 1G voltage is restored. The active safety function of the 30 second time delay for the Service Water to REC crosstie valves (SW-MOV-650MV and SW-MOV-651MV) auto-open, is to provide adequate time delay to prevent the opening of the REC critical loop supply valves (REC-MOV-711MV and REC-MOV-714MV) during voltage dips caused by ECCS pumps starting (0-15 seconds) but open REC-711MV and REC-714MV before the non-critical headers isolation valves are fully closed (t=60 seconds). This interlock prevents allowing REC coolant to the critical loops from a standby or isolated REC heat exchanger. The actual Service Water valve position of 10% open is not part of the safety-function of this interlock because the Operator will have to manually adjust SW-MOV-650MV and SW-MOV-651MV during the post-accident time period depending on which REC heat exchanger was in service prior to the accident.

Under a transient (that leads to a Group VI isolation), a Loss of Offsite Power or a LOCA scenario, the following automatic operations occur;

1. An automatic start of the Standby REC pumps 20 seconds after power is restored to the critical buses (in the event of a Loss of Offsite Power).

2. An automatic opening signal to the Division I Critical Service Header Motor Operated Valve (REC-MOV-711MV) 30 seconds after a Group VI Isolation signal is received and SW-MOV-650MV has automatically opened to its minimum flow position or is already at its minimum flow position. REC-MOV-711MV will be fully open approximately 120 seconds after power is restored to the critical buses.

3. An automatic opening signal to the Division II Critical Service Header Motor Operated Valve (REC-MOV-714MV) 30 seconds after a Group VI Isolation signal is received and SW-MOV-651MV has automatically opened to its minimum flow position or is already at its minimum flow position. REC-MOV-714MV will be fully open approximately 120 seconds after power is restored to the critical buses.

Sufficient pressure is generated by one pump to preclude starting of additional REC pumps. In the event of pump failure, the low pressure condition in the essential services supply header is indicated in the Control Room and another pump is manually started by a remote manual switch to correct the low pressure condition.

Service Water can be intertied to REC to provide a backup cooling water supply to the Reactor Building Quad coolers in a post LOCA environment. This function is utilized if the REC surge tank level decreases below the minimum required for adequate net positive suction head to the REC pumps. This feature is credited to ensure satisfactory Quad cooling for a 30 day DBA LOCA event duration. See Section X-6.6.1 for further discussion on the Service Water intertie.

Control for REC Pumps 1-C and 1-D can be transferred to the alternate shutdown panels. The pumps can then be controlled independent from the Control Room in the event of a fire.

## 6.6 Safety Evaluation

The REC System is designed with sufficient redundancy so that no single active system component failure nor any single active component failure in any other plant system can prevent it from achieving its safety objective. Two subsystems, each with full heat transfer capacity are provided. It is concluded that the Safety Design Bases are met.

The plant is capable of a safe shutdown following a Design Basis LOCA considering the REC system allowable leakage as defined in Section X-6.5.1 above.

### 6.6.1 Passive Failure Evaluation

During the design and licensing of CNS, the Atomic Energy Commission (AEC) did not have formal guidance established for the postulation of passive failures of Seismic Class IS moderate energy piping. The position taken by the AEC during the CNS licensing proceedings was that required cooling water be provided to the safety-related REC cooling services, assuming:

1. A catastrophic failure of all interfacing Seismic Class IIS piping systems concurrent with a single active failure in the Class I portion of the system, and

2. A catastrophic failure of any passive Class I system component not concurrent with a Safe Shutdown Earthquake or Design Basis Accident, without an additional single active failure.

NPPD accepts these criteria as licensing bases for the REC System[13].

The REC System contains both Seismic Class IS and Seismic Class IIS piping. The system can still support plant shutdown if there is a failure in the Class II part of the system by remotely isolating the failure from the Control Room.

In the event of a failure (line break) in the Seismic Class IIS system piping, the operator will be alerted to this malfunction from signals received from various alarms connected to instruments located in different portions of the REC system. The operator will perform the following functions[12]:

1. Shut off the operating REC pumps. (Non-Critical supply header isolation valves REC-MOV-700MV, REC-MOV-702MV, REC-MOV-712MV, REC-MOV-713MV and REC-MOV-1329MV automatically close on loss of pressure after a 40 second time delay).

2. Isolate Seismic Class IS piping system by manually closing drywell isolation valve REC-MOV-709MV.

3. Initiate a manual reactor scram (if an automatic scram has not already occurred).

4. Restart one of the REC pumps to supply cooling water to the equipment connected to the critical cooling loops (Table X-6-1) and open either REC-MOV-711MV or REC-MOV-714MV.

If the above measures are unsuccessful in restoring the essential REC cooling functions, or if a single passive failure occurs in the Seismic Class IS portion of the system, service water can be manually introduced from

the Control Room into the REC system to provide backup cooling water. This action must be completed within 1 hour after cooling is lost concurrent with the start of two pumps. If cooling is lost after the pumps and fan cooler units have been operating for an extended time period and the room has heated to equilibrium conditions, then SW backup flow must be supplied within about 1 hour after cooling is lost.[29,53] With this function, the system is able to provide an adequate supply of raw cooling water to the surviving ECCS area coolers in the event of a single, passive REC component failure. REC cooling to the RHR pump seals is not required for accident mitigation.[51]

The Service Water intertie is established by isolating the critical services headers feeding the compartment air coolers from the rest of the REC system by manually closing REC-MOV-697MV, REC-MOV-698MV, REC-M0V-711MV, and REC-M0V-714MV. The service water is obtained from the headers feeding the REC heat exchangers by opening SW-MOV-886MV, SW-MOV-887MV, SW-MOV-888MV and SW-MOV-889MV from the Control Room (see Burns and Roe Drawing 2036, Sheet 1). The concept uses only service water to cool the compartment air coolers; operation of the REC pumps and heat exchangers is not required. The introduction of service water into the two loops of the REC system assures the AEC passive failure criteria for REC are met.

## 6.7 Inspection and Testing

REC pumps and motor operated isolation valves can be tested, during normal operation, to assure they are capable of meeting design function by operating manual switches in the Control Room and observing the position lights.

The pumps and motor-operated valves are tested at least quarterly. The pumps are tested to ensure each can deliver 1175 gpm at 65 psid once/3 months and after pump maintenance.

Heat transfer capacity performance testing, of REC heat exchangers, is conducted at least once per operating cycle to ensure design heat removal capabilities are met for heat exchangers cooled by service water.[116]

The REC Surge Tank level is monitored and maintained above the calculated minimum level. The REC system leakage rate is also maintained less than the calculated rate to ensure system will operate for 30 days in post DBA LOCA conditions. No credit is taken for any non-essential make up source.

The REC System is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), Selective Leaching (see USAR Section K-2.1.34), Service Water Integrity (see USAR Section K-2.1.35), and Water Chemistry Control - Closed Cooling Water (see USAR Section K-2.1.40). There are no Time-Limited Aging Analyses that are applicable.

# 7.0 TURBINE EQUIPMENT COOLING SYSTEM

## 7.1 Power Generation Objective

The power generation objective of the Turbine Equipment Cooling (TEC) system is to provide cooling to the equipment located in the Turbine Building, to the station air conditioning systems, and to certain equipment in the Control, and Radwaste Buildings, Heating Boiler Room, and Intake Structure.

## 7.2 Power Generation Design Basis

The TEC system shall provide an adequate supply of coolant to the required power generation equipment located in the Turbine Building and to the station air conditioning systems.

## 7.3 Description

The TEC system was called the Turbine Building Closed Cooling Water system in the FSAR. TEC consists of a single closed loop with three half-sized centrifugal pumps in parallel, pumping through two full-sized TEC heat exchangers arranged in parallel, and delivering cooling water to the equipment listed in Table X-7-1 (See Burns and Roe Drawing 2007). The TEC system is designed for a system pressure of 150 psig. TEC system equipment data is shown in Table X-7-2. The Service Water System provides a heat sink for the TEC System during planned operations in all operating states.

The 500 gallon capacity surge tank, located at the highest point of the system, accommodates system volume changes, maintains static suction pressure on the pumps, detects gross leaks in the TEC system and provides a means for adding make-up water. Make-up water to TEC is supplied by a connection from the Demineralized Water system. Tank level is maintained automatically by means of level switches, mounted on the surge tank, operating a control valve. Venting of the tank is directed to the Turbine Building.

The discharge side of each TEC system pump has a pressure indicator. The heat exchanger discharge header is monitored for low pressure and alarmed in the Control Room. Pressure test connections are provided on the inlet and outlet of each exchanger. A temperature element is located on the heat exchanger discharge header to indicate the temperature of the cooling water on the indicator in the Control Room. Cooling water sampling points are located at the outlet of each TEC heat exchanger. Samples are taken periodically to determine activity levels and quality of the cooling water.

The TEC system has a "slip-stream" type filter demineralizer skid that is utilized to maintain the TEC system water chemistry.

The following conditions will alarm in the Control Room indicating a loss of system function or integrity:

1. Surge tank low level
2. Surge tank high level
3. Heat exchanger discharge header low pressure
4. TEC pump A,B,C trip.

During normal station operation, two TEC pumps and one system heat exchanger are operating. The TEC system is designed to transfer a maximum heat load of $54 \times 10^6$ Btu per hour based on a Service Water inlet water temperature of 85°F. During warm weather months when elevated river temperatures are encountered, both TEC heat exchangers are typically needed to provide adequate cooling.

TABLE X-7-1

EQUIPMENT COOLED BY THE TEC SYSTEM

| Quantity | Equipment |
|---|---|
| 4 | Generator hydrogen coolers |
| 4 | Exciter air coolers |
| 1 | Generator bus duct cooling |
| 3 | Compressor inter and after coolers and water jackets (2 normal and 1 backup supply) |
| 2 | Turbine-Generator lube oil coolers |
| 2 | Electro-Hydraulic governor oil coolers |
| 2 | Hydrogen seal oil coolers |
| 2 | Reactor feed pump turbine lube oil coolers |
| 2 | Condenser mechanical vacuum pump coolers |
| 2 | Condenser mechanical priming pump coolers |
| 3 | Condensate pump motor coolers |
| 3 | Condensate booster pump oil coolers |
| 1 | Control Room air conditioning |
| 1 | Computer Room air conditioning |
| 1 | Radwaste Building air conditioning |
| 2 | Steam Tunnel Fan Coil Units |
| 4 | Circulating water pump motor coolers |
| 1 | Turbine Building Sample Rack |
| 1 | Heating Boiler Room Sample Rack |

TABLE X-7-2

TURBINE EQUIPMENT COOLING
SYSTEM EQUIPMENT DATA

| | |
|---|---|
| <u>TEC Pumps</u> | |
| Quantity | 3 Half Capacity |
| Type | Horizontal Centrifugal |
| Flow and Head (each) | 4,500 GPM at 125 ft |
| Material: | |
| Casing/Impeller/Shaft | Cast Iron/Bronze/Stainless Steel |
| Motor: | |
| Size | 200 HP |
| Voltage/Phase/Cycle | 460 Volt/3 Phase/60 Hertz |
| RPM | 1,770 |
| <u>TEC Heat Exchangers</u> | |
| Quantity | 2 Full Capacity |
| Type | Horizontal, Shell and Tube, Single Pass |
| Heat Transfer Area (each) | 17,870 Sq. Ft. * |
| Shell Design: | |
| Pressure/Temperature | 150 psig/150°F |
| Material | Carbon Steel |
| Coolant Medium | Demineralized Water |
| Tube Design: | |
| Pressure/Temperature | 150 psig/150°F |
| Material: | |
| Tube | SB-338, Grade 2, Titanium |
| Tube Sheet | Carbon Steel |
| Tube Joint | Rolled |
| Coolant Medium | River Water |

* Spec sheet data only - actual heat duty rate and heat transfer area of the heat exchanger is a function of fouling and number of tubes plugged, which are both controlled by the applicable plant procedures and analyses.

Following a loss of coolant accident concurrent with the loss of AC power, the Control Room air conditioners will be supplied with cooling water through connections from the Service Water system.

TEC and REC supply normal and backup cooling water to the three plant air compressors. Air-operated isolation valves on the TEC and REC supply and return headers to each air compressor are controlled from common selector switches which prevent cross-connecting the systems. TEC normally supplies two of the air compressors and is available as a backup supply for the third.

## 7.4 Inspection and Testing

Pumps in the TEC are proven available by their use during normal station operations. Remote operated valves in the system can be tested to assure that they are capable of opening and closing by operating manual switches in the Control Room and observing the position lights. System subsections normally closed to flow can be tested periodically to ensure their availability and integrity.

The TEC System is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), Selective Leaching (see USAR Section K-2.1.34), and Water Chemistry Control - Closed Cooling Water (see USAR Section K-2.1.40). There are no Time-Limited Aging Analyses that are applicable.

# 8.0 SERVICE WATER AND RHR SERVICE WATER BOOSTER SYSTEM

## 8.1 Service Water System

### 8.1.1 Safety Objective

The safety objective of the Service Water (SW) system is to provide a heat sink for the Reactor Equipment Cooling (REC), Residual Heat Removal (RHR), and diesel generator cooling systems under transient and accident conditions.

### 8.1.2 Safety Design Basis

1. No single active system component failure shall be able to prevent the system from achieving its safety objective.

2. The system shall continuously provide a supply of cooling water directly to the diesel generator and to the secondary side of the REC heat exchangers and to the RHR Service Water Booster Pumps adequate for the requirements under both normal operations and under transient and accident conditions.

3. The system shall be capable of providing direct cooling to essential REC heat loads post accident or after a passive REC failure.

### 8.1.3 Power Generation Objective

The power generation objective of the SW system is to provide a heat sink for the REC system and the TEC water system during planned operations in all operating states, and to provide backup coolant to the RHR Service Water Booster Pump Room Fan Coil Unit.

### 8.1.4 Power Generation Design Basis

1. The system shall function as the ultimate heat sink for all the systems cooled by the REC and TEC systems during all planned operations in all operating states by continuously providing adequate cooling water flow to the secondary sides of the REC and the TEC heat exchangers, and shall provide a backup cooling supply to the RHR Service Water Booster Pump Room Fan Coil Unit to support ambient heat removal in that space.

2. The system shall provide a supply of cooling water to the REC, RHR, and diesel generator cooling systems in the event of a fire.

### 8.1.5 Description

The SW system other than that portion supplying the Turbine Building and other non-essential areas is designed in accordance with Class I criteria.

The SW system consists of four vertical SW pumps located in the Intake Structure, and two associated strainers, piping, valving, and instrumentation (See Burns and Roe Drawings 2006, Sheets 1 through 4, and 2036, Sheet 1). The SW pumps discharge to a common header from which independent piping supplies two Seismic Class IS cooling water loops and one Turbine Building loop. In the event of a loss of header pressure below 20 psig, automatic valving is provided to shutoff all supply to the Turbine Building loop, thus assuring supply to the Seismic Class IS loops. Each Seismic Class IS loop feeds one diesel generator, two RHR service water booster pumps, and one REC heat exchanger. Valves are included in the common discharge header to permit the SW system to be operated as two independent loops. Either loop can supply normal cooling water to the REC Critical Loops and the diesel generators. Either loop can also supply the RHR service water booster pump room fan coil unit, and Control Room air conditioning units. A

sealed closed valve (SW-V-122) cross-connects the SW supply to the REC heat exchangers. When permitted by station cooling water heat load, the REC heat exchangers are valved such that they can be individually backwashed without interrupting system operation.

Each set of SW pumps has a normal water bearing lubrication supply utilizing the safety-related discharge of the SW pumps.

The following number of SW pumps will be used during each of the indicated operating modes:

| | Number of Pumps |
|---|---|
| Normal Operation | 1-4 |
| Accident Conditions (LOCA) | 1 (per loop) |
| Shutdown Conditions (Normal) | 2-3 |

To ensure that sufficient river flow is maintained through the REC heat exchangers under all conditions, a balancing orifice is provided on the Turbine Building supply branch.

SW minimum flow requirements following a postulated LOOP/LOCA event are as follows:

| Item | Less than 10 Minutes Post Accident GPM | 10 Minutes and Longer after Accident GPM |
|---|---|---|
| 1. RHR Service Water Booster Pumps(128) | 0 gpm | 4000 gpm |
| 2. REC Heat Exchanger(131) | 400 | 400 |
| 3. Control Room Air Conditioning(132) | 70 | 70 |
| 4. Strainer Backwash(133) | 370 | 370 |
| 5. Diesel Generator Engine Cooling(129) (1002 gpm flow provides 26 gpm to each of the two Intercoolers with the remaining 950 gpm to the Lube Oil Cooler. The outlet supply from the Lube Oil Cooler then supplies 490 gpm to the Jacket Water Cooler with the balance to the bypass line around the Jacket Water Cooler.) | 2004 | 1002 |
| 6. Service Water Gland Water(130) | 3 | 3 |
| 7. RHR SW Booster Pump Gland Water[115] | 1 | 1 |
| | 2848 gpm | 5846 gpm |

The above can be attained with one SW Pump operating under low river water level conditions. Items 2, 4, 5, 6, and 7 will be required continuously during the entire shut-down period. Item 3 is required on an intermittent basis only. Item 5 may be reduced to zero when normal power is restored. Item 1 is required continuously after 10 minutes. SW header connections and other details are shown on Burns and Roe Drawings 2006, Sheets 1 through 4, and 2036, Sheet 1.

Adequate distribution of SW is assured during the postulated LOCA as follows:

1. Refer to Burns and Roe Drawing 2006, Sheet 1; SW flow to the Diesel Engines and Control Room is assured by automatic closing of valves SW-MOV-36MV and SW-MOV-37MV[75] on low pressure, thereby isolating the Class II

systems from the Class I systems. Flow through the Diesel will be limited to 1400-1500 gpm by orifice restriction, sending the balance of SW to RHR SW Booster Pumps, REC Heat Exchangers, Control Room HVAC, SW Gland Water, and RHR SWBP Gland Water Systems. Also, if required, manual valve SW-V-268 (or SW-V-269) can be used to throttle service water flow to the Diesel Engines.

2. Refer to Burns and Roe Drawings 2006, Sheet 4, and 2036, Sheet 1. SW entering the Control Building is routed to the REC Heat Exchangers and the RHR Heat Exchangers. In addition, flow is taken off the REC heat exchanger supply line to cool the Control Room air conditioning units. Flow control is established by the flow controllers at the outlets of the air conditioning units. Flow indication in the Control Room permits the operator to monitor the desired flow rates of 4000 gpm to the RHR and 400 gpm to the REC heat exchangers during a LOOP/LOCA event. Flow adjustments are available, if necessary, by remote manual operation of the heat exchanger outlet valves from the Control Room.

3. Each of the four SW pumps have mode selector switches for setting in Automatic-Manual-Standby positions. Annunciation is arranged so that at least one selector switch in each loop must be set in the standby position to avoid an immediate alarm. This assures automatic startup of at least one SW pump per subsystem in an emergency.[17]

The loss of all AC power will trip all operating SW pumps. The automatic emergency diesel generator start system and emergency equipment starting sequence will then start one selected SW pump within 31 seconds. (For further information on sequential loading, see USAR Section VIII-5). Prior to SW pump restart the drop in SW header pressure will isolate the TEC supply header. This assures supply to the Reactor Building, the Control Building, and the diesel generators from the one SW pump.

For a design basis LOCA concurrent with a LOOP, the case of not isolating the flow to the idle diesel generator has been evaluated. [121] The SW system is throttled to assure adequate SW flow to all the essential loads even if the idle DG is not isolated.

In the event that AC power is not lost upon LOCA occurrence, the non-essential header may not isolate. In this case, low header pressure and the attendant isolation of non-essential balance-of-plant equipment would not occur. This contingency has been analyzed in conjunction with summer operating conditions of 95°F service water at CNS. [97,121] For this case, it has been determined that adequate SW flow will be supplied to the essential SW loads, even at the low pressure isolation setpoint of the non-essential SW header. The REC heat exchanger capability has also been analyzed for this case. For 95°F service water, limitations are placed on the REC heat exchanger fouling in order to ensure that the ECCS pump room temperatures remain within their analyzed limits.

8.1.5.1 Silting

During plant construction the presence of a large amount of silt in the SW system intake bay indicated that silting problems may occur in the SW system. Silt buildups will occur in areas of low water velocity. Typically these areas occur where the piping undergoes large diameter changes or where the normal flow path is intersected by piping with very low normal flow. Typical examples include instrument sensing lines and passive heat removal systems.

Primary concern was focused on the piping of safety related systems. Systems of this type served by the SW system include the RHR service water booster pumps, RHR heat exchangers, REC heat exchangers and the emergency diesel generators. In case of failure of the REC system, the SW system supplies the ECCS area coolers and the RHR pump seal coolers.

An analysis of the SW system was made using the piping isometric drawings. Plant inspections were made to determine areas where silt buildups may occur including such things as low velocity areas, low point traps, check valve orientation and instrument sensing lines.[16]

At the conclusion of the preoperational test program, a complete set of system flow, pressure and temperature data was taken and notes on system operational equipment made. After the data taking was complete, inspections were made. The inspections following preoperational testing provided sufficient information to identify and combat any silt accumulation problems that exist. In particular, analysis of the time period of SW system operation versus the degree of silt accumulation found during the inspections was used to define the frequency that corrective action must be taken during plant operation. The operating procedures were modified as necessary to prevent serious silt buildup in critical systems. The spray wash assembly and/or the traveling screens may be turned off for short periods of time (≤ 7 days) to perform maintenance. Silting has been evaluated and determined not to be a problem for these short periods of time. In addition to the above, flow, pressure and temperature data from the critical heat exchangers is periodically analyzed to detect any trends that could occur as a result of silt accumulation.

