## 8.1 Input Parameters

The balance-of-plant (BOP) input parameters used for the Kewaunee Nuclear Power Plant (KNPP) power uprate are based on BOP heat balances developed at the Nuclear Steam Supply System (NSSS) power level of 1780 MWt. The BOP secondary plant system and component parameters were developed from the heat balance mass flow and temperatures. A hydraulic flow model was developed to determine the secondary plant expected operating flow and pressure at the power uprated conditions. System calculations were prepared to determine the impact of the power uprate. BOP/NSSS interface parameters for BOP support systems were developed from revised cooldown and accident analysis documented in the NSSS evaluations.

## 8.2 Heat Balances

Heat balance models for the Kewaunee current and power uprate conditions were developed to determine the impact of the increased NSSS power. The model was tuned to match recorded plant field data taken at the current 100-percent power level. The tuned model then served as the baseline to predict the performance of the BOP thermal cycle for the 7.4-percent power uprate at a steam generator operating pressures of 767 psia to 797 psia. The power uprate heat balances were made with the same steam turbine geometry and performance characteristics as the currently installed turbine (that is, no replacement or steam path modifications). The power uprate heat balances were used to perform the evaluation of the BOP systems at the power uprated conditions. The following heat balances were developed:

- Current base case (current power level of 1656 MWt)
- Uprated power level of 1780 MWt at 767 psia steam generator pressure
- Uprated power level of 1780 MWt at 782 psia steam generator pressure
- Uprated power level of 1780 MWt at 797 psia steam generator pressure

## 8.3 Systems Assessments

### 8.3.1 Main Steam System and the Steam Dump System

#### 8.3.1.1 Introduction and Background

The Main Steam System (MSS) transports saturated steam from the steam generators to the high-pressure turbine. The Steam Dump System provides a steam flow path to the condenser and/or atmosphere bypassing the turbine. This feature helps accommodate turbine load transients without reactor trip. The MSS also supplies steam to a number of plant auxiliaries including the following:

- Moisture separator reheaters
- Turbine gland seal steam
- Condenser air ejectors
- Hogging jet
- Turbine-driven auxiliary feedwater (AFW) pump
- Plant auxiliary steam loads including, Heating Steam System, and the Carbon Dioxide Fire Protection (FP) System heat exchanger

The portions of the MSS from the steam generators up to and including the main steam isolation valves (MSIVs), the steam generator power-operated atmospheric relief valves (PORV), and the main steam safety valves (MSSVs) are designed as safety related. The MSS supply to the turbine-driven AFW pump including the turbine drive exhaust piping is also safety-related. The balance of the MSS and the Steam Dump System is non-safety related.

#### 8.3.1.2 Description of Analyses

The MSS and Steam Dump System components (main steam [MS] piping and MSIVs were evaluated to ensure they are capable of performing their intended functions at power uprate conditions thereby ensuring the functionality of the MSS and Steam Dump System at power

uprate conditions. The evaluations compared design parameters of the MSS components with power uprate conditions to ensure margin exists. Specifically:

- The MSS piping was evaluated for expected power uprate pressure, temperature, and flow velocity conditions. Pressure drops through MSS and steam dump piping at power uprate conditions were calculated. The calculated pressure drops were also utilized to determine turbine capacity and throttle inlet conditions. The MSS drain system was also evaluated for power uprate conditions.

The MSS safety, steam dump, and MSIVs performance capability was evaluated as documented in Section 4.2.

#### 8.3.1.3 Results

**Main Steam Isolation Valves**

The flows passed by the MSIVs at power uprate conditions will increase approximately 8.6 percent. These steam conditions at power uprate will cause the pressure drop through these valves to increase approximately 10 percent from the current conditions. The resultant relatively minor increase (0.4 psi is the greatest increase) does not affect the operation of the MSIVs.

The MSIV bypass lines and valves are used for warming and pressure equalization functions at no load and low load operation conditions; the change in full-load operation conditions due to power uprate will not impact performing these functions. Additionally, the design pressure and temperature of the bypass valves bound the steam supply conditions at power uprate.

**Main Steam Piping**

Power power uprate will result in an MS flow rate increase of approximately 8.4 percent with a steam generator steam outlet operating pressure increase of approximately 7.6 percent.

The MSS design pressure of 1100 psia bounds the power uprate operating condition of 797 psia. Additionally, the highest normal operating pressures and temperatures occur at no load conditions. These conditions are not affected by the power uprate.

Pressure drop and flow velocities through MS piping from the steam generators to the turbine control and stop valves and through the steam dump piping were calculated at current and power uprate conditions.

Most calculated MS flow velocities at power uprate do not exceed the previously accepted recommended maximum values for continuous operation. The exception is that the calculated flow velocities through the 18- and 8-inch diameter lines to the steam dump valves exceed the recommended maximum value (Stone & Webster [S&W] standard practice) at current and power uprate conditions. However, since the Steam Dump Systems are operated in an intermittent manner and at conditions less than full power (that is, during plant start up and cooldown, and sudden load reductions), which will not change with the implementation of power uprate, the piping velocities are acceptable for the power uprate.

The moisture separator reheater evaluation is addressed in subsection 8.3.7. Each moisture separator reheater has three vent paths (the flow path to the condenser is used during start up, one of the two vent paths to FW heaters is normally closed) and each is fitted with a control section. Evaluation by the main turbine supplier identified that the use of just one path open to FW heaters at power uprate conditions will not be adequate to pass the required scavenging steam flow. Therefore, both paths will be used at power uprate conditions. If one path must be removed from service for any reason, the path to the condenser could be used to ensure adequate flow.

The MS flows required by the Gland Steam System, main condenser air ejectors and heating steam, are small flows (<3 percent) in terms of the MS total flow, and are not appreciably changed by implementation of power uprate. The operation of these systems and components, and their ability to perform their functions, are not affected by the power uprate.

Drain flow from the MSS will remain similar to the current drain flow. Based on the current and power uprate heat balances, MS quality is 0.9990. This value is higher than the original design steam quality of 0.9975. In addition, modifications were made at the time of the steam generator replacements to improve the moisture removal ability of the steam generators. Therefore, while MS flow will increase at power uprate conditions the expected drain flow due to the moisture in the steam is still below original design. Drain flow due to start up operations is not affected by the power uprate since this is a low/no load condition.

The MS power-operated relief valves' (PORV's) and the steam generator power-operated atmospheric relief valves' actuation points and the MS safety valves' and the steam generator safety valves' and the MS safety valves' setpoints are not affected by the power uprate and no steam pressure setpoints are affected. The MS pressure range is not affected since the lowest safety valve setting does not change. The MS pressure instruments still conform to Regulatory Guide 1.97 requirements at the power uprate conditions.

*Section 4.3 discusses the review of the NSSS control systems setpoints for the power uprate* conditions and remain applicable for the power uprate conditions. Results indicate adequate margin to protection systems setpoints. Therefore, the Steam Dump System instruments and controls are not impacted by the power uprate conditions.

The steam generator steamline flow instrument loops are also not affected by the power uprate. The existing Regulatory Guide 1.97 MS flow instruments still conform to Regulatory Guide 1.97 requirements.

The Regulatory Guide 1.97 ranges for the steam generator wide and narrow range level instruments are defined by the physical structure of the steam generators. Since the power uprate does not affect the physical structure of the steam generators, the existing Regulatory Guide 1.97 steam generator level instruments still conform to Regulatory Guide 1.97 requirements.

#### 8.3.1.4 Conclusions

The steam pressures and temperatures associated with power uprate are bounded by the designs of the MS and its components with margin.

The MS flow velocities and pressure drops at power uprate remain acceptable. The MS safety, MSIV, power-operated, and steam dump valve design capacity remains adequate for the power uprate.

### 8.3.1.5 References

1. PEPSE Heat Balance No. 13225-HB(D)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

2. PEPSE Heat Balance No. 13225-HB(B)-204-1, 1757 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

3. PEPSE Heat Balance No. 13225-HB(B)-207-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

## 8.3.2 Bleed Steam System

### 8.3.2.1 Introduction and Background

The Bleed Steam System conveys steam extracted from various stages of the high-pressure and low-pressure turbines to the shell side of the FW heaters and to the moisture separator side of the moisture separator reheaters. The Bleed Steam System also includes vent paths from the moisture separator reheaters, heater drain tank, and the FW heaters. The moisture separator reheater and heater drain tank vents are included in this section; the FW heater vents are included in subsection 8.4.2.1.7.

Bleed steam is supplied to FW heaters 15A and 15B (15A/B) from the high-pressure turbine. Heater 14A/B is supplied with steam from the high-pressure turbine exhaust lines. Bleed steam is supplied to FW heaters 13A/B, 12A/B, and 11A/B from the low-pressure turbine. The extractions to each of the FW heaters 14A/B and 15A/B are drawn from two nozzles on the high-pressure turbine or turbine exhaust lines. Nozzles and associated piping combine into a single line for each pressure, and then split into two lines to feed the two half-sized FW heaters. Moisture separator reheaters reheating steam is drawn from the MSS header upstream of the high-pressure turbines.

The extractions from the low-pressure turbines are contained in the condenser neck to FW heaters 11A/B, 12A/B, and 13A/B. Each low-pressure turbine has four lines to heater 11, two lines to heater 12, and one line to heater 13.

Two common extraction lines to FW heaters 14A/B and 15A/B are equipped with non-return valves (NRVs) and motor-operated shutoff valves (MOVs). The NRVs prevent reverse steam flow and limit turbine overspeed after a turbine trip. The MOVs close on high FW heater water level to prevent water induction into the turbine. For FW heaters 13A/B, 12A/B, and 11A/B, no valves are in the bleed steam inlets. Upon high-water level for these heaters, the bypass line dump valve to the condensers is opened automatically. Refer to subsection 8.3.3 for additional details on the FW heaters.

#### 8.3.2.2 Description of Analysis

The Bleed Steam System was evaluated to ensure its ability to supply steam to the FW heaters at the power uprate conditions. Existing design parameters were reviewed and compared against power uprate conditions for system acceptability.

#### 8.3.2.3 Results

The bleed steam flows and process conditions at power uprate conditions increase at the various extraction points.

**Component Design Pressures / Temperatures**

The Bleed Steam System pressures and temperatures predicted at power uprate conditions are bounded by the system component design conditions except for heaters 13. The originally specified design temperature for thermal movements and reactions for associated extraction piping as part of the condenser will be exceeded at power uprate conditions by less than 0.7°F (Reference 7). This difference is considered acceptable since this value is within the analytical tolerances of piping and components for stresses and internal loads.

Relative to pressure/temperature design, the Bleed Steam System meets requirements for operation under the power uprate condition.

**Extraction Line Pressure Drops**

Based on comparison of the current and power uprate heat balances for the lower pressure heaters, the extraction line pressure drop from the turbine to FW heaters has increased. This results in a slight reduction in shell-side temperature and pressure, as well as a slight

degradation of heater (and overall cycle) thermal performance. The higher pressure heaters' calculated pressure drops tend to be lower than the heat balance model results. This results in slightly higher shell-side pressure and temperature conditions as well as a slight increase in thermal performance. Additionally, the higher pressure heater performance tends to have a greater effect on the overall cycle thermal performance. Therefore, the expected result of the calculated pressure drops on the power uprate heat balances would be similar or slightly better thermal performance.

**Piping Velocities**

Power uprate conditions had a maximum increase of 5 percent over the baseline case. All lines and nozzles that had velocities exceeding Heat Exchange Institute, Inc. (HEI) recommendations for baseline conditions also exceeded them for the power uprate conditions. The only additional line exceeding HEI recommendations is to heater 14B, which for power uprate conditions increases a maximum of 3.3 percent over HEI recommendations. This condition may result in some additional noise, vibration, and erosion, and will be monitored.

The bleed steam power uprate process conditions require updating of the Flow-Accelerated Corrosion (FAC) Program.

**Fluid Flow Regimes**

A review of the Bleed Steam System piping shows that it will support proper operation at the power uprate conditions.

**Drainage Provisions**

The required drainage capacity is not impacted by power uprate.

**Entrained Energy for Turbine Overspeed Protection**

Results indicate that with the present trip settings, the unit would overspeed to 121 percent at the power uprate conditions, which slightly exceeds the 120-percent overspeed design. Therefore, an adjustment to the overspeed trip setting is recommended. The recommended power uprate settings are as follows:

| Overspeed Trip | Current Setpoint | New Setpoint |
|---|---|---|
| Mechanical | 111% | 109% |
| EHC | 111.5% | 109.5% |
| ROST | 111.5% | 109.5% |

These setpoint changes will be made prior to 7.4-percent power uprate.

**Extraction Line Isolation Valve Closure Times**

The maximum flooding rate is not a function of full load operating conditions, and thus power uprate has no impact on the required closure time. Design closure time for these valves is unaffected by the power uprate.

**Vent Lines**

The heater drain tank is maintained at the same pressure as heater 14 via a vent line. At power uprate conditions, this line is expected to continue satisfactory operation with a possible minor increase in flow.

The extraction steam side of the moisture separator reheater is fitted with an excess steam vent. This connects to the extraction line to heater 15. While power uprate conditions may increase (due to increased reheat flow) the vent line flow, these lines are expected to continue to operate similarly to current operation.

The level, pressure, and temperature instruments and controls in the Bleed (Extraction) Steam System are acceptable for power uprate conditions based on the results of the evaluation. The turbine overspeed trip setting will be adjusted to accommodate Bleed (Extraction) Steam System conditions for the power uprate.

#### 8.3.2.4 Conclusions

The Bleed Steam System evaluation has determined that the Bleed Steam System is acceptable for operation at the power uprate conditions, with the adjustment of the turbine overspeed trip setting to accommodate power uprate conditions.

#### 8.3.2.5 References


1. Heat Balances:

   a. PEPSE Heat Balance No. 13225-HB (D)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

   b. PEPSE Heat Balance No. 13225-HB (B)-205-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 782 psia), March 20, 2002.

   c. PEPSE Heat Balance No. 13225-HB (B)-206-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 782 psia), March 20, 2002.

   d. PEPSE Heat Balance No. 13225-HB (B)-207-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.


### 8.3.3 Condenser and Feedwater System

#### 8.3.3.1 Introduction and Background

The FW/condensate train is the closed type with de-aeration accomplished in the condenser. Condensate is taken from the condenser hotwell by the condensate pumps and pumped through air ejector and gland steam condensers and low-pressure heaters to the suction of the FW pumps. The FW pumps then send FW through the high-pressure heater stage to the FW control valves and then to the steam generators.

The condenser is the double-flow, single-pass type with fabricated steel water boxes at both ends. The hotwell has sufficient storage for 3.4 minutes operation at maximum throttle flow with an equal free volume for surge protection. It has two condensate outlets from one shell with a hotwell crossover between shells. The steam-jet air ejector maintains a vacuum in the condenser. Refer to subsection 8.3.5 for additional condenser details and evaluations.

There are two-multistage, vertical, pit-type centrifugal condensate pumps with vertical-motor drives. Each condensate pump is designed to provide 5650 gpm with a total discharge head (TDH) of 895 ft under normal conditions. The condensate pumps are started and stopped by manual controls on the main control board.

The first, second, and third stage low-pressure FW heaters and the fifth stage high-pressure FW heater (numbers 11, 12, 13, and 15) are provided with level control valves. There are no level controls for the moisture separators and the number 14 heaters, which drain to the heater drain tank by gravity flow. The number 11 and 12 low-pressure heaters are combined into one heater shell (duplex) with bolted head construction. Duplex heater 11/12 and heater 13 are located in the condenser neck.

An automatic bypass is provided around the low-pressure heaters to ensure sufficient suction pressure at the FW pumps during a transient and to restore normal level in the steam generators after a loss of external electrical load. Without this bypass, flashing might occur at the FW pump (FW pumps) suction due to loss of heater drain pump flow. This bypass is also used when FW heaters are out of service for maintenance or repair.

The two main FW pumps are single-stage, constant-speed, motor-driven, centrifugal pumps with barrel casings. Each FW pump is rated at 9250 gpm and 2050-ft. TDH. Since the FW pumps operate in series with the condensate pumps and depend on the condensate pumps for continuous water supply to the suction, the number of condensate pumps operating must be equal to or greater than the number of FW pumps operating. Interlocking of condensate-pump trip to FW-pump trip is provided to ensure that this condition is met.

The two main FW pumps discharge through check valves and motor-operated gate valves. The FW then flows into a common header. Two 16-inch lines containing the FW Control Systems feed the two steam generators from the header. Each FW Control System consists of one main FRV and one bypass FRV in parallel.

#### 8.3.3.2 Description of Analysis

The Condensate and FW System was evaluated at power uprate conditions for the following:

- System piping pressures and temperatures

- FRV operation and expected position at power uprate conditions
- Condensate and FW pumps operation at power uprate conditions, including flow capability, discharge pressure, and net positive suction head (NPSH)
- FW heater shell and tube operation (pressure, temperature, flow rate)

A hydraulic flow model of the Condensate and FW System was used to evaluate system performance under normal and transient conditions. Ten cases were evaluated. The model analyses included runs to simulate existing plant conditions, and to evaluate plant power uprate normal and transient conditions. The model was also used to determine FW pumps performance and FRV valve trim performance via pressure drop information.

**System Piping Pressure and Temperature**

The expected system pressure and temperatures were obtained from the power uprate heat balances and the hydraulic model calculation. These values were compared to the design specifications.

**Feedwater Control Valve Operation**

The hydraulic model determined the expected power uprate pressure drop across the FRVs. This pressure drop, and the FW flow, was used to evaluate the required valve flow coefficient (Cv), also included in the hydraulic calculation.

**Condensate/Feedwater Pump Operation**

The hydraulic model and supporting calculation evaluated pump operation at power uprate conditions.

**Feedwater Heaters**

The FW heaters were evaluated based on design parameters and expected power uprate operating pressures, temperatures, and flow rates for the tube and shell sides. The power uprate conditions and design information was obtained from the heater specifications sheets and the current conditions heat balance. The power uprate conditions were obtained from the power uprate conditions heat balances and the hydraulic model calculation. The expected

power uprate pressure and temperature were compared to the design values. The drain line inlet energy was reviewed. The adequacy of the safety valves and vents lives was also evaluated.

Modeling to assess tube vibration was performed.

**Transient Review**

The Condensate and FW System's capability to support the plant design basis load transient has been evaluated for the power uprate conditions. The capability of the Condesate and FW System pumps were reviewed to evaluate the maximum step load decrease the plant is designed to accommodate without reactor trip (50 percent), and reviewed the capability of the Condensate System to provide adequate flow to match FW flow and maintain sufficient FW pumps NPSHa. (Section 8.6 discusses the transient analysis and conclusions.)

### 8.3.3.3 Results

**System Piping Pressure and Temperature**

The adequacy of the condensate and FW piping under power uprate conditions was reviewed to ensure that the operating pressure and temperature of the piping are within their design values and in compliance with applicable codes.

The system pressure at the power uprate, both during normal operating and transient conditions, is enveloped by the system design pressure.

With the exception of the piping from heater 14 to the FW pumps suction, all piping is bounded by the design temperature for both power uprate power levels. The change factors for this pipe section are:

| | Operating Temp. °F | Difference from Design, °F | Change Factor from Design | Change Factor from Current |
|---|---|---|---|---|
| Current | 360 | 10 | 1.036 | N/A |
| 6-% Uprate | 365 | 15 | 1.054 | 1.017 |
| 7.4-% Uprate | 366 | 16 | 1.057 | 1.021 |

*The change factor is (Uprate temp – 70°F)/(Current or Design temp – 70°F).

The above change factors are minor. Current and power uprate conditions show a 10°F and 16°F difference above design temperature, respectively. The KNPP Piping Specification allows a maximum temperature of 650°F for the same pipe at a maximum pressure of 400 psi. As this pressure is not exceeded at power uprate conditions, this section of pipe is considered acceptable.

The increase in flow rate and velocities, as well as changes in operating pressure and temperature, can affect pipe corrosion/erosion rates and will be incorporated into the Kewaunee FAC Program as part of power uprate implementation.

### Feedwater Control Valve Operation

The analysis used in the hydraulic model indicated that the current valve Cv would not be adequate to support power uprate operations. The FRV trim will be replaced. The design will be based on the following parameters:

### Condensate Pumps

The condensate pumps have sufficient head and capacity margin to support the power uprated plant conditions. The new operating points for the condensate pumps are within design parameters for flow, turbine-drivenH and NPSH.

### Feedwater Pumps

The FW pumps have sufficient head and capacity margin to support the power uprated plant conditions. The new operating point for the FW pumps, while above the design point, is within design curve limits for flow, head and NPSH.

The FW pumps available NPSH is not adequate for the 50-percent load rejection transient or a 50-percent reduction in heater drain flow with normal condensate flow. For both scenarios, the low-pressure FW heaters need to be bypassed to obtain adequate available NPSH. With the low-pressure FW heaters bypassed, adequate NPSH is maintained for continued FW pumps operation.

**Feedwater Heaters**

**Tube Side**

The FW heater tube-side pressure and temperature design conditions are bounding for power uprate conditions. Power uprate temperatures remain lower than rated.