Based upon findings of the preoperational tests, the technical specifications have been modified to provide assurance of operability.

Silt accumulation in the entrance and interior of the intake is controlled by the following design features of the system:

1. A water jet sparging system is installed near the bottom of the Intake Structure to agitate the silt and keep it in suspension, thus preventing its settling out. The sparging system consists of two rows of jets in each circulating water bay and five rows in the SW bay, as shown in Figure X-8-4. Jet J-3 is installed within the traveling screens to keep the screen boot area free of silt buildup. The above-mentioned principal operating jet J-3 is utilized on an automatic sequential schedule for periods determined by field experiment after installation. J-2 header is used to clear the guides for the screens when they are replaced following maintenance. J-2 nozzles have been removed from circulating water bays A-D. Circulating water bay jets J-4 are used only in the unlikely event that an undesirable amount of silt accumulates near the circulating water pump. SW bay jets J-4A and J-4B agitate silt around the SW pumps. The jets J-4A and J-4B are double headers, either one could act as backup to the other. The J-4C jets in the SW bay are used to clear the bay floor area near the service water pump inlet bell. Supply water to the jet sparging system is provided by two pumps, one to act as standby. Supply water for the jet sparging system, to the jets for the SW pumps (E-bay), may be supplied by SW in the event sparging pumps are not available post LOCA. A maintenance schedule for the sparging system is set up based upon field experimentation and operating experience.

2. Silt panels are provided in stoplog guides which can be used to block the waterway when the pumps are not in operation or screens have been removed for maintenance. This can help prevent unnecessary silt accumulation in idle bays.

3. The traveling water screens are two-speed units (8.2 fpm and 24.6 fpm). The low speed is expected for normal plant operation. High speed operation is only expected for periodic high debris/silt levels in the river.

4. A guide wall and an array of submerged flow turning vanes has been installed in order to streamline the river flow in front of the intake and reduce the amount of silt and sand entering the structure.[16]

8.1.6 Common Mode Failure Analysis[18]

The SW pumps are located within the Intake Structure SW pump room, which is designed to missile protection criteria. A turbine rotor is the only missile capable of damaging or penetrating the roof of this structure. However, the possibility of multiple damage is precluded due to the spacing of the pumps and equipment. This spacing is the ultimate protection against common mode failure of the SW system.

The SW pumps and piping and automatic strainers are designed, restrained and supported to both the Class I earthquake criteria, and barge impact criteria based on a statically-applied horizontal acceleration or response spectrum analyses in consideration of the original design basis barge impact conditions. This support system included the SW pump suction column below the 903'6" elevation. These pump columns are structurally restrained at approximately the 1/3 and 2/3 column length locations to preclude them from becoming missiles. The SW pump motors are either the weather protected enclosure design or the drip-proof enclosure design with water splash shields installed to prevent splashing water due to a pipe break from affecting the operation of any pump motor. In addition, flooding of the structure from a pipe break is not possible due to the several drains leading directly to the suction bay below. The SW pump systems are completely redundant and separate so that the failure of one pump or system will not cause loss of the SW system capability for safe shutdown of the plant.

A common mode failure due to a missile emanating from a SW pump motor may be postulated. These motors, being of the induction type, are incapable of overspeed operation. Any missile leaving the motors would have to gain sufficient momentum from operating speed to penetrate the motor casing. In addition, to cause failure, the missile would have to pass through the water splash shields when applicable and the adjacent motor's casing. Even if this exceedingly improbable event should occur, the pumps are arranged such that the pump adjacent to the missile source would be the only one affected. Thus, two SW pumps would remain functional, providing more than enough capacity to meet system obligations under accident conditions.

The fan coil units providing normal HVAC to the Service Water pump room are not powered from critical buses, and are therefore not credited with supporting the safety functions of the Service Water pumps. Assuming a sustained outside air temperature of 97°F and 95°F Service Water temperature, the Service Water pump room maximum allowable temperature of 156°F can eventually be exceeded with the Service Water pump room doors closed. With four Service Water pumps in service there is approximately 3.8 hours until that temperature is reached. This is sufficient time for Operators to recognize the condition, secure two of the four Service Water Pumps, and block open the doors to assure adequate cooling for the remaining Service Water pumps through natural ventilation. If two Service Water pumps are initially operating there is approximately 34 hours to establish a similar natural ventilation flowpath. Service Water pump room temperature will remain within the minimum allowed temperature of 32°F after a loss of normal HVAC, assuming an outside air temperature of -5°F and operation of a single Service Water Pump.[87][122]

The potential for a common-mode failure as a result of a fire in the Intake Structure has been evaluated as acceptable in NEDC 11-089 of the CNS Fire Safety Analysis.

8.1.7 Safety Evaluation

The Class I portion of the SW system is designed with sufficient redundancy so that no single active system component failure nor any single active component failure in any other system can prevent it from achieving its

safety objective. Two independent closed loops with full heat transfer capacity on each loop are provided. It is concluded that the safety design basis is met.

The system provides a backup cooling water source to the REC system critical cooling loads in the event of a passive failure in the REC system, as described in Section X-6.6.1. The REC-Service Water intertie is also credited after a DBA LOCA to ensure satisfactory Quad cooling is available for a 30 day event duration.

The SW system feeding the REC exchangers is designed for Class I. CNS was not designed to support a single passive failure. If the body of valve SW-V-122 splits, SW supply to both exchangers would be cut-off. If a piping spool between one of the check valves and one of the REC exchangers splits, having valve SW-V-122 sealed closed will assure flow to one of the two REC exchangers. (The flow through the break can then be stopped by shutting off valve SW-V-105 or SW-V-106 in the Control Room basement).[14]

### 8.1.8 Inspection and Testing

The pumps and motor-operated valves are tested quarterly. Pump discharge head tests are conducted once/three months. The motor operated valve on the Turbine Building supply branch can be tested to assure it is capable of opening and closing by operating manual switches in the Control Room and observing the position lights.

The Intake Structure is inspected for silt, debris, and deterioration (including corrosion) and monitoring of silt levels. In addition, the Intake Structure basin is sampled and analyzed for macro fouling. The SW system flow requirements are verified by testing periodically to ensure the SW system and associated components meet or exceed the post-LOCA design flow requirements. The safety related heat exchangers cooled by the SW system are either tested to verify the heat transfer capability or are periodically opened and inspected. Selected wall thickness testing (UT) of SW system piping, fittings and valves are performed to ensure erosion and corrosion concerns are addressed. Administrative controls are provided for proper lay-up of all safety related heat exchangers supplied by SW.[116]

To assure that the REC-Service Water intertie connection is not blocked by silt from the Service Water system during normal plant operation, the following measures are taken:

1. Flow is established periodically through the REC-Service Water intertie connections by flushing water through appropriate drain valves during the routine performance of inservice testing of the applicable motor-operated valves.

2. Following maintenance evolutions when the silt may become dry and less fluid, post-maintenance testing is completed to assure that affected REC-Service Water intertie connections are not blocked prior to restoring the REC system to full functionality.

The SW System is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), Buried Piping and Tanks Inspection (see USAR Section K-2.1.3), External Surfaces Monitoring (see USAR Section K-2.1.14), Oil Analyses (see USAR Section K-2.1.28), Selective Leaching (see USAR Section K-2.1.34), and Service Water Integrity (see USAR Section K-2.1.35). There are no Time-Limited Aging Analyses that are applicable.

## 8.2 RHR Service Water Booster (RHRSWB) System

### 8.2.1 Safety Objective

The safety objective of the RHRSWB System is to provide cooling to the RHR System without an uncontrolled release of radioactive material to the environment.

### 8.2.2 Safety Design Bases

1. The RHRSWB System shall prevent uncontrolled release of fission products to the environment after design basis events or after RHR heat exchanger tube failure by maintaining the RHRSWB System pressure greater than the RHR System pressure.

2. No single system component active failure shall be able to prevent the system from achieving its safety objective.

3. The system shall provide an adequate supply of cooling water to the RHR System under all accident and transient conditions.

### 8.2.3 Power Generation Objective

The power generation objective of the RHRSWB System is to provide cooling to the RHR System under normal operating condition.

### 8.2.4 Power Generation Design Bases

The system shall be designed with sufficient redundancy and flexibility of components such that the system will be able to perform its power generation objectives to maintain adequate cooling water supply to the RHR System heat exchangers during planned operations.

### 8.2.5 Description (See Burns and Roe Drawings 2006, Sheet 4, and 2036, Sheet 1)

The RHRSWB System consists of two mechanically and electrically independent loops each with two pumps taking suction from the station SW System headers and providing coolant to the RHR heat exchangers. Final discharge is to the circulating water discharge canal. Both loops are designed to Class I Seismic criteria (See Section XII and Appendix C). The RHRSWBPs are each rated 4000 gpm at 840 feet TDH, maintaining the SW side of the RHR exchangers at a higher pressure than the RHR System side to prevent outleakage of radioactive water into the SW System. When the reactor is in Modes 4 or 5 and the shutdown cooling system is operating, the RHRSWBPs can be secured from operation, referred to as "windmilling of the RHRSWBP." In this mode of operation, the SW side of the RHR heat exchanger will be at a lower pressure than the RHR side. Thus windmilling of the RHRSWBP, while in the shutdown cooling mode, can have radiological effects during normal shutdown cooling operations. The SW coolant flow from the RHR heat exchangers is monitored by a radiation detector which alarms on a high radiation level in the SW effluent. The SW radiation setpoint is maintained such that, with no alarm annunciation present, the plant liquid discharge to the environs is only a small percent of the 10CFR20 limits, provided that there is at least a 6000 gpm effluent flow in the discharge canal. Thus, even with the RHRSWBP being windmilled while in the shutdown cooling mode, the SW discharge to environs is only a small fraction of the 10CFR20 limits, provided that the SW radiation monitor is operable and at least one circulating water pump is operating or SW flow is at least 6000 gpm. Station operating procedures include these restrictions prior to securing the RHRSWBP while in the shutdown cooling mode.

The event which could potentially be affected by windmilling of the RHRSWBP is a critical crack of a single tube of the RHR heat exchanger. The radiological effect of windmilling of the RHRSWBP, while in the shutdown cooling mode, in the event of a critical crack of a single tube of the RHR heat exchanger, has been analyzed[102]. The conclusion of this calculation for this event is that the increase in the release of radioactive materials to the environs, due to windmilling of the RHRSWBP is negligible and within ODAM limits for assessment of gaseous and liquid effluents during normal operation. One additional restriction added to the station procedures, due to assumptions in the calculations, is that the reactor coolant water temperature must be less than 200°F, prior to securing of the RHRSWBP while in shutdown cooling.

In summary, windmilling of the RHRSWBP is allowed provided the following conditions are met:

1. Reactor is in Modes 4 or 5 and average reactor coolant water temperature is less than 200°F.

2. Reactor water gross activity is less than or equal to 1E-2 μCi/ml.

3. The SW effluent radiation monitor is operable.

4. At least one circulating water pump is operating or SW flow is ≥ 6000 gpm.

5. At least one of the windmilling RHRSWBPs is protected to the extent that no maintenance, testing or other activity is performed that would prevent its prompt restoration to service.

6. RHR shutdown cooling flow > 5000 gpm.

Piping is provided from the RHRSWBPs to the RHR piping system for emergency core flooding in the event the engineered safeguards systems are inoperative during a loss-of-coolant accident. This piping is sized to provide 4000 gpm of SW and is designed to Class I Seismic requirements. The interconnection of the SW and the RHR System is manually initiated. The capability to flood the core using the RHRSWB System would only be required in the event of multiple failures of ESF equipment and is considered to be beyond the scope of credible accidents. Core flooding is not an analyzed safety function of the RHRSWB System, but rather a design feature provided for conservatism for beyond design basis events. Inadvertent admission of SW to the RHR System is prevented by requiring the operator to close a sealed-open tell-tale and to open two sealed-closed valves. Leaks from either system can be detected by periodic inspection of the sealed-open tell-tale.

RHRSWBPs are manually controlled from switches in the Control Room and have no automatic start feature. Each pump is electrically interlocked with its respective RHR heat exchanger outlet valve (SW-MO89A or SW-MO89B). When pump control switch is taken to START its respective RHR heat exchanger outlet valve receives an open signal. When the valve reaches a position that ensures pump minimum flow requirements can be met, the pump receives a start signal. The RHR heat exchanger outlet valve is throttled to obtain the desired flow. Each RHR heat exchanger outlet valve is electrically interlocked to close when both associated RHRSWBPs are shutdown. This RHR heat exchanger outlet valve interlock is defeated when "windmilling the RHRSWBP."

Simultaneous operation of both RHRSWBPs in either RHRSWB loop for periods greater than one minute is prohibited at all times except when required by emergency operating procedures.

Power for the four RHRSWBPs (2 pumps in each of two loops) is normally provided through the two independent 4160 volt critical buses. In the event that the normal power supply is not available, the 4160 volt buses serving the two loops are powered separately from the diesel generators.

### 8.2.6 Planned Operations

During shutdown operations, when the RHR System is in the shutdown cooling mode the RHRSWBPs are manually started by remote manual switch from the Control Room. Two pumps are normally required to be available for each loop. Each pump is provided with a pressure switch which alarms in the Control Room on low pressure. Flow to each RHR heat exchanger is indicated in the Control Room. Temperature and pressure test points are provided at the inlet and outlet of each heat exchanger. As discussed above, it is permissible to secure the RHRSWBPs during cold shutdown conditions and provide cooling for the shutdown cooling heat exchangers directly from the SW pumps.

Coolant samples from each RHR SW System discharge header are periodically obtained on a programmed basis and monitored for radioactivity level. On detection of a high radiation level, an alarm will be set off automatically in the Control Room.

### 8.2.7 Accident and Transient Operations[19]

Either RHRSWB loop has sufficient capacity with one pump operating to remove the design RHR System heat load during postulated transient or accident conditions.

Following a postulated loss-of-coolant accident, the RHRSWBPs will be manually started by remote manual switch from the Control Room approximately 10 minutes after the RHR System has been initiated. (The ten minutes is the time delay assumed for the purpose of the LOCA analysis.) Only one RHRSWB loop, with one pump operating is required, following a LOCA, for containment cooling as shown in Sections XIV-6.3.7.2 and VI-5.3.

During reactor isolation the RHR System may be operated in suppression pool cooling mode, as required, when the RCIC System is used for vessel water inventory maintenance, and the relief valves are used for pressure control.

The operator will manually start the RHRSWB System, after determining the number of loops and pumps required based upon the information displayed in Control Room and the electric power available. Changing the operational mode of the RHR System only affects the quantity of heat the RHRSWB System is required to dump to the SW. Because of the volume of the suppression pool, mode changes of the RHR System are slow to be reflected in the requirement for the operation of the RHRSWB System.

Both RHRSWBPs in each loop are powered through an independent 4160 volt critical bus with bus 1F supplying pumps 1A and 1C and bus 1G supplying pumps 1B and 1D. In the event of the loss of the normal off-site power supply, the two independent 4160 volt buses serving the two loops are powered separately from the diesel generators. The diesel generators are each normally loaded with a single RHRSWBP.

### 8.2.8 Common Mode Failure Analysis[21]

All four RHRSWBPs are located in the Control Building basement without any physical separation barriers. Accordingly, a common mode failure (CMF) of the RHRSWBPs due to flooding, missiles, or fire has been

analyzed as discussed below. CMF due to missiles has been found not be credible. The risk of CMF due to fire is acceptable as described in NEDC 11-084 of the CNS Fire Safety Analysis. CMF due to flooding, while credible, would be mitigated by engineering measures designed to control flooding.

8.2.8.1 Flooding

The condition of maximum flooding of the Control Building basement that has been postulated is due to failure of one Class I Seismic SW pipe. If the water is permitted to rise sufficiently, this could result in CMF of the RHRSWBPs and failure to critical MCCs in the area.

A failure of a Class I Seismic SW supply header could result in flooding of the Control Building basement. If a guillotine break is postulated, the flow of three SW pumps at run-out conditions could result in a water discharge in the Control Building basement of approximately 27,000 gpm. A failure of this type could result in a one-foot depth of water in the basement in approximately 3 minutes.

In order to assure that SW will reach the RHR heat exchangers for cooling in the unlikely event of flooding of the RHRSWBP motors and to assure that critical MCCs will not be flooded, the system design incorporates the following:

1. To reduce the rate of flooding, SW header cross-tie valve SW-MO-37MV is automatically closed at a basement water level of two inches and there is an alarm in the Control Room. Further basement flooding alarms allow the leak to be stopped by manually shutting down the SW pumps in the SW header with the break.

To further reduce the chance of flooding, Class IIS piping systems that could potentially cause flooding of any significance have been upgraded to provide Seismic Class I restraint. The Class IIS piping systems upgraded to a Seismic Class I restrained design include the following:

a. The 12" Fire Protection System line located one level above the Control Building basement.

b. The 10" fill line from the condensate storage tank to the emergency condensate storage tanks located in the Control Building basement.

Although these lines are classified Class IIS, they are supported and restrained to withstand a Class I Seismic occurrence and maintain structural and pressure integrity. These design features effectively preclude the possibility of the degradation of engineered safety systems by flooding[15] resulting from failure of these systems due to a seismic event.

2. The SW lines to the RHR heat exchangers have been designed to permit 4000 gpm flow to each RHR heat exchanger without operating the RHRSWBPs.

3. The critical service MCCs have been relocated to the floor above (elevation 903'6"). These critical MCCs serve the following equipment:

SW Auxiliaries
Control Room HVAC and Lighting
Battery Room Exhaust Fan
Battery Chargers
D-G Auxiliaries
Critical AC Power
Emergency Station Service Transformer Coolers

Consideration of CMF as a result of flooding in the switchgear and battery rooms due to failure of the lines in the passageway outside these rooms in the Control Building has also been evaluated.

The following lines are located in the passageway outside the battery and switchgear rooms:

1. One 12" Fire Protection System supply header. This line is part of the fire protection ring header. Although this line is classified Class IIS it is supported and restrained to withstand a Class I Seismic occurrence and maintain structural and pressure integrity. Therefore, this line does not pose a problem.

2. Two 6" TEC System lines serve as supply and return headers for cooling water to Control and Radwaste Building H & V units and for the Service Air Compressors. Normal flow is about 500 gpm. Major flooding by these lines is unlikely since the system volume is maintained by a surge tank (550 gal.) with a 2" automatic makeup line. Rupture of one of the 6" TEC lines would produce a low level alarm in the surge tank and a system low pressure alarm. Both alarms are in the Control Room.

3. Two 3" SW System lines provide an emergency cooling water source for the Control Room air conditioner. These lines are credible internal flooding sources; however the effects of a postulated break in these lines are bounded by other larger pipes in the area. Therefore, these lines pose no problems.

4. One 4" Demineralized Water line runs down the passageway and serves the Radwaste System on a demand basis. This line could provide 30,000 gallons at a rate of 800 gpm, with two pumps running. The normal operation of the system requires that one pump operate continuously with a minimum flow bypass. As the demand increases, the pressure drops starting the second pump and sounding an alarm in the Control Room. Although this line is classified Class IIS it is supported and restrained to withstand a Class I Seismic occurrence and maintain structural and pressure integrity. Therefore, this line does not pose a problem.

The bottom of the DC switchgear in the switchgear room is approximately 6" above the 903'6" floor level. The floor area in the passageway and one switchgear room will accommodate approximately 4000 gallons of water at a 6 inch depth.

A 3" floor drain and the stairway to the basement would provide drainage for this area.

The gap under the door and the stairway leading to the Control Building basement provide adequate drainage so flooding of the switchgear will not occur.

8.2.8.2 Missiles

An analysis of external missiles from a turbine disc breakup shows that the Control Building could not be penetrated in the event of a turbine disc breakup and would, therefore, not endanger the SW System.

The only other possible missile source is from within the Control Building. Fan coil units, air conditioning units, and exhaust fans compose the rotating equipment and pose no threat to SW System operation. Two possible objects of concern are the low pressure air compressors (including their associated air receivers) and the RHRSWBPs themselves. The geometry of the air compressors limits damage to a single RHRSW Booster Pump. Analysis of missiles resulting from a postulated failure of bolting of attachments or appurtenances

on the air receivers indicated that such missiles would have insufficient kinetic energy to damage the SW System piping or equipment. In addition, the probability of a pipe system attachment failure to the air receiver is not considered credible because of the high factor of safety on the bolted attachments of the flanged joints.

The other possibility of failure would be to assume breakage of an RHRSWBP impeller. If an impeller fragment could pass through the thick steel pump casing and strike the adjacent RHRSWBP motor, resulting in failure, two RHRSWBPs would still be available for operation.

During postulated transient or accident conditions, only one RHRSWBP is required to remove the design RHR System heat load. In the event of a loss-of-coolant accident concurrent with inoperability of the engineered safeguard systems, one pump is sufficient for emergency core and/or containment flooding. Thus, in spite of the above improbable failure, pumping capacity is still ample to meet the system's safety objective.