Tube-side mass flow rate and flow velocity will exceed the design values. However, the power uprate flow velocities remain bounded by HEI standards.

The FW heaters have tube-side relief valves. These valves are designed to provide overpressure protection from thermal effects when the tube side is completely isolated. Therefore, these valves are not affected by the power uprate.

**Shell Side**

All power uprate operating temperatures and pressures are bounded by design.

The current extraction steam flow to heater 13 is predicted, based on the current conditions, to exceed the design flow by approximately 3 percent. For the 7.4-percent power uprate conditions, heater 11 extraction steam flow will remain bounded by design. The remaining extraction and drain flows exceed the design conditions. Heater 13 has the largest increase over design (13-percent at 7.4-percent power uprate conditions). The increased drain flow will increase velocities in the heaters and require the heater drain control valve to open further.

The extraction steam flow increase to beyond design conditions will increase the potential for tube erosion and vibration. For cascaded heater drains, the increase in drain flow combined with changes in the operating pressure of the heaters results in drain inlet conditions that are beyond HEI recommendations. This also may result in increased erosion and deterioration of heater components. Tube vibration modeling results were acceptable. An inspection and monitoring program will be established to monitor potential heater degradation at the power uprated conditions. Initial inspection and analyses will be accomplished to establish a baseline prior to the implementation of the power uprate.

The heater drain inlet velocities and energy ("rho-v squared") are above HEI standards for heaters 11 and 12. Depending upon velocity and energy of the flow draining into the heater,

accelerated erosion of heater baffles and walls could result. Normal operating heater pressure is currently lower than design. This results in a higher specific volume of the drain flow and greater drain inlet energy.

Inspections will be performed and attention will be placed on evaluations of current erosion conditions in the heater drain baffles and shells, as well as increased monitoring for additional erosion due to power uprate.

The shell-side relief valve set points of FW heater 14 and 15 are not affected by the power uprate. The design capacity of the safety valves is not affected by the power uprate. Both the heater shell and pressure vessel pressures remain bounded by the design pressures. In case of a tube failure at power uprate, the conditions are bounded by the system design conditions; therefore, the design conditions bound power uprate operation of the heater shell-side safety valves.

Operating vents are installed on all heater shell sides to prevent non-condensable gas buildup in the heaters. There is adequate margin in all vent lines to support power uprate operations. Excessive gas buildup is not anticipated.

The power-uprate-related changes will be incorporated into the Kewaunee FAC Program as part of the implementation of the power uprate.

Inspection of the current conditions of the heaters, as well as monitoring of heater conditions during power uprate operation, is recommended.

The existing ranges of the Condensate System temperature and pressure instruments are acceptable for the power uprate. Instrumentation and controls in the Condensate System are not affected power uprate.

Gland Seal System instruments and controls are not affected power uprate since the Gland Seal System is not impacted by the implementation of power uprate.

The ranges of the other instruments monitoring the FW System are acceptable for the power uprate conditions. The feedwater bypass flow nozzle flow transmitter and indicator maximum calibration value is only about 103 percent of the calculated operating flow at the power uprate. This is acceptable since the instruments are only used during the calorimetric for a short time

and are not monitoring operating transients. The FW heater water level instruments and controls are not affected by the power uprate.

The existing Regulatory Guide 1.97 FW flow instruments still conform to Regulatory Guide 1.97 requirements.

#### 8.3.3.4 Conclusions

The Condensate and FW System (except FRVs) is adequate to support both power uprate power levels. The analysis concluded that the existing FRVs would need replacement trims in order to support the 7.4-percent power uprate plant conditions. Additionally, the FW pumps available NPSH is not adequate for the 50-percent load rejection transient or a 50-percent reduction in heater drain flow with normal condensate flow. The low-pressure FW heaters will be bypassed to support these conditions (similar to current operation). The current setpoint of 220 psig at which automatic bypass of the low-pressure FW heaters is initiated is acceptable for power uprate operation.

At power uprate conditions, the FW heaters will be operating beyond their design conditions. (Current operation also exceeds some heater design conditions.) This could result in tube vibration and increased erosion rates of heater components. The increased flow rates will require FAC Program monitoring of the heater components. The results of this monitoring will identify any replacements or modifications to the existing heater components.

#### 8.3.3.5 References


1. PEPSE Heat Balance No. 13225-HB(D)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

2. PEPSE Heat Balance No. 13225-HB(B)-207-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

3. PEPSE Heat Balance No. 13225-HB(B)-205-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 767 psia), March 20, 2002.

4. PEPSE Heat Balance No. 13225-HB(B)-206-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 782 psia), March 20, 2002.

### 8.3.4 Steam Generator Blowdown System

#### 8.3.4.1 Introduction and Background

The Steam Generator Blowdown System (SGBS) (in combination with the Chemical Injection System [CIS]) is used to control the chemical composition of the steam generator shell-side water and controls the buildup of solids in the steam generator water.

During normal operation, blowdown is conveyed to the main condenser hotwell. Other modes of operation allow the blowdown flow to be directed to the Circulating Water System (CWS) (via either the blowdown tank or the Condensate Heat Recovery System), the holdup tanks, or the monitoring tanks.

#### 8.3.4.2 Description of Analysis

The SGBS is evaluated in terms of the effect of the power uprate on blowdown flow, design pressure and temperature. When expected power uprate operating parameters remain bounded by design the system was considered acceptable with no additional analysis required.

The required blowdown rates are based on chemistry control and tubesheet sweep requirements and are not parameters impacted by the power uprate. The required flow range (15 gpm minimum and 100 gpm maximum) is not affected by the power uprate.

The SGBS is able to accommodate these blowdown flow rates at power uprate conditions. The control valves can handle the full range of steam generator normal to power uprate operating pressures. Since the design no-load and full-load pressures bound the power uprate conditions, the blowdown control valve inlet conditions at power uprate remain bounded by design. Therefore, the power uprate does not impact the system's ability to meet the required flow rates.

#### 8.3.4.4 Results

The SGBS design pressure is higher than the power uprate operating pressure. Temperatures at power uprate remain bounded by the SGBS design temperature. Additionally, the SGBS flow out of the steam generator's remains bounded by design conditions. Therefore, the SGBS is considered acceptable for power uprate operation at both power uprate power levels without further analysis.

The maximum blowdown flow requirements will not be changed with the power uprate. The flow rate requirements will continue to be supported for the power uprate conditions.

The ranges of instruments monitoring SGBS upstream of the "Hydrop" pressure reducing valves and the steam generator blowdown tank are acceptable for power uprate conditions.

The pressure instruments and controls downstream of the Hydrop pressure reducing valves are not expected to be affected by the upstream pressure changes due to the power uprate.

The operation of the Steam Generator Blowdown Treatment System downstream of the steam generator blowdown tank is also assumed to be the same as current operation. The instruments and controls of the SGBS downstream of the steam generator blowdown tank are not affected by the power uprate.

Instrumentation and controls in the SGBS are not affected by power uprate.

#### 8.3.4.4 Conclusions

Based on the above evaluation, the SGBS is acceptable for the 7.4-percent power uprate conditions. No equipment changes are required.

#### 8.3.4.5 References


1. PEPSE Heat Balance No. 13225-HB(D)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

2. PEPSE Heat Balance No. 13225-HB(B)-207-1, 1780 MWt, 7.4-percent power uprate, March 20, 2002.


### 8.3.5 Condenser and Air Removal System

#### 8.3.5.1 Introduction and Background

The scope of this evaluation included:

- The capability of the condenser to condense the low-pressure turbine exhaust
- The expected condenser backpressure
- The capability of the condenser air removal systems

The KNPP has two main condensers (1A and 1B) that extract the latent heat of vaporization from the low-pressure turbine exhaust steam and the steam dump system (when in operation). This heat is transferred to the CWS. The resulting condensate is collected in the condenser hotwell reservoirs before entering the Condensate and FW Systems. The condenser hotwell level control system maintains level within limits required for proper condensation, deaeration, and suction head for the condensate pumps. Normal and emergency makeup is from the condensate storage tanks (CSTs). In case of high hotwell levels, condensate may be pumped to the CSTs or to the Turbine Building standpipe. The hotwell has sufficient storage for three minutes operation at maximum throttle flow with an equal free volume for surge protection. The condensers are double-flow, single-pass type with steel water boxes at both ends.

The air removal systems associated with the condenser are the Condenser Air Removal System and the Water Box Priming System.

The Condenser Air Removal System removes non-condensable gases from the condenser to draw a vacuum for start up and then to help maintain condenser vacuum during operation. The air removal system consists of a three-element set of two-stage steam air ejectors and hogging air ejector. The two condensers share a common connection to the three-first stage and three-second stage air ejectors. Inter- and after-condensers, that use condensate for condensing entrained vapor, are provided. The hogging air ejector is used for system start up. Therefore, it is not affected by the power uprate.

The Water Box Priming System aids the CWS in maintaining circulating water (CW) flow and adequate condenser water box water level. The system contains an air ejector, supplied by heating steam, which can provide a vacuum source to each of the four water boxes. Differential pressure switches automatically cycle the water box priming system. When in automatic operation, the priming cycle starts when water box level decreases to the top of the water box and secures when the water level is two feet above the top of the water box. Manual operation is also possible.

#### 8.3.5.2 Description of Analysis

**Main Condensers**

The main condenser analysis determined the condenser duty (or total heat rejection to the CWS). Condenser duty was found based on an energy balance of the change in enthalpy of the

low-pressure turbine exhaust flow and various drain flows into the condenser compared to the condensed water entering the Condensate System.

The resulting condenser duty was used to find expected condenser backpressure based on design tables which list backpressure based on condenser duty for various condenser cleanliness values. These backpressures were used to calibrate the PEPSE model for current conditions, in order to project power uprate backpressures and electrical generation at various CW inlet temperatures: 56°F, 65°F, and 75°F. Vibration of condenser tubes can be caused by an increase in exhaust steam flow to the condenser. A calculation was performed to evaluate the possibility of condenser tube vibration at power uprate conditions.

The steam dumps to the condenser are designed to pass a total flow of 3,000,000 lb/hr (40 percent of the steam flow at maximum calculated load) when operated with 750 psia in the steam generators. The effect of increasing the steam generator pressure on dump valve flow was addressed as part of the Replacement Steam Generator (RSG) and $T_{avg}$ Operating Window Program. The steam generator pressures evaluated in that report bound the 7.4-percent power uprate expected steam generator pressures. The proposed power uprate does not change the flow conditions for the steam dump to condenser valves from current analysis and therefore, the condenser operation is expected to remain satisfactory for steam dump operation.

Based on a sensitivity review of the condenser hotwell capacity, the storage volume of the hotwell was evaluated. The hotwell volume was found based on the area of the hotwell and usable water level in the hotwell. A low level of 54 percent (setpoint for initiation of emergency makeup water) was considered as the initial water level. The hotwell was considered empty when the first condensate pump low-level trip is reached (14-percent level). Based on these water levels, the usable water volume is approximately 2440 cubic feet. Condensate flow, at power uprate, is approximately 730 cubic feet per minute. (This flow bounds both possible power uprate power levels.) Based on this review, the current hotwell storage capacity supports approximately 3.4 minutes of power uprate operation, without emergency makeup.

**Condenser Air Removal**

The Condenser Air Removal System must be capable of removing all non-condensable gases and air in-leakage to the condenser to maintain vacuum. Air in-leakage will not be affected by the power uprate. As a result of power uprate, condenser duty will increase approximately

8 percent; that, in turn, will result in slightly higher backpressure (an increase of 1.2 inch Hg. is possible). Theoretically, any existing air leakage may be slightly reduced due the higher condenser backpressure. However, this effect was minor and not included in any analysis. Therefore, the air removal system was evaluated by comparing the air removal capability with recommended values based on the increased low-pressure turbine exhaust flow rate.

The two-stage air ejectors are designed for air removal capability of 90-lb/hr dry air plus 210-lb/hr vapor with a steam flow of 2600 lb/hr at 110 psig to the air ejectors. This removal capacity is per condenser; the total removal capacity would be double the values shown. The reduced pressure steam supply system and the steam to the air ejectors will not be affected by the power uprate. Therefore, the air-ejectors will maintain current capability. The air removal capability was compared to the HEI standards for surface condensers recommended removal capability.

**Water Box Priming**

The Water Box Priming System uses an automatically operated (while online and generating electricity) air ejector that cycles to maintain desired water level in the water box. One air ejector takes suction from all the water boxes. The 7.4-percent power uprate power levels will increase the CW outlet temperature. Therefore, the evolution of air from the water will increase slightly due to the increase in the partial pressure of the air. This increase is insignificant for the purposes of the system impact, and therefore, no further evaluation of this system is required. Additionally, any increase in air generation rates could be accommodated by the automatic control shortening the system cycling interval.

#### 8.3.5.3 Results

Condenser duty will increase due to power uprate. The condenser is still acceptable for power uprate based on ability to condense the required steam load while maintaining acceptable vacuum. However, the increased condenser backpressure will reduce cycle efficiency and reduce the maximum generator output. A calculation confirmed that condenser tube vibration is not expected at power uprate power levels. Steam-dump-to-condenser-valve capacity requirements do not increase from current analysis. Therefore, the ability of the condenser to cope with steam dump operation will not be affected by the power uprate.

The steam-jet-air-ejector capacity exceeds the minimum capacity recommended by the HEI standards for both the current and power uprate conditions. Therefore, the Air Removal System is acceptable for power uprate.

The Water Box Priming System will be capable of supporting power uprate conditions. No major power-uprate-related changes are expected to the system, and the system's automatic controls can accommodate minor changes in water box priming system automatic cycle time due to slightly higher CW outlet temperatures.

The current condenser pressure instruments and controls are acceptable for the power uprate conditions. Instrumentation and controls associated with the condenser are not affected by power uprate. The condenser exhaust spray instrumentation and controls are used at low power and are not affected by the power uprate.

The current Air Removal System instruments and controls are acceptable for the power uprate conditions. Since the current Air Removal System design is acceptable and does not change, the instrumentation and controls in the Air Removal System are not affected by power uprate.

No major power uprate related changes are required to the Water Box Priming System, and the system's automatic controls can accommodate minor changes in water box priming requirements due to higher CW outlet temperatures. Instrumentation and controls in the Water Box Priming System are, therefore, not affected by power uprate.

#### 8.3.5.4 Conclusions

The Main Condensers, Air Removal, and Vacuum Priming Systems are considered acceptable at power uprate conditions for the 7.4-percent power uprate conditions. No equipment changes are required. The expected increase in condenser backpressure will slightly reduce the power uprate electrical generation capability when compared to power uprate steam flow and pressure at a constant backpressure.

#### 8.3.5.5 References

1. PEPSE Heat Balance for Kewaunee Nuclear Power Plant, Drawing No. 13225-HB(B)-205-1, 1780 MWt, 593.4MW, March 20, 2002.

2. PEPSE Heat Balance for Kewaunee Nuclear Power Plant, Drawing No. 13225-HB(B)-206-1, 1780 MWt, 594.5MW, March 20, 2002.

3. PEPSE Heat Balance for Kewaunee Nuclear Power Plant, Drawing No. 13225-HB(B)-207-1, 1780 MWt, 595.9MW, March 20, 2002.

4. *HEI Standards for Steam Surface Condensers*, 9th Edition, 1995.

5. PEPSE Heat Balance for Kewaunee Nuclear Power Plant, Drawing No. 13225-HB(B)-201-1, 1656.0 MWt, 554.9MW, March 20, 2002.

6. PEPSE Heat Balance for Kewaunee Nuclear Power Plant, Drawing No. 13225-HB(B)-208-1, 1780 MWt, 595.6MW, CWIT 56.0°F, March 20, 2002.

7. PEPSE Heat Balance for Kewaunee Nuclear Power Plant, Drawing No. 13225-HB(B)-209-1, 1780 MWt, 591.8MW, CWIT 65.0°F, April 15, 2002.

8. PEPSE Heat Balance for Kewaunee Nuclear Power Plant, Drawing No. 13225-HB(B)-210-1, 1780 MWt, 584.0MW, CWIT 75.0°F, April 15, 2002.

### 8.3.6 Circulating Water System

#### 8.3.6.1 Introduction and Background

The CWS is designed to provide a reliable supply of Lake Michigan water, regardless of weather or lake conditions, to the suction of two circulating water pumps, four service water pumps and two fire pumps. The CWS pump discharge flows through individual check valves and discharge pipes. The discharge pipes combine and proceed through a main conduit until it splits into four individual conduits. Each conduit supplies a water box on condensers 1A and 1B. Water flows through the condensers to individual discharge water boxes and out four individual conduits. These conduits join into a common CWS discharge tunnel.

Normal operation is two circulating water pumps and two or three service water pumps operating. One circulating water pump operation is acceptable when the CW temperature increase is less than 30°F. The condensers are the double-flow, single-pass type utilizing type 439 stainless steel tubes, with fabricated steel water boxes at both ends. Refer to subsection 8.3.5 of this report for additional details on the condenser.

#### 8.3.6.2 Description of Analyses

The scope of review includes an evaluation of the effect of power uprate conditions on main condenser backpressure, on main condenser tube vibration and tube erosion, and on CWS equipment limitations, including temperature and flow rate.

The potential for damaging condenser tube vibration after the proposed power uprate was examined with the aid of the HEI Condenser Tube Vibration Algorithm. These calculations empirically integrate the mechanical design details of the tube support spacing, and tubing itself with the power uprate turbine exhaust flow conditions. The specifics of the flow, the onset of sonic conditions, ligament spacing between adjacent tubes, the material and wall thickness of the tubing are considered.

Condenser backpressure was calculated via PEPSE model under 7.4-percent power uprate conditions at three circulating water inlet temperatures (CWITs): 56°F, 65°F and 75°F. Results were compared with the current power generation PEPSE model. This formed the basis for power uprate flow, temperature, and backpressure evaluations.

#### 8.3.6.3 Results

**Circulating Water Temperature and Pressure**

The power uprate has no effect on CWS operating pressures and the CWS pump discharge conditions will not be affected. The increased levels of rejected heat, approximately an 8-percent increase in turbine exhaust flow for 7.4-percent power uprate, will increase the CW outlet temperature by approximately 1.5°F. This increase in temperature is bounded by the CWS piping design and can be accommodated by the cooling system. Refer to Section 8.10 of this report for information concerning the CW outlet increase and environmental impact considerations.

**Condenser Backpressure**

The heat load under power uprate conditions will result in approximately a 0.35-inch Hg increase in the condenser backpressure. The increase in pressure is considered acceptable based on condenser design curves. However, condenser performance (and electrical generation capability) will be slightly reduced at higher backpressures.

**Condenser Performance**

The performance effect on the condenser will be a small increase in turbine backpressure and an accompanying loss in power generation.

**Vibration**

The main condenser was evaluated at the power uprate conditions and verified that tube vibration would remain within acceptable limits. Adequate protection against flashing and high energy impingement is a part of the existing design, and the slight increases in power uprate flows will not have additional impact in this area.

Performance of the condenser vacuum system and steam jet air ejectors remains unchanged (Refer to subsection 8.3.5 of this report).

**Instruments & Controls**

Since CWS flow and pressure will remain essentially unchanged following power uprate, the CWS flow and pressure instruments and automatic controls are not affected by the power uprate.

### 8.3.6.4 Conclusions

Modifications to the CWS pumps are not required for a power uprate to 1780 MWt. The higher condenser duty will increase the CW outlet temperature and condenser backpressure.

The power uprate to the NSSS power level 1780 MWt can be performed without hardware modifications to the CWS.

The CWS is acceptable under power uprate conditions because:

- The CW temperature increase is bounded by CWS piping and component design
- The condenser backpressure increase remains below turbine manufacturer recommended limits
- The main condenser tube vibration analysis results remain within acceptable industry guidelines.

### 8.3.6.5 References


1. PEPSE Heat Balance No. 13225-HB(B)-108-2, 1780 MWt, 595.6MW, CWIT 56.0°F, June 4, 2002.

2. PEPSE Heat Balance No. 13225-HB(B)-109-2, 1780 MWt, 591.8MW, CWIT 65.0°F, June 4, 2002.

3. PEPSE Heat Balance No. 13225-HB(B)-110-2, 1780 MWt, 584.0MW, CWIT 75.0°F, June 4, 2002.

4. PEPSE Heat Balance No. 13225-HB(B)-111-1, June 4, 2002.


## 8.3.7 Heater Drains System

### 8.3.7.1 Introduction and Background

The Heater Drain System is a non-safety-related system that collects drains from the Main Steam, Extraction Steam, and Bleed Steam Systems. These drains are then returned to the Condesate System via either the condensers or the heater drain tank/pump. The Heater Drain System consists of the FW heater drains, moisture separator reheater (moisture separator reheater) drains, reheater drain tanks, heater drain tank, heater drain pumps, connecting piping, and associated valves. These components were evaluated to ensure their ability to operate at the increased flow rates, temperatures, and pressures associated with the proposed power uprate.