#### 8.2.8.3 Fire

Fire was considered as another source of CMF for the RHRSWBPs. However, the combustible materials are limited in the vicinity of the pumps to a level that would not involve all of the pumps should a fire occur. Therefore, the probability of the pumps being endangered by fire is minimal.

### 8.2.9 Safety Evaluation

The RHRSWB System is designed with sufficient redundancy so that no single active system component failure nor any single active component failure in any other plant system can prevent it from achieving its safety objective. Two independent loops are provided, each capable of full design capacity with only one pump available.

The RHRSWB System is designed to provide an adequate supply of cooling water to the RHR heat exchangers during postulated accident and transient conditions to remove the design RHR System heat load and at adequate pressure to prevent uncontrolled release of fission products to the environment due to a RHR heat exchanger tube failure.

It is concluded that the safety design bases are met.

### 8.2.10 Inspection and Testing

Pumps and emergency core flooding valves are located in the Control Building basement and are accessible at all times for inspection and testing.

RHRSWBP and valve testing is conducted once every three months. The pump capacity test ensures each pump can deliver 4000 gpm and is performed every three months, and after pump maintenance, as necessary.

The RHRSW System is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Oil Analyses (see USAR Section K-2.1.28), and Service Water Integrity (see USAR Section K-2.1.35). There are no Time-Limited Aging Analyses that are applicable.

## 9.0 FIRE PROTECTION SYSTEM

The information presented in this section describes in a summary fashion the SSCs that are relied on for conformance to 10CFR50 Appendix A, General Design Criterion 3, 'Fire Protection'. The CNS Fire Safety Analysis provides the detailed discussion and analyses that demonstrates compliance with the requirements of 10CFR50.48(c).

### 9.1 Power Generation Objective

The power generation objective of the Fire Protection System is to provide adequate fire protection capability to the station.

### 9.2 Power Generation Design Basis

The Fire Protection System shall furnish water, carbon dioxide, Halon 1301, foam, and/or dry chemicals as necessary for fire protection to the station.[47][56] The Fire Protection System shall provide the following:

1. A reliable source of fresh water for fire fighting.

2. A reliable system for delivery of water to potential fire locations.

3. Automatic fire detection in selected areas.

4. Fire extinguishment by fixed equipment activated either automatically or manually for areas with a high fire risk.

5. Manually operated fire extinguishing equipment for use by operating personnel at selected points throughout the station.

### 9.3 Description

#### 9.3.1 General Description

The Fire Protection System (See Burns and Roe Drawing 2016, Sheets 1, 1A, 1B, and 1C) consists of two fire water storage tanks, two electric-driven fire pumps, one diesel-driven fire pump, one jockey fire pump, fire water yard mains, hydrants, standpipes, hose stations, sprinklers, deluge spray systems, automatic Halon 1301 systems, carbon dioxide systems, ionization smoke detectors, flame detectors, heat detectors, alarms, fire barriers and penetration seals, fire stops, portable fire extinguishers, portable breathing apparatus, smoke and heat ventilation systems, and associated controls and appurtenances.[61]

#### 9.3.2 Suppression Systems

The SSCs used to suppress a fire are discussed below. A more detailed description, as well as a complete listing of these SSCs, can be found in the CNS Fire Safety Analysis.

##### 9.3.2.1 Water Supply

The fire water supply is stored in two 500,000 gallon capacity fire water tanks.[63] These tanks are vented to atmosphere and provide clean fire water to the electric motor driven pump (FP-P-E) and a diesel driven pump (FP-P-D). Makeup water to the fire water storage tanks is normally supplied by the Fresh Well Water Pumping System or the Makeup Water Treatment System.

Fire pumps FP-P-E and FP-P-D are each rated for 3,000 gpm. They are sized to provide water for the largest fire suppression system demand plus the simultaneous flow of 1,000 gpm from manual hose stations for two hours. A 30 gpm jockey pump maintains system header pressure by automatically starting on low system pressure and stopping when system pressure is restored.[22] If pressure continues to drop (as from a system actuation) FP-P-E will automatically start. A continued drop in system pressure will automatically start FP-P-D. Electric fire pump FP-P-C (rated at 2,000 gpm) and the screenwash pumps can provide a backup fire suppression water source from the Missouri River.

An outside, 12-inch, underground yard loop surrounds the Station and provides water to hydrants, wet standpipes, hose stations, deluge spray systems, and sprinkler systems. Hydrants with two gated discharge ports are provided on the yard main at approximately 250-foot intervals. Fire hydrants are provided with an isolation valve in order to isolate the hydrant in the event of physical damage or mechanical malfunction.

### 9.3.2.2 Hose Stations

Wet standpipe hose stations are located throughout the plant in strategic locations to assure hose stream coverage and to serve as backup for fixed suppression systems. Hose stations have either 75 or 100 feet of 1 1/2-inch lined hose, as deemed necessary. Where appropriate, hoses are supplied with a nozzle suitable for use on Class A, B, and C type fires.

### 9.3.2.3 Sprinkler Systems

Wet pipe sprinkler systems with individually activated sprinkler heads are provided in specific areas of the plant. The wet pipe sprinkler systems are activated by the operation of a fixed temperature element due to high ambient temperature. Operation of the sprinkler system is then signaled to the Control Room by a water flow sensing device.

The plant is also provided with pre-action sprinklers. Upon sensing a fire condition, the pre-action system signals the condition locally and in the Control Room so that an operator will be alerted to investigate.

### 9.3.2.4 Deluge Spray Systems

Deluge systems consist of strategically placed open spray nozzles. Sensing a fire condition will activate the system producing a fog spray. Manual activation is also possible. Operation of a deluge spray system is signaled in the Control Room and locally.

### 9.3.2.5 Carbon Dioxide Systems

Carbon dioxide for fire protection is stored in a low pressure bulk storage tank. The tank supplies protection for the turbine bearing areas in proximity to high temperature turbine parts. A separate high pressure carbon dioxide Fire Protection System is provided for each Diesel Generator.

### 9.3.2.6 Halon 1301 System

The Service Water Pump Room is protected by an automatic Halon 1301 total flooding system[47] with a design concentration of 8%. A second total flooding Halon 1301 system is designed for the Computer Room with a design concentration of 6% of Halon.[56] All systems are designed with reserve tank for back-up.

### 9.3.2.7 Portable Extinguishers

Portable fire extinguishers are located strategically throughout the plant. Portable fire extinguishers are selected based on an evaluation of the type of combustibles present to properly match the type of extinguisher required. Portable Extinguishing Equipment consisting of the following types are found in the plant:

1. Pressurized water extinguishers - wall mounted.
2. Carbon dioxide extinguishers - wall mounted.
3. Dry chemical extinguishers - wall mounted.
4. Wheeled dry chemical extinguishers each with 50 feet of hose.
5. Wheeled foam carts.

### 9.3.2.8 Fire Water Drainage

Drains are installed in safety related areas provided with automatically operated water-type fire suppression systems where flooding is of concern. These drains are designed to handle the projected quantity of spray water and oil (tank or pipe rupture) spills and to prevent local flooding for up to two hours.

## 9.3.3 Fire Area Barriers and Fire Penetration Seals

Fire area barriers are installed throughout the Station to limit or prevent the spread of fire as required by NFPA 805. The fire area barriers are depicted and discussed in the CNS Fire Safety Analysis. These fire area barriers serve to divide the Station into different fire areas using the criteria described in NFPA 805. A brief description of these fire area barriers is provided below.

### 9.3.3.1 Fire Area Barriers

Fire area barriers are located strategically throughout the Station as a means of passive fire protection. The fire area barriers are designed to contain the effects of possible fires for the minimum amount of time for which the barrier is rated.

### 9.3.3.2 Fire Penetration Seals

The fire area barrier fire penetration seals (i.e., cable penetration, dampers) ensure that fires will be confined or adequately retarded from spreading to adjacent portions of the facility. The fire penetration seals have fire protection ratings consistent with those of the fire barrier in which they are installed, with exceptions as allowed by an Engineering Evaluation. This design feature minimizes the possibility of a single fire rapidly involving several areas of the facility prior to its detection or extinguishment.

### 9.3.3.3 Fire Doors

Fire doors are installed in fire area barriers throughout the Station. These fire doors have a fire resistance rating of either 1 1/2-hours (Class B), or 3-hours (Class A), or have been otherwise evaluated as providing

adequate margin considering the fire loading on both sides of the door. The CNS Fire Safety Analysis describes the fire doors that are credited in each fire zone along with their fire rating. The fire doors installed at CNS are clearly labeled, and those credited as fire barriers are controlled as described in the Technical Requirements Manual (TRM).

### 9.3.4 Detection and Alarms

The fire detection and alarm systems found at Cooper Nuclear Station are discussed below. A more complete discussion of these systems and the areas in which they are installed can be found in the CNS Fire Safety Analysis.

#### 9.3.4.1 Smoke Detection

Ionization smoke detectors are located strategically throughout the plant. The smoke detectors are designed to provide an early warning capability to permit prompt reaction by the onsite fire brigade. The smoke detectors signal in the Control Room and locally.

Smoke detectors are used to automatically isolate and trip ventilation systems, and to actuate the high pressure carbon dioxide system in the diesel generator rooms and the Halon 1301 System in the Service Water Pump Room and Computer Room.

#### 9.3.4.2 Incipient Fire Detection

Incipient, or aspirating fire detection systems, operate by continuously sampling the air for minute levels of smoke and other early products of combustion. An incipient fire detection system is provided in Auxiliary Relay Room Panels 9-32 and 9-33, and provides alarm notification in the Control Room and locally. The incipient fire detection system does not provide any automatic actions.

#### 9.3.4.3 Flame Detection

Flame detectors respond directly to the presence of flame and sense the infrared radiation emitted from a flickering flame. They are provided for the Service Water Pump Room Halon System, the Standby Gas Treatment System deluge piping, and fire detection in various other plant areas.

#### 9.3.4.4 Heat Detection

Rate-of-rise heat detectors are provided for the deluge, pre-action, high pressure carbon dioxide and halon suppression systems. Fixed temperature heat detectors provide an early warning capability for the Diesel Generator Rooms to permit prompt reaction by the onsite fire brigade. These detectors annunciate in the Control Room upon sensing a high ambient temperature or a high rate of rise in ambient temperature.

Fixed temperature heat detectors are provided for the four main power transformers, the normal station transformer, and the startup station transformer deluge systems.

Electric thermostats activate the low pressure carbon dioxide systems and the pre-action systems upon sensing a high ambient temperature.

### 9.3.4.5 Manual Fire Alarms

Pull-type alarms are located strategically within the Station. The pull-type alarms are manually actuated by personnel. This activates local alarms and annunciates in the Control Room.

## 9.3.5 Ventilation

### 9.3.5.1 Heating and Ventilating System Interfaces

Various station heating and ventilating systems have fire protection features to control the spread of fires. Fire dampers are provided, where needed, to isolate the ventilation ducting on detection of fire conditions. Manually controlled exhaust ventilation systems are available, as necessary, to remove smoke and heat.

The Main Control Room Air Conditioning system is provided with smoke detectors to alarm in the Control Room and shut down the system supply fans and isolate dampers in the Main Control Room ventilation supply and return ducting.

The Control Building Heating and Ventilating System exhaust ducting has a smoke detector that will shut down the system supply fans in the event of a fire.

The response of the Diesel Generator Building heating and ventilating units to initiation of the high pressure carbon dioxide system is described in Subsection X-10.5.5.1.

The Service Water pump room fan coil units each have a smoke detector in the exhaust duct of each unit which will trip the fans and annunciate in the Main Control Room.

### 9.3.5.2 Breathing Apparatus

Portable self-contained breathing apparatus (SCBA) and back-up air are available for the fire brigade. The breathing apparatus is used by the fire fighters when fighting interior structural fires or where the substances present could release dangerous gases and vapors.

## 9.4 Codes and Standards

The design, materials, manufacturing, examination, testing, inspection, certification, and documentation requirements are as described in USAR Section XIII-10.

## 9.5 Seismic Criteria

The safety-related Class I systems and equipment necessary for safe shutdown are located only in the Reactor Building, the Control Building, the Diesel Generator Building, and in the Intake Structure. The Fire Protection System piping is Seismic Class IIS. However, the fire water piping and sprinklers in the Reactor Building and Control Building and the high pressure $CO_2$ system in the Diesel Generator Building have been supported and restrained to Seismic Class IS criteria. The Intake Structure fire water piping in the Service Water Pump Room is supported to the barge impact criteria (see USAR Section XII-2.3.7). In this manner, when Fire Protection System piping passes over or near the Seismic Class IS piping or Class I equipment in the above buildings, it is supported and restrained to withstand a Class I Seismic occurrence and maintain structural and pressure integrity.[103]

In the Control Building the fire protection control cabinet in the Control Room has been designed and restrained to maintain structural integrity during a Class I seismic occurrence.[24]

## 9.6 Inspection and Testing

The equipment (i.e., pumps, fire doors, penetrations) and systems (i.e., sprinklers, hydrants) are inspected and tested upon installation to conform with the requirements of the local and state authorities and fire underwriters having jurisdiction. The fire pumps are shop and field-tested to ensure characteristics are as specified.

The Limiting Conditions for Operation and the surveillance requirements for the Fire Protection System are provided in the CNS Technical Requirements Manual.

The fire protection system is in scope for License Renewal per 10 CFR 54.4(a)(2) and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Aboveground Steel Tanks (see USAR Section K-2.1.1), Bolting Integrity (see USAR Section K-2.1.2), Buried Piping and Tanks Inspection (see USAR Section K-2.1.3), Diesel Fuel Monitoring (see USAR Section K-2.1.12), External Surfaces Monitoring (see USAR Section K-2.1.14), Fire Protection (see USAR Section K-2.1.16), Fire Water Systems (see USAR Section K-2.1.17), Oil Analysis (see USAR Section K-2.1.28), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), and Selective Leaching (see USAR Section K-2.1.34). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

# 10.0 HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS

## 10.1 General

The heating, ventilating and air conditioning systems provide individual air supplies to the areas of the Station that may be occupied by personnel or that contain temperature sensitive equipment.

Most of the Station heating and ventilating systems utilize 100% outside air with no recirculation. Inlet air temperature is controlled with heating coils.

Exhaust from areas where potentially radioactive gases may be present is not recirculated but is separated from non-radioactive effluents and monitored for radiation level prior to discharge. Non-radioactive air is discharged to the outside atmosphere from roof vents or wall louvers near roof level. Normal airflow is routed from lesser to progressively greater areas of radioactive contamination potential prior to final exhaust.

The general ventilation air exhaust from each of the buildings when discharged at roof level is done in a manner to minimize the possibility of the same air being drawn into a fresh air intake.

Areas designed for continuous personnel occupancy or which contain temperature sensitive equipment are provided with cooling to the air supplied to these spaces.

Main systems start manually, after which they will operate automatically until stopped manually.

Spare or standby equipment is installed in the HVAC systems, as required, to maintain proper air pressures or temperatures during normal operation of the plant.

Equipment for temperature indication, high temperature alarm, air flow failure indication and differential pressure measurement is provided.

Balancing dampers and flow control dampers are provided to control flow rate and to insure balanced flow in the principal Station buildings.

Radiation monitors are provided for ventilation systems where potential contamination may reasonably occur. Airflow to and from rooms of potential high radiation passes through offset ducts, usually embedded in concrete walls, to assure against radiation shine in non-radioactive areas.

The design of the Station heating, ventilating, and air conditioning systems are based on a minimum outdoor temperature of -5°F (dry bulb), and a maximum outdoor temperature of 97°F (dry bulb) and 79°F (wet bulb). Based on historical records, this temperature range is only expected to be exceeded 1% of the time during the summer and winter.

### 10.1.1 Steam Heating System

The station is principally heated during cold weather operation by a 150 psig steam system with pressure reducing stations provided as required (Refer to Burns and Roe Drawing 2012, Sheet 3). The Steam Heating System consists of two electrode steam boilers, two electrode boiler control panels, 12.5 kV switchgear, two feedwater pumps, duplex condensate return units, deaerator, piping, valves and feedwater controls, control instrumentation, chemical feed tanks, blowdown tank and a nitrogen header. The electrode boilers are located in the Heating Boiler Room, adjacent to the Turbine Building.

Both electrode steam boilers have an output of 21,000 lbs. of saturated steam per hour at 150 psig pressure. The boiler's electrodes, in production of steam, utilize a 12.5 kV source supplied by an underground outside ringbus.

Steam at 150 psig pressure from any boiler depending on heating demand, connects through a common header with required piping from the manifold to various buildings. Steam pressure reducing stations are provided to reduce initial pressure of 150 psig to 50 and 15 psig as required. Duplex type condensate return pumps are utilized.

During cold weather, upon loss of an electrode boiler the operator, in a very short time, can start up the other electrode boiler that is kept on standby. The electrode boilers are operated through separate control cabinets. The cabinets monitor and control various important parameters such as water level, conductivity of the water and pressure. Annunciators in the Control Room warn the operator in the event of undesirable conditions.

Whenever the steam boilers are in operation, condensate is returned from the steam heated building heaters into a condensate duplex pump unit. It is then automatically pumped to the deaerator. Make-up demineralized water is provided by a control valve to the deaerator. The two 100% feedwater pumps (one normally operating – one standby) electrically interlocked, provide the flow from the deaerator to the boilers at the required pressure.

Heating and ventilating equipment steam coils (all non-freeze type) have pneumatically actuated modulating valves (with adequately valved bypass) to control required steam flow on demand of temperature controllers.

Unit heaters have constant steam flow through their coils with space thermostats controlling the fan motor.

### 10.1.2 Chilled Water Systems

Chilled water is provided as shown on Burns and Roe Drawing 2019 Sheets 1 and 2 by two systems whose principal components are located in the Radwaste Building and the Office Building. Electric power for both systems is supplied from non-critical buses.

The Radwaste Building chilled water system consists of a roof mounted chiller unit, one chilled water pump and associated piping systems.

Building heating steam is supplied to the absorption unit at 15 psig pressure through a pressure reducing station. The Turbine Equipment Cooling system provides the condenser water requirements.

The Office Building chilled water system consists of two reciprocating type water chillers, eight chilled water pumps and associated piping systems. A cross-connection allows the Office Building chilled water system to supply the air conditioning loads of the Radwaste Building chilled water system when the roof mounted chiller unit is out of service.

### 10.1.3 Inspection and Testing

The Steam Heating System and auxiliary condensate drains are in scope for License Renewal per 10 CFR 54.4(a)(2) and were subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Flow-Accelerated Corrosion (see USAR Section K-2.1.18), Selective Leaching (see USAR Section K-2.1.34), and Water Chemistry Control - Auxiliary Systems (see USAR Section K-2.1.38). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

## 10.2 Reactor Building Heating and Ventilating System

### 10.2.1 Safety Objective

The safety objective of the Reactor Building Heating and Ventilating System is to provide adequate area cooling to support ECCS pump operation for credited events, and to minimize the unfiltered release of radioactive materials.

### 10.2.2 Safety Design Basis

1. The Reactor Building Heating and Ventilating System fan coil units installed in the Reactor Building quads and HPCI room shall be capable of removing sufficient heat from the rooms to support ECCS pump operation.

2. The Reactor Building Heating and Ventilating System shall monitor the Reactor Building exhaust plenum and isolate the system upon detection of high radiation levels.

### 10.2.3 Power Generation Objective

The power generation objective of the Reactor Building Heating and Ventilating System is to control the Reactor Building air temperatures and the flow of airborne radioactive contaminants to support the function of equipment and the accessibility and habitability of the Reactor Building.

### 10.2.4 Power Generation Design Basis

The Reactor Building Heating and Ventilating System shall:

1. Provide temperature and humidity control and air movement for personnel comfort and optimum equipment performance.

2. Provide a sufficient supply of filtered fresh air for personnel.

3. Provide for air movement from lesser to progressively greater areas of radioactive contamination potential prior to final exhaust.

4. Minimize the possibility of exhaust air recirculation into the fresh air intake.

Where spaces are occupied by personnel and are without high heat producing equipment, the ventilation quantity requirements are defined by establishing air change rates required for personnel comfort and safety in accordance with accepted practices.

### 10.2.5 Description

The Reactor Building consists of the primary containment area (drywell and pressure suppression chamber), the secondary containment area which surrounds the primary containment area, and various rooms housing equipment and/or processes which require separate ventilation treatment. Description of these systems is given below (Refer to Burns and Roe Drawing 2020).

#### 10.2.5.1 Primary Containment Ventilation

The drywell cooling system provides and maintains an average 135°F dry bulb temperature condition within the drywell during reactor normal operation and has a second objective of assisting in drywell cooling during

the cool-down period after reactor shutdown. Analysis has been performed to permit station operation with average drywell temperatures of up to 150°F.

The drywell portion of the primary containment is cooled by four water-cooled fan-coil units located inside the drywell, recirculating the contained air and/or nitrogen volume. The system is designed to limit the average air/nitrogen temperature to 135°F during reactor normal operation and to provide cool-down capability after reactor shutdown.