The FW heater strings consist of five stages of FW heaters (heater 11A/B, 12 A/B, 13 A/B, 14 A/B, and 15 A/B). Fluid flow is split between the two heaters for each stage, and converges to a common header after heaters 13 A/B, 14 A/B and 15 A/B. Heaters 11, 12, and 13 (located in the condenser neck) receive extraction steam from the low-pressure turbines.

Heaters 11A/B, 12A/B, and 13A/B contain a drain cooler section, with drains being cascaded from heater 13 to 12, and 12 to 11. Drain flow from each of these heaters is controlled by modulation of control valves based on heater water level. Emergency drain (dump) valves are provided in case of high water levels to provide a drain path directly to the condenser. The

emergency drains for heaters 11 and 12 are also used as start-up drains; start-up functions are not affected by the power uprate.

Heater 14 receives steam directly from the high-pressure turbine exhaust and drains directly to the heater drain tank (no control valves).

The final FW heating section consists of two parallel heaters (15A/B) that receive condensed reheat steam (via the reheater drain tanks) and high-pressure turbine extraction steam and drain to the heater drain tank via a control valve.

The heater drain tank receives drain flow from heater 15A/B, heater 14A/B, and the moisture separator reheater moisture separator section and a minor flow from the SGBS. The drain line from heater 15 has a control valve; the other lines (from heater 14A/B and the moisture separator reheater) drain by gravity directly to the heater drain tank at saturation conditions, with no control valves. Water in the heater drain tank is pumped into the Condensate System by the heater drain pumps, at a point between heater 14 and the FW pumps suction. Two half-capacity heater drain pumps are provided. Normally, both pumps operate for full power operation. The heater drain pump speed is varied to control heater drain tank level; therefore, control valves are not required to maintain normal level. A dump valve is provided to prevent a high-level condition on the heater drain tank. This valve (heater drain-621/CV-31054) opens on high level condition and directs heater drain tank condensate directly to the condenser. The dump valve capacity is similar to the capacity of one heater drain pump.

There are four moisture separator/reheaters, two serving each low-pressure turbine. The moisture separator section removes moisture from the high-pressure turbine exhaust and drains to the heater drain tank. Reheat steam is condensed in the tubes of the reheat section, adding heat to the high-pressure turbine exhaust steam, and drains to one of the four reheater drain tanks. The reheater drain tanks have level control valves to control drain flow to heater 15. Heater 15 then drains via a drain cooler section and control valve to the heater drain tank.

The effects of power uprate on the FW heater shell- and tube-side conditions are reviewed in subsection 8.3.3 of this report.

### 8.3.7.2 Description of Analysis

The analysis compared current conditions with predicted power uprate conditions with respect to the following:

- System pressure/temperature
- Heater drain control valve operation
- Heater drain pump operation (pump flow, turbine-drivenH, etc.)
- Heater drain gravity drain lines
- FAC

**System Pressure/Temperature**

Analysis of system pressures and temperatures was based on heat balance conditions for current and power uprate operation. For each of the two sets of power uprate power level heat balances, the limiting (highest) value for predicted power uprate temperatures and pressures was used for analysis. These values were compared to the pipe design ratings. If a section of pipe was not bounded by the design values, an evaluation of the acceptability of the piping, based on the predicted change from current conditions was made. All piping was bounded by the design values, with the exception of the heater drain pump discharge piping. The design pressure of this section of piping is adequate (as discussed below); however, the rated temperature is exceeded for current and power uprate conditions.

The heater drain pump discharge line is designed for a temperature of 350°F. The current and expected power uprate operating temperatures marginally exceed the design temperature. These operating temperatures are based on saturation conditions in the heater drain tank at the same pressure as the bleed steam inlet to FW heater 14. The 7.4-percent power uprate condition produces the highest temperature (362°F). This is approximately a 4-percent increase above design (350°F) and a change factor of 1.02 from the current temperature (356°F). This temperature change is considered acceptable for power uprate.

The design pressure and temperature for the heater drain tank is 175 psig/400°F. The normal operating pressure and temperature is 150 psig/365°F. The expected power uprate operating pressure is marginally above the stated normal operating pressure and below the design

pressure. The expected power uprate operating temperature is similar to the current normal operation temperature.

**Heater Drain Control Valve Operation**

Each of the control valves was reviewed to determine whether or not choked conditions exist in the control valve. Then the analysis, using the appropriate expected pressure drop, determined the expected percent change in operating valve Cv.

The current positions of all control valves have been found to be no more than 60-percent open. This indicates margin is available for dealing with larger drain flows for the proposed 7.4-percent power uprate. (Based on the acceptance criteria presented in this section, the control valves have approximately 25-percent margin in valve travel.)

Based on the calculated "percent Cv difference," it was shown that the greatest change in required Cv for the control valve is less than 10 percent. These considerations are based on the simplification that the pressure drops in the drain piping will not change significantly with respect to the pressure across the control valve. The control valves CV31035 and CV31036 for the FW HTR-11A and -11B currently have the widest open positions (60 percent), and analysis shows that they will have the largest percent change in Cv. More importantly, they are the final receiver of the low-pressure cascading drains (FW HTR-13 → FW HTR-12 → FW HTR-11). For these reasons, the drain lines of FW HTR-11A and -11B are selected for the pressure drop calculation to confirm the validity of the above-mentioned simplification. Although the two heaters FW HTR-11A and -11B are operated under slightly different pressures and temperatures, FW HTR-11A is used for the calculation because it has a larger drain flow than FW HTR-11B. (The reheater drain tank control valves have a slightly greater change in percent open than the heater 11A control valve. This is acceptable and does not affect the methodology (selection of heater 11A drain valve for the calculation) presented in this section of the Engineering Report.)

It should be noted that the start up drains of the FW HTR-11A, -11B and FW HTR-12A, -12B could serve as the emergency drain lines. Except for FW HTR 11A/B and 12A/B, the emergency drain control valve sizes and line sizes are identical to those for the normal drains. Therefore, the conclusions reached for the normal drain valves apply to the emergency drain valves (but not to the start-up drain valves of FW HTR 11A/B and 12 A/B).

**Heater Drain Pump Operation**

The heater drain pump was evaluated based on ability of the pump to support power uprate flow and pressure requirements while maintaining adequate NPSHa. The analysis compared expected power uprate parameter to current operation and pump design.

**Heater Drain Gravity Drain Lines**

The reheater-to-reheater drain tank, heater-14-to-heater drain tank, and moisture-separator-reheater-to-heater drain tank lines are all saturated system gravity drains. The Froude numbers in the power uprate conditions are only about 10-percent higher than for the current conditions, therefore, since the drains are operating satisfactorily now, this will remain the case after power uprate.

Furthermore, calculation results show that the power uprate conditions friction pressure drop is only -0.33 psi, while the driving head pressure due to the difference in elevation is +11.1 psi. As a result, the hydrostatic pressure difference will more than compensate for the friction pressure loss in the drain line, and gravity flow will be achieved.

The parameter changes, as shown on the related heat balances, will be used as inputs to current FAC Program computer model. The new model results will be incorporated into the existing FAC Program and estimates of component life.

Heater drain process conditions requires update of the FAC Program due to heater drain inlet energy levels greater than the HEI-recommended values. If excessive erosion rates are noted during FAC Program monitoring, future modifications may be evaluated to reduce the erosion.

### 8.3.7.3 Results

The heater drain piping and component design bound the power uprate conditions for pressure and temperature, with the exception of the heater drain pump discharge line temperature rating. However, this line was determined to have a system pressure change factor of 1.02 from current, and therefore is acceptable for power uprate.

Heater-drain-flow-to-FW-flow ratio will remain essentially unchanged at power uprate conditions. Based on comparison of cascading heater drain flows at existing plant conditions and power

uprate conditions, it was determined that the increase in flow rates and corresponding velocities will not have a significant effect on heater drain system operation. All of the normal heater drain control valves have sufficient margin to accommodate power uprate conditions.

Based on evaluation results for normal drain valves, all emergency control valves are acceptable for power uprate conditions.

The heater drain pump design parameters for flow and turbine-drivenH accommodate the power uprate conditions. As the heater drain pump will be operating within design conditions, NPSH is adequate. Heater drain flow increases (~11 percent) and estimated pump head decreases (~7 percent). Given the current pump speed and expected changes in pump flow/head requirements (which are below design flow conditions), pump operation below design limits would be expected. Therefore, the heater drain pump system operation is acceptable for power uprate conditions.

The gravity drain lines from the reheaters to their drain tanks, from FW heater 14 to the heater drain tank, and from the moisture separator reheater shell to the heater drain tank have adequate size for power uprate. Even though both current and projected power uprate conditions predict temperatures above pipe design in the heater drain discharge, analysis of these pipes confirms that they are acceptable for power uprate.

The Kewaunee FAC Program will be updated due to minor changes in operating pressures and temperatures and due to higher flow rates and resultant higher flow velocities in the drain line piping. Subsection 8.3.3 of this report addresses the heater shel-l and tube-side flow conditions in additional detail.

The reheater drain tanks and heater drain tank level instruments and controls are not affected by power uprate. The existing ranges of the system temperature and pressure instruments are acceptable for the power.

### 8.3.7.4 Conclusions

The KNPP Heater Drain System is acceptable for power uprate conditions. No modifications to existing equipment are required.

All piping, except the heater drain pump discharge line temperature, remains bounded by design ratings, and is acceptable for power uprate. The heater drain pump discharge line is also judged to be adequate due to its small change factor from current conditions.

All drain lines are acceptable for power uprate operation. Although control valve operation positions are expected to increase, sufficient margin will remain. Gravity drain lines will continue to function properly.

Heater drain pumps will remain within design operating points.

#### 8.3.7.5 References


1. PEPSE Heat Balance No. 13225-HB(B)-205-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 767 psia), March 20, 2002.

2. PEPSE Heat Balance No. 13225-HB(B)-205-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 782 psia), March 20, 2002.

3. PEPSE Heat Balance No. 13225-HB(B)-207-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

4. PEPSE Heat Balance No. 13225-HB(D)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

5. PEPSE Heat Balance for 7.4-percent Uprate, 1780 MWt, Drawing No. 13225-HB(B)-107-1.

6. PEPSE Heat Balance No. 13225-HB(D)-101-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

7. PEPSE Heat Balance No. 13225-HB(B)-107-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), 593.4 MW, March 20, 2002.

### 8.3.8 Spent Fuel Pool Cooling System

#### 8.3.8.1 Introduction

The Spent Fuel Pool Cooling System is designed to remove decay heat from the spent fuel to maintain the spent fuel pool temperatures below a maximum temperature of 150°F. Heat removal is accomplished by drawing water from the surface of the pool, circulating the water through the filters, pumping it through a heat exchanger, and returning the cooled water to the pool. The spent fuel pool also has purification components and piping; however, as the purification subsystem is not impacted by the power uprate, it will not be addressed.

Refueling operations are performed in either a one-third core (approximate) offload or a temporary full core offload where two-thirds (approximate) of the fuel assemblies are returned to the reactor vessel along with the new fuel assemblies.

The Kewaunee spent fuel pool is actually three separate pools: a large south pool, designated as 1B; a smaller north pool, designated as 1A; and another pool designated as the canal pool. The original spent fuel pool was sized to accommodate a total of 168 fuel assemblies (144 in 1B and 24 in 1A), which was sufficient to accommodate one and one-third core. The spent fuel pool subsequently was reracked with high-density racks providing 990 storage locations in pools 1A and 1B. An additional 215 storage locations were added in the north end of the transfer canal in 2001.

Currently, there are 1205 storage locations for spent fuel assemblies in high-density storage racks in the spent fuel pool (720 in 1B, 270 in 1A and 215 in the canal pool). The Spent Fuel Pool Cooling System is designed to maintain the temperature of the pool below 150°F when the maximum number of fuel assemblies is stored in the pool. During normal refueling (approximately one-third of a core), the Spent Fuel Pool Cooling System will maintain the spent fuel pool at a maximum temperature of 140°F with a postulated failure of a single active component and will maintain a maximum temperature of 150°F following a full core offload.

The Spent Fuel Pool Cooling System consists of two centrifugal pumps, one U-tube, horizontal shell heat exchanger, and associated valves, piping and instrumentation. Each Spent Fuel Pool Cooling System pump supplies about half the total design flow of the Spent Fuel Pool Cooling System heat exchanger tube side. Redundancy of the components is not required because of the large heat absorption capacity of the water in the spent fuel pools.

The heat load due to discharged spent fuel is dependent upon the length of time between reactor shutdown and the moment when the fuel is placed in the spent fuel pool. Under normal refueling, up to 48 fuel assemblies are discharged with a spent fuel pool water heat inertia (time to heat from 140°F to 212°F assuming no heat loss) of approximately 15 hours. A full-core discharge consists of 121 fuel assemblies discharged. The spent fuel pool water heat inertia (from 162.4°F to 212°F) in this case was calculated to be 5.27 hours. (If a more realistic initial spent fuel pool temperature of 150°F is assumed, the time to boiling would be 6.5 hours.)

The impact of the increase in core power from 1650 MWt to 1772 MWt was evaluated to determine the resulting maximum spent fuel pool heat load, temperature, and heat-up times with the existing Spent Fuel Pool Cooling System.

### 8.3.8.2 Description of Analyses

The thermal power uprate will increase the core power level from 1650 MWt to 1772 MWt. Since the decay heat rate of the spent fuel is a function of the core power level, the spent fuel pool cooling heat load and temperature will increase. This increase will result in higher heat loads transferred to the Service Water System (SWS) and increased operating temperatures in the spent fuel pool. The power uprate is not expected to affect the impurity levels in the spent fuel pool and the design of the cleanup system will not be impacted.

To determine the increased heat load for the power uprate level, a calculation was performed using a calculated maximum spent fuel pool decay heat load value. This calculation determined that, under the worst case scenario spent fuel pool temperature would increase to approximately 163°F.

### 8.3.8.3 Results

Based upon a conservative set of assumptions (that is, the service water [SW] temperature is 80°F, initial spent fuel pool temperature is 120°F, the spent fuel pool heat exchanger has 5-percent tube plugging, the core is completely off-loaded to the spent fuel pool at 168 hours after reactor shutdown), the resulting temperature of the spent fuel pool was calculated to be 162.4°F. It was determined that with a SW temperature of 66.7°F, the spent fuel pool temperature would not exceed 150°F assuming all other conservative assumptions. In the event of a loss of the Spent Fuel Pool Cooling System, the time for the spent fuel pool temperature to rise to 212°F from this temperature is about 5.25 hours. It would take about 6.5 hours for the spent fuel pool

temperature to rise to 212°F from 150°F. At worst-case conditions, the boil-off rate of the spent fuel pool would not exceed 42 gpm.

Since no physical or analytical modifications or operational changes to the Spent Fuel Pool Cooling System are required for the power uprate, the Spent Fuel Pool Cooling System instruments and controls are not affected.

### 8.3.8.4 Conclusions

A full-core offload initiated at 148 hours after shutdown (and completed 20 hours later) under the extremely conservative assumptions of a completely full spent fuel pool, 80°F SW, two spent fuel pool pumps operating with a combined flowrate of 1080 gpm and 5-percent spent fuel pool heat exchanger tube plugging would likely result in the spent fuel pool temperature exceeding 150°F. Due to the conservatism in the heat load calculations and the remote probability that the maximum allowable SW temperature and 5-percent plugging of the spent fuel pool heat exchanger tubes would occur simultaneously and coincident with a full-core refueling offload, a cycle-specific heat load calculation will be performed prior to each refueling outage. This calculation, based on expected SW temperature and spent fuel pool heat exchanger performance capability, will determine the adequacy of the spent fuel pool cooling capability.

If the calculation shows that the spent fuel pool temperature will exceed 150°F, then movement of fuel from the reactor into the spent fuel pool will not occur until the fuel has decayed to an acceptable level. The required hold time beyond the Technical Specification limit of 148 hours will be documented in the calculation. Maintaining the spent fuel pool bulk temperature at 150°F or less is consistent with the current operation and design of the Spent Fuel Pool Cooling System's components, piping, and instrumentation and controls, as well as the spent fuel pool structure itself. Therefore, by administratively controlling the in-core hold time of the fuel after shutdown to ensure that the spent fuel pool temperature does not exceed 150°F, it will not be necessary to make physical or analytical modifications to the spent fuel pool or its cooling system as a result of the power uprate.

In the event of a total failure of the Spent Fuel Pool Cooling System, the spent fuel pool heat inertia will allow sufficient time to place alternate cooling systems into service. Additionally, if the spent fuel pool were to boil, alternate make-up sources of inventory (for example, residual heat

removal, reactor make-up water supply, emergency SW) are available that can make-up at a rate greater than boil-off, that is, 42 gpm.

### 8.3.9 Auxiliary Feedwater System

#### 8.3.9.1 Introduction and Background

The Auxiliary Feedwater System (AFS) supplies FW to the steam generators following any interruption of the main FW supply, thereby maintaining the required heat sink (provided by the steam generators) for the Reactor Coolant System (RCS). The AFS also provides FW to the steam generators during normal plant startup, hot stand-by and cooldown operations, when FW flow demand is too low for the main feedwater supply. The AFS is safety-related as it forms part of the engineered safeguards systems; therefore the AFS is redundant and is required to operate during events including station blackout (loss-of-all-AC power) or a loss of offsite power. The AFS supports the engineered safeguards system function by preventing core damage and RCS overpressurization (for example, reactor coolant discharge from the pressurizer safety valves) in the event of non-LOCA plant transients and design bases accidents such as loss of normal FW or a secondary system pipe break (for example, steam line break).

The AFS normally delivers FW from the CSTs or from the safety-related SWS. The system consists of the AFW pumps (two motor-driven and one turbine-driven), associated valves and piping and control systems so that the entire AFS complies with single-failure criteria. The AFS flow performance requirements are derived from the various safety analyses described further in the NSSS accident analysis.

Five essential functions provided by the AFS are:

- Using the steam generators, it removes residual heat from the RCS to support reactor shutdown and maintain hot shutdown conditions.
- Using the steam generators, it removes residual heat from the RCS to support reactor shutdown and maintain stable plant conditions during the 4-hour coping period associated with the loss-of-all-AC power event (for example, until AC power is restored).

- Using the steam generators, it removes residual and sensible heat from the RCS until the RCS temperature reaches 350°F, which is when the Residual Heat Removal System (RHRS) can be used to complete plant cooldown to cold shutdown.

- It maintains an inventory of water within the steam generators' narrow range during normal startup, shutdown, hot standby, and following a LOCA.

- It maintains a minimum inventory of water (above the tubesheet) in the steam generators upon loss of main feedwater to prevent thermal cycling of the steam generator tubesheet.

### 8.3.9.2 Description of Analyses

The AFS evaluation consists of comparing the post-power uprate AFW CST minimum inventory requirements for the loss-of-all-AC power 4-hour coping period with the existing design and TS minimum usable volume. A calculation prepared for power uprate revised the CST volume and revised CST level setpoints have been determined. Since the limiting AFW flow requirements are dictated by the accident analyses, the AFW evaluation also compared the AFW flow rates applicable to the power uprate conditions with the capability to supply sufficient FW flow to the steam generators for the various accident analyses.

### 8.3.9.3 Results

Acceptable AFS flow performance has been demonstrated for the power uprate conditions, assuming the existing AFS flow performance. No AFS flow performance changes are required as a result of the power uprate. The revised required usable volume to support the 7.4-percent plant Power Uprate Project is 41,500 gallons. This is revised from pre-power uprate requirement of 39,000 gallons. The coping period time remains at 4 hours. This value will be used as the basis for the revised Technical Specification 3.4.c for the 7.4-percent power uprate, which also maintains the current licensing basis of the plant.

A change in the CST level setpoints from 39,000 to 41,500 gallons is required. The revised CST level setpoints are as follows:

- Nominal CST level setpoint for one tank = 82 percent
- Nominal CST level setpoint for the total of two tanks combined = 89 percent

The other AFS instruments and controls are acceptable for the power uprate conditions. These AFS instruments and controls are not affected by power uprate.

Since the AFS flow does not change, the existing Regulatory Guide 1.97 AFW flow instruments still conform to Regulatory Guide 1.97 requirements.

#### 8.3.9.4 Conclusions

Acceptable CST performance has been demonstrated for the power uprate conditions. However, the CST level setpoints changes identified above will be implemented, along with the associated change, in Technical Specification, Section 3.4.

#### 8.3.9.5 References


1. *Kewaunee Nuclear Power Plant Updated Safety Analysis Report*, Rev. 17, Section 6.

2. *Kewaunee Technical Specifications*, Section 3.4, Amendment No. 123, January 3, 1996.


### 8.3.10 Service Water

#### 8.3.10.1 Introduction and Background

The Service Water System (SWS) supplies water from Lake Michigan for cooling equipment in the steam plant, the containment fan coil units (CFCUs), and reactor auxiliary systems. The purpose of the SWS is to provide redundant cooling water supplies for the engineered safeguards equipment required during post-accident conditions and for single non-redundant supplies to other systems including BOP equipment. The SWS utilizes four pumps with two redundant headers, and includes strainers and isolation valves, which are powered from emergency buses. The system also includes four traveling screens, two of which are powered from emergency buses. The isolation valves between the two headers are open during normal plant operation, and a sufficient number of pumps are operated to maintain the required header pressure. During accident conditions resulting in safety injection (SI) actuation, sequential diesel generator loading, and low SWS header pressure, the two SWS headers are isolated and supply water to the required loads independently. During plant emergency conditions, at least one SWS header (two SWS pumps operating) must supply the required SWS to one train of safeguards equipment, based on single-failure criteria.

Each of the SWS headers must be capable of providing sufficient cooling water flow to satisfy all post-accident heat removal requirements at the highest anticipated lake water temperature (80°F). For normal plant operation, the SWS provides cooling water to the Auxiliary Building heat loads, the CFCUs (which are also supplied from the Auxiliary Building headers), the Turbine Building heat loads, and other smaller loads supplied directly from the screenhouse headers. The Auxiliary Building is supplied SWS via two independent trains (A and B), one from each SWS header. The Turbine Building is supplied from a single SWS train, which can be either train A or B.

The SWS trains are normally connected together at the SWS pump headers. Each train supplies cooling water to a variety of heat loads, the major ones are the CFCUs, the component cooling water (CCW) heat exchangers, the spent fuel pool heat exchanger, and the fan coil units for the Auxiliary Building and the Turbine Building. The Turbine Building header supplies cooling water to loads associated with the turbine generator in addition to certain air conditioning loads and other smaller loads. The major loads are the generator hydrogen coolers, the main turbine oil coolers, and the feedwater pump oil coolers. The screenhouse headers supply SW to the two emergency diesel generator (EDG) cooling water heat exchangers, the SWS pump strainer backwash, the Fire Protection System Jockey pump, and other smaller loads.

#### 8.3.10.2 Description of Analysis and Evaluation

The purpose of this evaluation and supporting analysis was to establish that required SWS flow rates for the 7.4-percent power uprate conditions are available to critical heat loads for both the normal operation and accident conditions.

There are two available sources to establish the SWS flows: analysis using the Proto-Flo model generated for the SWS, and the results from the 2001 fall outage SWS flow testing. The SWS hydraulic model was generated before EDG and Control Room air conditioning modifications were completed, and for that reason, under-predicts the flows available to this equipment by the current SWS configuration. For the 2001 flow testing, Turbine Building flows consistent with 66°F SW temperatures (which is significantly less than required at 80°F SWS) were used for the system alignment. However, the testing was performed after the EDG and Control Room air conditioning SWS modifications were completed. Both of these sources were used to determine if the required SWS flows are available for the post-power uprate conditions.

### 8.3.10.3 Results of Evaluation and Analysis

The calculated Proto-Flo results indicate that SWS flows will be below the minimum required flow for 80°F service water for four loads: EDG 1A and EDG 1B, and Auxiliary Building Mezzanine fan cooling unit (FCU) 1A and 1B. Required minimums are met for all other loads.

The current SWS flow instruments are acceptable for the power uprate conditions, since the current SWS can provide sufficient flow to all SW cooling loads. The SW temperatures and pressures are not affected by the power uprate, so the current SW temperature and pressure instruments are acceptable.

**Table 8.3.10-1**

**Summary Flow Results of Proto-Flo Analysis (gpm)**

| | Minimum Flow 80°F SW | Data Point # 14 | Normal Operation Case A1 80°F SW | Turbine Building Isolated Initial Post-Accident Case A2 80°F SW | Long-Term Post-accident Case A3 80°F SW |
|---|---|---|---|---|---|
| EDG 1A | 604 | 751 | 0 | 577.9 | 562.8 |
| EDG 1B | 604 | 864 | 0 | 569.8 | 558.9 |
| Aux. Bldg. Mezzanine FCU 1A | 46 | 63 | 26.6 | 23.8 | 22.6 |
| Aux. Bldg. Mezzanine FCU 1B | 84 | 77.8 | 48 | 42.8 | 40.6 |

#### 8.3.10.3.1 Flows to Emergency Diesel Generators 1A and 1B

The required flow to each of these heat exchangers is 604 gpm. The Proto-Flo code calculates less than the required SWS flow to these heat exchangers. The EDG heat exchanger SWS discharge flow piping was modified to reduce the system backpressure and increase the SWS flow after the Proto-Flo model was developed.

The results of the 2001 flow testing (Reference 9, data point 14) give a measured flow of 751 gpm to EDG 1A. Since the SWS main header was 70 psig for this test condition without isolating the Turbine Building (see data point 18), the Turbine Building would isolate.

For EDG 1A the measured flow of 751 gpm gives a flow margin of about 24 percent for the current plant Instrumentation and Controls (I&C) and piping arrangements. For EDG 1B, the measured flow is 864 gpm, and the flow margin is 43 percent. Based on plant measurements the required SWS flow rates will be available to EDG 1A and 1B for accident conditions.

#### 8.3.10.3.2 Flow to Auxiliary Building Mezzanine Fan Cooling Units 1A and 1B

The analysis results indicate that the SW flows to Auxiliary Building Mezzanine FCUs 1A and 1B are significantly below the required values of 46 gpm and 84 gpm respectively during accident conditions. The flow measurements (Reference 9, data point 14) give 63 gpm for FCU 1A, and 77.8 gpm for FCU 1B with the Turbine Building isolated. For the current plant I&C arrangement there is a measured flow margin of about 37 percent for FCU 1A, and a negative margin of 7 percent for FCU 1B.

Reference 3 shows that the current negative flow margin of 21 percent for FCU 1B reduced the maximum acceptable SW inlet temperature to FCU 1B from 80°F to 78.2°F. This imposed limit is managed by plant procedure and Control Room annunciator (TLA-27). The isolation of the Turbine Building during accident conditions provides more flow to FCU 1B and, therefore, reduces the negative flow margin. The current limit of operation for FCU 1B to 78.2°F SW continues to be acceptable after the 7.4-percent power uprate based on use of the procedures that are already in place.

### 8.3.10.4 Conclusions

The required SWS flow rates to engineered safeguards equipment for accident conditions are not impacted by the 7.4-percent power uprate, since the current analysis was based on conditions that are still bounding. The most significant impact of the power uprate is the increase of the Turbine Building flow requirements for normal full-power conditions. The combination of the power uprate and the increased SW maximum temperature to 80°F increased the required flow to the Turbine Building header by about 73 percent above current requirements with 66°F SW for normal full power operation. The other SW heat loads, such as CCW heat exchangers, EDGs, spent fuel pool heat exchanger, and area FCUs, do not require

any increase in SW flow for normal and accident conditions above those already established for the current power level.

The existing requirements of the SWS are not affected by the power uprate or by the increased SW temperature. No changes or equipment additions are required for the SWS to support the 7.4-percent power uprate.

Existing administrative controls on Auxiliary Building Mezzanine FCU 1B will remain in effect after power uprate.

### 8.3.11 Component Cooling Water

#### 8.3.11.1 Introduction and Background

The Component Cooling Water System (CCWS) is required to provide cooling water to various plant components during normal, plant shutdown, and post-accident operations. The CCWS also acts as an intermediate system between the components being cooled and the SWS.

The CCWS consists of two CCWS pumps, two CCWS heat exchangers, one CCWS surge tank and associated valves, piping and instrumentation. Both CCWS pumps discharge to a common header so that either pump can supply either one or both heat exchangers. The outlet of the two CCWS heat exchangers then discharges to a single CCWS supply header. The CCWS piping is arranged to form parallel flow paths to the various components cooled by the CCWS. Each component cooled by the CCWS receives cooled water from the CCWS supply header. The water from each component then returns to the CCWS pump suction through the common CCWS return header. The CCWS surge tank is connected to the CCWS return header. The surge tank is normally half-full to provide an expansion volume that accommodates CCWS fluid volume changes resulting from temperature changes and potential system in-leakage. The surge tank also provides CCWS pump suction head pressure for CCWS pump NPSH requirements.

During normal full-power operation, one pump and one heat exchanger are required to accommodate the entire CCWS heat load. Therefore, the second CCWS heat exchanger and CCWS pump provide 100-percent redundancy during full-power operation. During normal full-power operation, one CCWS pump is operating, with the second pump in standby, and both CCWS heat exchangers are in service.

The CCWS provides cooling water to the following equipment:

- Residual heat removal (RHR) heat exchangers and RHR pumps
- Chemical and Volume Control System (CVCS) letdown, excess letdown (two heat exchangers), and seal water heat exchangers
- Reactor coolant pumps (RCPs) (motor and pump)
- Process sampling system coolers (including high radiation sample room)
- Boron recycle evaporator
- Waste evaporator
- Waste gas compressors
- Safety Injection System (SIS) pumps
- Internal containment spray pumps

During normal plant operation, essentially all of the above components are aligned with cooling, except the RHR heat exchangers. The RHR requires cooling water to remove both decay heat and sensible heat during cooldown of the RCS, and for long-term core cooling during post-accident operation. Following a design basis accident, the CCWS and RHRS, in conjunction with the containment spray and fan coolers, also maintain the containment peak temperature and pressure within design limits during the long-term recirculation phase. The limiting post-accident heat loads on the CCWS occur for a simultaneous LOCA and loss of offsite power and assume a single failure (diesel generator).

The design of this system is based on a maximum normal operating CCWS supply temperature of 95°F, maintained by 80°F SW, while transferring heat from the design heat loads. This temperature is allowed to reach 120°F during RCS cooldown following a unit shutdown. The CCWS supply temperature limitations are dictated by the design of the RCPs, and the temperature is allowed to increase to 130°F during post-accident operations.

#### 8.3.11.2 Description of Analyses

For normal plant operation, the normal operating heat loads for the power uprate were evaluated. It was concluded that the CCWS as currently configured can remove the increased heat loads resulting from the power uprate.

For normal plant cooldown, a two-train cooldown can continue to remove the power uprate heat load(s). The CCWS supply temperature is maintained at or below 120°F, utilizing two CCWS pumps and two CCWS heat exchangers.

For the 10CFR50 Appendix R plant cooldown, it was concluded that one train cooldown, coincident with a loss of offsite power, can continue to remove the power uprate heat load(s). The CCWS supply temperature is maintained at or below 120°F using one CCWS pump and one CCWS heat exchanger.

For the post-accident (post-LOCA) heat loads, it was concluded that the CCWS can remove the power uprate heat load and still maintain a CCWS supply temperature at or below 130°F as long as the 80°F SW flow rate is at least 2000 gpm to the operating CCWS heat exchanger.

#### 8.3.11.3 Results

The CCWS is able to remove the power uprate heat loads while maintaining the existing limits on CCWS operating supply temperatures. The results demonstrate that plant operation at full power can be supported with two CCWS pumps and two CCWS heat exchangers operable, as required by KNPP Technical Specification 3.3.d. A normal two-train plant cooldown can be supported with two CCWS pumps and two CCWS heat exchangers. The one train 10CFR50 Appendix R plant cooldown can be supported with one CCWS pump and one CCWS heat exchanger. In addition, post-accident analyses have concluded that the CCWS can provide adequate heat removal with a single CCWS pump and a single CCWS heat exchanger, provided the minimum required SW flow (at 80°F maximum temperature) is provided. Since no physical modifications or operational changes to the CCWS are required for power uprate, the CCWS instruments and controls are not affected.

#### 8.3.11.4 Conclusions

The existing CCWS capability is adequate for the proposed power uprated conditions with no equipment changes required. The limiting heat loads for the CCWS occur during a normal plant cooldown, the 10CFR50 Appendix R plant cooldown or during post-accident (post-LOCA) operations. For normal full power operation, the CCWS supply temperature will not exceed 95°F, while for normal plant cooldown or Appendix R cooldown operation, the CCWS supply temperature will not exceed 120°F. For post-accident operation, the CCWS supply temperature will not exceed 130°F as long as the minimum SW flow is maintained to the operating CCWS heat exchanger.

### 8.3.12 Containment Cooling System

#### 8.3.12.1 Introduction and Background

The Containment Ventilation Systems, which includes the Containment Air Cooling System (CCS), is designed to remove the normal heat loss from equipment and piping in the reactor containment vessel during normal plant operation. The CCS is designed to remove sufficient heat from the reactor containment vessel, following a design basis accident (DBA) pressure transient, to keep the pressure from exceeding the design pressure of the containment. The containment fan cooler units (CFCUs) cooling coils continue to remove heat and reduce the containment pressure following the DBA.

There are four CFCUs in the CCS. Two are supplied SW from SW header A, and two from SW header B. Each CFCU is capable of removing heat from a saturated air-steam mixture at a rate consistent with the performance data given. The CFCUs are sized to remove sufficient heat from the containment to maintain the pressure and temperature below its design values following a DBA with all four CFCUs available. The bounding DBA analysis, based on single failure criteria, is documented. The bounding case utilizes a combination of two CFCUs and one containment spray pump for containment heat removal.

The heat transfer characteristics for the CFCUs during accident conditions were established based on fully saturated steam conditions at the containment temperature. The thermal performance, which has been substantiated by vendor testing, is affected by the tube-side fouling factor, the air-side pressure drop, and the amount of moisture entrainment in the air-steam mixture entering the coils. In order to establish a CFCU's minimum heat removal

capacity (conservative for containment analysis), a tube-side fouling factor of 0.001 hr-ft$^2$-°F/Btu was used.

In addition to the heat removal capacity during accident conditions, the potential for flashing and two-phase flow of the SW in the outlet/drain lines from the CFCUs was evaluated. Two-phase flow could result in higher backpressure conditions that could reduce the SW flow to the CFCU below the minimum required flow of 800 gpm during accident conditions. Heat transfer for accident conditions has not been established for SW flows below 800 gpm. For the purpose of SWS outlet temperature evaluation, heat transfer from the containment to the SW is maximized by assuming zero tube-side fouling, resulting in the maximum SWS outlet temperature from the CFCUs.

### 8.3.12.2 Description of Evaluation Performed

For normal operation, the containment heat loads increased as a result of the 7.4-percent power uprate. The power uprate results in a temperature increase of 6°F ($T_{ave}$) for the RCS, 9°F for the main steam piping, and about 7°F for the final FW temperature. The additional heat loads are expected to increase the highest summer/fall average containment temperature from about 110°F to 112°F.

An evaluation performed for the CFCUs consisted of comparing the containment pressure and temperature for the bounding DBA (large-break LOCA or main steam line break [MSLB]) with the containment design basis pressure and temperature. This evaluation was based on a design fouling for the tube side of the CFCU of 0.001 hr-ft$^2$-°F/Btu to minimize the heat removal from the containment.

A second evaluation was performed to determine if the saturation pressure based on the SW temperature at the outlet of the CFCUs exceeded the static fluid pressure in the discharge lines. This evaluation was performed by comparing the bounding containment temperature and pressure during a DBA. The resulting SW outlet temperature based on a tube-side fouling of 0.0 hr-ft$^2$-°F/Btu was used to maximize the outlet temperature.

#### 8.3.12.3 Results

The bounding case is a 1.4 $ft^2$ MSLB at 0-percent power with the loss of one containment spray pump and two containment fan coolers. For this condition, the maximum CFCU heat load was approximately 30,000 Btu/sec, or 54 MBtu/hr for each of the two CFCUs.

The bounding transient for the analysis was the "in-containment MSLB" that resulted in 267.5°F peak containment temperature. The containment temperature bounds the maximum containment temperature for the 7.4-percent power uprate conditions, and the maximum SW outlet temperature of 261.9°F also remains bounding.

A containment temperature at or below the design value will assure that two-phase flow can not occur at the CFCU outlet since the SW outlet temperature can not exceed the containment temperature.

The CCS instruments and controls are discussed in subsection 8.3.13.3 of this report. The instruments and controls of the SW that cools the CCS are discussed in subsection 8.3.10.3 of this report.

#### 8.3.12.4 Conclusions

The containment temperature and pressure for the bounding DBA transient response for the 7.4-percent power uprate conditions are below the design values for the containment. The heat removal capacity of the CFCUs with a SW fouling of 0.001 hr-$ft^2$-°F/Btu, SW flow of 800 gpm/CFCU, and 80°F SW inlet temperature is sufficient to meet containment cooling requirements after a 7.4-percent power uprate.

The saturation pressure for the maximum SW temperature in the drain piping from the CFCUs is below the static pressure at this location (acceptance criterion 3) for all containment temperatures up to and including the 268°F design temperature. The static pressure, based on the current return line arrangement, is sufficient to prevent flashing and two-phase flow in these lines for the 7.4-percent power uprate conditions.

No changes or equipment additions are required for the CCS to support the 7.4-percent power uprate.

### 8.3.13 Heating, Ventilation, and Air Conditioning Systems

#### 8.3.13.1 Introduction and Background

The purpose of this evaluation is to determine the adequacy of the existing Heating, Ventilation, and Air Conditioning (HVAC) Systems for the proposed power uprate and to determine if any modifications are required to support the power uprate. Power uprate conditions were evaluated for a 7.4-percent (1780-MWt NSSS power) increase from current power (1656-MWt NSSS power)

The power uprate at the KNPP will result in an increase in heat loss to plant environment from main steam, generator blowdown, and FW piping. Other systems may experience a slight increase. Increased electrical loading may also slightly increase cooling requirements.

The following HVAC Systems were evaluated to ensure that sufficient margin and capability exist to operate satisfactorily to support the plant thermal power uprate to 1780 MWt:

- Auxiliary Building Ventilation and Cooling Systems
- Auxiliary Equipment Areas
- Spent Fuel Pool Area
- Non-Radioactive Area
- Control Room Area
- Control Room Air Conditioning System
- Auxiliary Building Special Ventilation System (Zone SV)
- The Turbine Building Ventilation System
- Diesel Generator Cooling
- Containment Ventilation System
- Shield Building Ventilation System

The HVAC Systems cool, heat, and ventilate, as well as filter plant areas to maintain a suitable environment for plant personnel and equipment, as appropriate. Each of the systems is described below.

For the power uprate evaluation, the bounding case is operating at 1780 MWt (100 percent of 7.4-percent power uprate) during weather conditions that result in maximum supply temperatures for the ventilation and air conditioning systems.

**Auxiliary Building Ventilation Systems**

The Auxiliary Building Ventilation System has separate normal ventilation systems for the auxiliary equipment areas, the spent fuel pool, containment penetration areas, non-radioactive area, and the Control Room. In general, these systems were designed to provide maximum safety and convenience for operating personnel while separating potentially contaminated areas from clean areas. The system was designed to maintain a maximum air temperature not to exceed 10°F above the outside air temperature while maintaining a slightly negative pressure. The system includes cooling for various Auxiliary Building locations.

Ventilation air is drawn from outside, through two makeup air units. Exhaust air is discharged through HEPA filters to remove particulates. Special provisions are included to exhaust air through activated charcoal beds and high-efficiency filters from areas subject to possible radioactive contamination, through the use of the Auxiliary Building Special Ventilation System (discussed in additional detail below.)

The spent fuel pool is ventilated by an air sweep system (discussed below).

High-energy line break (HELB) situations in the Auxiliary Building compartments at power uprate conditions resulted in updated temperature and pressure profiles. Refer to Section 8.4 of this report for details on the analysis and recommendations.

**Control Room Air Conditioning System**

The Control Room Air Conditioning System is designed to provide a reliable means of cooling and filtering air supplied to the Control and Relay Room under both normal and post-accident conditions for personnel comfort and equipment cooling. There is normally a 20-percent fresh air makeup to the Control Room from the Auxiliary Building air conditioning unit air intake. The air passes through roughing filters, cooling coils, and fans in one of the two 100-percent air conditioning units, and is then distributed to the Control and Relay Room. The Control Room Air Conditioning System is designed to remove 557,000 Btu/hr from the areas served and to

maintain the Control Room temperature at 75°F+10°F dry bulb under summertime design conditions.

One of two Control Room air conditioning units is normally operating. If that unit or its associated chiller package fails to operate, the second system is automatically placed into service by a trip signal from the operating unit. Each unit is also manually controlled from the Control Room. Under normal conditions, approximately 20 percent of this air is exhausted to the Turbine or Auxiliary Buildings, and the remainder is recirculated to the Control Room air conditioning unit where it is mixed with fresh air from the Auxiliary Building air conditioning unit air intake. Following a LOCA, the Control Room air conditioning will begin a 100-percent recirculation mode of operation. During this period, approximately 20 percent of the recirculation flow will pass through one of the two Control Room post-accident recirculation filters and fans. At this time, all outside air is stopped by closure of the dampers in the fresh air supply, and both post-accident recirculating fans are started.

**Auxiliary Building Special Ventilation System (Zone SV)**

The Auxiliary Building Special Ventilation System is designed to collect any potential Containment System leakage that might bypass the Shield Building annulus and to cause it to pass through charcoal filters before reaching the environment. The Auxiliary Building Special Ventilation System is designed to remove and filter any leakage. The potential for leakage is not affected by power uprate conditions. Therefore, this system is not affected by the power uprate, and further analysis is not required.