The fan-coil units are connected to common supply duct headers (upper and lower ring headers) and a common return duct header, arranged with dampers locked in a predetermined position, so that the air distribution and cooling effect will operate satisfactorily. Ductwork extends to all spaces of concentrated heat loads to maintain the design temperatures.

Four fan-coil units are available, with all normally operating. Cooling water is supplied by the Reactor Equipment Cooling system to the unit coils.

Each fan-coil motor is controlled manually from the main control room with pilot light indication of which units are operating. Temperature of the fan discharge is recorded and is annunciated on high discharge temperature.

The drywell and the Suppression Chamber are connected, through suitable valving, to the normal Reactor Building Heating and Ventilating System supply and exhaust paths and also to the Standby Gas Treatment (SGT) System. This provides purge and clean-up capability. The primary containment is also connected to the Nitrogen Inerting System which provides an atmosphere high in nitrogen content and low in oxygen content. Refer to USAR Section V-2.0 for details.

10.2.5.2 Secondary Containment Ventilation

The secondary containment area (most of the Reactor Building) has supply and exhaust ventilating systems. The supply system furnishes filtered 100% outdoor air to all floors of the building through ductwork. The supply system heating and ventilating unit consists of a manually advanced filter, a heating coil, and duplex fans.

The supply unit has an operating and standby (100% capacity) fan with vortex dampers to provide regulation of air capacity. The fans will deenergize in the event of loss of offsite power. During normal operations, if the operating fan fails, this is annunciated in the Main Control Room and the standby fan will automatically start after a time delay. Dampers are interlocked with each supply fan and close when a fan is not operating.

A heating coil is provided to heat the outside supply air when necessary with station heating steam. The supply air temperature is controlled automatically through the modulation of the control valves that admit steam to the heating coils. Failures of the heating coil are detected by annunciation in the main control room of supply fan low air temperature.

The exhaust air is induced from the ventilated areas to a common plenum connected to the two exhaust fans, each of 100% capacity. The air is then exhausted to the atmosphere.

During normal plant operation, a minimum average negative pressure of 0.25 inches (w.g.) is maintained by differential pressure controllers which receive signals proportional to the pressure difference between outside air and the secondary containment atmosphere, and control the position of the exhaust fan vortex dampers. The differential pressure is detected by four separate probes, with one on each side of the building. Control action is initiated from the average value of the four sensor probes.

If a Loss of Coolant Accident should occur, all ventilation systems of the primary containment area and secondary containment area will be isolated automatically and the SGT and Control Room Emergency Filter Systems will be automatically initiated. Details of the SGTS and CREFS are given in USAR Section V-3.0 and X-10.4.

The Reactor Building supply fans are electrically interlocked with the exhaust fans and run when any exhaust fan is operating.

10.2.5.3 Potentially Contaminated Areas

For areas or rooms with a high potential of contamination, the exhaust air is first passed through banks of prefilters and HEPA filters before discharging into the main exhaust system. These rooms are the RWCU Sludge Tank Cell, the RWCU Recirculating Pump Rooms, RWCU Regenerative Heat Exchanger Room, Phase Separator Tank Room, and RWCU Filter Demineralizer Rooms.

Two identical parallel filter units are provided, each containing an efficient prefilter plus a high efficiency (HEPA) filter in series, with one unit functioning as a 100% capacity standby unit. A differential pressure controller actuates a modulating damper to assure constant air volume. Two (2) full capacity booster fans (one a standby), provide additional system pressure required in excess of the main exhaust system. Exhaust air from booster fans is discharged into the main exhaust fans suction plenum.

Exhaust fume hoods in the Reactor Building include ducting through individual booster fans and filters which maintains a negative pressure at potentially contaminated areas and filters air prior to discharge through the main Reactor Building exhaust plenum.

The walls of the spent fuel pool, reactor cavity, and dryer/separator storage pit contain multiple openings in their sides just above water level (when flooded up) for embedded exhaust ducts. Part of the ventilation air supplied to the refueling floor is drawn through these ducts, discharging to the monitored common exhaust plenum. During normal conditions, this airflow effectively prevents the spread of airborne contamination from these areas to other parts of the refueling floor that are of lower contamination potential.

10.2.5.4 Below Grade Areas

In the four quads, ventilation air is provided individually to each room. The air then flows through wall penetrations to the Suppression Chamber area where it enters exhaust ducts to the main exhaust system. During periods of emergency operation, to prevent overheating of pump motors due to possible high room temperatures, water-cooled, recirculation fan coil units, are provided to maintain quad temperatures within design temperature limits. The fan coil unit motors are powered from critical buses and cooled by REC. The fan coil units automatically start on actuation of their associated ECCS pumps. During certain accident scenarios, the NW and SW (RHR) quads may lose fan coil unit cooling. Adequate natural convection cooling is available, under these conditions, for continuous operation of a single RHR pump in each quad through the grating at elev. 903’-6" and elev. 881’-9" (see USAR Section X-6.5.3).

Ventilation air is also supplied to the HPCI room. The HPCI room fan coil unit is interlocked to run continuously with the HPCI Turbine. The

fan motor for this unit is powered from a critical bus and cooling water is supplied by REC. The fan coil unit is designed to limit the maximum average HPCI Room temperature to 135°F during HPCI operation.[92]

10.2.5.5 Motor-Generator Sets Ventilation

The two Reactor Recirculation system motor-generator sets have their own common ventilation system. Outside air (100%) is induced through weatherproof louvers into an intake area, through a bank of roughing filters, via separate ductwork and shutoff (isolation) valves to the casing of each motor-generator set. The exhaust is through separate ducts and shutoff isolation valves to a fan room. Two exhaust fans, each of 100% capacity (one operating-one spare), convey the air through ductwork and an exhaust stack to atmosphere.

A recirculation line is provided from the Exhaust Fan Room back to the Air Intake Room to help control air temperature. Manual dampers are used to control the amount of air that is drawn in from the outside or recirculated.

Both the intake room and the fan room have air locks to isolate these areas from the secondary containment area.

With a motor-generator set running, a separate air flow switch will sense a loss of cooling air flow, and after a time delay will start the standby selected fan and provide an alarm signal to the Main Control Room.

For normal operation, one fan runs with the other as standby. Both fans can be operated in parallel to provide additional ventilation if required. If the operating fan fails, the standby fan starts automatically and an alarm is actuated in the Main Control Room.

Closure of the isolation valves after a Group 6 PCIS signal is described in Section V-3.

10.2.5.6 Miscellaneous Area Cooling

The steam tunnel is cooled by two fan coil units located in the steam tunnel. The fan coil units are manually controlled from the Main Control Room. They are powered from non-critical buses and supplied with cooling water from the Turbine Equipment Cooling system. Steam tunnel high temperature is annunciated in the Main Control Room.

The Alternate Shutdown Room has an air conditioning unit which consists of a fan coil unit (which includes a duct heater), a condenser, and a humidity controller unit. The unit is thermostatically controlled from inside the room to maintain temperature and humidity for personnel comfort. The air conditioning unit is powered from a non-critical source.

10.2.6 Safety Evaluation

The Reactor Building Heating and Ventilating system provides cooling to the ECCS pump rooms in the form of area coolers to ensure the protection of equipment during transient and accident conditions. The equipment is Class I and is powered from divisionalized critical power.

The ECCS pump cooling support function can be achieved during postulated accidents concurrent with a loss of offsite power with a single active failure. The limiting scenario for this ECCS support function

occurs with a Core Spray line break concurrent with the failure of the opposite division diesel generator, disabling both Core Spray subsystems. During this event, fan coil unit cooling is available for a single powered RHR pump. The remaining powered RHR pump is cooled by natural convection cooling through the quad overhead grating to upper elevations. In this manner, the separate safety functions of core cooling and containment cooling can be accomplished, respectively, by the two available RHR loops.

If an accident should occur, the ventilation systems of the Primary and Secondary Containment will be automatically isolated and the SGT system will start (see USAR Sections V-2.0 and V-3.0).

The effects of a loss of HPCI and RCIC room cooling during a Station Blackout have been assessed. HPCI is credited for only a single cycle of operation (approximately 10 minutes) after which it is secured. For this short time interval, the heatup effects on the HPCI room are relatively insignificant. The RCIC room peak steady-state temperature is 121.9°F over the 4-hour coping duration, which is below the rated RCIC continuous operation temperature of 148°F. The Station Blackout special event is described in USAR Section XIV-5.0.

#### 10.2.7 Inspection and Testing

The fan coil units in the Reactor Building quads and the HPCI room are tested to assure they will continue to be capable of performing their ECCS support function. This testing includes periodically verifying the fan coil unit auto-start feature, fan capacities, and REC flow to the units.

The Reactor Building Heating and Ventilating system is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), Selective Leaching (see USAR Section K-2.1.34), Water Chemistry Control - Auxiliary Systems (see USAR Section K-2.1.38), and Water Chemistry Control - Closed Cooling Water (see USAR Section K-2.1.40). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

The testing and inspections performed for the Secondary Containment functions of the Reactor Building HVAC system is described in USAR Section V-3.5 and the Technical Specifications.

### 10.3 Control Building Heating and Ventilating System

#### 10.3.1 Safety Objective

The safety objective of the Control Building Ventilating System is to provide temperature controls to critical electrical heat loads and to prevent an explosive accumulation of hydrogen from the station batteries.

#### 10.3.2 Safety Design Basis

1. The Control Building Ventilating System shall be capable of removing sufficient heat from the essential electrical equipment in the Control Building to support their required function.

2. The Control Building Ventilating System shall be capable of providing adequate circulation through the battery rooms to control the ambient temperature and to prevent localized flammable concentrations of hydrogen during normal operations, accidents and transients.

## 10.3.3 Power Generation Objective

The power generation objective of the Control Building Heating and Ventilating System is to control the Control Building air temperatures and air flows to ensure the function of equipment and the habitability of the Control Building during normal operations.

## 10.3.4 Power Generation Design Basis

The Control Building Heating and Ventilating System shall:

1. Provide temperature and humidity control and air movement for personnel comfort and optimum equipment performance.

2. Provide a sufficient filtered fresh air supply for personnel.

3. Minimize the possibility of exhaust air recirculation into the air intake.

Where spaces are occupied by personnel and are without high heat producing equipment, the ventilation quantity requirements are defined by establishing air change rates required for personnel comfort and safety in accordance with accepted practices.

## 10.3.5 Description

The Control Building Heating and Ventilating system supplies filtered and tempered air to the Control Building except for the Main Control Room, Computer Room and Cable Room. The Main Control Room and the Cable Room are supplied by one air conditioning unit 1-AC-C-1A, while the Computer Room is supplied by separate units.

The battery exhaust system provides for dilution and removal of potentially flammable concentrations of hydrogen in the battery rooms.

Two recirculation fans provide pressure required to recirculate the return air or discharge this air to atmosphere during periods of suitable outside air temperature for cooling requirements.

The recirculation fans vortex dampers are modulated by a differential pressure indicator controller to maintain the building under negative pressure.

A network of safety-related supply and exhaust fans provide cooling to the Critical AC Switchgear Rooms and 903'-6" elevation of the Control Building during abnormal and accident conditions. The non-essential Control Building ventilating supply and recirculation fans are automatically tripped when the essential Control Building ventilating system is in operation.

### 10.3.5.1 Control Building Heating and Ventilating Unit

The Control Building Heating and Ventilating Unit supplies both outside and recirculated air and consists of a manually advanced filter, heating and cooling coils and fans (Refer to Burns and Roe Drawing 2018). The heating coil is supplied with station heating steam to augment the recirculated air in providing temperature control during cold weather conditions. A chilled water coil assists in building cooling capabilities during elevated temperature conditions. Chilled water is supplied by a chilled water system as described in USAR Section X-10.1.2.

The unit has an operating and standby (100% capacity) fan with vortex dampers to provide constant air capacity during periods of increased filter differential pressure or other changes in system pressure drops. The

fans will deenergize in the event of loss of offsite power or actuation of the Essential Control Building Ventilation System. During normal operations, if the operating fan fails, this is annunciated in the Main Control Room and the standby fan will automatically start after a time delay.

10.3.5.2 Essential Control Building Ventilating System

The Essential Control Building Ventilating System will provide cooling to the Critical AC Switchgear rooms and 903'-6" elevation of the Control Building under abnormal and accident conditions. This system consists of two redundant trains, each consisting of a 100 percent capacity supply fan and a 100 percent capacity exhaust fan, to remove the heat generated by the essential electrical equipment (Refer to Burns and Roe Drawing 2018). These fans are powered by critical power sources and automatically start when the normal Non-Essential Control Building HVAC System fails to maintain room temperatures at a preset value.

Temperature switches are provided to start and stop the essential fans. The start temperature switches are located in each Critical AC Switchgear Room and in each DC Switchgear Room. The stop temperature switches are located in the exhaust ductwork downstream of the exhaust fans. Fan and damper status indication is provided in the main Control Room.

Backdraft, fan check, motor operated and air-operated dampers are provided for isolation purposes as follows:

1. Backdraft dampers are located in the air intake and air exhaust ducts to provide isolation during normal non-essential system operation.

2. Fan check dampers are provided in a parallel path to each fan to preclude recirculation of air in the system.

3. Motorized isolation dampers are provided in the supply ductwork for the battery rooms. These dampers automatically close to cut-off air flow to the battery rooms when low temperature conditions exist.

4. Redundant air operated-spring return to closed position dampers are provided in the ductwork at the discharge of the non-essential system fans and at the supply ductwork to and exhaust ductwork from the RHR Service Water Booster Pump Room. These dampers close during essential system operation.

The ventilation supply ducts for switchgear rooms 1F and 1G contain back flow dampers to inhibit the spread of fire. Additionally, fire dampers have been installed in the exhaust ducts in each critical switchgear room. These fire dampers will close on high temperature in the exhaust duct to preclude the spread of fire from one room to the other.

10.3.5.3 Battery Rooms Exhaust Fans

The battery rooms air is both exhausted directly to the atmosphere and recirculated to the Control Building Ventilation System. The exhaust to atmosphere is controlled by two manual exhaust fans (one operating and one standby). During periods of low battery room temperature, ventilation flow is reduced by motor-operated dampers which isolate a portion of the battery room ventilation supply air. The dampers reopen when high battery room temperature conditions are present.

The battery room exhaust system ductwork insures constant air movement through potential pocket areas, so that explosive concentrations of hydrogen cannot accumulate. Since the exhaust system ductwork is common to battery rooms 1A and 1B, fire dampers have been installed in the exhaust

ducting for each battery room. These fire dampers close on high temperature in the exhaust duct to preclude the spread of fire from one room to the other.

A standby fan is provided to automatically start upon failure of the fan in the operating mode, eliminating possible accumulation of an explosive mixture of hydrogen.

All battery room exhaust fans are automatically tripped when the essential Control Building ventilating system is in operation. Under this condition the essential Control Building ventilating system provides adequate air movement to eliminate the accumulation of an explosive mixture of hydrogen.

The battery rooms ventilation ducting that exhausts to atmosphere is welded of acid resistant material. However, where exhaust ventilation passes through the Main Control Room and Cable Spreading Rooms, the ducting consists of heavy wall, explosion-proof piping. The piping exits the Main Control Room to the Control Corridor, where the battery room exhaust fans exhaust to atmosphere, via ductwork, through the roof of the corridor.[30]

10.3.5.4 RHR Service Water Booster Pump Room Fan Coil Unit

An air recirculation fan coil unit is located in the RHR Service Water Booster Pump Room. The fan coil unit is started automatically on high temperature and serves as a backup to the Control Building Heating and Ventilating System in providing normal room cooling. The fan coil unit cooling coil is normally cooled by a recirculation loop to a cooling tower. The fan coil unit and recirculation loop equipment motors are fed from either Division I or II critical power. The fan coil unit cooling coil can be manually aligned with service water to allow operational flexibility for room cooling if the recirculation loop is unavailable. However, acceptable room temperatures can be maintained for a single RHR service water booster pump without forced ventilation through operator action to reduce the room heat load and establishment of a natural ventilation flowpath.[93, 94]

10.3.6 Safety Evaluation

1. The essential Control Building Ventilating System utilizes redundant supply and exhaust fans to ensure area heat removal requirements are provided upon loss of a fan. The fans are powered by critical buses and automatically start if the normal non-essential Control Building Ventilating System fails to maintain room temperatures at a preset value.

2. Isolation dampers, backdraft dampers and fan check dampers are provided to isolate the normal non-essential Control Building HVAC System from the Essential Control Building Ventilating System upon the automatic initiation of the essential system.

3. The battery room exhaust fans provide the principal means of hydrogen removal during normal plant operations. They are automatically tripped when the essential Control Building Ventilating System is in operation to allow the essential system to exhaust air from the battery rooms. The essential Control Building Ventilating System exhaust fans have adequate capacity to remove sufficient air from the battery rooms to preclude the buildup of hydrogen to explosive levels.

4. The ventilation flowpath through the Battery Rooms maintains the ambient temperature within the range necessary to support the safety functions of the batteries.

It is concluded that the Safety Design Bases are met.

## 10.3.7 Inspection and Testing

The Essential Control Building Ventilating System is functionally tested periodically to assure it will continue to be capable of performing its critical AC and DC Distribution System support functions. Battery room ventilation is tested as described in the Technical Requirements Manual.

The Control Building Ventilating system is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), and Water Chemistry Control - Closed Cooling Water (see USAR Section K-2.1.40). There are no Time-Limited Aging Analyses that are applicable.

## 10.4 Main Control Room Air Conditioning System and Habitability Controls

### 10.4.1 Safety Objective

The safety objective of the Main Control Room Air Conditioning System and habitability controls is to assure continuous occupancy of the Control Room during credited plant events, and during the movement of non-fuel light loads that can potentially damage irradiated fuel.

### 10.4.2 Safety Design Basis

The main Control Room Air Conditioning System and habitability Controls shall:

1. Have sufficient capacity to maintain the control room envelope at a positive pressure with respect to the adjoining areas.

2. Isolate the Main Control Room unfiltered outside air supply on a Group 6 isolation signal.

3. Limit the radiation exposure to Main Control Room personnel during any one of the postulated design basis events to within regulatory limits.

4. Allow continued occupancy of the Main Control Room in the event of external toxic gas releases.

5. Mitigate the consequences of non-fuel light load movements with the potential to damage irradiated fuel.

### 10.4.3 Power Generation Objective

The power generation objective of the Main Control Room Air Conditioning System and habitability controls is to assure continuous occupancy of the Control Room during normal plant operations.

### 10.4.4 Power Generation Design Basis

The Control Room Building Air Conditioning System and habitability controls shall:

1. Provide temperature and humidity control and air movement for personnel comfort and optimum equipment performance.

2. Provide a sufficient filtered fresh air supply for personnel.

3. Minimize the possibility of exhaust air recirculation into the air intake.

Where spaces are occupied by personnel and are without high heat producing equipment, the ventilation quantity requirements are defined by establishing air change rates required for personnel comfort and safety in accordance with accepted practices.

## 10.4.5 Description

The Main Control Room Air Conditioning System and habitability controls are designed to maintain the Control Room emergency zone environment suitable for occupancy by plant personnel. The emergency zone consists of the Control Room proper (including the kitchen and toilet facilities) and access area around the Main Control Room. The area serviced by the Main Control Room Air Conditioning System includes the cable spreading room below the Main Control Room.

The Main Control Room Air Conditioning System and habitability controls include radiation shielding, air conditioning, emergency air filtering, lighting, fire protection equipment, storage capacity of food and water, and kitchen and sanitary facilities. These systems are intended to protect the operators and equipment located in the emergency zone to ensure that the Control Room is a place from which the operators can safely operate the plant under normal conditions and during transients, accidents, and Special Events. The Main Control Room Air Conditioning System is described below. Fire protection and lighting systems are discussed in USAR Sections X-9.0 and X-17.0, respectively.

Protection of personnel from wind and tornado loads is discussed in USAR Section XII-2.3.3. The seismic design is discussed in USAR Section XII-2.3.5. Environmental Qualification of electrical equipment is discussed in USAR Section VII-1.7. Fire protection is described in USAR Section X-9.0.

### 10.4.5.1 Main Control Room Air Conditioning System

The main control room is air conditioned by its own package type self-contained air conditioning unit system, complete with filters, cooling coils, heating coils, two supply fans (one operating-one 100% spare), compressor-condenser unit, dampers, controls, and ductwork (Refer to Burns and Roe Drawing 2019, Sheet 1). Conditioned air is distributed to the main control room, rest rooms, pantry, and main cable room. Reheat coils are employed in ductwork to obtain close dry bulb temperature control through modulating valves actuated by room thermostats. A moisture controller controls a modulating valve to a humidifying unit in the ductwork to the control room to assure humidity requirements.

If required, the Refrigeration Cycle condenser water requirements will be manually transferred from the TEC system to the Service Water System which is on critical buses.[32] Although manually transferred, the control room air conditioner is classified as a post-LOCA heat load of the Service Water system (see USAR Section X-8.0).

The Control Room air conditioner is constructed and supported to withstand Seismic I conditions. Ductwork and piping to and from the unit are Seismic Class I supported, and the unit is designed to function following a DBE. However, if the Control Room air conditioner became inoperable, the temperature and humidity of the room would increase due to personnel and equipment heat generation.

An exhaust fan induces air into the toilet and pantry and through ductwork discharges to atmosphere.