**Spent Fuel Pool Area Ventilation System**

The Spent Fuel Pool Area Ventilation System is part of the Auxiliary Building Ventilation System. The spent fuel pool is ventilated by an air sweep system, which maintains a continuous air sweep across the pool when the system is operating. In normal operation, exhaust air from the system passes through HEPA filters before being discharged to atmosphere through the monitored auxiliary building vent. Charcoal filters are provided, which are bypassed during normal operation. Administrative procedures assure that the bypass is closed during fuel handling operations. Also, the monitor in the Auxiliary Building vent will close bypass dampers, if they are open, in event of high radiation.

**The Turbine Building Ventilation System**

The Turbine Building Ventilation System provides ventilation to the following areas:

- Turbine Room Operating Floor and Basement
- Control Rod Drive Room
- Water Treatment Area
- Operating Floor Penetration Area
- Work Shops and Machine Rooms
- Turbine Room Mezzanine Floor
- Switchgear and Battery Rooms
- Safeguard Component Rooms (East and West)
- Motor-Driven and Turbine-Driven Auxiliary FW Pump Rooms

**Diesel Generator Cooling**

The Diesel Generator Facilities Ventilation System provides outside air for cooling the diesel generators.

**Containment Vessel Air-Handling System**

The Containment Vessel Air-Handling System consists of the CCS and the Purge and Ventilation System.

The CCS is designed to remove the heat loss from equipment and piping in the reactor containment vessel during normal plant operation. The CCS is also designed to remove sufficient heat from the reactor containment vessel, following the initial LOCA pressure transient, to keep the containment pressure from exceeding the design pressure. (The power uprate containment cooling accident analysis capability is discussed in subsection 8.3.12 of this report.)

The Purge and Ventilation System provides fresh, tempered air for comfort during maintenance and refueling operations and to purge contaminated air from the reactor containment vessel whenever required for access. The normal mode of operation requires the reactor containment vessel to be completely closed whenever the reactor is less than 1.0-percent $^{\Delta k}/_{k}$ sub-critical or the RCS's temperature exceeds 200°F. For entry at or below hot shutdown, the reactor

containment vessel may be vented using the Purge and Ventilation System to reduce the concentration of radioactive gases and airborne particulates. The health and safety of the public is ensured by the quick closure of the purge and vent valves in the event of high radiation in the containment system vent. The Purge and Ventilation System is not used when the reactor is above the hot-shutdown operating condition.

**Shield Building Ventilation System**

The Shield Building Ventilation System is a system of fans and ducts for collecting the leakage from the reactor containment vessel penetrations into the annulus of the Shield Building and discharging it through filters (particulate-absolute-charcoal) to the monitored containment system vent.

### 8.3.13.2 Description of Analyses and Evaluation

The HVAC evaluation consists of determining the impact of power uprate on the subject systems' ability to maintain normal operating temperatures. The subject systems were evaluated by determining the changes in the operation of equipment located in the areas they serve due to power uprate.

**Auxiliary Building Ventilation**

Most Auxiliary Building Ventilation and Cooling System loads are not affected by the power uprate. Some component electrical loads may increase. However, these increases are bounded by component ratings. Additionally, some localized area piping temperatures may increase due to the power uprate. The heat increase in the penetration areas will be proportional to the increase in temperature of the fluid systems. Therefore, the expected heat load increase on penetration cooling would be less than 2 percent. Operating temperatures of fluids piped through the Auxiliary Building (CCWS and RHRS) will remain bounded by design, with a minor increase from current temperatures. Therefore, as these fluid temperatures are bounded by rated values, the building heat load is not affected and the system design is bounding for power uprate conditions.

**Control Room Air Conditioning**

The Control Room HVAC System is not affected by the power uprate. Therefore, the Control Room area will not experience an increase in HVAC loading. There are no increases in electrical loads expected in the Control Room, therefore, the Control Room HVAC is acceptable for power uprate.

**Spent Fuel Pool Area Ventilation**

The air sweep requirements and system operation are not affected by the power uprate. There are no SPF cooling requirements for the ventilation system.

**Turbine Building Ventilation**

The Turbine Building will experience an increase in heat load due to components (for example, pumps) operating at higher operating conditions (increased pump horsepower) and an increase in fluid system temperatures (for example, condensate/FW). Most components are expected to remain operating within motor ratings. (Condensate pumps may slightly exceed the motor ratings; refer to subsection 8.3.3.) Fluid system temperature increases are expected to be minor. These loading and temperature increases will result in a slightly higher turbine building temperature for the same cooling air conditions. Based on the FW temperature increase of approximately 2 percent, a conservative estimate of the Turbine Building temperature increase would be 2 percent as well. This is conservative as it assumes all heating loads increase, while many loads will not be affected by power uprate. Additionally, this increase would only be noticeable when all building ventilation is operating; at other times the higher heat load could be dissipated by turning on additional ventilation.

**Diesel Generator Cooling**

Based on the diesel generator review (see subsection 8.3.14) there were no new loads added to the diesel generator, and there were no load increases resulting from the power uprate. Therefore, based on expected power uprate diesel generator loads remaining bounded by current rated loads, the cooling system is adequate.

**Containment Vessel Air Handling System**

The Containment Vessel Air Handling System is composed of the Containment Purge System and the CCS. (Refer to Section 8.3.12.)

For normal operation at power uprated conditions, the heat load to the CCS is expected to increase slightly. This heat load is dependent upon the operating temperatures of the systems inside containment. As a result of the power uprate and increased steam generator pressures, the average reactor coolant temperature, MSS temperature, and FW temperature will all increase. This will increase the temperature of components inside containment and the heat load on the containment cooling system.

The increase in heat load is assumed to be directly related to the increase in system temperatures. While there are many systems at different operating temperatures inside containment, the analysis will conservatively assume that the percent increase in containment temperature is related to the percent increase in $T_{ave}$, main steam, and FW. (A temperature increase of 2 percent will be used for estimation, since this bounds the increase for $T_{ave}$, MSS, and FW.) This estimated increase in containment temperature will then be added to current temperature information and compared to the maximum allowed containment temperature.

For this analysis, the temperature inside containment is assumed to be 110°F during current operation. The Containment Purge System is designed for operation during shutdown conditions and is, therefore, not affected by the power uprate.

**Shield Building Ventilation System**

The Shield Building Ventilation System is not used except for testing during normal operation of the plant. The Shield Building Ventilation System is designed to provide three functions. The first function is to produce a negative pressure within the annulus immediately following the LOCA. The second function is to ensure the mixing of any reactor containment vessel penetration leakage into a large portion of the Shield Building annulus, thereby avoiding potential direct streaming of the radioisotopes to the exhaust duct and, hence, increasing holdup within the annulus. The third function is to provide long-term cleanup of fission products from the annulus air by recirculation after the LOCA.

The ability to produce a negative pressure in the annulus after a LOCA (first function from above) may be affected by the power uprate. The other functions of this system are not affected by the power uprate.

The ability of the Shield Building Ventilation System to produce a negative pressure in the annulus following a LOCA is dependent on the post-LOCA containment temperature profile. A comparison of the expected power uprate containment profile and the temperature profile indicates that the containment temperature will increase more rapidly post-power uprate for approximately the first 30 seconds of the transient. This will tend to increase the annulus wall temperature faster than the current analysis. A review of this increase in temperature and time at higher than current temperatures indicates an increase of approximately 3 percent. This would result in a slight increase in containment wall temperature and a slight increase in time required to develop a negative pressure in the annulus. A negative pressure is currently developed in 3.18 minutes. This time will increase marginally.

The required time for a negative pressure in the annulus is stated as 6 minutes in the USAR. A negative pressure must be produced in 4.5 minutes. Using the 4.5-minute requirement, there is approximately a 30-percent margin from the current analysis (3.18 minutes) to the time limit. Therefore, the small increase in containment temperatures immediately following a LOCA (~3 percent) will by bound by the margin in the current calculation.

### 8.3.13.3 Results

**Auxiliary Building Ventilation**

The Auxiliary Building Ventilation System is adequate for power uprate operation because the heat load increase is expected to be minor. Penetration cooling is the only subsystem expected to be significantly affected by the power uprate. Based on operating temperatures, the penetration cooling may experience a 2-percent increase in cooling load. The penetration cooling flow is only 10 percent of the Auxiliary Building ventilation flow, so the increase to the entire system would be only 0.2 percent.

The electrical load increase at power uprate for electrical equipment does not impact the Auxiliary Building Ventilation Systems' design and/or operation as the power uprate has not required an increase in the safety related electrical loads in these areas, and the existing design loads are not impacted.

**Control Room Air Conditioning**

Control Room heat loads do not increase as a result of the power uprate; therefore, the Control Room HVAC System is not impacted.

**Spent Fuel Pool Area Ventilation**

For the Spent Fuel Pool Area Ventilation System, the power uprate does not impact the system ventilation equipment capability in providing the air sweep requirements.

**Turbine Building Ventilation**

The Turbine Building Ventilation System is not affected by a power uprate, since the expected incremental increase in heat loss to the Turbine Building will be small in comparison to the total existing heat loss.

**Diesel Generator Cooling**

The Diesel Generator Rooms' Ventilation System is unaffected by a power uprate because the rated capacity of the generator bounds power uprate loads.

**Containment Vessel Air Handling Systems**

Based on the increase in $T_{ave}$, the normal operating temperature inside containment is estimated to increase by 2 percent. This would correlate to a 1.2°F increase, and the highest summer/fall average temperature is estimated to be 112°F. This remains below the 120°F limit. Therefore, at power uprate conditions, containment temperature limits are not violated.

Based on previous power uprate experience, the actual containment temperature increase due to the power uprate will be approximately 1°F. Therefore, post-power uprate containment temperatures are expected to experience minimal change compared to current temperatures for similar, non-power uprate related, environmental conditions.

CCS accident conditions are discussed in subsection 8.3.12 of this report.

**Shield Building Ventilation System**

The power uprate requirements to produce a negative pressure within the shield annulus following a LOCA are affected by the containment temperature profile for a LOCA. The result is a slight increase in the time required to produce negative pressure in the annulus. This increase is bounded by the system and USAR stated required time.

**Instruments & Controls**

Based on the HVAC System evaluations, the instruments and controls of the following are not affected by the power uprate:

- Auxiliary Building Ventilation and Cooling Systems
- Control Room HVAC System
- Spent Fuel Pool Area Ventilation System
- Turbine Building Ventilation System
- Diesel Generator Rooms Ventilation System
- Containment Vessel Air-Cooling Handling System.

The Shield Building Ventilation System instruments and controls provide for equipment protection and monitoring. The Shield Building Ventilation System instruments and controls are not impacted by the power uprate conditions (see Section 8.8 of this report).

### 8.3.13.4 Conclusions

Due to negligible changes in environmental conditions, or margin in design, the subject systems' ability to maintain operating temperature at or below the maximum normal operating temperature is not impacted by plant thermal power uprate to 1780 MWt. No additional modifications are required to these HVAC Systems to support the power uprate.

### 8.3.13.5 References


1. PEPSE Heat Balance No. 13225-HB(B)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

2. PEPSE Heat Balance No. 13225-HB(B)-207-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

### 8.3.14 Electrical Systems

#### 8.3.14.1 AC/DC

##### 8.3.14.1.1 Main Generator

###### 8.3.14.1.1.2 Introduction and Background

**Main Unit Generator**

The KNPP turbine generator is a three-phase, 60-Hz, 1800-rpm, four-pole, hydrogen inner-cooled machine. The nameplate rating is 622.389 MVA (based on 60 psig hydrogen pressure) at 0.90 power factor, 20 kV. This equates to a gross output of the main generator of 560.15 MWe. The PEPSE heat balance analysis for the plant at current conditions shows the plant operating at 1656 MWt and a generator gross output of 554.6 MWe.

Following the Kewaunee power uprate of approximately 7.4 percent, the unit will produce 1780 MWt and an equivalent gross power output from the main generator of 595.7 MWe). This power uprate MWe increase will be accomplished by operating the existing turbine generator at a higher power factor. The generator overall rating of 622.389 MVA will remain unchanged.

###### 8.3.14.1.1.2 Description of Analysis

At power uprate conditions, a thermal output of 1780 MWt, the real power output of the main unit generator is 595.7 MWe. The generator overall rating is 622.389 MVA; 595.7 MWe and 180.3 MVAR. The power factor for power uprate is 95.7 percent.

The generator capability curve shows the limits of safe generator operation with leading and lagging power factors at various hydrogen pressures. The Kewaunee generator operates at 622.389 MVA at 60 psig hydrogen and is capable of operation in both the lagging and leading mode. The direct connected, brushless exciter is rated 2600 kW, 500 volts, 5200 amps, 1800 rpm. The original exciter design for Kewaunee was sized to exceed the generator rating. The exciter was reviewed as part of the KNPP Power Uprate Study.

The generator is hydrogen-cooled and the hydrogen is, in turn, cooled by passing it through the hydrogen coolers. The hydrogen serves to cool the generator and reduce windage losses. The coolers were reviewed as part of the Turbine Generator Power Uprate Study Report.

#### 8.3.14.1.1.3 Results

The generator output at power uprate is within the existing generator capability curve. The existing generator, exciter and cooling equipment are adequate to support unit operation at power uprate conditions.

#### 8.3.14.1.1.4 Conclusions

The main generator is capable of supporting the unit at power uprate conditions without modification. It will operate within its nameplate and within its current capability curve. The exciter and hydrogen cooling system will support power uprate without modification.

### 8.3.14.1.2 Main Transformer

#### 8.3.14.1.2.1 Introduction and Background

The main transformer (MT) delivers the power from the main generator to the power system grid during normal operation. The main generator output is delivered to the primary of the MT at 20 kV. It is transformed to 345 kV and supplies the switchyard from the transformer secondary via the overhead lines. At power uprate, the output from the main generator will increase, and this will result in a comparable increase delivered by the main transformer to the grid.

This evaluation compares the power delivered at power uprate by the transformer to the transformer rating. The evaluation will be performed for both the lagging and leading power factor cases.

#### 8.3.14.1.2.2 Description of Analysis

**Main Transformers**

The evaluation compares the transformer design ratings and the anticipated operating load with the unit generator output at the power uprate capability. The MT loading condition was reviewed for the normal operation condition. This is the only loading condition evaluated for the MT. The MT transformer load was evaluated with the main generator operating at both a lagging power factor and a leading power factor. The transformer was evaluated with the hotel load at power uprate conditions being supplied by both main auxiliary transformer (MAT) and the reserve auxiliary transformer (RAT).

For the lagging pf case, the MT load is the generator output minus the hotel load and transformer losses. However, for the leading pf case, the MT load for real power is the generator less the hotel load and transformer losses, and imaginary power is the generator output plus the hotel load and transformer losses.

Four cases were evaluated. They are:

**Case 1** – Main generator with lagging power factor, the MAT supplying buses 1-1, 1-2, 1-3, and 1-4, the tertiary auxiliary transformer (TAT) supplying bus 1-5 and the RAT are supplying 1-6.

**Case 2** – Main generator with leading power factor, MAT buses 1-1, 1-2, 1-3, and 1-4 and the TAT supplying bus 1-5 and the RAT supplying bus 1-6.

**Case 3** – Main Generator with lagging power factor, RAT supplying buses 1-1, 1-2, 1-3, 1-4, and 1-6 and the TAT supplying bus 1-5.

**Case 4** – Main generator with leading power factor, RAT supplying buses 1-1, 1-2, 1-3, 1-4, and 1-6 and the TAT is supplying bus 1-5.

**8.3.14.1.2.3 Results**

The MT is capable of supporting station operation at power uprate conditions with the main generator operating in the lagging mode for all cases. The MT operates within its 55°C rating with the hotel load supplied by the MAT. It operates within the 65°C rating with the hotel load supplied by the RAT.

The MT is capable of supporting station operation at power uprate conditions with the main generator in leading mode and the hotel load supplied by the MAT. Under these conditions, the MT operates within its 65°C rating.

The MT is not capable of supporting station operation at full power uprate conditions with the main generator operating in the leading mode with the hotel load supplied by the RAT. Under this operational scenario, the maximum amount of Reactive Power that can be accepted, measured at the MT secondary, is limited to 262 MVARs. Under these power uprate conditions, the MT operates within its 65°C rating.

#### 8.3.14.1.2.4 Conclusions

The MT is capable of supporting station operation at full-power uprate with the MAT supplying hotel load. It is also capable of supporting full power uprate with the RAT supplying hotel load and the main generator operating in the lagging mode. The MT has limited capability to support power uprate with the main generator operating in leading mode and the hotel load supplied from the RAT.

Uprate generator operation in the underexcited region, when the hotel load is supplied from the TAT and the RAT, reactive load will be limited to 250 MVAR or less in order to avoid overloading the MT at the 65°C rating.

### 8.3.14.1.3 Auxiliary Transformers

#### 8.3.14.1.3.1 Introduction and Background

The MAT, the RAT, and the TAT provide power to the station distribution system. The RAT and TAT provide two independent sources of offsite power to the station.

This evaluation compares the load on each transformer under normal and SI operation to the transformer rating.

### 8.3.14.1.3.2 Description of Analysis

**Main Auxiliary Transformer**

The loading on the MAT is shown in the following table. Two cases are shown, normal and SI.

**Table 8.3.14.1-1**

**Main Auxiliary Transformer Loading**

| Winding | Design (Notes 1 and 2) | Normal | Safety Injection |
|---|---|---|---|
| "X" | 12/16/20 MVA OA/FOA/FOA | 12.2 MVA | 0 |
| "Y" | 12/16/20 MVA OA/FOA/FOA | 18.8 MVA | 0 |
| Total | 24/32/40 MVA OA/FOA/FOA | 31.0 MVA | 0 |

1. Rating shown is the 55°C rating.
2. The term OA/FOA/FOA is defined in IEEE 100-1996, The IEEE Standard Dictionary of Electrical and Electronics Terms, Sixth Edition. "oil-immersed self cooled/forced air, forced-oil-cooled/forced-air, forced-oil-cooled transformer (class OA/FOA/FOA) (power and distribution transformers) A transformer similar to class OA/FA/FOA transformer except that its auxiliary cooling controls are arranged to start a portion of the fans for the first auxiliary rating and the remainder of the pumps and fans for the second auxiliary rating. (PE) C57.12.80-1987r". For convenience, the definition of OA/FA/FOA follows. "oil-immersed self-cooled/forced-air-cooled/forced-oil-cooled transformer (class OA/FA/FOA) (power and distribution transformers) A transformer having its core and coils immersed in oil and having a self-cooled rating with cooling obtained by the natural circulation of air over the cooling surface, a forced-air-cooled rating with cooling obtained by the forced circulation of air over this same cooling surface, and a forced-oil-cooled rating with cooling surface, and a forced-oil-cooled rating with cooling obtained by the forced circulation of oil over the core and coils and adjacent to this same cooling surface over which the air is being forced circulated.

**Reserve Auxiliary Transformer**

The loading on the RAT is shown in the following table. Two cases are shown, normal and SI.

| Table 8.3.14.1-2<br>Reserve Auxiliary Transformer Loading | | | |
|---|---|---|---|
| **Winding** | **Design (Note 1)** | **Normal** | **Safety Injection** |
| "A" | 12/16/20 MVA OA/FOA/FOA | 1.8 MVA | 18.2 MVA |
| "B" | 12/16/20 MVA OA/FOA/FOA | 0 | 10.3 MVA |
| Total | 24/32/40 MVA OA/FOA/FOA @650C | 1.8 MVA | 28.5 MVA |

1. The transformer is rated at 65°C.

**Tertiary Auxiliary Transformer**

The loading on the TAT is shown in the following table. Two cases are shown, normal and SI.

| Table 8.3.14.1-3<br>Tertiary Auxiliary Transformer Loading | | | |
|---|---|---|---|
| **Winding** | **Design (Note 1)** | **Normal** | **Safety Injection** |
| Total | 5/6.25 MVA OA/FA @55°C | 0.034 MVA | 0 MVA |

1. The transformer is rated at 65°C.

### 8.3.14.1.3.3 Results

The MAT is capable of supporting station operation at power uprate conditions with the BOP loads operating at their power uprate operating points. The MAT operates at its 55°C rating at power uprate.

The RAT is capable of supporting station operation at power uprate conditions with the BOP loads operating at their power uprate operating points. The RAT operates at its 65°C rating at power uprate.

The TAT is capable of supporting station operation at power uprate conditions with the BOP loads operating at their power uprate operating points. The TAT operates at its 65°C rating at power uprate.

#### 8.3.14.1.3.4 Conclusions

The MAT, RAT, and TAT are capable of supporting station operation at full-power uprate.

#### 8.3.14.1.4 Iso-Phase Bus Duct

#### 8.3.14.1.4.1 Introduction and Background

The Iso-Phase bus (IPB) duct connects the main generator output to the primary windings of the MT and MAT. The main portion of the IPB runs from the main generator terminals to the MT. The main portion is tapped and a segment runs from the IPB to the MAT.

This review evaluates the IPB electrical parameters relevant to station operation at power uprate conditions.

The main segment of the IPB has a forced air-cooled rating of 20,000 amps continuous with a 65°C rise over a 40°C ambient. The tap that feeds the MAT has a self-cooled rating of 1600 amps continuous @ 65°C rise over a 40°C ambient. The equipment's voltage rating is 20 kV nominal.

#### 8.3.14.1.4.2 Description of Analysis

The rated design capacity of the IPB connecting the main unit generator and MT and associated cooling equipment, and the isolated phase bus duct tap to the MAT were evaluated for capacity and margin for operation under core power uprate conditions. The maximum amount of current the IPB must carry is when the main generator is operating at rated output and at minimum voltage.

1. Maximum IPB current at Uprate

$P = \sqrt{3} * V_{LL} * I_L$ in volt-amperes

$V_{LL}$ – voltage Line to Line in kilo-volts

$I_L$ – Current, Line in kilo-amps

P – Mega volt-amps

$I_L = ( P ) / \sqrt{3} * V_{LL}$

NEMA MG-1, states the generator operating voltage tolerance as ± 5 percent of nominal. This is a maximum of 1.05 pu to 0.95 pu voltage. The generator current at rated output and minimum voltage is:

$I_L$ in amps = ( ( P in MVA ) * (1000 kVA / 1 MVA ) ) / √3 * generator minimum voltage in kV

$$\frac{622.389MVA*1000}{20kV*0.95*\sqrt{3}} = 18{,}912 \text{ amps}$$ (<IPB rating of 20,000A)

2. Maximum IPB tap current at uprate

The maximum MAT rating at 65°C is 44.8 MVA. The maximum current through the tap occurs with the MAT at full capacity and the generator voltage at its low limit.

$$\frac{44.8MVA*1000}{20kV*0.95*\sqrt{3}} = 1361 \text{ amps}$$ (<IPB rating of 1600A)

3. Voltage rating

ANSI C37.20 and ANSI C37.23 indicate the maximum bus rating of 24.5 kV. The generator has a rating of 20 kV nominal with a maximum of 105 percent, or 21 kV. The maximum voltage rating of the IPB exceeds the generator maximum rating.

#### 8.3.14.1.4.3 Results

The calculated maximum output current of the main unit generator at 622.389 MVA, power uprate, with minimum generator voltage (95 percent of nominal 20 kV) is 18,912 amps. It does not exceed the forced-air-cooled rating (20,000 amps) of the isolated phase bus duct connecting the main unit generator and the MT (main IPB).

The calculated MAT input current at maximum rating (44.8 MVA) coincident with minimum generator voltage is 1361 amps. It does not exceed the self-cooled rating (1600 amps) of the isolated phase bus duct tap to the MAT (auxiliary IPB).

The voltage rating of the IPB is compatible with the main generator range. The nominal rating of these components is the same, and the maximum voltage exceeds the generator.

Therefore, the existing isolated phase bus ducts and associated cooling equipment have sufficient capacity and margin to support, without modification, the output of the main unit generator for continuous operation at core power uprate conditions.

#### 8.3.14.1.4.4 Conclusions

The IPB duct, associated cooling equipment and tap to the MAT are adequate for the power uprate.

### 8.3.14.1.5 Non-Segregated Phase Bus Ducts and Feed from the Tertiary Auxiliary Transformer

#### 8.3.14.1.5.1 Introduction and Background

The non-segregated bus duct connects the secondary windings of the MAT and the RAT to the 4 kV switchgear non-safety buses 1-1, 1-2, 1-3, and 1-4. The TAT is connected to the 4 kV switchgear safety buses 1-5 and 1-6.

The ratings for the bus segments are as follows:

- The main bus segments from the MAT and the RAT to switchgear 1-1 and 1-2 are rated 4000 amps each.
- The main bus segments from the MAT and the RAT to switchgear 1-3, 1-4, 1-5 and 1-6 are rated 3000 amps each.
- The taps from the 4000 amp main runs to switchgear 1-1 and 1-2 are rated 3000 amps each.

- The taps from the 3000 amp main runs to switchgear 1-3 and 1-4 are rated 2000 amps each.
- The taps from the 3000 amp main runs to switchgear 1-5 and 1-6 are rated at 1200 amps each.
- The feed from the TAT is a cable feed, 750 MCM, one cable per phase.

#### 8.3.14.1.5.2 Description of Analysis

The non-segregated bus ducts were reviewed to ensure they had sufficient capacity to power the station loads for both the normal power operation case and Safety Injection case at power uprate conditions. The Electrical Auxiliary Systems Study was used to determine the loading on the bus ducts.

The load imposed on the TAT during normal conditions and SI conditions did not change as a result of power uprate. The buses fed by the TAT are the safety buses and only the BOP loads were impacted by power uprate. Therefore, no additional load was imposed on the cables from the transformer secondary buses to buses 1-5 and 1-6. As a result, these cables are bounded by their existing analysis.

#### 8.3.14.1.5.3 Results

The non-segregated bus duct was evaluated at power uprate conditions. The buses are adequate to carry the currents from the MAT or RAT to the buses they feed for the normal case and the SI case under power uprate conditions.

#### 8.3.14.1.5.4 Conclusions

The non-segregated bus duct will be able to accommodate power uprate requirements without exceeding equipment ratings.

#### 8.3.14.1.6 Station AC/DC Distribution System

#### 8.3.14.1.6.1 Description of Analysis and Evaluation

The power uprate generally affects the medium-voltage and low-voltage systems at the switchgear level. However, the impact does not extend to the Motor Control Center (MCC)/power panel level. The switchgear buses and circuit breakers were evaluated. The voltage levels for the portion of the system impacted by power uprate were reviewed. The motors with increased loading were evaluated and the cables feeding the loads and any buses with increased load were reviewed for ampacity and voltage drop.

**Medium-Voltage Level**

<u>General</u>

The medium-voltage bus loadings were evaluated based on the current-station load flow analysis. The results of the load flow were summarized and the impact of the increased medium-voltage motor loads resulting from increased fluid system flow were added to the bus loadings to reflect the power uprate conditions.

Table 8.3.14.1-1 compares the present motor operating points (input to existing load flow analysis) in the current station load flow analysis to current operating point and the operating point at power uprate, reactor power level of 1780 MWt. The operating points are the steady-state operating points. The small transients, 50-percent load rejection and one-pump flow, are considered transient conditions that last only a matter of minutes and are not evaluated. Table 8.3.14.1-1 evaluates steady-state conditions only.

Two items bear explanation. First, although the table is to show changes in operating points for motors as a result of power uprate, the circulating water pump (its operating point does not change) is also listed. This pump operates below nameplate. This difference between nameplate and operating point offsets an increase in condensate pump loading. Second, the heater drain pump current operating point was determined from field readings of current, along with the voltage and the assumed power factor and efficiency of 90 percent.

## Table 8.3.14.1-1

### Comparison of BOP Motors at Design, Current and Uprate Operating Points and Impact on Bus Loading

| Bus | Motor/Design Rating (Hp) | Input to Existing Load Flow Analysis (kVA/Hp) | Current Operating Point from Fluid System Uprate Calculation (BHp) | Uprate Operating Point from Fluid System Uprate Calculation (BHp) | Notes |
|---|---|---|---|---|---|
| 1-1 | Reactor Coolant Pump/6000 | 5161, 6000 | 5940 | 5942 | 3, 4 |
| | Feedwater Pump/5000 | 4164, 5000 | 5000 | 5150 | 1, 2, 4 |
| Bus Total | | 9325/11000 | 10940 | 11092 | |
| 1-2 | Reactor Coolant Pump/6000 | 5161, 6000 | 5940 | 5942 | 3, 4 |
| | Feedwater Pump/5000 | 4164, 5000 | 5000 | 5150 | 1, 2, 4 |
| Bus Total | | 9325/11000 | 10940 | 11092 | |
| 1-3 | Condensate Pump/1500 | 1323, 1500 | 1500 | 1528 | 1, 2, 4 |
| | Heater Drains Pump/500 | 433, 500 | 252 | 500 | 1, 2, 4, 5 |
| | Circulating Water Pump/1750 | 1767, 1750 | 1695 | 1695 | 1, 2, 4, 6 |
| Bus Total | | 3523/3750 | 3447 | 3723 | |
| 1-4 | Condensate Pump/1500 | 1323, 1500 | 1500 | 1528 | 1, 2, 4 |
| | Heater Drains Pump/500 | 433 , 500 | 252 | 500 | 1, 2, 4, 5 |
| | Circulating Water Pump/1750 | 1767, 1750 | 1695 | 1695 | 1, 2, 4, 6 |
| Bus Total | | 3523/3750 | 3447 | 3723 | |
| 1-5 | | | | | 7 |
| Bus Totals | | 0 | 0 | 0 | |
| 1-6 | | | | | 8 |
| | | 0 | 0 | 0 | |

Notes:

1. The original system operating point is from the Condensate and Feedwater System Flow Model Calculation, C11380.
2. The power uprate operating point is from the Condensate and Feedwater System Flow Model Calculation, C11380 for 1780-MWt conditions data.
3. The data for the RCPs was taken from PEPSE Heat Balance No. 13225-NB(D)-101-0.
4. The kVA data for the existing load flow calculation. MVA was determined using the formula kVA = $\sqrt{3}$*V*FLA, where V is nameplate voltage. The horsepower rating is from the circuit diagram.
5. The BHp for the heater drain pump operating points at the current condition has been estimated by taking the operating data as provided by the station assuming 4000 v at motor, 90% efficiency and power factor. Projected operating points were taken at full load since no operating points are available from the fluid system analysis. (No pump data were available from the station.)
6. Data for the circulating water pump from the pump curve.
7. None of the BOP loads impacted by power uprate are fed from bus 1-5.
8. None of the BOP loads impacted by power uprate are fed from bus 1-6.

For each bus, the existing load flow analysis does not bound the station auxiliary system at power uprate. All motors are bounded by their value, with the exception of the FW pump motors that are fed from bus 1-1 and 1-2, and the condensate pump motors that are fed by bus 1-3 and 1-4. The table shows that the loading for buses for 1-3 and 1-4 in the existing load flow analysis bound the bus loading for the station at power uprate. However, the existing analysis does not bound bus 1-1 and 1-2, the large motor buses. The load on these buses is over the existing analysis by 192 Hp, or 0.9 percent. This results in a reduction in voltage to 3969 from the value in the analysis of 3981. Allowing for the voltage drop in the cable, from the existing analysis, the voltage at the RCP is 3965 and the FW pumps is 3966. These values are within the operational limits of NEMA MG-1. It is also noted that buses 1-1 and 1-2 are fed from the "y" winding of the MAT and the "B" winding of the RAT. Buses 1-3, 1-4, 1-5, and 1-6 are fed from the "x" winding of the MAT and the "A" winding of the RAT. A three-winding transformer has characteristics similar to two two-winding transformers, therefore, the increase in load on the large motor winding of the MAT and RAT will have minimal impact on the low motor windings.

**4160 VAC Switchgear**

The switchgear ratings were compared to the anticipated operating requirements at power uprate conditions. The continuous and short circuit ratings of the switchgear and circuit breakers are potentially impacted by the load increase and the resulting increase in system power flow. The bus rating and circuit breaker ratings are also impacted by potential increases in fault duty resulting from additions of new equipment, modifications to existing equipment that would result in changes in electrical load or changes in bus voltages. There were no new equipment installed or modifications to equipment that changed the short circuit characteristics of the installed equipment at the medium voltage level.

Based on the equipment ratings and the calculated fault currents for the current plant condition, the fault current available, non-safety medium voltage buses 1-1 through 1-4 and their associated circuit breakers are overdutied. This condition was previously evaluated and found acceptable. The available fault current for buses 1-5 and 1-6 is within the ratings of safety buses 1-5 and 1-6, so these buses are acceptable.

The pre-fault voltage is taken at 102.4 percent, allowing for 105 percent in the switchyard and a 2.5-percent volt drop between the switchyard and the plant buses. This approach was indicated to be conservative.

The buses are fed by the RAT for the SI case. When the usual RAT is installed, the fault current available at buses 1-1 through 1-4 for the SI case is enveloped by the normal case. This condition has been evaluated and found acceptable. The available fault current for buses 1-5 and 1-6 is within the ratings of buses 1-5 and 1-6, so these buses are acceptable.

The station has a spare RAT. The spare, when installed, provides increased fault current. With the spare RAT installed, buses 1-1 and 1-2 are enveloped by the normal case. Buses 1-3 and 1-4 are not enveloped by the normal case. Buses 1-5 and 1-6 are overdutied with the spare RAT feeding the buses. This condition of increased fault current availability was addressed in the fault current analysis that indicates the spare RAT should not be installed "...without some provision for reducing fault current on its low-voltage side."

The increased load resulting from the increased motor loads on buses 1-1 through 1-4 will reduce bus voltage from its current operating value at power uprate. This reduction in the actual pre-fault voltage will result in a decrease in fault current available at the power uprate condition with respect to the current operating point.

**Medium-Voltage (4160 V) Motors and Motor Feeder Cables**

Unit operation at power uprate conditions will result in increased loads on several medium voltage motor-driven pumps. The motors affected are the RCP motors, the FW pumps motors, the condensate pump motors, and the heater drains pump (heater drain) motors. All of these motors are fed from non-safety buses, 1-1 through 1-4.

**Reactor Coolant Pumps**

The RCP motors operate both in cold-loop and hot-loop conditions. The cold-loop operation is for a matter of hours and hot loop is continuous operation. At power uprate conditions, the motors experience an increase in load during cold-loop operations from 7653 BHp to 7656 and during hot loop operation from 5940 to 5942 BHp. The RCP motors are rated 6000 Hp. The motors were analyzed by their supplier, Westinghouse, for operation at the power uprate conditions and found acceptable.

The cables to the RCPs are 750 MCM, two conductors per phase. The cables were analyzed as three conductor cables in conduit. Table 310.75 of the National Electrical Code, 2002

indicates the ampacity of three conductors in conduit is 525. The ampacity of these cables, 2 * 525 = 1050 amps exceeds the full load nameplate rating of the motors, 745 amps.

The RCP motor operation is addressed for both cold-loop and hot-loop operation. The motor current at cold loop conditions is determined by direct proportion.

FLA = (7656/7653) * 950.25 amps = 950.62 A

The power uprate operating point of 7656 BHp equates to approximately 950.62 amps while the current cold loop operating point, 7653 BHp has a current of 950.25 amps. This is an increase of approximately 0.4 amps.

The voltage drop in the cable under current conditions (the motor is at nameplate) is approximately 3 volts with a load current of 749 amps. By proportion, the cable voltage drop under cold loop operation is approximately 3.8 volts. (This assumes the current at full load is linear with motor output.)

Cable voltage Drop = (7656/6000) * 3 = 3.8 volts

The motors at hot loop are running less then nameplate, so the existing analysis is bounding. The cables are acceptable for running conditions.

The motor starting current is 4800 amps and is not impacted by the change in operating point. Therefore, the current analysis is bounding, and the cables to the RCP motors at power uprate are acceptable.

The increase in motor current at power uprate for cold loop increases temporarily by approximately 0.4 amps. This increase in cold loop operation is small with regard to overall ampacity and of short duration. The motor current at hot loop is bounded by the existing analysis. Therefore, the existing analysis for the reactor containment penetrations is considered bounding.

__Feedwater Pumps__

The FW pumps motors are rated at 5000 Hp with a FLA of 601 amps and have a service factor (SF) of 1.15 at rated voltage and frequency. The motors experience an increase in load from 5000 BHp to 5150 BHp under power uprate conditions and operate slightly into the motor

service factor. At power uprate conditions, the FW pumps motors operate at approximately 1.03 of full load. During analyzed abnormal operations (for example, fluid system transient, load rejection or one pump operation), the FW pumps will operate at approximately 5500 BHp for up to a five-minute period. This temporary operating point is within the motor SF rating. Thus, FW pumps motors are capable of operating at these points.

The cables to the FW pumps are 500 MCM, two conductors per phase. The cables were analyzed as three conductor cables in conduit. The National Electrical Code, Table 310.75, indicates the ampacity of three conductors in conduit is 425. The ampacity of these cables, 2 * 425 = 850 exceeds the nameplate rating of the motors, 601 amps. The motor current at temporary conditions is determined by direct proportion. 5180 BHp equates to approximately 622 amps. The voltage drop in the cable under current conditions is approximately 3 volts with a load current of 604 amps. By proportion, the cable voltage drop at power uprate is approximately 3.1 volts. The ampacity of the cable and the voltage at the pump are acceptable. Therefore, the cable to the feedwater pumps at power uprate is acceptable.

**Condensate Pumps**

The condensate pump motors are sized at 1500 Hp at 4000 volts with an SF of 1.15. The motor nameplate indicates it has Class B insulation. NEMA MG-1 allows a 90°C rise in a 40°C ambient as measured with embedded detectors and the condensate nameplate data shows a rise by thermocouple of 60°C for continuous operation. The condensate motors have a full load current of 191 amps.

The condensate motors currently operate at 1500 BHp, their nameplate rating. Their operating point at power uprate will be 1528 BHp and will, therefore, operate at 102 percent of nameplate. Additionally, during analyzed abnormal operations (for example, fluid system transient, load rejection or one pump operation), the condensate motors will operate above nameplate. Specifically, for a 50-percent load rejection at power uprate, the motors can operate as high as 1698 BHp, or about 13 percent above nameplate. Under present operating conditions, this type of operation results in a BHp of 1668 or operation approximately 11 percent above nameplate. As this condition is a transient condition, it is expected to last a few minutes with the motor then returning to its normal operating point.

IEEE 666 – 1991, notes that "General Purpose motors having an SF greater than one are suitable for loading to a value of rated hp x SF at rated voltage and frequency." Operation above the rated horsepower will cause higher temperature rise and the performance may differ from that at rated horsepower.

The condensate pump motor maximum service factor of 1.15 equates to the motor temperature rise of 90°C and a horsepower of 1500 * 1.15 = 1725 Hp. The current operating point of 1500 is service factor of 1.0 and has a temperature rise of 60°C, as shown by nameplate. The new operating point of 1528 BHp translates into motor operation at a service factor of 1.019 and the projected motor winding temperature rise is 62.3°C. The temperature is determined by the square of the ratio of new operating point to old operating point and service factor (1.0) at full load (1528/1500) 2 * (1.0). The square value is used since the motor current increase at the new operating point is assumed to be linear over a small range and only copper losses will be affected. The motors operate above nameplate voltage (4000 VAC) for the normal operation case, and since the unit is tied to the grid under these analyses, they are operating at rated frequency.

The condensate motor is acceptable for the operating conditions described above.

The cables to the condensate motors are 4/0. The cables were analyzed as three conductor cables in conduit. The ampacity of three conductors in conduit is 255 amps. The nameplate current of the motors is 191 amps. The motor current at 1528 BHp, determined by proportion to the nameplate rating, is approximately 195 amps. The motor current during abnormal conditions, 1698 BHp, is 216 amps. The voltage drop in the cable under current conditions is approximately 4 volts with a load current of 189 amps. By proportion, the cable voltage drop at power uprate is approximately 4.1 volts and under abnormal conditions, 4.5 volts. The ampacity and voltage drop of the cable are acceptable. Therefore, the cable to the condensate motors at power uprate is acceptable.

**Heater Drains Pumps**

The heater drain motors are rated at 500 Hp with a FLA of 62.5 amps. The motor operating point was not determined, although pump flows were calculated. Data taken by the station at the current operating point show the motor currents at 44 and 45 amps. The current operating point was estimated by proportion to be approximately 350 BHp, or 70 percent of nameplate.

Since the operating point at power uprate was not provided, it is assumed the motor will operate at nameplate for normal and abnormal conditions. This allows for a 30-percent increase in motor horsepower and is considered conservative. Therefore, the motor is acceptable.

The cables to the heater drain motors are #6AWG. The cables were analyzed as three conductor cables in conduit. The ampacity of three conductors in conduit is 69 amps. The ampacity exceeds the nameplate rating of the motors. The voltage drop in the cable under current conditions is bounding since the analysis was performed using the motor at nameplate rating and the motor is assumed not to exceed its rating under all conditions. Therefore, the cable is acceptable.

**Low-Voltage Level**

There are no low-voltage level electrical load increases resulting from fluid system demands resulting from power uprate. Therefore, the loading at the 480-volt switchgear buses is not impacted.

**DC Systems**

The DC Systems at the station were reviewed for addition of loads or modification of loads resulting from additional medium voltage loads, additional control circuits or changes to motor loads fed from the DC System, specifically the emergency bearing oil pump (EBOP) and emergency seal oil pump (ESOP). No new motors were added at the medium voltage level. No medium voltage circuits required the change of circuit breaker size. No new DC control circuits were added as a result of the power uprate. The turbine generator was not revised and the EBOP and ESOP motors were not modified. Therefore, no load additions or modifications were made to the existing DC System.

#### 8.3.14.1.6.2 Results

**Switchgear**

The continuous ratings of the medium-voltage switchgear incoming and motor circuit breakers affected by power uprate are acceptable.