The control room envelope (control and cable spreading room) is positively pressurized to ensure leakage is into all adjoining areas. Normally open Class I fire/smoke dampers are installed in the floor between the control room and cable spreading room to equalize the pressures between the two rooms. These fire/smoke dampers are designed to remain open during a design basis event but automatically shut in the event of fire/smoke in the cable spreading room. The control room ventilation system contains a smoke detector in the return air duct from the cable spreading room which is interlocked to shut fire/smoke dampers, to shut down the supply air system, and to actuate an alarm in the control room.

10.4.5.2 Control Room Emergency Filter System

To insure safe operation for personnel in the Main Control Room, in the event of possible radioactive contamination of the outdoor air in the vicinity of the air conditioning unit intake louver, an emergency filter system has been installed. (Refer to Burns and Roe Drawing 2019, Sheet 1.

The emergency filter system consists of shutoff valves, prefilter, HEPA filter, carbon filter and fans and is sized for the normal minimum outside air requirements.

The minimum quantity of outside air is adequate for control room personnel comfort and health requirements according to ASHRAE published data.

When a Group 6 Isolation occurs, it is annunciated in the control room and provides automatic control of the emergency filter system. The emergency filtration system can be manually initiated upon receipt of high radiation annunciator from a continuous air monitor located inside the control room envelope. On either automatic or manual initiation, outside air is diverted through the emergency filter system before entering the air conditioning ductwork. The return air from the control room and cable room is recirculated downstream of the emergency filter system. This method maintains a positive pressure to the two rooms with air leakage into adjoining areas. Loop seals have been added to the equipment and floor drains in the Cable Spreading Room to improve the control room pressurization boundary.[99] The following events occur when the Control Room Emergency Filter System (CREFS) is actuated:

1. Start fan 1-BF-C-1A
2. Close intake damper HV-AOV-270AV
3. Close damper HV-AOV-272AV
4. Open damper HV-AOV-271AV
5. Stop exhaust fan 1-EF-C-1B

The air flows through a pre-filter (1-PF-C-1A), a HEPA filter (1-HEF-C-1A) and a carbon filter (1-CF-C-1A) all in series. The emergency filter fan (1-BF-C-1A) is sized to handle the ventilation flow rate up to 1000 CFM.

The prefilter (1-PF-C-1A) is of 1000 CFM capacity-88% DOP efficiency rating.

The HEPA filter (1-HEF-C-1A) is of 1000 CFM capacity-99.97% DOP efficiency on 0.3 micron particles. The filter is a high humidity fire resistant all glass media type with corrugated aluminum separators and rubber base adhesive sealer, tested and inspected in conformance with AEC Health and Safety Information Issue No. 212.

The carbon filter (1-CF-C-1A) is of 1000 CFM capacity activated granular carbon impregnated as required to provide the needed iodine and methyl iodine removal efficiency.

The charcoal filters are iodide-impregnated activated carbon filters capable of removing in excess of 97.5% of the methyl iodide in the air stream when tested per ASTM D3803-1989 (@30°C) under entering conditions of 95% relative humidity. This laboratory testing acceptance criteria provides a safety factor of 2 when compared to the efficiency used in the safety analysis to allow for degradation of the filter efficiency between tests.

Trays are of perforated stainless steel connected to 304 stainless steel channels, and are of welded steel construction to preclude leakage.[33]

The filters adhesives and sealants are fire-retardant, water resistant and capable of resisting temperature of 300°F for 24 hours.

The emergency filter system fans (1-BF-C-1A/1-BF-C-1B) are powered from either Division I or Division II through a manual transfer switch located in the Auxiliary Relay Room. If the emergency filter fan (1-BF-C-1A) is not energized, the air valves and exhaust fan shift to their emergency status on a Group 6 isolation signal to limit unfiltered air in-leakage.

Electric requirements of the CREFS equipment are on critical buses.

10.4.6 Safety Evaluation

For information concerning Main Control Room shielding and operator dose consequences refer to USAR Section XII-3 and Chapter XIV, respectively.

10.4.6.1 Evaluation of Loss of Main Control Room Air Conditioning

If the Main Control Room Air Conditioner System became inoperable due to a Station Blackout (SBO) event, the temperature in the Main Control Room would increase to approximately 100°F during the four hour postulated SBO duration.[88] This temperature rise is based upon the remaining heat loads in the Main Control Room after the SBO event. Operator actions would not be impacted significantly at this projected temperature for the four-hour duration.

If the Main Control Room Air Conditioner System became inoperable for reasons other than SBO, the temperature in the Main Control Room would not exceed 110°F within a twenty-four hour period.[89] Studies suggest that long term occupancy in higher temperature environments does not prevent performance of tasks of various difficulties.[90] Such studies have been the basis of guidance in the heating and ventilation industry handbooks (e.g. ASHVE-1950, and ASHRAE-1985). ASHRAE, in particular, correlates temperature, humidity, and pressure and concludes that light work at 110°F and a relative humidity up to 50 percent would not be intolerable.[91] Operator actions would not be impacted significantly at this projected temperature.

Additionally, the Main Control Room lighting, which is the major heat source in the room, could be reduced by shutting off various circuits and still provide sufficient lighting for operational requirements.

If it is assumed that the Main Control Room is completely closed and sealed, and there is a staff of 8 moderately active personnel, there is no ventilation air, and there is initial concentrations by volume of 0.03% $CO_2$ and 20.9% $O_2$, then the 0.5% $CO_2$ limit will occur in 3.75 days and the 1.5% $CO_2$ limit will occur in 11 days. These rates are calculated from the ASHRAE Guide, Chapter 16, "Survival Shelters." The 0.5 $CO_2$ limit is the preferable environment and the 1.5% $CO_2$ limit is the reasonable tolerable environment without producing a sickening effect on most personnel.

After a Safe Shutdown Earthquake, outside air would still be available to maintain the temperatures in the Main Control Room by using CREFS.

Based on the above discussion, it is concluded that loss of the Main Control Room Air Conditioner System would not result in equipment malfunctions nor would occupancy by operating personnel be affected.[31]

Following a Main Steam Line Break, steam from the break can enter the Main Control Room and Cable Spreading Room through the mechanical and electrical penetrations and around the door frames. The resulting peak temperature in the Main Control Room has been conservatively calculated to reach 85°F at a relative humidity of 86%.[95] This temperature poses no safety problems for either operating personnel or equipment in the Main Control Room. This maximum temperature in the Main Control Room is dependent on the doors, H105, H202, H300, H307, connecting the Main Control Room and the Reactor and Turbine Buildings, being blast proof. These doors are designed to sustain an overpressure of 0.5 psi and still maintain their integrity. The radiological consequences of a Main Steam Line Break Accident are described as acceptable in Section XIV-6.5.7.3.2.

In summary, it is concluded that, even with loss of the air conditioning system, the Main Control Room temperature and $CO_2$ will not rise to unacceptable levels. Thus, the air conditioning system and pre-planned operations provide assurance that the Main Control Room is habitable for normal operations and for transients, accidents, and special events.

10.4.6.2 <u>Long Term Occupancy Provisions</u>

For toxic gas or other events requiring breathing protections, sufficient emergency air is provided such that a six-man emergency team could operate ten hours before replenishment from offsite supply would be required (i.e., 60 man-hours). Considering the low probability of such an event detailed in the following assessment of the toxic hazards, this level of protection is sufficient. The Main Control Room normally stores provisions for 20 to 150 meals as an emergency food supply. Also there is a 6,000-gallon potable water storage tank.

10.4.6.3 <u>Control Room Toxic Hazards Assessment</u>

As prescribed in NUREG-0737 Item III.D.3.4, and as updated per Generic Letter 2003-01, a toxic hazards assessment has been performed for personnel in the Main Control Room. As described in Regulatory Guide 1.78, Revision 1, the onsite and offsite toxic sources located within 5 miles of the Main Control Room intakes have been considered.

Deterministic evaluations are performed for the following onsite toxic gas (including asphyxiant) sources: liquid nitrogen, carbon dioxide, and hydrochloric acid (aqueous 37%). Other hazardous materials screen out of deterministic evaluation per RG 1.78 guidance due to quality, concentration limit, or volatility. Hydrogen is discounted because of its buoyancy.

Deterministic evaluations are performed for the following offsite toxic gas sources: chlorine and anhydrous ammonia. Other hazardous materials screen out per RG 1.78 guidance based on quantity, concentration limit, volatility, or shipment frequency.

Without operator intervention, the resulting chemical concentrations in the Main Control Room for chlorine could

exceed the toxicity limits of Regulatory Guide 1.78, Revision 1, or applicable NIOSH standards. The chlorine cloud results from a 20 ton truck tanker accident. To assure the capability for continued Control Room occupancy, breathing apparatus are donned and Control Room ventilation intake flow is manually isolated upon detection of chlorine or notification by various site, local and regional hazardous material emergency notification procedures and systems.

It is concluded that habitable conditions can be maintained in the Main Control Room under toxic gas releases.

#### 10.4.6.4 Movement of Non-Fuel Light Loads Over Irradiated Fuel

The CREFS function is credited in mitigating the consequences of non-fuel light load movements that have the potential to damage irradiated fuel. Light loads have been analyzed which develop a kinetic energy of up to that of a dropped fuel assembly during the Fuel Handling Accident when striking an irradiated fuel bundle (38,700 ft-lbs). For light load movements with the potential to damage irradiated fuel that are below that kinetic energy threshold, CREFS is required during the first 7 days following shutdown. CREFS is not required after that point provided the other mitigative elements of the Fuel Handling Accident are in place (see USAR Section XIV-6.4.3). Light loads that exceed this kinetic energy are individually evaluated to ensure the Fuel Handling Accident remains bounding. The seven day restriction ensures that the dose consequences of the Fuel Handling Accident remain bounding for light load movements.

#### 10.4.6.5 Protection of CRE Occupants from Toxic Gas and Smoke

The effect of a postulated accidental on-site or off-site hazardous chemical release on Control Room Habitability was evaluated. The methodology used in the analyses was based on NRC Regulatory Guide 1.78, Revision 1, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release." The analyses concluded that the Control Room Habitability is maintained for all identified hazardous chemicals, both on-site and off-site.[125]

An assessment of the Control Room to withstand a smoke challenge was performed by a consultant based on NRC Regulatory Guide 1.196, "Control Room Habitability at Light-Water Nuclear Power Reactors," and the general criteria and guidance presented in NEI 99-03, Revision 1, "Control Room Habitability Assessment Guidance." The assessment was evaluated by NPPD and found to be acceptable.

### 10.4.7 Inspection and Testing

The testing requirements for the Main Control Room Air Conditioning System are described in the Technical Specifications.

The Main Control Room Air Conditioning System is in scope for License Renewal per 10 CFR 54.4(a)(1) and (a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), Selective Leaching (see USAR Section K-2.1.34), and Water Chemistry Control - Auxiliary Systems (see USAR Section K-2.1.38). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

## 10.5 Diesel Generator Building Heating and Ventilating Systems

### 10.5.1 Safety Objective

The safety objective of the Diesel Generator Building Heating and Ventilating Systems is to provide ambient heat removal whenever the Diesel Generators are performing their safety function.

10.5.2 Safety Design Basis

The Diesel Generator Building Heating and Ventilating Systems shall be capable of removing sufficient heat from the Diesel Generator Building during diesel generator operation.

10.5.3 Power Generation Objective

The power generation objective of Diesel Generator Building Heating and Ventilating Systems is to control the Diesel Generator Building air temperatures to support the diesels in meeting their power generation objective and the accessibility and habitability of the Diesel Generator Building.

10.5.4 Power Generation Design Basis

The Diesel Generator Building Heating and Ventilating Systems shall:

1. Provide temperature and humidity control and air movement for personnel comfort and optimum equipment performance.

2. Provide a sufficient filtered fresh air supply for personnel.

3 Minimize the possibility of exhaust air recirculation into the air intake.

Where spaces are occupied by personnel and are without high heat producing equipment, the ventilation quantity requirements are defined by establishing air change rates required for personnel comfort and safety in accordance with accepted practices.

10.5.5 Description

The heating and ventilating system is typical for two identical diesel-generator rooms. The two heating and ventilating units for each room maintain conditions during two modes of operation; one with no diesel generator unit operating and the second during diesel generator operation cycle.

The small heating and ventilating unit normally operates continuously. The large unit and the exhaust fan are energized when the diesel generator unit is operated. The exhaust fan, with ductwork, discharges the hot air to the atmosphere.

Fan failure is annunciated in the control room. The system will maintain the diesel generator room environments within a nominal maximum temperature range of 120°F to 137°F.[72]

10.5.5.1 Diesel-Generator Building Heating and Ventilating Units

Both the small and large heating and ventilating units are comprised of filters, steam heating coils, cooling water coils (large units do not have a cooling water supply), fan and controls. Outside air enters through louvers and labyrinths to prevent possible missile damage to room equipment.

Air is supplied in close proximity to all heat producing equipment to maintain operating efficiency of diesel-generator units. Exhaust air is also passed through labyrinths to atmosphere to prevent possible missile penetration.

The small unit will trip and annunciate in the Main Control Room upon cardox initiation. The large units isolate on cardox initiation provided the associated diesels have not emergency started.

10.5.6 Safety Evaluation

The large heating and ventilating unit is automatically initiated upon an automatic diesel generator start signal. The supply and exhaust fans provide adequate airflow to remove heat generated by the diesel generators to maintain room temperature at an acceptable level for diesel generator operation during normal and accident conditions.

10.5.7 Inspection and Testing

The Diesel Generator Building Heating and Ventilating System is periodically tested to assure the continuing capability of performing its Diesel Generator support function. This testing includes periodically verifying the operation of the fan auto-start features and satisfactory airflows. The CARDOX isolation functions are tested as described in the Technical Requirements Manual.

The Diesel Generator Building and Ventilating System is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), Selective Leaching (see USAR Section K-2.1.34), and Water Chemistry Control - Auxiliary Systems (see USAR Section K-2.1.38). The following Time-Limited Aging Analyses are applicable: Metal Fatigue (see USAR Section K-2.2.2.2).

10.6 Non-Essential Heating, Ventilating and Air Conditioning Systems

10.6.1 Power Generation Objective

The power generation objective of the various non-essential heating, ventilating, and air conditioning systems is to control their respective building and compartment air temperatures and the flow of airborne radioactive contaminants to support the function of non-essential station equipment and the accessibility and habitability of these buildings and compartments.

10.6.2 Power Generation Design Basis

The non-essential heating, ventilating, and air conditioning systems shall:

1. Provide temperature and humidity control and air movement for personnel comfort and optimum equipment performance.

2. Provide a sufficient filtered fresh air supply for personnel.

3. Provide for air movement from lesser to progressively greater areas of radioactive contamination potential prior to final exhaust.

4. Minimize the possibility of exhaust air recirculation into the air intake.

Where spaces are occupied by personnel and are without high heat producing equipment, the ventilation quantity requirements are defined by establishing air change rates required for personnel comfort and safety in accordance with accepted practices.

## 10.6.3 Description

### 10.6.3.1 Turbine Building Heating and Ventilating Systems

The Turbine Building ventilating systems supply filtered air to all areas of the Turbine Building (Refer to Burns and Roe Drawing 2018). This air is routed to areas of progressively greater radioactive contamination potential prior to final exhaust.

Three heating and ventilating units, through distribution ductwork, send 100% outside air to all areas of the Turbine Building outside of the shielded spaces. All air from the non-radiation potential areas, if not induced directly into shielded rooms, flows up to the operating floor level via hatches and stairwells. It is induced over the shielded walls in the operating floor, flowing downward to the basement through a concrete plenum labyrinth to the exhaust fans. Exhaust air is discharged to the atmosphere above the roof of the fan room. Air movement is from clean areas to areas with progressively greater contamination potential.

All rooms or areas employing oil or other combustible materials have fire dampers in the ventilation system.

The non-critical switchgear room is independently temperature controlled with a rooftop mounted-package air conditioning unit capable of supporting the cooling load generated within the room.

The electric shop is independently temperature controlled with an air handling unit mounted above the suspended ceiling capable of supporting the cooling load generated within the room.

The Turbine Building Heating and Ventilating System equipment is powered from non-critical buses.

#### 10.6.3.1.1 Turbine Building Ventilating Units

Three heating and ventilating units supply 100% outside air and consist of manually advanced filters, heating coils, and fans. Each unit has operating and standby (100% capacity) fans with vortex dampers to provide regulation of air capacity.

The fans are shut down in the event of loss of offsite power. During normal operations, if an operating fan fails, a time delay relay will be picked up and after 15 seconds will annunciate in the main control room. The standby fan is started automatically if two exhaust fans are running and building differential pressure is normal. If the fan supply air temperature drops below 40°F, a temperature switch will annunciate in the main control room.

Heating coils are provided to heat the outside supply air when necessary. The supply air temperature is controlled by modulating the control valve to the heating coils. Dampers are interlocked with each supply fan and close when fans are off.

10.6.3.1.2 Turbine Area Ventilating System

Two fans, one operating and one full spare, circulate ventilation air between the condenser shield walls to avoid possible heat pockets due to physical limitations in the normal air path. These fans are started manually and are interlocked to automatically start the standby fan on failure of operating fan, with an alarm provided to annunciate fan failure.

10.6.3.1.3 Turbine Building Exhaust Fans

Four (4) exhaust fans are located in the Fan Room adjacent to the Turbine Building. Three or four fans are normally operated, with the fourth in standby, if available, all electrically interlocked; the selection of operating fans is made by the control room operator. All fans are provided with alarms, annunciating in the main control room.

A differential pressure controller (sensing the difference in pressure between atmosphere and the Steam Jet Air Ejector Room) maintains a minimum negative pressure of 0.25 inches (w.g.) by controlling the fan vortex dampers.

10.6.3.2 Radwaste Building Heating and Ventilating System

The Radwaste Building Heating and Ventilating System maintains required space temperatures, provides adequate ventilation to remove heat rejected from operating equipment compartments and provides adequate supply and exhaust to maintain the direction of air flow from lesser to increasingly greater areas of potential radioactive contamination. (Refer to Burns and Roe Drawing 2021). Exhaust hoods with negative pressure are provided at locations where, under normal operation, contaminants could escape to the surrounding areas. Filtered and tempered air is supplied to all personnel occupancy areas in sufficient quantities to maintain space temperatures and ventilation. The air is supplied through ductwork by a full capacity heating and ventilating unit. Exhaust air from the contaminated equipment tank cells, the conveyor section, the baling machine area, and other potentially contaminated ventilation system exhausts are routed through either of two banks of exhaust air filter assemblies prior to discharge. Exhaust air from the clean areas is handled by separate ducting and fans. The air from the clean and potentially contaminated area exhaust systems are discharged to a common exhaust header for both the Radwaste Building and Augmented Radwaste Building Heating and Ventilating systems. The exhaust air which passes through this common header is monitored for radiation (see USAR Subsection VII-12.6).

The potentially contaminated areas are kept at a minimum average negative pressure of 0.25 inches (w.g.) relative to atmosphere by automatic actuation of the vortex dampers which are controlled by a differential pressure controller. The clean areas are similarly kept at a less negative pressure relative to the potentially contaminated rooms to prevent cross-contamination.

10.6.3.2.1 Radwaste Building Heating and Ventilating Supply Unit

The supply unit consists of automatic inlet dampers, prefilters, heating coils, and duplex fans. Each fan is 100% capacity with one operating and one standby.

The fans are shutdown in the event of loss of offsite power. The fans are manually started. If the normal operating fan fails, the standby fan automatically starts and annunciates in the Radwaste Control Room. The fan discharge air temperature is controlled by a thermostat through a limit sensor and controller which modulates the heating coil valve. The heating coil is

supplied by the station steam heating system. The pre-filters are removable filters which require periodic replacement upon a high dp alarm located in the Radwaste Control Room.

10.6.3.2.2 Radwaste Building Exhaust Fans and Filters

Four exhaust fans are installed, each of full capacity, with two serving the potentially contaminated area and two serving the uncontaminated area. The fans are started manually and are shutdown automatically in the event of loss of offsite power. If the normal operating fan fails, a flow switch senses loss of pressure, automatically starts the standby fan, and annunciates in the Radwaste Control Room. Differential pressure (atmosphere to internal) is maintained by inlet vanes automatically positioned.

For the potentially contaminated exhaust, two separate full capacity filter assemblies are installed. Each filter assembly is isolated automatically with fan operation. Prefilter and HEPA filter differential pressures are indicated outside each filter assembly compartment.

10.6.3.2.3 Radwaste Building Control Room Air Conditioning

A separate air conditioning unit maintains the required temperature and humidity for this building's control room. The unit includes filters, steam heating coil, chilled water coil, and blower. The room is at a positive pressure in relation to the rest of the building. Chilled water is supplied by a chilled water system as described in USAR Section X-10.1.2. Modulating valves control flow to the cooling coils of the air conditioning unit through temperature controllers. Ventilation air for personnel is ducted off the filtered and cooled building ventilation system.

10.6.3.3 Augmented Radwaste Building Heating and Ventilating System

The Augmented Radwaste Building Heating and Ventilating System maintains required space temperature, provides adequate ventilation to remove heat rejected from operating equipment compartments, and provides adequate supply and exhaust air to maintain the direction of air flow from lesser to increasingly greater areas of potentially radioactive contamination. One exhaust hood with negative pressure is provided where, under normal operation, contaminants could escape to the surrounding areas. Once through air is distributed in the building by a balanced duct system connected to a full capacity heating and ventilating air supply unit. Exhaust air is routed through filters and discharged to atmosphere at roof level by a separate exhaust system.