The switchgear bus bracing and short circuit ratings of the circuit breakers are 250 MVA. The fault duty for buses 1-1, 1-2, 1-3, and 1-4 exceed this rating. Station documents indicated that this condition has been evaluated and the use of the 250 MVA circuit breakers is acceptable. The fault duty for safeguards buses 1-5 and 1-6 does not exceed the bus bracing and the 250-MVA rating of the circuit breakers.

The low-voltage switchgear continuous current and short circuit ratings under power uprate are bounded by the existing analysis.

The DC System was unaffected by the power uprate so the existing equipment and analysis are not changed and are, therefore, addressed by the existing analysis.

**Motors**

The medium-voltage motors affected by power uprate are the RCPs, the FW pumps, the heater drains pumps, and the condensate pumps. No low-voltage motors were affected by power uprate.

The condensate pump motors will operate slightly into their service factor. This condition was evaluated, and the motor will carry the increased load and remain well within the temperature rise limitation for the motor.

The FW pump motors will operate slightly into their service factor. This condition was evaluated, and the motor will carry the increased load and remain well within the temperature rise limitation for the motor.

In addition, the FW pump and condensate pump motors are required to temporarily operate above nameplate, a period of minutes under fluid system transient conditions. The motors were evaluated for this type of operation and are acceptable.

The RCP operation was evaluated and found to be acceptable.

**Cables**

The cables for the motors affected by power uprate were evaluated at the new operating points. The cables were analyzed using three conductors run in conduit from the National Electric Code (NEC) as cables in conduit have a lower ampacity than in free air. The analysis showed the cables ampacities were adequate to support the loads at power uprate.

**System Voltages**

The medium- and low-voltage levels are bounded by the existing analysis. The existing analysis was performed using motor nameplate ratings as input. The motors that are affected by power uprate either have operating points less then nameplate or the sum of operating points of motors on a bus is less then the sum of the nameplate ratings of the motors on a bus. The degraded-voltage relay settings are unchanged since no safeguards buses were impacted by load changes at power uprate conditions.

**Protective Relays**

The protective relays for the subject motors are acceptable. The motors affected by power uprate all operate within their current settings.

**8.3.14.1.6.3 Conclusions**

The review concluded that the continuous ratings of the existing switchgear and circuit breakers are adequate. Although the medium-voltage switchgear and circuit breakers are overdutied for fault duty, the station has analyzed the condition and demonstrated it is acceptable.

The existing medium-voltage pump motors affected by power uprate are adequate as installed. The condensate pump and FW pump motors will operate slightly into their service factors but are adequate to perform at power uprate.

The motor feeder cables are adequate and will carry the required currents within their ratings. The containment penetrations for the RCPs are adequate based on an unremarkable increase in motor current.

The DC System was not affected by the power uprate. Therefore, all equipment and analyses remain unchanged.

### 8.3.14.1.7 Protection

#### 8.3.14.1.7.1 Introduction and Background

The protection for electrical systems and equipment for Kewaunee were evaluated at the power uprate level to determine if the equipment and settings were adequate for operation at the new power level. The AC and DC Systems were reviewed as well as the protection provided for specific pieces of equipment. Specifically, the protection for the following equipment was reviewed:

- Main unit generator
- IPB bus duct
- Main transformers
- MAT
- RAT
- TAT
- Non-segregated bus duct
- Large cables
- Medium-voltage motors
- Medium-voltage bus feeds
- Degraded-voltage relays

The review was limited to those systems and equipment that were affected as a result of power uprate.

#### 8.3.14.1.7.2 Description of Analysis

The protection schemes for Kewaunee were examined for impact of the power uprate. In general, only those schemes for the systems and equipment that were impacted were evaluated. The protection for existing systems and equipment that were not impacted by the power uprate is addressed in existing station analyses and was not reviewed during the power uprate analysis.

The current transformers (CTs) used with the protection schemes are rated above the potential loading on them. All loading was less than 95 percent of the CT ratings. No additional burden was added to the existing CTs.

The potential transformers (PTs) are rated at the high limit of the generator voltage, 1.05 pu. No additional burden was added to the PTs as a result of power uprate.

**Main Unit Generator**

Differential protection evaluates the balance between input and output of the zone it is monitoring; the main unit generator, and the unit (the main unit generator, the IPB duct and the MT). There were no changes to equipment within the protection zone, and the equipment operates within its nameplate rating after power uprate. Therefore, the differential protection schemes are not affected by the power uprate.

Phase-to-ground fault protection is provided by an overvoltage relay in the generator neutral grounding connection. The generator was not modified during the power uprate and continues to operate within its existing capability curve. Therefore, the ground fault protection scheme is not affected by the power uprate.

Distance relaying protection is established based on the impedance of the devices in its zone of protection. None of the components have been changed. Therefore, the distance relaying scheme is not affected by the power uprate.

Negative sequence protection settings are based on generator parameters. Since the generator has not been changed to support the power uprate, the existing scheme is acceptable as is.

Loss of excitation (field) protection schemes are based on generator parameters. Since the generator has not been changed to support the power uprate, the existing scheme is acceptable as is.

Reverse power (anti-motoring) protection is based on generator parameters. Since the generator has not been changed to support the power uprate, the existing scheme is acceptable as is.

Blown fuse protection guards against a blown fuse in the PT. This is dependent upon the PT. Since the PT was not modified as a result of the power uprate, this scheme is not affected by the power uprate.

**Main Transformer**

Differential protection evaluates the balance between input and output of the zone it is monitoring; the main unit generator, and the unit (the main unit generator, the IPB duct, and the MT). This unit is harmonically restrained to prevent inadvertent tripping due to magnetizing inrush current. There were no changes to equipment within the protection zone and the equipment operates within its nameplate rating after power uprate. Therefore, the differential protection scheme is not affected by the power uprate.

Differential protection evaluates the balance between input and output of the zone it is monitoring, the connection of the MT to the 345-kV switchyard. There were no changes made to equipment within the zone and the equipment operates within its rating at power uprate. Therefore, the differential protection scheme is not affected by the power uprate.

Ground protective relays are located in the grounded neutral of the high-side winding. This relay guards against line to ground faults that are external to the transformer. Since no changes have been made to the transformer or lines connecting it to the switchyard, the ground fault protection scheme is not affected by the power uprate.

Sudden pressure relays respond to an increase in transformer tank pressure due to arcing of turn-to-turn faults or phase-to-ground faults inside the transformer. Since the MT was not modified during the power uprate, this protection is not affected by the power uprate.

**Main Auxiliary Transformer**

Differential protection evaluates the balance between input and output of the zone it is monitoring, the MAT and the feeds to the medium-voltage buses. No changes were made to the equipment within the zone and the equipment operates within its rating after power uprate. Therefore, the differential protection scheme is not affected by the power uprate.

Overcurrent protection on the transformer primary provides backup protection for faults external to the transformer. Since no changes have been made to the MAT or the feeders to the buses it feeds, this scheme is not affected by the power uprate.

Ground protection is located on both the "X" and "Y" secondary windings of the MAT and protects against faults on the low side windings and in the connections to these windings. Since neither the transformer nor the feeders fed by the transformer have been modified during the power uprate, this protection is not affected by the power uprate.

Sudden pressure relays respond to an increase in transformer tank pressure due to arcing of turn-to-turn faults or phase to ground faults inside the transformer. Since the MAT was not modified during the power uprate, this protection is not affected by the power uprate.

**Reserve Auxiliary Transformer**

Differential protection evaluates the balance between input and output of the zone it is monitoring, the RAT and the feeds to the medium-voltage buses. No changes were made to the equipment within the zone and the equipment continues to operate within its rating after power uprate. Therefore, the differential protection scheme is not affected by the power uprate.

Differential protection evaluates the balance between input and output of the zone it is monitoring, the feed from the 138-kV switchyard to the RAT. No changes were made to the equipment within the zone and the equipment operates within its rating after power uprate. Therefore, the differential protection scheme is not affected by the power uprate.

Ground Protection is located on both the "X" and "Y" secondary windings of the RAT and protects against faults on the low-side windings and in the connections to these windings. Since neither the transformer nor the feeders fed by the transformer have been modified during the power uprate, this protection is not affected by the power uprate.

A sudden pressure relay guards against internal transformer faults. Additionally, breaker failure protection is provided in case a 138-kV switchyard breaker fails to operate on command.

Sudden pressure relays respond to an increase in transformer tank pressure due to arcing of turn-to-turn faults or phase to ground faults inside the transformer. Since the RAT was not modified during the power uprate, this protection is not affected by the power uprate.

**Tertiary Auxiliary Transformer**

Differential protection evaluates the balance between input and output of the zone it is monitoring, the TAT and the feeds to the medium voltage buses. No changes were made to the equipment within the zone and the equipment continues to operate within its rating at power uprate. Therefore, the differential protection scheme is not affected by the power uprate.

The incoming line to the TAT is protected by a directional time-overcurrent relay scheme. Since neither the TAT nor the incoming lines have been modified during the power uprate, this protection is not affected by the power uprate.

Ground protection is located on both the "X" and "Y" secondary windings of the TAT and protects against faults on the low-side windings and in the connections to these windings. Since neither the transformer nor the feeders fed by the transformer have been modified during the power uprate, this protection is not affected by the power uprate.

Sudden pressure relays respond to an increase in transformer tank pressure due to arcing of turn-to-turn faults or phase to ground faults inside the transformer. Since the RAT was not modified during the power uprate, this protection is not affected by the power uprate.

**Medium-Voltage Motors**

Instantaneous and time overcurrent relays provide protection for overcurrent and failure to start conditions. No changes were made to any motors or feeders. Therefore, the protection is not affected by the power uprate.

Ground fault relays provide protection for phase ground currents. Neither the motors nor feeders were modified during power uprate. Therefore, this protection is not affected by the power uprate.

**Bus Feeds**

Overcurrent relays provide overload protection to the bus feeders. None of the bus feeders were modified by the power uprate, therefore, this protection is not affected by the power uprate.

An overcurrent relay provides protection against ground faults. None of the bus feeders were modified by the power uprate, therefore, this protection is not affected by the power uprate.

**Degraded-Voltage Protection**

Undervoltage relays provide protection for prolonged low voltages on the ESF buses. The analysis that establishes voltage levels for these relays was performed based on motor nameplate. As a result the incremental increase in BHp on each bus does not exceed the motor load on the bus (the analyzed load). Therefore, the relay settings are acceptable, and no changes are required to these relays.

### 8.3.14.1.7.3 Conclusions

The protection schemes for the equipment that could be potentially affected by the power uprate were reviewed. The schemes are acceptable without need for modification or replacement as a result of the power uprate.

## 8.3.14.2 Emergency Diesel Generators

### 8.3.14.2.1 Introduction and Background

KNPP has two EDGs. The two generators feed the safety-related buses 1-5 and 1-6. Bus 1-5 is fed by EDG D-1A and bus 1-6 is fed by EDG D-1B. Two diesel generators are connected to the engineered safety features buses to supply emergency shutdown power in the event of loss of all other AC auxiliary power.

### 8.3.14.2.2 Description of Analysis

The loading on the EDGs was evaluated under power uprate conditions for the maximum loading for DBA, LOCA/loss-of-offsite power. The evaluation identified any load changes, determined the impact of the load changes on the existing analysis and confirmed the diesel generator would remain capable of performing its safety-related functions.

The loading of the EDGs under accident conditions is shown by Table 8.2-1 of the USAR. The loading is composed of both NSSS and BOP loads and is both motor and non-motor in nature. The NSSS loads were reviewed, and no new loads were added and no increase for the existing loads was determined. The BOP loads were reviewed during the fluid systems review, and it

was determined that there were no new loads added and that there were no load increases resulting from power uprate that would result in a change to EDG loading.

The existing protection schemes for the EDGs were not affected by power uprate. No new loads were added and no existing loads were increased to the EDG loading, as shown by Table 8.2-1 of the USAR.

### 8.3.14.3 Results

The review of the NSSS loads and the BOP loads showed that there were no loads fed by the EDGs under DBA conditions that would increase and, therefore, impact the existing analysis. Therefore, the existing EDG analysis is bounding.

There were no load additions or modifications to the EDG loading. Therefore, the existing protection schemes are acceptable.

### 8.3.14.2.4 Conclusions

The EDGs are capable of performing their design and licensing functions under the power uprate conditions. No additional analysis is required to demonstrate the acceptability of the EDGs.

The protection schemes are acceptable without modification.

### 8.3.14.3 Switchyard

### 8.3.14.3.1 Introduction and Background

The KNPP is served by two switchyards: a 345-kV switchyard and a 138-kV switchyard. The 345-kV switchyard connects the KNPP to the grid through the main transformer and accepts the output of the station. The offsite source of power is provided by the 138-kV switchyard. This switchyard connects to the station through the RAT. The 345-kV and the 138-kV switchyards are connected via transformer bank no. 10. This transformer also provides a source of power to medium-voltage buses 5 and 6 via a tertiary winding.

The increase in output from the main generator is carried to the grid via the 345-kV switchyard.

The station electrical loads impacted by the power uprate are the BOP loads that are fed from medium-voltage buses 1 through 4. The loads on buses 5 and 6 are safety-related loads and are not impacted.

Under power uprate conditions, some medium-voltage BOP motor loads increased. This increased motor load flow is enveloped by the present station load flow analysis, Reference 9. Therefore, while the actual station auxiliary power loads increased under power uprate, this increase is bounded by the existing analysis.

The switchyard review focused on the overhead leads from the main transformer to the 345-kV switchyard bus 1. Inside the yard, the review looked at the buses, disconnect switches and circuit breakers. The 138-kV switchyard and transformer bank no. 10 were not evaluated since the existing analysis is bounding. Similarly, the load flow within the 345-kV switchyard and between the 345-kV and 138-kV switchyards was not evaluated.

#### 8.3.14.3.2 Description of Analysis

For the purpose of this evaluation, unit output delivered to switchyard at power uprate conditions is determined from the capacity of the main transformer that has been shown to be adequate for power uprate condition. The ability of the switchyard components to operate at the new power level is based on a comparison between equipment loading at power uprate and the applicable equipment design ratings.

#### 8.3.14.3.3 Results

The MT is capable of operating at 649.5 MVA at its 65°C rating. This rating determines the maximum amount of power that will flow between the unit and the 345-kV switchyard. Therefore, based on the transformer rating, the maximum current that flows through the 345-kV overhead lines to the switchyard from the transformer is limited to approximately 1.4 kA, (649.5 MVA / $\sqrt{3}$ * 0.95*345 kV). The overhead conductors that connect the 345-kV switchyard to the main transformer are 2156 Aluminum Cable Steel Reinforced (ACSR). The ampacity of this circuit, assuming a 40°C rise is approximately 1600 amps. The line between the MT and the 345-kV switchyard is capable of carrying the full 65°C rating of the main transformer.

The buses in the 345-kV switchyard are rated 3000A. The unit at power uprate will supply 1400 amps at 345-kV. The bus ratings exceed the current, 1100 amps, they are required to

carry at the power uprate condition, therefore, the buses between the overhead leads and bus 1 are acceptable.

The disconnect switches in the 345-kV switchyard associated with the incoming power circuit breaker are rated 1600 amps. The maximum current from the unit at power uprate is approximately 1400 amps. The disconnect switch ratings exceed the current they will carry at the power uprate condition. Therefore, the disconnect switches associated with the generator leads are acceptable.

The circuit breakers in the 345 kV switchyard are rated 1600 amps. The maximum current from the unit at power uprate is approximately 1400 amps. The rating of the circuit breakers exceeds the amount of current they will carry at the power uprate condition, therefore, the circuit breaker associated with the overhead lines is acceptable at power uprate.

The 345 switchyard instrument transformers were reviewed. The current transformers ratings envelop the ratings of the 345-kV circuit breakers and unit output, 1400 amps, at power uprate. The burden on the transformers was not increased, therefore, the instrument transformers are acceptable.

The voltage under power uprate conditions did not change, and the burden on the devices was not increased. Therefore, the power uprate does not impact the existing qualification of the bushing potential devices.

**8.3.14.3.4 Conclusions**

The lines from the MT to the 345-kV switchyard are adequately sized to carry the increase in power from the unit operating at power uprate condition. The 345-kV disconnect switches, circuit breakers, instrument transformers and buses associated with the generator leads are adequate for the unit output at power uprate.

The load flow supplied to the unit from the 138-kV switchyard at power uprate conditions is bounded by the current station load flow analysis. Although several non-station loads increased, the existing load flow analysis bounded them.

### 8.3.15 Instrumentation and Control Systems Summary

Based on the instrumentation and control (I&C) valve review it was concluded that the difference between power uprate and current design is minimal for the plant instrumentation and control valves. The following is a summary of the changes for BOP instrumentation and control valves for the power uprate.

BOP instruments that are impacted are:

- P21012, turbine impulse chamber pressure transmitter (to EH System): A higher maximum calibration value will be used to adequately (110 percent) envelope the new power uprate 100-percent power pressure.
- High-pressure turbine impulse pressure instrument loops for NSSS control and reactor safety, to reflect the new 100-percent power pressure, which will be changed, are:
  - PC-485A (4858801), alarm bistable
  - PC-485C (4858805), block auto rod withdrawal, P-2
  - PC-486A (4862001), alarm bistable
  - PC-486D (4862006), turbine first-stage pressure 60-percent load reject trip unit
  - PC-486C (4862007), turbine first-stage pressure 10-percent load reject trip unit
- The existing FRV trim will be replaced to support power uprate operations.
- Revision of calibration procedures to extend the maximum temperature of the calibration check will be performed on:
  - TE-15043 – FW to steam generator 1A RTD
  - TE-15044 – FW to steam generator 1B RTD
- The low-level alarm setpoints for the CST will be revised. The instruments that require re-scaling are:
  - TU-4851002, CST 1A level low alarm
  - TU-4151102, CST 1B level low alarm
- The turbine overspeed trip settings will be adjusted to accommodate Bleed (Extraction) Steam System conditions for the power uprate.

## 8.4 Piping and Supports

### 8.4.1 Introduction and Background

The purpose of the piping review is to evaluate piping systems for the effects resulting from power uprate conditions to demonstrate design basis compliance in accordance with the USAS B31.1.0 Power Piping Code. System operation at power uprate conditions may increase piping stress levels, pipe support loads, equipment nozzle loads, etc., due to slightly higher operating temperatures, pressures, and/or flow rates.

The piping system evaluations have considered power uprate data from the 7.4-percent power uprate condition.

The scope of the KNPP piping that was evaluated for power uprate conditions included the following piping systems:

**Steam and Power Conversion Systems**

- Main Steam
- Bleed Steam
- Condensate
- Feedwater
- Circulating Water
- Steam Generator Blowdown
- Heater Drains

**Auxiliary Systems**

- Spent Fuel Pool Cooling
- Auxiliary Feedwater
- Residual Heat Removal
- Chemical Volume and Control

**Water Systems**

- Service Water
- Component Cooling Water

**Emergency Core Cooling Systems**

- Containment Spray
- Safety Injection

### 8.4.2 Description of Evaluation and Analysis

System operation at power uprate conditions generally results in increased pipe stress levels and pipe support loads due to slightly higher operating temperatures, pressures, and flow rates internal to the piping. The piping systems affected by the power uprate conditions were evaluated as follows:

Pre-power uprate and power uprate system operating data (operating temperature, pressure, and flow rate) were obtained from heat balance diagrams, calculations, and/or other applicable reference documents.

Change factors were determined, as required, to evaluate and compare the changes in operating conditions. The thermal, pressure and flow rate change factors were based on the following ratios:

- The thermal change factor was based on the ratio of the power uprate to pre-power uprate operating temperature. That is, thermal change factor is $(T_{power\ uprate}-70°F)/(T_{pre\text{-}power\ uprate}-70°F)$.

- The pressure "change factor" was determined by the ratio of $(P_{power\ uprate}/P_{pre\text{-}power\ uprate})$.

- The flow rate "change factor" was determined by the ratio of $(Flow_{power\ uprate}/Flow_{pre\text{-}PowerUprate})$.

These thermal, pressure, and flow rate change factors were used in determining the acceptability of piping systems for power uprate conditions.

Based on the thermal, pressure, and flow rate change factors determined as described above, the following engineering activities were performed and/or conclusions reached.

For thermal, pressure, and flow rate change factors less than or equal to 1.0 (that is, the pre-power uprate condition envelops or equals the power uprate condition), the piping system was concluded to be acceptable for power uprate conditions.

For thermal, pressure, and flow rate change factors greater than 1.0 through 1.05 (that is, a greater than zero and less than or equal to 5-percent increase in thermal expansion, pressure, and/or flow rate effects), this minor increase was concluded to be acceptable based on the following rationale. Certain levels of deviation from design basis conditions can be concluded to be permissible if that level of change would not alter the piping system results to an appreciable degree. Relatively small temperature changes can be concluded to be acceptable as the increase in pipe stresses, including stress levels used to postulate pipe break locations, pipe support loads, nozzle loads, jet impingement forces, pipe break loads, pipe whip restraint loads, and piping displacements, are correspondingly small and generally predictable. These increases are somewhat offset by conservatism in analytical methods used to calculate thermal and/or fluid transient stresses and loads. Conservatism may include the enveloping of multiple thermal operating conditions, as well as not considering pipe support gaps in thermal analyses. Also, for supports installed on safety related systems which are evaluated for seismic loading effects, a potential 5-percent increase in a specific thermal loading condition will generally result in a less than 5-percent overall pipe support design load increase due to the existence of seismic earthquake loads.