The building is kept at a minimum negative pressure of 0.25 inches water gauge relative to atmosphere. Potentially radioactive contaminants are contained, filtered, and monitored prior to release to atmosphere. All of the exhaust air from the Augmented Radwaste Building is filtered through prefilters and high efficiency (HEPA) filters to eliminate the potential release of any contaminated air to atmosphere.

10.6.3.3.1 Augmented Radwaste Building Heating and Ventilating Air Supply Unit

The unit consists of inlet and outlet dampers, traveling filter, steam coils, and two fans. Each fan is rated for full capacity.

The fans are manually started and shut down in the event of a loss of offsite power. If the operating fan fails, a flow switch senses a reduction in flow and automatically starts the standby fan. A freezestat trips the

operating fan on low inlet temperature. Both conditions annunciate in the Augmented Radwaste Control Room and Main Control Room. The fan discharge air temperature is controlled by a thermostat, which modulates a valve to the steam coil. The steam coil is supplied by the Steam Heating System.

10.6.3.3.2 Augmented Radwaste Building Exhaust Fans and Filters

Two exhaust fans are provided, each capable of providing system design flow. The fans are started manually and shutdown in the event of loss of offsite power. If the fan selected for normal operation fails, it starts the standby fan and annunciates in the Augmented Radwaste Control Room and Main Control Room. Building vacuum is maintained by vortex dampers driven by a differential pressure controller.

For the potentially contaminated exhaust, a filter assembly is provided for each fan. The filter assembly consists of a roughing filter and HEPA filter arrangement rated for full air capacity. A fire deluge system is part of each filter assembly, and fire dampers are installed in the exhaust duct. Air is sampled by a radiation monitor at the furthermost exhaust point to atmosphere.

10.6.3.3.3 Augmented Radwaste Building Control Room Air Conditioning

Air conditioners maintain the required temperature and humidity for the building off-gas and auxiliary control rooms. Each unit contains a filter, freon coiling coil, compressor, electrical heating element, and blower.

10.6.3.4 Intake Structure Heating and Ventilating Systems

The intake structure is comprised of two areas: the Service Water Pump Room and the Intake Structure Main Area.

The Service Water Pump Room is a missile protected room having two fan-coil units and the general area is served by unit heaters and roof ventilation. All fans are manually started and powered from non-critical buses.

10.6.3.4.1 Service Water Pump Room

Two fan coil units operate together. Each contains a filter, cooling coil, heater coil, and fan in a sheet metal casing. Both units are controlled by room thermostats regulating freon or steam to the coils control valves.[69] The units bring in sufficient outside air for ventilation purposes, and the resulting excess room air is forced through relief openings to the main room for eventual exhaust. Service Water pump performance without the operation of these non-essential fan coil units is discussed in USAR Section X-8.1.6.

10.6.3.4.2 Intake Structure Main Area

Seven unit heaters provide steam heated air to maintain the building at a minimum of 50°F temperature. Steam is passed through coils with heater fans controlled by area thermostats.

Eight roof ventilators induce outside air through wall louvers (dampers manually operated) and are spaced to provide complete air movement throughout the building before exhausting to atmosphere.

10.6.3.5 Office Building Heating and Ventilating

The Office Building heating and ventilating system supplies filtered and tempered air to the Office Building rooms through Air Handling Unit AHU-1 except for the Technical Support Center (TSC) which is supplied by Air Handling Unit AHU-2. Chilled water is supplied to AHU-1 and AHU-2 as described in USAR Section X-10.1.2. The design of the system to support TSC continuous occupancy during a station emergency is described in the NPPD Emergency Plan for Cooper Nuclear Station.

10.6.3.5.1 Office Building Heating and Ventilating Unit

Air Handling Unit AHU-1 consists of filters, cooling coils, a humidifier, an electric heat coil and a supply fan. Conditioned air is distributed through ductwork to ceiling diffusers and registers.

Room temperatures are controlled by thermostats which signal pressure controllers to maintain setpoints at the various volume boxes and fan-powered VAV boxes. The setpoints for the fan-powered VAV boxes are controlled by modulating the dampers.

A roof exhaust fan induces air into the toilets, janitor's closet, and other possible odor producing rooms and through ductwork discharges this air to the atmosphere.

A differential pressure controller modulates Relief Fan RF-1 speed to maintain a positive pressure in the building relative to outdoors. By providing slightly more supply than return air, the building is kept under positive pressure, resulting in leakage to atmosphere.

10.6.3.5.2 TSC Heating and Ventilating Unit

Air Handling Unit AHU-2 consists of filters, an electrical heat coil, a cooling coil, and a supply fan. During normal operation, outside air is routed through a fiberglass filter section to AHU-2 and is distributed through ductwork to ceiling diffusers.

Odor producing rooms which are located in the TSC are ventilated by three (3) exhaust fans which condition the air through charcoal filters and discharge into a plenum.

10.6.3.6 Control Corridor Area Heating and Ventilating

The access control area ventilation system maintains ventilation and constant temperature in the control corridor area. The equipment, ductwork and controls are completely independent from other station heating, ventilating, and air conditioning services. The system independence will insure uninterrupted operation during normal and shut down modes.

10.6.3.6.1 Control Corridor Heating and Ventilating Unit

The Control Corridor Heating and Ventilating Unit supplies both outside and recirculated air and consists of an automatically advanced filter, heating coil, and fans. The heating coil is supplied with station heating steam to augment the recirculated air in providing temperature control during cold weather conditions. The unit has an operating and standby (100% capacity) fan with vortex dampers to provide constant air capacity during periods of increased filter differential pressure or other changes in system pressure

drops. During normal operation, failure of the operating fan is annunciated in the Main Control Room and the standby fan will automatically start after a time delay.

The fans are connected to non-critical buses and shut down if off-site power is lost.

10.6.3.6.2 Exhaust Systems

Uncontaminated air exhausts to the Turbine Building Heating and Ventilating System and directly to the outside atmosphere. Additionally, two recirculation fans (one operating - one 100% spare) recirculate the air to the ventilation unit supply or discharge it to the outside atmosphere by automatic actuation of dampers.

The exhaust fans are powered from non-critical buses.

10.6.3.7 Miscellaneous Laboratories Air Conditioning Units

The following laboratories and rooms have their own air conditioning units maintaining constant temperature and humidity:

1. Maintenance Lunch Room (Machine Shop Building) [temperature only]
2. Radiochemistry Laboratory, Counting Room, Sampling Room, Corridor B202 and Office (RW-918'), Metals Laboratory, Metals Office, Bio-analysis Laboratory, IC Hot Shop and Nonradiological Laboratory (RW-934').
3. Radwaste Control Room (Radwaste Building)
4. Cable Expansion Room (Control Corridor)
5. Alternate Operations Support Center (AOSC) (Instrument Shop, Adjacent Rooms) Located in the Turbine Building[49] (see NPPD Emergency Plan for Cooper Nuclear Station)
6. Off-gas and Auxiliary Control Rooms (Augmented Radwaste Building)

10.6.3.7.1 Air Conditioning Units

In general the ventilation air required is taken from the building ventilation system. Each air conditioning unit consists of filters, cooling coils, heating coils, fans, humidification equipment and required automatic controls. All but the Maintenance Lunch Room and the Augmented Radwaste Control Rooms receive chilled water from a chilled water system as described in USAR Section X-10.1.2. The Maintenance Lunch Room has its own compressor-condenser. The Maintenance Lunch Room Unit has no heating and humidification equipment.

The units are manually started and are shut down in the event of off-site power failure.

The air is recirculated except for the ventilation air and hood exhaust requirements. The HVAC System for the second and third floor Radiochemistry Laboratory is designed as a once-through system (i.e., no air recirculation) in conformance with laboratory standards. The air conditioned rooms are pressurized in relation to adjoining areas.

Exhausts which may be potentially contaminated are passed through roughing and high efficiency filters before being discharged to atmosphere.

Room thermostats and humidistats maintain automatic temperature and humidity control.

10.6.3.8 Computer Room Ventilating System

The computer room is air conditioned by two separate raised floor mounted, floor discharge, computer room air conditioners (Refer to Burns and Roe Drawing 2019, Sheet 1). Air cooled condensers for each unit are mounted on the computer room roof. Each unit is complete with self contained compressors, filters, direct expansion coils, controls, electric humidifier, electric heating coils, and roof mounted condensers. Cooling air is distributed to the Computer Room via grilles and cutouts in the raised floor system. Each unit has temperature and humidity controls that regulate air quality by modulating compressor, heating coil, and humidifier operation.

10.6.3.9 Heating Boiler Room Heating and Ventilating

The Heating Boiler Room is heated by two steam type unit heaters, manually started, with fan operation controlled by individual room thermostats. Steam is constantly passed through coils during winter cycle.

Two roof exhaust ventilators induce outside air through wall louvers and dampers to provide comfort condition for operating personnel. Fans are manually operated.

10.6.3.10 Fan Room Heating and Ventilating

The fan room is heated by two steam type unit heaters, manually started, with fan operation controlled by individual room thermostats. Steam is constantly passed through coils during winter cycle.

Two roof exhaust ventilators induce outside air through wall louvers and dampers to provide comfort condition for operating personnel. Fans are manually operated.

10.6.3.11 Water Treatment Area Heating and Ventilating Systems

Seven steam type unit heaters heat the water treatment area. Each heater has a manually started fan that is individually controlled by a thermostat. Steam is constantly passed through the heater coils during winter temperatures.

Outside air is induced through wall louvers and manual dampers providing ventilation.

10.6.3.12 Machine Shop Heating and Ventilating System

A heating and ventilating unit delivers filtered and tempered air to various rooms of the building, through distribution ductwork, with recirculation as required.

Several exhaust systems discharging to the atmosphere are used, as follows:

1. exhaust system from all abrasive material producing equipment (such as grinders, etc.), through a material separator-filter.

2. exhaust system from Grit Blast Booth and Welding Booth through ductwork to cyclone type separator before discharge to atmosphere.

3. exhaust system from possible odor or light dust producing areas such as paint storage, to atmosphere.

4. roof ventilator type exhausters for general ventilation exhaust.

10.6.3.12.1 Machine Shop Heating and Ventilating Unit

The Machine Shop Heating and Ventilating Unit supplies outside and recirculated air and consists of an automatically advanced filter, a heating coil, and a fan. The fan is provided with a vortex damper to assure constant air capacity during periods of increased filter dp or other changes in system pressure drops. The unit is manually started and receives non-critical power.

Heating coils are provided to heat the outside supply air when necessary. The supply air temperature is controlled by modulating the control valve to the heating coils. Dampers are interlocked with each supply fan and close when the fans are off.

10.6.3.12.2 Machine Shop Exhaust Fans and Systems

The exhaust fans are manually started. The fans are powered from non-critical buses.

The dust and grit separation cyclone type units have storage capacity to receive dirt particles for periodic manual removal.

Fire dampers are included in all potential fire hazard areas.

Air from the general areas flows to the hoods and booths of the various exhaust systems, with a high velocity of air maintained in ductwork to keep dust particles in suspension until deposited in separation containers.

10.6.3.13 Off-Gas Building Heating and Ventilating Unit

A single unit supplies the heating and ventilating requirements for the Off-Gas Building. This unit consists of an inlet damper, filters, supply fan, and a duct mounted resistance electric heating coil.[35] Outside air is supplied to the General Area and Fan Room and air is recirculated from the General Area.

The supply fan is manually started and stopped. The electric duct heater is controlled by two thermostats and can not be energized unless the supply fan is operating. A freezestat will automatically trip the supply fan when its setpoint is reached. This condition is annunciated in the Main Control Room.

10.6.3.14 Multipurpose Facility HVAC Systems

The MPF HVAC system utilizes four major air conditioning units consisting of condensing units, refrigerant coils, electric heaters, dampers, fans, and controls for the main part of the MPF Building. This system provides tempered air to the MPF for personnel comfort and optimum equipment performance. One unit supplies outside air and is designed and balanced in conjunction with the exhaust fans to maintain the building at a slightly negative pressure to the outside pressure. The attached battery room has its own self contained HVAC system.

10.6.3.14.1 Multipurpose Facility HVAC Units

Four condensing units are mounted on the roof and work in conjunction with four air handling units (AHU-1 through AHU-4) mounted on the MPF mezzanine level which serve various areas of the facility. In addition air

conditioning unit AC-1 serves the office area while units AC-2 and AC-3 serve the UPS battery room which is attached to the MPF.

10.6.3.14.2 Multipurpose Facility Exhaust Fans and Filters

Fan unit EF-1 is located on the mezzanine and will normally serve to exhaust the building air. If radiation is detected in the exhaust by either surveillance of the MPF Ventilation Monitoring System (see Section VII-12.8) particulate filters or a portable Continuous Air Monitoring (CAM) unit alarm, the system can be manually switched to using EF-2 which will exhaust building air through a HEPA filter which is located on the mezzanine. Fan unit EF-4 is located in the UPS battery room and controls the exhaust from this room. A separate exhaust fan (HV-F-MPF1) and HEPA filter unit are installed to control the exhaust from the decontamination room when the isolating door is closed over the room.

10.6.3.15 Optimum Water Chemistry Gas Generator (OWCGG) Building HVAC System

The ventilation system maintains the environment of the OWCGG Building within the limits recommended by vendors for equipment housed in the building and ensures the hydrogen concentration in the hydrogen room does not approach the ASHRAE recommended concentration limit for lower flammability limits.

10.6.4 Inspection and Testing

There are no inspection and testing activities specified for the non-essential heating and ventilating systems.

# 11.0 MAKEUP WATER TREATMENT SYSTEM

## 11.1 Power Generation Objective

The power generation objective of the Makeup Water Treatment System is to provide a supply of treated water suitable as makeup for the station, for systems containing reactor coolant, and for other demineralized water requirements.

## 11.2 Power Generation Design Basis

The Makeup Water Treatment System shall be designed to:

1. provide makeup water of reactor coolant quality.
2. provide an adequate supply of treated water for all station operating requirements.

## 11.3 Description

### 11.3.1 General

The Makeup Water Treatment System consists of a membrane processes based system. This system is comprised of contracted vendor equipment which is located inside the Water Treatment Area. This equipment uses reverse osmosis and electrodeionization along with ultrafiltration and is capable of producing 60 gpm of demineralized water. The Makeup Water Treatment System receives its supply of water from wells via two 250 gpm pumps. (See Burns and Roe Drawing 2034.)

The demineralized water is stored in a 30,000 gallon, lined carbon steel, demineralized water storage tank from which it is pumped by two transfer pumps to supply the station requirements for demineralized water.

The membrane processes based system discharges to the Fire Protection System, Potable Water System and the Demineralized Water Storage Tank.

The membrane processes based system is a leased system that is operated and maintained by vendor personnel per contract.

### 11.3.2 Demineralized Water Services

The demineralized water is taken from the demineralized water storage tank by one of two pumps and provides a makeup water source to the following equipment discussed in the USAR: the Condensate Storage Tanks, the REC and TEC Surge Tanks, the Standby Liquid Control System, and the Heating Boiler System. Demineralized water is also provided for other plant services where water purity is desirable.

In the Demineralized Water System to the Floor Drain discharge line, a check valve prevents back flow to protect against cross-contamination of the Demineralized Water System. Also, the solenoid-operated flush valve is interlocked with RW-AOV-AO230 and RW-AOV-AO231 to ensure that one of these valves is open in order to open the flush valve. This ensures that there is not excessive pressure downstream of the flush valve.[37]

## 11.4 Inspection and Testing

The Makeup Water Treatment System is in daily use and as such does not require periodic testing to assure proper system function. The performance of the system is monitored on an ongoing basis. High demineralizer effluent conductivity automatically initiates an alarm. Grab samples are periodically tested in the laboratory to verify demineralizer performance and to ascertain stored water quality.

The Makeup Water Treatment System is in scope for License Renewal per 10 CFR 54.4(a)(1) and (a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), Selective Leaching (see USAR Section K-2.1.34), and Water Chemistry Control - BWR (see USAR Section K-2.1.39). There are no Time-Limited Aging Analyses that are applicable.

# 12.0 INSTRUMENT AND SERVICE AIR SYSTEMS (Plant Air System)

## 12.1 Power Generation Objective

The power generation objective of the Plant Air System is to provide the station with a continuous supply of oil-free compressed air. This air is directed to station instrumentation and general station services.

## 12.2 Power Generation Design Basis

1. The instrument air system is designed to supply cool, clean, and dry air (design dewpoint of -40°F at 100 psig) to station instrumentation and controls within a normal range of 95 to 110 psig, and a minimum supply pressure of 70 psig.

2. The service air system is designed to provide sufficient cool, clean air to the instrument air system and to station services to support their functions.

## 12.3 Description

### 12.3.1 General

The Plant Air System is comprised of both the Service Air System and the Instrument Air System. (See Burns and Roe Drawing 2010, Sheets 1 through 5)

The Plant Air System provides the source of compressed air for pneumatic operated equipment and instruments required to operate the power plant and compressed air for general station services.

The air supply is developed by three air compressor units operating in parallel. Each compressor unit has an integrated intercooler, aftercooler and moisture separator, and discharge to a common header. The discharge header supplies two air receivers. The air receivers have a common discharge which feeds both the service air system and instrument air system. The service air is distributed throughout the plant by service air headers supplying various air operated equipment and service air hose stations. Two sets of air dryers are located in the instrument air line. There is an air filter before and after each set of air dryers to provide high quality dry air to the various instrument air headers.

### 12.3.2 Service Air System

The Service Air System includes the air compressors, air receivers, and other equipment necessary to generate the compressed air supply to the Service Air distribution header and the Instrument Air Dryers.

#### 12.3.2.1 Compressors

The three air compressors are 2 stage, water-cooled, oil-free, rotary compressors. Each is rated to deliver 843 cfm at 116 psig. Each compressor is equipped with a nominal 200 hp, 480 VAC motor. Compressors A and B are powered from critical buses and Compressor C is powered from a non-critical bus.

The three compressors operate in parallel and one of the three will be available on a demand basis with the other two in standby ready to operate as required[54].

Compressor operation is controlled by a control system that brings additional units on-line as operating units reach a fully loaded condition and there is a further increase in demand.

Each air compressor unit has an electronic regulator for controlling, monitoring, and protecting the compressor. An integral unloader, controlled by the regulator, provides for unloading the compressor, during compressor startup and each time the Instrument Air header pressure reaches the top of its operating range.

Each compressor has a shaft-driven lubrication system for the power-end parts. Each compressor unit has an intercooler, aftercooler, moisture separator, and automatic drain traps.

The intake filter-silencers are dry type cartridge filters, and are located within the compressor units.

Normally, one air compressor will maintain sufficient pressure in the air receivers to provide the desired instrument air header pressure. The second and third compressors serve as standby units. Actuation of standby units is automatic.

12.3.2.2 Compressor Cooling

Cooling water is supplied by the Turbine Equipment Cooling (TEC) System for two compressors and by the Reactor Equipment Cooling (REC) System for one compressor. An alternate supply of cooling water is available from the REC system (two compressors) and the TEC system (one compressor)[40,109].

Each compressor unit's intercooler, aftercoolers, and oil cooler are built to ASME Section VIII code for a maximum allowable working pressure of 145 psig.

12.3.2.3 Air Receivers

The air receivers are vertical vessels built to the ASME Section VIII code for a manufacture design pressure of 125 psig. Each receiver is equipped with three relief valves and an automatic drain trap. The volume of each receiver is 314 cubic feet. Low air receiver pressure is sensed by pressure switches, which annunciate in the Main Control Room.

12.3.2.4 Service Air Headers

The air receivers have a common discharge, which feeds both the service air system and instrument air system. The service air is distributed throughout the plant by service air headers supplying various air operated equipment and service air hose stations. Low air receiver discharge pressure will annunciate in the control room and will automatically isolate the service air header.

12.3.3 Instrument Air System

12.3.3.1 Air Dryers

The Instrument Air System contains two air dryers. Each air dryer is rated to pass 800 SCFM of air with up to 115°psig and 110°F moisture saturated inlet air to be dried to a 115 psig dew point of lower than -40°F. Each dryer has two chambers, built to the ASME Section VIII code for a

manufacture design pressure of 150 psig. The air is dried by passing it through the desiccant. Moisture is removed from the desiccant by a heated or heatless purge air flow. The Air Dryers are powered from critical buses.

The instrument air is filtered through prefilters and post filters as a part of the dryer assembly. The replaceable dry cartridge type filter elements are rated for 100% filtration efficiency of at least 0.6 and 0.9 micron particle size respectively.

The air filters downstream of the air dryers prevent the dryer particulate (desiccant) from entering the piping system. There is a bypass around the dryers and filters which can be opened to assure a continued supply to instrument air headers in the event of air dryer system failure.

12.3.3.2 Instrument Air Headers

The Instrument Air headers are divided into the non-critical instrument air headers (which supply non-critical instrumentation and control equipment) and the reliable air header (which supplies the critical instrumentation and control equipment). The reliable air header pressure is maintained between 95 and 110 psig. The non-critical Instrument Air headers can be isolated manually by a motor operated valve from the Control Room. Non-essential pressure regulators are provided, as needed, to control the air supply to air-operated components. In the case of safety-related air-operated valves and dampers, postulated failures of these regulators during design basis events can result in higher than normal differential pressures at the solenoid valves for the air-operators. However, the solenoid valve rated Maximum Operating Differential Pressures (MODPs) will not be exceeded, thereby assuring satisfactory fail-safe venting of the air operators. Similarly, pressure regulator failures that result in over-pressure conditions to essential air operators will not prevent subsequent travel to their fail-safe position.

When the primary containment is inerted, the reliable instrument air header is isolated from loads inside the primary containment in order to prevent air leakage into the drywell from the valve operators. Loads inside the primary containment are supplied by the nitrogen supply system. The reliable instrument air header is available as a backup.[107] See USAR Section V-2.3.8. Due to the higher pressure of the nitrogen supply, certain safety-related air-operated valves are provided with essential pressure regulators or relief valves to ensure that the air-operator solenoid valves do not exceed their rated MODP during design basis events.

12.3.3.3 Seismic Class IS Accumulators

Seismic Class IS accumulators, associated piping, and check valves of appropriate size are provided for the following equipment:

1. Main Steam Line Isolation Valves MS-AOV-AO80A,B,C,and D and MS-AOV-AO86A,B,C,and D (see USAR Section IV-6.3).

2. Main Steam Relief Valves MS-RV-71ARV, MS-RV-71BRV, MS-RV-71CRV, MS-RV-71DRV, MS-RV-71ERV, MS-RV-71FRV, MS-RV-71GRV and MS-RV-71HRV (see USAR Section IV-4.5.1 and IV-4.6).

3. Drywell Equipment Drain Sump Pump Discharge Isolation Valves RW-AOV-AOV94 and RW-AOV-AOV95 (see USAR Table V-2-2).

4. Drywell Floor Drain Sump Pump Discharge Isolation Valves RW-AOV-AOV82 and RW-AOV-AOV83 (see USAR Table V-2-2).

5. Secondary Containment Ventilation Isolation System Valves HV-AOV-257AV, HV-AOV-259AV and HV-AOV-261AV (see USAR Section V-3.3.3).

6. Control Room Ventilation Isolation Valve HV-AOV-271AV.

7. MG Set Ventilation Isolation Valves HV-AOV-263AV, HV-AOV-265AV, HV-AOV-267AV and HV-AOV-269AV (see USAR Section V-3.3.3).

8. Reactor Building-to-Suppression Chamber Vacuum Breakers PC-AOV-243AV and PC-AOV-244AV (see USAR Section V-2.3.6).

### 12.3.4 Instrument Air Quality

The design of the Instrument Air System inherently assures consistently high quality instrument air which assures proper operation of air operated components supplied by the system. The air compressors are oil-less in design, which precludes oil contamination as a problem.[108]

The Instrument Air System has two 100 percent capacity air dryers, each with a pre-filter and a post filter. One dryer is normally in service while the other is in a regenerative mode. A manual air dryer bypass capability ensures that bypass of the air dryers can only be accomplished through manual operator action. This arrangement reduces the probability of moisture introduction to the Instrument Air System. Additionally, each dryer train contains a sight-glass dewpoint failure indicator.

Other features include dedicated filters and oilers for certain air-operated components to improve the quality of the air supplied to those components, thus improving their reliability.

Through these measures, the Instrument Air System consistently produces high-quality air which meets the air-operated component manufacturer’s recommendations. This assures the reliability of components served by the Instrument Air System.

### 12.3.5 Seismic Design

Most of the Service and Instrument Air Systems are classified as Seismic Class II. The principal exceptions to this are the Seismic Class I Instrument Air accumulators (and associated piping and devices) that provide essential backup air to various safety-related air-operated valves (see USAR Subsection X-12.3.3.3). To provide additional operational flexibility during a seismic event, the reliable Instrument Air header is restrained and supported to withstand the effects of a Safe Shutdown Earthquake. The Service and Instrument Air piping and equipment that supply compressed air to the reliable header are similarly supported and restrained, up to and including the SA-AOV-PCV609 (Service Air Header isolation valve) and IA-MOV-80MV (Non-critical Instrument Air Header isolation valve).

### 12.3.6 Loss of Instrument Air

The Service and Instrument Air Systems have been designed with protective features and a degree of redundancy to permit operator intervention prior to a significant loss of Instrument Air pressure resulting from system casualties. The Plant Air System is monitored by pressure instrumentation. Pressure switches annunciate low pressure conditions in the control room, and

will automatically isolate the service air supply header. If the low pressure condition persists, the operators can manually isolate the non-critical instrument air headers, thereby leaving the reliable air header as the only demand on the plant air system. The operators can also cross-connect the service air header with instrument air header downstream of the instrument air dryers, although the period of time the system is in this configuration is minimized due to the potential for increased moisture in the instrument air lines. In any event, a complete loss of non-essential Instrument Air header pressure will not adversely affect plant safety.

In accordance with CNS commitments to Draft GDC 26, the plant protection systems are capable of performing their credited safety functions following the loss of non-essential Instrument Air (see USAR Appendix F). The following is a summary of the effect of loss of instrument air on the engineered safety features and nuclear safety systems that interface with the Instrument Air System.[112]

1. Primary Containment Isolation Systems

Air operated Primary Containment Isolation Valves will fail closed upon loss of the non-essential Instrument Air or nitrogen supply with the following exceptions;

a. The Reactor Building to Suppression Chamber Vacuum Breaker valves fail open and so have Class I accumulators to keep the valves closed on a loss of non-essential Instrument Air (see USAR Section V-2.3.6).

b. The Drywell Equipment and Floor Drain Sump Pump Discharge isolation valves fail open and so have Class I accumulators to close the valves on a loss of non-essential Instrument Air (see USAR Table V-2-2).

2. Secondary Containment Isolation Systems

Accumulators are provided for the air operated Secondary Containment Isolation Valves to ensure the isolation valves can be closed after a loss of the non-essential instrument air supply (see USAR Section V-3.3.3).

3. Control Rod Drive System

All Control Rod scram valves will open on loss of instrument air causing the reactor to scram.

4. Nuclear System Safety/Relief Valves

Each of the relief valves provided for automatic depressurization is equipped with an air accumulator to provide assurance that the valves can be held open, as described in USAR Section IV-4.5.1. Valves will, however, retain a mechanical safety valve feature.

5. ECCS and RCIC Systems

Auxiliary cooling water supply valves for HPCI and RCIC turbines will fail open on loss of instrument air, allowing for the maintaining of cooling water flow during emergency operation. All air operated drain valves for the RCIC and HPCI systems will fail closed upon instrument air failure. Loss of air will not prevent operation of the HPCI and RCIC systems. Operation of the RHR and Core Spray systems is unaffected by instrument air failure.

6. Standby Gas Treatment System

Air operated valves in the Standby Gas Treatment system fail open upon the loss of instrument air to allow for operation of the system.

7. Control Room Emergency Filter System

An accumulator is provided for the emergency bypass inlet valve (HV-AOV-271AV) which assures that the valve will open on CREFS initiation.

## 12.4 Inspection and Testing

As part of pre-operational testing and subsequent review activities made in response to Generic Letter 88-14, NPPD has verified that the safety-related air-operated components have been tested to assure their proper performance during loss of instrument air events.

The instrument and service air system is normally is service and is observed and maintained during normal operation. Instrument air dewpoint is monitored and consistently maintained below −32 degrees F [108].

The Seismic Class IS accumulators are functionally tested on a periodic basis to ensure that essential equipment will function as intended on loss of Instrument Air.

The Plant Air System is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), External Surfaces Monitoring (see USAR Section K-2.1.14), One-Time Inspection (see USAR Section K-2.1.29), and Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31). There are no Time-Limited Aging Analyses that are applicable.

# 13.0 POTABLE AND SANITARY WATER SYSTEMS

## 13.1 Power Generation Objective

The power generation objective of the Potable and Sanitary Water System is to provide the potable (drinking) water supplies and sanitation water necessary for normal station operations.

## 13.2 Power Generation Design Basis

The Potable and Sanitary Water System shall supply treated water in sufficient quantities to satisfy the normal station demand for potable and sanitary water and shall meet the design regulations of the State of Nebraska.

## 13.3 Description

Water for drinking and sanitary use is supplied from wells on site. The water is clarified, filtered and purified as necessary by the Makeup Water Treatment System to meet State of Nebraska drinking water standards.

Shower and lavatory waste water that does not contain radioactive material is directed to a sewage treatment system.

The station Potable and Sanitary Water Systems are independent of the station process systems.

## 13.4 Inspection and Testing

The system is normally in service and requires no testing.

The Potable and Sanitary Water System is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2) and Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31). There are no Time-Limited Aging Analyses that are applicable.

# 14.0 EQUIPMENT AND FLOOR DRAINAGE SYSTEMS

## 14.1 Safety Objective

The safety objective of the Equipment and Floor Drainage Systems is to support the functions of the Standby Gas Treatment (SGT) system and the Elevated Release Point (ERP) in meeting the Secondary Containment Safety Objective.

## 14.2 Safety Design Basis

The safety design basis of the Equipment and Floor Drainage Systems are to:

1. Ensure that Z Sump in-flows from condensation and other sources will not impede the Standby Gas Treatment (SGT) System flow to the Elevated Release Point (ERP).

2. Provide a barrier to ground level release via the Z Sump during accidents where the SGT system must operate.[105]

## 14.3 Power Generation Objective

The power generation objective of the Equipment and Floor Drainage Systems is to collect and remove all waste liquids from their points of origin and to transfer them to suitable treatment and/or disposal areas in a controlled manner.

## 14.4 Power Generation Design Basis

The Equipment and Floor Drainage System shall be designed to:

1. Remove equipment and floor drainage water produced during normal station operations.

2. Maintain separation of liquid wastes as follows:

   a. Normal drainage wastes - (non-radioactive)

   b. Clean radwastes - (all drain flows originating from closed drains having no process chemical content and low conductivity)

   c. Miscellaneous radwastes - (all drain flows having any process chemical content and high conductivity)

   d. Floor drainage - (all drain flows from an open drain).

## 14.5 Description

### 14.5.1 General

The Equipment and Floor Drainage Systems handle both normal and radioactive drainage.

Drains are collected in seven equipment sumps, eighteen floor drain sumps (radioactive and non-radioactive), three electrical manhole sumps, and one chemical drain sump. These collected wastes are then transferred to the river or to the Radwaste Building as required for filtration, demineralization, sampling and analysis prior to either dilution and safe disposal into the discharge flume or re-use in the station. Inadvertent drainage to the discharge flume is prevented by an atmospheric loop between

the discharge pumps and the flume. (See Burns and Roe Drawings 2017, 2028 and 2038, Sheet 1)

Free venting from the Reactor Building basement drains is prevented by maintaining water level in the sumps to seal the drain piping. In addition, all upper floor and equipment drains in the Reactor Building have loop seals to maintain ventilation integrity in the building. Inaccessible loop seals at the elevated release point are supplied with demineralized water to maintain seal integrity. Loop seals are maintained with the equipment and floor drains in the Cable Spreading Room to improve the Control Room pressurization boundary.[99]

### 14.5.2 Equipment Drainage System

In general, potential radioactive equipment drainage is collected throughout the station in seven sumps in the six following areas:

1. Drywell Equipment Drain Sump (G Sump)
2. Reactor Building Equipment Drain Sump (E Sump)
3. Turbine Building Equipment Drain Sumps (P and T Sumps)
4. Radwaste Building Equipment Drain Sump (J Sump)
5. Augmented Radwaste Building Equipment Drain Sump (BB Sump)
6. Augmented Radwaste Building Condensate Drain Sump (DD Sump)

Two pumps are provided in each of the potentially radioactive sumps to transfer the collected drainage from the sumps to the Radwaste System. Each pump is a full capacity unit that automatically starts, secures, and provides alarms based on the following description of sump water level settings:

At the first high water level setting (high), one pump is started (pumps are alternately selected for initial operation by an automatic pump alternator). If the water level continues to rise, a higher water level setting initiates the second pump. A further rise in the water to a prescribed level initiates an alarm (high-high) indicating excessive leakage and/or pump failure to start. The equipment drain and floor pumps are tripped by the low sump level.

The E, G, J P, T and BB Sump pumps discharge to the Waste Collector Tank. The DD Sump pumps discharge to the Main Condenser.

The G sump receives leakage from various Reactor Coolant Pressure Boundary (RCPB) components inside the drywell. The G Sump pump discharge flow provides the principal indication of drywell Identified Leakage (see USAR Section IV-10). The sump discharge is automatically aligned for recirculation via the drywell equipment drain sump heat exchanger on high sump water temperature conditions. The G Sump pump discharge lines are provided with Primary Containment Isolation Valves (PCIVs). These valves close on a PCIS Group 2 containment isolation signal (see USAR Sections V-2 and VII-3). The PCIVs are provided with essential Instrument Air accumulators to provide the motive force required to close the valves should an isolation signal be received when the Instrument Air System is not available. The PCIS isolation signal can be manually overridden to permit Post Accident Sampling System (PASS) samples to be discharged to the G sump. Under these conditions a downstream block valve is interlocked with the containment isolation and recirculation cooling valves to prevent PASS discharge fluids from leaving the secondary containment.[110]

### 14.5.3 Radioactive Floor Drainage System

Potentially radioactive floor drainage is collected in twelve sumps in the following six areas:

1. Drywell Floor Drain Sump (F Sump)
2. Reactor Building Floor Drain Sumps (A, B, C, and D Sumps)
3. Turbine Building Radioactive Floor Drain Sumps (Q, R, and S Sumps)
4. Radwaste Building Floor Drain Sumps (H and K Sumps)
5. Augmented Radwaste Building Floor Drain Sump (AA Sump)
6. Elevated Release Point Sump (Z Sump)

Two pumps are provided in each of the potentially radioactive sumps to transfer the collected drainage from the sumps to the Radwaste System Floor Drain Collector Tank. The Z Sump pumps normally discharge to the Waste Collector Tank. The alternate path, via a 3-way valve, is to the Floor Drain Collector Tank. Each pump is a full capacity unit that automatically starts, secures, and provides alarms based on the following description of sump water level settings:

At the first high water level setting (high), one pump is started (pumps are alternately selected for initial operation by an automatic pump alternator). If the water level continues to rise, a higher water level setting initiates the second pump. A further rise in the water to a prescribed level initiates an alarm (high-high), with the exception of Z Sump pumps, which alarm on high-high-high, indicating excessive leakage and/or pump failure to start. The equipment drain and floor pumps are tripped by the low sump level, with the exception of Z Sump, which is tripped by low-low level.

The F sump receives leakage from the drywell fan coil units and drywell floor drains inside the drywell. The F Sump pump discharge flow provides the principal indication of drywell Unidentified Leakage (see USAR Section IV-10). The F Sump pump discharge lines are provided with PCIVs. These valves close on a PCIS Group 2 containment isolation signal (see USAR Sections V-2 and VII-3). The PCIVs are provided with essential Instrument Air accumulators to provide the motive force required to close the valves should an isolation signal be received when the Instrument Air System is not available.

The Z Sump receives drainage from the Standby Gas Treatment System (SGTS) and the Off Gas System. The Z Sump provides an active support function for SGTS by preventing water backup into the SGTS piping. The Z Sump pumps and level controls are essential and are powered from divisonalized critical buses. The Z Sump heat trace is powered on a delayed basis by the use of a pre-planned repair using an electrical cord from MCC-DG1 or MCC-DG2. Z Sump is a potential hydrogen environment. Controls are in place to minimize the potential for hydrogen buildup and ignition.

The A, B, C, and D Sumps are located in the Reactor Building Quads and receive drainage flows, respectively, from the NW, NE, SW, and SE Quads, and from the upper levels of the Reactor Building. The A, B, and D Sumps additionally receive drainage flow from the Suppression Chamber area. In addition to the sump level controls previously described, high-high sump level isolates the air-operated isolation valves for the A, B and D Sump drain lines from the Suppression Chamber area, and from the inlet line from the Reactor Building Floor Drains (A, B, C, and D Sumps). This prevents flooding of the Quads in the event of excessive drainage flows from a line break outside of Primary Containment. Upon closure of these isolation valves, drainage flows are directed to the Suppression Chamber area for temporary storage until the sump pumps have reestablished a low sump level. NEDCs 11-092, 11-093, 11-094,

and 11-095 of the CNS Fire Safety Analysis describe the effects of fire suppression activities on the functionality of essential equipment in the Quads.

Drains from the hopper and conveyor areas in the Radwaste Building are directed to the waste sludge tank utilizing shielded pipe chases.

### 14.5.4 Non-Radioactive (Normal) Drainage System

Roof drains on the principle Station Buildings are collected and discharged by gravity to the storm sewer.

Other non-radioactive low-point drains are collected in sumps and then pumped to the storm drain system. Non-radioactive floor drainage is collected in six sumps in the following areas:

1. Turbine Building Non-Radioactive Floor Drain Sumps (M, U, and V Sumps)
2. Control Building Floor Drain Sump (L Sump)
3. Diesel Generator Building Floor Drain Sumps (DG-1 and DG-2 Sumps)

Two sumps, U and L, are considered nonradioactive floor drain sumps. Due to their location and the location of the floor drains they serve, there exists the remote possibility of these sumps becoming contaminated. The discharge piping of these two sumps can discharge either to the Floor Drain Collector Tank or the river.[42]

Additional sumps are provided in electrical manholes, two of which are located in the yard area, W and Y Sumps, and one in the Control Building basement, X Sump. These sumps are equipped with a single pump and discharge to the storm drain system.

### 14.5.5 Miscellaneous Drainage System

The discharge from the Chemical Drain Sump, CC Sump, as well as laboratory, general chemical and detergent type liquid wastes are collected in the Chemical Waste and Laboratory Drain Tanks, and discharged to the Floor Drain Collector Tank.

Oil drains and borate contaminated liquid drains are collected locally for offsite disposal.

Drains from the Metals Laboratory are discharged via the floor drains to the H Sump.[55]

## 14.6 Safety Evaluation

### 14.6.1 Z Sump

The purpose of the SGT System is to provide the ability to process effluent from the Primary Containment and Secondary Containment when required to limit the discharge of radionuclides to the environs.

Upon auto-initiation, the SGT System draws air from the Reactor Building, processes the air, and discharges it to the Elevated Release Point (ERP). As this air flows through various piping, the moisture contained within the air condenses. This condensed water is drained to Z Sump. The Z Sump has the active support function of pumping out the collected water, which would otherwise eventually fill the sump and back up into the SGT exhaust line, impeding the flow of air.

The SGT System is specifically designed to mitigate the radiological dose consequences of postulated accidents, and serves an Essential function for that purpose. The SGT System is not required for safe shutdown of the plant following a Safe Shutdown Earthquake (SSE) event.

Based on the above discussion, the Z Sump is classified as Seismic Class IS (Operating Basis Earthquake (OBE) only). The sump design does not include the Seismic Class IS criteria for SSE because Z Sump serves no reactor safe shutdown function and is not required to maintain the reactor coolant pressure boundary.

An additional input of water to Z Sump is from the Off Gas 48" Hold-Up Line. Since the Augmented Off Gas (AOG) third stage air ejector is tripped during the initiation of plant events, this water would cease to flow to Z Sump via the 48" Hold Up Line drain line. An Off Gas dP equalization line and monitoring equipment is installed to equalize the vacuum between the Off Gas 48" Hold-Up line and the Z Sump. In addition the drain piping in Z Sump is sized to limit the inflow of water from the hold-up line.

The Z Sump pumps normally discharge to the Waste Collector Tank. A 3-way valve is installed in this discharge line to allow flow to the Floor Drain Collector Tank as an alternate storage. The Floor Drain Collector tank has a capacity of 20,000 gallons, with the Waste Collector Tank having a capacity of 22,000 gallons, both being emptied and processed regularly. These capacities are more than adequate to handle the SGT line flow of 903 gpd. This also provides sufficient capacity to handle the flow from the Off Gas hold up line. The piping from the sump to the Reactor Building is evaluated to OBE requirements and will retain its integrity to direct any contaminated water from the sump to radwaste. After the piping enters the Reactor and Radwaste Building the piping is Seismic Class IIS, but is seismically restrained to maintain structural integrity. Therefore, it will not impede the ability of this piping to direct all Z Sump discharge to the Floor Drain Collector Tank.

The Z Sump pumps, controls and instrumentation are supplied from Essential power supplies and have been designed and installed in accordance with the single failure criteria of IEEE 279-1968 and the separation requirements of IEEE 384-1981. The conduit routing has been evaluated, and found satisfactory, for the effects of turbine missile impacts.[118]

In all LOCA/LOOP response scenarios the Z Sump heat trace is powered on a delayed basis by the use of a pre-planned repair using an electrical cord from MCC-DG1 or MCC-DG2.

### 14.6.2 Reactor Building Quad Internal Flooding

The Environmental Qualification Rule (10CFR50.49) requires CNS to consider the effects of submergence on electrical equipment important to safety if the equipment is subject to being submerged during a design basis event. The events that have been considered for quad flooding are the High and Moderate Energy Line Breaks (HELB and MELB). In conformance with Draft GDC 2, the Quads are also protected against internal flooding resulting from a seismic event. Environmental Qualification (EQ) program internal flooding calculations indicate Class I Seismic pipe failures to be the worst cases for the Quads. Flooding caused by these Class I Seismic HELBs or MELBs envelope flooding caused by failure of any Seismic Class IIS line.

The Quads are designed to limit the potential for internal flooding in multiple Quads. The ECCS pumps and equipment are located in the Reactor Building 859'-9" elevation in four physically separated Quads adjacent to the common Suppression Chamber area. Dams are installed around grated openings for the NW and SW Quads, on the 903'-6" elevation floor, to prevent an internal flooding path into these Quads. The piping penetrations between the Quads and the Suppression Chamber area that are below the Suppression Pool water level are provided with sealed sleeves. The doors connecting the Suppression Chamber area and the Quads are water-tight bulkhead type, provided with alarm switches which annunciate in the Control Room when a door is not closed.[114]

14.6.2.1 High and Moderate Energy Line Breaks of Seismic Class IS Piping

The postulated HELBs for the Environmental Qualification Program consider the submergence effects that may be caused by circumferential and longitudinal breaks in high energy piping. Moderate energy lines assume a critical crack, not to exceed ½ the pipe diameter in length and ½ the pipe wall thickness in width. An operator response time of 10 minutes is used in the HELB calculations. For the MELB calculations, a response time of 30 minutes is used.

The Maximum Postulated Flood Height (MPFH) as determined by internal flooding calculations for each Quad is as follows:[83]

| | MPFH | Line | Affected System |
|---|---|---|---|
| Northeast Quad | 1.15' | 12" CS | CS, RCIC |
| Northwest Quad | 18.71' | 24" RHR | RHR |
| Southeast Quad | 2.24' | 2" CRD | CS |
| Southwest Quad | 15.71' | 24" RHR | RHR, HPCI |

The MPFH for each Quad was compared to the allowable flood level in each Quad. The allowable flood level in each Quad is based on the height of the lowest installed Environmentally Qualified component in the Quad and is based on formal plant walkdowns. In all the cases above the MPFH exceeds the level of EQ component (MHEQ) except for the Northeast Quad. This is acceptable since the submerged devices are not required to safely shutdown the plant following the line break and these line breaks only affect a single Quad so the other Quads are still available.[83]

A break in an 18" Feedwater line within the Steam Tunnel is the bounding break that would affect all four quads and presents the largest challenge to the plant. The Maximum Postulated Flood Heights following a Feedwater line (MPFH-FW) break as determined by the internal flooding calculations for each Quad are as follows;

Northwest Torus Hatch Plug not Installed

| | MPFH-FW | Affected System |
|---|---|---|
| Northeast Quad | 0.620' | CS, RCIC |
| Northwest Quad | 0.690' | RHR |
| Southeast Quad | 0.00' | CS |
| Southwest Quad | 0.00' | RHR, HPCI |

Northwest Torus Hatch Plug Installed

| | MPFH-FW | Affected System |
|---|---|---|
| Northeast Quad | 0.727’ | CS, RCIC |
| Northwest Quad | 0.851’ | RHR |
| Southeast Quad | 1.612’ | CS |
| Southwest Quad | 0.256’ | RHR, HPCI |

An assumed single failure of the Reactor Building floor drain isolation valve to close on high-high sump level allows propagation in the Northwest, Northeast, and Southeast Quad to exceed MHEQ. However, this is acceptable due to equipment located in the other Quads capable of shutting down and maintaining the plant in cold shutdown. The ten minute time period is sufficient for identification and isolation of the line break.

#### 14.6.2.2 Seismic Failures of Seismic Class IIS Piping

The 8 Quad Floor Drain Sump pumps and part of their discharge piping have been designed to withstand a Safe Shutdown Earthquake (SSE). The Seismic Class IS supports for the discharge piping are terminated 20 feet after passage through the Quad walls into the Suppression Chamber area. The Suppression Chamber area drain piping is embedded in the Reactor Building mat, which is of Seismic Class IS design.

An SSE can cause a failure of portions of the Seismic Class IIS piping or valves, which could result in Quad flooding.[44]

Floor drains in the Suppression Chamber area are connected to sumps in three of the four Quad rooms with Seismic Class IIS drain piping. Assuming a seismically-induced failure of these drain lines upstream of the drain line isolation valve, water would flow into the A, B, and D Sumps (NW, NE, and SE Quads respectively. Assuming a similar failure of the Reactor Building floor drain piping to these sumps upstream of the isolation valves, sump water could backup into the NW, NE, and SE Quads. Since the Southwest Quad has no drain piping from the Suppression Chamber area and since there is a flood dam surrounding the open grating to the quad at the Reactor Building 903'-6" Level, this room is considered isolated from any flooding during an SSE.

An internal flooding scenario from a postulated failure of IIS piping is bounded by the High and Moderate Energy Line Break analyses described in Subsection X-14.6.2.1.

#### 14.6.2.3 Post-Accident ECCS Leakage Considerations

The ECCS Leakage is defined as leakage from ECCS components, such as pump seals, valve packing, and flanges, bypassing Primary Containment barriers into Secondary Containment. The Loss-of-Coolant Accident is the only design basis accident for which ECCS leakage contributes to the radiological dose consequences. As discussed in USAR Section XIV-6.3.8.2, 45,000 cc/min is the assumed ECCS leakage rate during postulated LOCA condition. This is equivalent to a leakage of approximately 3000 cc/min during a test of the ESF system.

During a design basis LOCA, ECCS component leakage is routed directly or indirectly by the radioactive drainage system to the Reactor Building sumps. Since the A, B, C, and D Sump pumps are powered from divisionalized critical buses, they can be expected to operate the duration of the LOCA to maintain the sump level and process drain flow from ECCS component leakage and other Reactor Building sources. In the event that there is a failure of or loss of power to the instrumentation which controls the pumps, the sump will isolate and all drainage intended for that sump would be directed to the Suppression Chamber area for temporary storage to prevent Quad flooding.[100]

### 14.7 Inspection and Testing

Z Sump equipment is functionally tested on a periodic basis.

The remainder of the Equipment and Floor Drainage system is normally in service and requires no testing.

The Equipment and Floor Drainage system is in scope for License Renewal per 10 CFR 54.4(a)(1), (a)(2), and (a)(3) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2), Buried Piping and Tanks Inspection (see USAR Section K-2.1.3), External Surfaces Monitoring (see USAR Section K-2.1.14), Periodic Surveillance and Preventive Maintenance (see USAR Section K-2.1.31), and Selective Leaching (see USAR Section K-2.1.34). There are no Time-Limited Aging Analyses that are applicable.

## 15.0 PROCESS SAMPLING AND POST-ACCIDENT SAMPLING SYSTEMS

### 15.1 Power Generation Objective

The power generation objective of the process sampling system is to monitor the operational performance of station equipment.

### 15.2 Power Generation Design Basis

The process sampling systems shall be designed to:

1. Obtain representative samples in forms which can be used in radiochemical laboratory analysis for determination of station equipment effectiveness.

2. Minimize the radiation effects at the sampling stations.

### 15.3 Description

The Process Sampling System is comprised of multiple points distributed through various systems such as the Reactor Recirculation System (RR), Main Steam (MS), Residual Heat Removal System (RHR), Reactor Water Cleanup System (RWCU), Main Condensate System (MC), Reactor Feedwater System (RF), Service Water System (SW), Turbine Equipment Cooling System (TEC), Reactor Equipment Cooling System (REC), Fuel Pool Cooling (FPC), Water Treatment System (WT), Radwaste System (RW), Off-Gas and Standby Gas Treatment Systems. These points provide sampling for various reasons such as reactor water quality, deaeration, moisture carryover, tube leakage, filter effectiveness, process data, and post accident conditions.

Process Samples are taken from various locations. Sample points are grouped as much as possible at normally accessible locations, and drains are so provided at these locations to limit the risk of contamination. Lines are sized to insure purging and sufficient velocities to obtain representative samples. Samples are taken to the laboratory for appropriate analysis. In addition, continuous automatic monitoring and alarm of undesirable conditions is provided using in-line detectors where necessary.

The Post-Accident Sampling System (PASS) was removed as a required system under License Amendment 250; however, CNS continues to have the ability to obtain samples, utilizing PASS, following an accident.

PASS provides for remote sampling of the reactor coolant water, suppression pool water, and containment atmosphere under conditions where reactor building entrance is prohibited. Remote PASS operation is performed from a panel in the Radwaste Building. PASS wastes are returned to the Drywell Equipment Drain Sump via the sump discharge and recirculation piping (see USAR Section X-14.5.2).[25]

Since the system may be filled with highly radioactive water, the system has been designed to minimize the leakage of sample liquid or gas. The small size of the sample lines also serves as a passive flow restriction to limit reactor coolant loss or containment air leakage in the unlikely event of a sample line failure. Particular attention to reducing or eliminating radiation exposure has been stressed in the system design and the material and equipment selected.

The PASS sample line from Reactor Recirculation loop “A” is isolated by a PCIS Group 7 containment isolation signal. For further details, see Section VII-3.

15.4 Inspection And Testing

PASS Instruments are located in the Reactor Building and Radwaste Building which permits calibration and testing to be performed during reactor power operation.

The Post-Accident Sampling System is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2) and Water Chemistry Control - BWR (see USAR Section K-2.1.39). There are no Time-Limited Aging Analyses that are applicable.

# 16.0 COMMUNICATIONS SYSTEMS

## 16.1 Power Generation Objective

Internal and external communications are established by separate systems of loud-speakers and telephones designed to provide convenient, effective operational communications between various station buildings and locations.

## 16.2 Power Generation Design Basis

1. Voice communications between selected office areas and to points outside the station shall be provided by a telephone system.

2. The Industrial Communication System (Gaitronics) shall provide voice communication and audible or visual warnings for various station buildings and locations using transistorized, industrial quality equipment with the following characteristics:

   a. Satisfactory voice communications shall be possible even in areas of extreme noise.

   b. Multiple separate and independent communication channels shall be provided; i.e., one page and either one or five party line channels. The page channel may be used to call personnel over the speakers, to issue station-wide instructions, or for intercommunication between two or more handset stations.

   c. All system speakers shall carry the conversation during the page mode of operation.

   d. A party line channel shall be used for intercommunication after the page call is completed, thereby making the page channel available to others.

   e. Simultaneous conversations may take place on the page and party channels without interference.

3. The maintenance and special operation system (sound powered phones) shall provide voice communication using one independent party line. This system shall be provided for use in areas requiring maintenance or special communication.

   a. Portable equipment shall be provided using permanent plug-in receptacles.

   b. Receptacles to be provided at selected locations which shall be wired to a patchboard located in the Control Room. The patchboard shall allow for making interconnections between different areas.

4. Voice communication shall be provided between selected safe shutdown locations to facilitate operator actions following a fire.

5. Voice communication for fire fighting teams shall be provided via three self-contained two-way radios for their exclusive use.

## 16.3 Description

The station communication systems are as follows:

1. The public telephone system furnished and installed in accordance with an agreement between NPPD, owner of the system, and the local telephone company consisting of components described below:[48]

a. Telephones are located in selected office areas and are connected to an automatic switchboard providing communication between the office areas within the station and the District's offices at other locations.

b. Telephones are located in selected areas (Emergency Operations Facility (EOF), Main Control Room, Operations Support Center (OSC), and Technical Support Center (TSC)), which are connected to the local community (Brownville) exchange providing communication between the areas within the station and the local community.

2. The Industrial Communication System is installed throughout the station site. The components of the system receive power from the 120 volt AC No-Break Power System. An alternate supply is also available through the Critical Power Panel. The components are described below.

a. Speakers of various types are provided throughout the station for paging, public address, and carrying the evacuation warning signal. Each speaker was selected to insure adequate sound coverage through the area that the speaker covers.

b. Handsets are provided throughout the station, each with access to the page channel and either one or five party line channels. To call an individual, the page line channel is actuated by pressing the paging mechanism, the individual is paged throughout the station site, and a party line is used for conversation. The page channel may be used for conversation and emergency instructions as an additional line of communication. While paging, handsets mute nearby speakers to eliminate system feedback. The system is functional in high noise areas without soundproof booths.

c. Emergency signals (fire, evacuation, all clear) are generated by a tone generator located in the Main Control Room[57] or the Simulator Control Room. An emergency signal for an actual event is initiated from the Main Control Room. A keylocked transfer switch (located in the Simulator Control Room) allows emergency signals to also be initiated from the Simulator Control Room during drills. The emergency signals are carried over the paging channel and all of the speakers, and override any ongoing conversations on the paging channel.

d. Certain high-noise areas have strobe lights installed to augment the audible alarms. These strobes are activated automatically with the initiation of the emergency alarms.

e. The Industrial Communication System is divided up into eleven separately fused zones, so that if one zone is lost due to malfunction of equipment or a postulated fire scenario, the other zones will continue to function. The exception to this is if the postulated fire scenario occurs in the Cable Spreading Room, Zone 2, Control Building, Elev. 918'-0".

The zones are as follows:

| | |
|---|---|
| ZONE 1 | Reactor Building |
| ZONE 2 | Control Building |

| | |
|---|---|
| ZONE 3 | Turbine Generator Building<br>Diesel Generator Building<br>Intake Structure |
| ZONE 4 | Water Treatment Area<br>Machine Shop<br>South Substation<br>East Warehouse<br>South and Southeast Out Buildings |
| ZONE 5 | Multi-Purpose Facility (MPF) Building<br>Condensate Storage Tank Yard Area<br>North Out Buildings and Area |
| ZONE 6 | Security Building<br>Communications Building<br>Craft Change Building |
| ZONE 7 | Training Building |
| ZONE 8 | Office Building |
| ZONE 9 | Radwaste Building<br>Augmented Radwaste Building |
| ZONE 10 | West Warehouse |
| ZONE 11 | Technical Support Building |

f. Plant designated Operations Areas shall contain the six channel (1 page and 5 party line channels) system. All other areas shall remain two channel (1 page and 1 party line).

g. Channel 1 of the six channel system corresponds with the single party line of the two channel system.

3. Maintenance and special operation system is installed throughout the station. Since the components of the system are sound powered, no electrical power supplies are required. The components are described below:

a. Portable handset/speakers are provided. The set must be plugged in to one of the many receptacles to establish a conversation.

b. Receptacles are provided throughout the station at selected locations such as instrument racks.

c. A central patch panel is provided in the Control Room which can interconnect multiple receptacles or groups of receptacles.

4. A dedicated line exists from the Main Control Room to the dispatching center over a leased telephone line.

Voice communications are provided between selected safe shutdown locations to facilitate operator actions following a fire.

Voice communication for fire fighting teams is provided via three self-contained two-way radios for their exclusive use.

Microwave facilities exist to provide a method of transmitting information for control, relaying, telemetry, and voice communication to offsite organizations.[45]

## 16.4 Inspection and Testing

The design of the system permits routine surveillance and testing without disrupting normal communication facilities.

## 17.0 STATION LIGHTING SYSTEM

### 17.1 Power Generation Objective

The station lighting systems shall provide adequate normal and emergency station lighting using reliable system components, with power supplied from normal and critical AC sources or from the station battery system.

### 17.2 Power Generation Design Basis

1. Lighting intensities shall be maintained at levels recommended by the Illuminating Engineering Society.

2. Lighting fixtures shall be mercury vapor, metal halide, fluorescent or incandescent type selected with due consideration for environmental conditions and ease of maintenance. Mercury and metal halide fixtures and mercury switches shall not be used inside the primary containment.

### 17.3 Description

The normal service lighting system receives power from the normal service buses of the auxiliary power distribution system, described in Chapter VIII. Fluorescent fixtures throughout the station are provided for 120/208 volts 3-phase, 4-wire or 277/480 volts 3-phase, 4-wire service. Incandescent fixtures are provided in some areas for 120 volt AC 3-phase, 4-wire service. Mercury vapor or metal halide fixtures for high bay lighting are provided for 277/480 volt service.

The emergency service lighting system is divided into two sub-systems:

1. The AC sub-system receives power from the critical service buses of the auxiliary power distribution system, described in Section VIII-4. Fluorescent fixtures in most areas required for control and maintenance of safety related equipment and a minimum of one egress route from each floor of the station are provided for 120 volt AC, 3-phase, 4-wire service. Incandescent fixtures in the remaining areas required for control and maintenance of safety related equipment and a minimum of one egress routed from each floor of the station are provided for 120 volt AC, 3-phase, 4-wire service. All of these AC fixtures are normally lighted.

2. The DC sub-system (fed from AC sources) consists of battery operated lighting fixtures which shall be available in a quantity and size to permit maintenance of emergency power sources. They shall be available in the Control Room, Battery Room, Diesel Generator Rooms, critical service switchgear areas, stairways and exits.

### 17.4 Inspection and Testing

Design permits routine surveillance and test of all emergency lighting systems without disrupting normal lighting service.

# 18.0 OPTIMUM WATER CHEMISTRY (OWC) SYSTEM

## 18.1 Power Generation Objective

The power generation objective of the Optimum Water Chemistry (OWC) System is to prevent and reduce the growth rates of inter-granular stress corrosion cracking (IGSCC) in recirculation piping and wetted reactor vessel internals.

## 18.2 Power Generation Design Basis

Reduce the electrochemical potential of reactor coolant surfaces below $-230mV_{SHE}$ (SHE= Standard Hydrogen Electrode).

## 18.3 Description

The OWC system consists of the Hydrogen/Oxygen Generation and Injection, Electrochemical Corrosion Potential (ECP) rack, Mitigation Monitoring System (MMS) panel, Depleted Zinc Oxide (DZO) Injection and Noble Metal Application. The ECP rack/MMS panel and the Noble Metal application are used to satisfy the power generation design basis.

### 18.3.1 Electrochemical Corrosion Potential Rack and Mitigation Monitoring System Panel

The Electrochemical Corrosion Potential (ECP) rack and Mitigation Monitoring System (MMS) panel work together to routinely monitor the electrochemical corrosion potential of the primary reactor coolant surfaces and the noble metal deposition. Reduction of oxidants results in a reduction of the electrochemical corrosion potential. When the electrochemical corrosion potential value is below $-230mV_{SHE}$ IGSCC crack initiation stops and crack growth rates are minimized.

The MMS panel takes inputs from the ECP rack, namely ECP probe and temperature data, and converts the Electrochemical Potential for the reactor coolant system to the SHE scale.

### 18.3.2 Depleted Zinc Oxide Injection Skid

Depleted zinc is typically injected into the reactor feedwater so that it may displace CO-60 within the RCS, and thereby reduce shutdown dose rate.

The Depleted Zinc Oxide (DZO) Injection skid consists of piping, a vessel containing deleted zinc oxide pellets, valves and associated instrumentation to monitor flow. Reactor feedwater is supplied to the DZO skid via a tap located downstream of the reactor feed pump 'B' while the return line from the skid connects with the reactor feed pump common supply header.

### 18.3.3 Noble Metal Application

A microscopic layer of noble metal has been applied on wetted reactor vessel and reactor coolant system surfaces. The Classic NobleChem process utilizes platinum and rhodium as the noble metals while the On-Line NobleChem (OLNC) process utilizes only platinum. These noble metals act as catalysts to enhance the recombination of free oxygen and hydrogen. This reduces the total concentration of hydrogen to be routinely injected during power operation, to obtain an ECP value of $\leq -230mV_{SHE}$, into the Feedwater and Condensate system.

The noble metal has no adverse impact on plant components and can be reapplied, when necessary, to ensure the desired ECP values are achieved. The Classic NobleChem application is performed during plant shutdowns, with equipment installed temporarily in the reactor building during the time of application. The OLNC application is performed while the plant is operating in Mode 1 at reactor core flow >75%, with injection equipment installed in the turbine building.

### 18.3.4 Hydrogen/Oxygen Application

To reduce the quantity of oxidants in the reactor coolant, the OWC System injects hydrogen into the condensate/feedwater systems at the suction of the condensate booster pumps via the Hydrogen Injection Module. The injected hydrogen suppresses the radiolytic formation of oxidants in the reactor core.

To maintain a stoichiometric mixture of hydrogen and oxygen in the offgas system, the OWC System also provides an oxygen supply upstream of the offgas recombiner via the Oxygen/Air Injection Module (Air supplied by Instrument Air). With the oxygen (Instrument Air) injection at this point, the offgas system operates as intended prior to the OWC addition. This portion is used as a backup to the normal bleed air in the AOG system.

To counter the effect of a reduced dissolved oxygen concentration in the feed and condensate systems, the OWC System injects a small amount of oxygen into the Condensate Pump discharge piping, via the use of the Oxygen Injection Module.

The function of the OWC Gas Generation Building is to provide suitable protection from the elements and to house the gas generation equipment.

## 18.4 Inspection and Testing

No special tests are required because the MMS panel/ECP rack and the DZO skid are normally in operation.

The Optimum Water Chemistry System is in scope for License Renewal per 10 CFR 54.4(a)(2) and was subject to aging management review. Aging effects are managed by the following Aging Management Programs: Bolting Integrity (see USAR Section K-2.1.2) and Water Chemistry Control - BWR (see USAR Section K-2.1.39). There are no Time-Limited Aging Analyses that are applicable.

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