For thermal, pressure, and flow rate change factors greater than 1.05, more detailed evaluations were performed to address the specific increase in temperature, pressure and/or flow rate in order to document design basis compliance. Descriptions of the evaluations performed are provided in the following individual piping system sections.

#### 8.4.2.1 Steam and Power Conversion Systems

##### 8.4.2.1.1 Main Steam

A review of the power uprate data indicates that the operating temperature, pressure and flow rate will be increasing at 100-percent power conditions. A summary of these increases, including corresponding thermal, pressure and flow rate change factors follows:

**Table 8.4.2-1**

**MSS Pre-Uprate and Power Uprate Operating Data**

| Outlet of Steam Generator | Pre-Uprate | Power Uprate | Change Factor |
|---|---|---|---|
| Temperature °F | 509 | 518 | 1.02 |
| Pressure psia | 741 | 797 | 1.08 |
| Flow Rate lb/hr | 7.13M | 7.75M | 1.09 |

Although the temperature and pressure have increased based on the heat balance data, the existing main steam (MS) pipe stress analyses considered higher bounding temperatures and pressures (that is, 550°F and 1100 psig) in the piping analyses. Since the operating temperature and pressure associated with power uprate are bounded by the corresponding values in the piping analyses, these temperatures and pressures were concluded to be acceptable.

The main concern for the MS piping was related to the flow rate increase and its impact on the determination of fluid transient loads resulting from a turbine-stop-valve closure event.

A detailed assessment of the MS piping and support system from the steam generators to the turbine stop valves was performed to evaluate the higher flow rate resulting from power uprate conditions. The results of this analysis concluded that the existing main steam piping system remains acceptable for power uprate conditions.

#### 8.4.2.1.2 Bleed Steam

The existing operating temperature, pressure, and flow rate will be increasing as a result of power uprate. A summary of the temperature and pressure increases including applicable change factors is provided in Table 8.4.2-2.

| Table 8.4.2-2<br>Bleed Steam System Pre-Uprate and Power Uprate Operating Data | | | | |
|---|---|---|---|---|
| **System Boundary** | **Operating Parameter** | **Pre-Power Uprate** | **Power Uprate** | **Change Factor** |
| Extraction at Inlet of Feedwater Heaters 11A&B | Temperature (°F) | 158 | 162 | 1.05 |
| | Pressure (psia) | 4 | 5 | 1.25 |
| Extraction at Inlet of Feedwater Heaters 12A&B | Temperature (°F) | 215 | 219 | 1.03 |
| | Pressure (psia) | 15 | 16 | 1.07 |
| Extraction at Inlet of Feedwater Heaters 13A&B | Temperature (°F) | 281 | 287 | 1.03 |
| | Pressure (psia) | 47 | 51 | 1.09 |
| Extraction at Inlet of Feedwater Heaters 14A&B | Temperature (°F) | 362 | 368 | 1.02 |
| | Pressure (psia) | 157 | 169 | 1.08 |
| Extraction at Inlet of Feedwater Heaters 15A&B | Temperature (°F) | 436 | 443 | 1.02 |
| | Pressure (psia) | 364 | 394 | 1.08 |

As shown above, the resulting thermal change factors for the extraction piping are less than or equal to the 1.05 acceptance limit. Hence, the power uprate temperatures indicated above are concluded to be acceptable.

The pressure data summarized above results in change factors greater than 1.05. However, the actual pressure and piping pressure stress increases are not significant. Therefore, pressure increases summarized above are concluded to be acceptable.

Extraction steam line flow rate increases vary from 9 to 11 percent. There are no specific fluid transient analyses that have been considered in the existing qualification of the Extraction Steam System, and historically this system does not experience severe flow induced fluid transients. Therefore, the flow rate increases for this piping are concluded to be acceptable.

### 8.4.2.1.3 Condensate

A review of the power uprate data for the Condensate System reveals that the existing operating temperature and flow rate will be increasing as a result of power uprate. The operating pressure of the Condensate System will remain unchanged at 400 psia as a result of power uprate.

A summary of the Condensate System temperature increases, including "change factors," is provided in Table 8.4.2-3.

**Table 8.4.2-3**

**Condensate System Pre-Uprate and Power Uprate Operating Data**

| System Boundary | Operating Parameter | Pre-Power Uprate | Power Uprate | Change Factor |
|---|---|---|---|---|
| Condensate Pump to Heaters 11A&B | Temperature (°F) | 90 | 95 | 1.25 |
| Heaters 11A&B to 12A&B | Temperature (°F) | 152 | 156 | 1.05 |
| Heaters 12A&B to 13A&B | Temperature (°F) | 210 | 214 | 1.03 |
| Heaters 13A&B to 14A&B | Temperature (°F) | 273 | 278 | 1.02 |
| Heaters 14A&B to Feedwater Pumps | Temperature (°F) | 360 | 366 | 1.02 |

As shown above, for the piping between the condensate pump and FW heaters 11A and B, the resulting thermal change factor of 1.25 is based on the temperature increasing from 90°F to 95°F. Since the temperature increase is limited to only 5°F, and the resulting 95°F value is considered a low temperature with respect to piping qualification concerns, this portion of the Condensate System is considered acceptable for power uprate operating conditions.

The resulting thermal change factors for the balance of the Condensate System are less than or equal to the 1.05 acceptance limit. Hence, the power uprate temperatures indicated above are concluded to be acceptable.

The flow rate through the condensate pumps will be increasing by approximately 8 percent from 4.98M lb/hr to 5.39M lb/hr. Since the Condensate System does not contain any fast closing valves, no previous flow-induced fluid transient events have been identified, and no specific fluid transient evaluations/analyses have been performed on this piping, the subject flow rate increase is concluded to be acceptable.

#### 8.4.2.1.4 Feedwater

A review of the power uprate data for the AFS reveals that the existing operating temperature and flow rate will be increasing as a result of power uprate. The operating pressure of the AFS will remain unchanged at 1200 psia as a result of power uprate. A summary of the temperature and pressure data including applicable change factors is provided in Table 8.4.2-4.

**Table 8.4.2-4**

**FW System Pre-Uprate and Power Uprate Operating Data**

| System Boundary | Operating Parameter | Pre-Power Uprate | Power Uprate | Change Factor |
|---|---|---|---|---|
| FW Pump Discharge to Inlet of FW Heater | Temperature (°F) | 362 | 368 | 1.02 |
| | Pressure (psia) | 1200 | 1200 | 1.0 |
| Outlet of FW Heater to Steam Generators | Temperature (°F) | 430 | 437 | 1.01 |
| | Pressure (psia) | 1200 | 1200 | 1.0 |

As shown above, the maximum temperature increase is only 7°F, and the resulting thermal change factors are less than the 1.05 acceptance limit. Hence, the power uprate temperatures summarized above are concluded to be acceptable.

The pressure change factors are 1.0 and are also concluded to be acceptable.

Since the AFS does not contain any fast closing valves, and no previous flow induced fluid transient events have been identified, and no specific fluid transient analyses have been performed on this piping, the subject flow rate increase is concluded to be acceptable.

#### 8.4.2.1.5 Circulating Water

An overall evaluation for the CWS is given in subsection 8.3.6 of this report. A review of these assessments determined that no significant changes to operating temperatures and pressure are expected as a result of power uprate. Specifically, the system operating pressure remains unchanged and any potential increase to operating temperatures are limited to only 1.5°F.

Hence, the CWS is concluded to be acceptable for power uprate conditions.

#### 8.4.2.1.6 Steam Generator Blowdown

An overall evaluation for the SGBS is given in subsection 8.3.4 of this report. As described in subsection 8.3.4, the operating temperature and pressure of the steam generator blowdown piping will be 509°F and 797 psia, respectively, at power uprate conditions. The existing steam generator blowdown piping analysis has considered a higher bounding operating temperature and pressure (that is, 561°F and 1115 psia) for the pipe stress qualification.

As such, the SGBS is concluded to be acceptable for power conditions.

#### 8.4.2.1.7 Heater Drains

A review of the power uprate data for the Heater Vents and Drains System reveals that the existing operating temperature, pressure, and flow rate will be increasing as a result of power uprate. A summary of the temperature and pressure increases including applicable change factors is provided in Table 8.4.2-5.

**Table 8.4.2-5**

**Heater Drains System Pre-Uprate and Power Uprate Operating Data**

| System Boundary | Operating Parameter | Pre-Power Uprate | Power Uprate | Change Factor |
|---|---|---|---|---|
| Drain Piping from Heaters 15A&B to Heater Drains Tank | Temperature (°F) | 372 | 378 | 1.02 |
| | Pressure (psia) | 360 | 390 | 1.08 |
| Drain Piping from Heaters 14A&B to Heater Drains Tank | Temperature (°F) | 362 | 368 | 1.02 |
| | Pressure (psia) | 156 | 169 | 1.08 |
| Drain Piping from Heaters 13A&B to Heaters 12A&B | Temperature (°F) | 221 | 225 | 1.03 |
| | Pressure (psia) | 45 | 48 | 1.07 |
| Drain Piping from Heaters 12A&B to Heaters 11A&B | Temperature (°F) | 163 | 166 | 1.03 |
| | Pressure (psia) | 13 | 14 | 1.08 |
| Drain Piping from Heaters 11A&B to Condenser | Temperature (°F) | 97 | 102 | 1.19 |
| | Pressure (psia) | 3 | 3 | 1.00 |

As shown above, for the drain piping from heaters 11 A and B to the condenser, the resulting thermal change factor of 1.19 is based on the temperature increasing from 97°F to 102°F. Since the temperature increase is limited to only 5°F, and the resulting 102°F value is considered a low temperature with respect to piping qualification concerns, this portion of the Heater Vents and Drain System is considered acceptable for power uprate operating conditions.

The resulting thermal change factors for the balance of the heater vents and drain piping are less than the 1.05 acceptance limit. Hence, the power uprate temperatures indicated above are concluded to be acceptable.

The pressure data summarized above typically results in change factors greater than 1.05. However, the actual pressure and piping pressure stress increases are not significant.

The flow rate increase for heater drain lines is approximately 10 percent. There are no specific fluid transient analyses that have been considered in the existing qualification of the Heater Drains System, the system does not contain any fast closing valves, and historically this system

does not experience severe flow induced fluid transients. Therefore, the flow rate increases within the Heater Drains System are concluded to be acceptable.

#### 8.4.2.2 Auxiliary Systems

##### 8.4.2.2.1 Spent Fuel Pool Cooling

An overall evaluation of the Spent Fuel Pool Cooling System is given in subsection 8.3.8 of this report. Subsection 8.3.8 does not indicate that any increases occur to system operating pressures and/or flow rates as a result of power uprate. However, it was determined that the Spent Fuel Pool Cooling System may not be capable of maintaining the spent fuel pool temperature below 150°F (the existing TS limit), when considering a conservative set of assumptions. It is recommended that a cycle-specific calculation be performed prior to each refueling outage to determine the adequacy of the spent fuel pool cooling capacity based on expected SW temperature and heat exchanger performance capability. If the calculation shows that the spent fuel pool temperature will exceed 150°F, then movement of the fuel from the reactor into the spent fuel pool will not occur until the fuel has decayed to an acceptable level.

As such, there will be no change to the existing operating parameters of the Spent Fuel Pool Cooling System as a result of power uprate.

##### 8.4.2.2.2 Auxiliary Feedwater

An overall evaluation of the AFS is given in subsection 8.3.9 of this report. A review of these assessments concluded that no changes to operating temperature, pressure and/or flow rate have been identified as a result of power uprate.

##### 8.4.2.2.3 Residual Heat Removal

An assessment of the RHRS is provided in Section 4.1 of this report. The assessments performed do not indicate any increases to operating temperatures, pressures and/or flow rates as a result of power uprate.

#### 8.4.2.2.4 Chemical Volume and Control

An assessment of the CVCS is provided in Section 4.1 of this report. The assessments performed do not indicate any increases to operating temperatures, pressures and/or flow rates as a result of power uprate.

### 8.4.2.3 Water Systems

#### 8.4.2.3.1 Service Water

An overall evaluation for the SWS is given in subsection 8.3.10 of this report.

Subsection 8.3.10 of this report notes that the SW outlet temperature for power uprate from the CFCUs is approximately 262°F, but that this temperature was unaffected by power uprate. The existing pipe stress analyses for this portion of the SWS has considered a maximum operating temperature of 210°F. This issue will be resolved prior to power uprate.

Westinghouse analysis of the SWS indicated that the service water outlet piping from the component cooling heat exchangers will experience an operating temperature of 114°F as a result of power uprate. The existing pipe stress analyses for this portion of the service water system has considered a maximum operating temperature of 95°F. This issue will be resolved prior to power uprate.

#### 8.4.2.3.2 Component Cooling Water

An overall evaluation for the CCWS is given in subsection 8.3.11 of this report. The increased CCWS heat loads due to power uprate are primarily due to the increased RHR decay heat load during plant cooldown and RHR decay heat load during post-LOCA recirculation mode.

Westinghouse analysis of the CCWS indicates that the component cooling water outlet piping from the RHR heat exchangers will experience an operating temperature of 185°F as a result of power uprate.

The existing pipe stress analyses for this portion of the CCWS has considered a maximum operating temperature of 115°F. This issue will be resolved prior to power uprate.

#### 8.4.2.4 Emergency Core Cooling Systems

##### 8.4.2.4.1 Containment Spray

An evaluation of the Containment Spray System (CSS) is described in Section 4.1. Based on a review of the evaluations presented in Section 4.1, the maximum operating temperature considering power uprate conditions for containment spray piping is not impacted and will be less than 250°F, which is the existing temperature considered in the containment spray piping stress analyses.

The CSS is concluded to be acceptable for power uprate conditions.

##### 8.4.2.4.2 Safety Injection

An assessment of the Safety Injection System (SIS) is given in Section 4.1. A review of these assessments concluded that no adverse changes to operating temperature, pressure and/or flow rate have been identified as a result of power uprate.

#### 8.4.2.5 High-Energy Line Break Evaluation

Since changes to operating temperatures, pressures, and flow rates for applicable High-Energy Piping Systems were determined to be sufficiently small, the existing design basis for pipe break, jet impingement and pipe whip considerations remains acceptable for the power uprate conditions. That is, the power uprate does not result in any new or revised pipe break locations, and the existing design basis for pipe break, jet impingement and pipe whip considerations remains valid for power uprate conditions.

### 8.4.3 Results

The detailed results of the piping and pipe support evaluations are provided within the individual piping system summary sections.

The results of these evaluations determined that piping stress levels, pipe support loads, equipment nozzle loads, etc., associated with power uprate conditions, are within acceptable limits for all piping systems, assuming resolution of items noted above in this report section.

### 8.4.4 Conclusions

The piping and pipe support evaluations performed conclude that all piping systems remain acceptable, and will continue to satisfy design basis requirements when considering the temperature, pressure, and flow rate effects resulting from power uprate conditions, assuming resolution of items noted above in this report section.

### 8.4.5 References


1. PEPSE Heat Balance No. 13225-HB(D)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

2. PEPSE Heat Balance No. 13225-HB(D)-101-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

3. PEPSE Heat Balance No. 13225-HB(B)-205-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 767 psia), March 20, 2002.

4. PEPSE Heat Balance No. 13225-HB(B)-105-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 767 psia), March 20, 2002.

5. PEPSE Heat Balance No. 13225-HB(B)-206-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 782 psia), March 20, 2002.

6. PEPSE Heat Balance No. 13225-HB(B)-106-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 782 psia), March 20, 2002.

7. PEPSE Heat Balance No. 13225-HB(B)-207-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

8. PEPSE Heat Balance No. 13225-HB(B)-107-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

## 8.5 Structural Evaluation

### 8.5.1 Structural Evaluation of High-Energy Line Break Outside Containment

#### 8.5.1.1 Introduction and Background

The consequence of core power uprate on the structural loads associated with HELB outside containment is evaluated in this section. These loads are compartment differential pressures, temperature transients, and the static and dynamic effects of pipe rupture restraint reactions, jet impingement loads, and pipe whip loads. In addition to the structural loads, the high-energy pipe breaks result in the severe environmental conditions used for equipment qualification, comprising temperature, pressure, and flooding. Systems with piping outside the containment for which breaks are considered a part of the HELB licensing basis include:

- MSS piping including 30-inch diameter pipes, 18-inch branch pipes
- FW System piping, including 16-inch diameter pipes no branch pipes
- SGBS piping
- Auxiliary steam piping to the turbine-driven AFW pump

This power uprate evaluation addresses the consequences of postulated breaks in the large bore main steam piping systems, which affect the structural loadings, since breaks in the other systems do not govern the differential pressure loading on the structural components.

#### 8.5.1.2 Description of Analysis

The analysis of the MSLBs outside containment consists of the following elements: the identification of the MS pipe break locations and the verification of the hardware available to mitigate the effect of pipe break; an assessment of the capacity of the MS Line Pipe Rupture Protective System to withstand the incremental pressure related forces due to power uprate; and a review of the results of the compartment pressurization analysis to identify whether the protective system was used to mitigate the effects of the pipe break.

The encapsulation sleeves are designed to stress "limits associated with 'emergency condition' as stated in ASME III - Nuclear Power Plant Components Code, for Class I or II components." Rupture restraints are designed using limits equal to 90 percent of yield for membrane stresses and 135 percent of yield for the combination of membrane and peak bending stresses. System

pressure is a proxy for the pipe-rupture-related loads, pipe rupture restraint reactions, jet impingement loads, and pipe whip loads. The loads used for the design of these components are the pipe rupture loads due to the (no-load) hot-standby condition, which do not change with power uprate. Since no other loads are used for the hardware design, there is no change in the loads imposed on the pipe rupture mitigation hardware.

The cubicle pressurization analysis recognizes the break mitigation hardware by reducing the pipe discharge to 50 percent of the no-load flow. Had the mitigation hardware been accounted for in the mass and energy release model, the compartment pressure and temperature for main steam pipe breaks outside containment would have been shown not to change for power uprate.

#### 8.5.1.3 Results

The original, design basis differential pressures for the Auxiliary Building compartments are considered bounding for power uprate. Equipment provided to mitigate the effects of large-bore HELB will be loaded by power uprate reactions of the same magnitude compared to original design basis loads. This equipment will mitigate the effects of pipe rupture, and the structural walls, partitions and other barriers to HELB will remain effective for the compartment pressures associated with power uprate. Outside-containment HELBs do not create environmental conditions that result in challenges to the structural integrity of the barriers isolating the Special Ventilation Zone, Control Room, Control Room Air Conditioning Room, Relay Room, and Class I Aisle from the adverse effects of HELB.

#### 8.5.1.4 Conclusions

The power uprate will not result in compartment pressures exceeding the structural capacity of the walls and partitions protecting the areas housing equipment important to safety from the adverse environment associated with steam line rupture.

#### 8.5.1.5 References


1. Heat Balance Diagrams

   a. S&W Drawing No. 13225-HB(B)-201-1, 656.0 MWt NSSS Baseline Case KNPP (554.9 MWe - 740.5 psia)

b. S&W Drawing No. 13225-HB(B)-207-1, 1780.0 MWt NSSS Uprate Case KNPP (595.9 MWe - 797.0 psia)

### 8.5.2 Assessment of Containment Pressure and Temperature

#### 8.5.2.1 Introduction, Input Parameters, and Assumptions

The containment atmosphere pressure and temperature transients resulting from postulated accident scenarios have been estimated for power uprate conditions. For each accident scenario, the peak containment pressure and temperature have been determined and compared to the design values used for the design of the steel containment. It is assumed that the maximum steel containment temperature is the atmosphere temperature and no accounting for the details of heat transfer has been considered.

#### 8.5.2.2 Analysis, Acceptance Criteria, and Results and Conclusions

The following containment design temperature and pressure values were identified:

- Containment design temperature - 268°F
- Containment design pressure - 46 psig

Of the transients reviewed, it was found that the MSLBs resulted in the maximum values of the peak containment atmosphere temperature and pressure. These values were found to be:

- Uprate MSLB peak temperature - 267.3°F
- Uprate MSLB peak pressure - 60.6 psia or 45.9 psig

It is concluded that reactor power uprate for KNPP does not result in transient peak containment pressure and transient peak temperature values exceeding the containment design limits.

## 8.6 OPERATIONAL TRANSIENT ASSESSMENT

This section of this Engineering Report presents the evaluation, based on bounding conditions, of the capability of the Condensate, FW, and Heater Drain Systems to meet the current design and licensing basis for operational transients at the power uprate level. Conclusions will specifically state the applicable power uprate level.

### 8.6.1 Introduction and Background

The KNPP is designed to operate through various transient conditions. These transients include a range of load change scenarios. The ability of the BOP systems to cope with these transients is key to ensure proper operation, as well as meeting design and licensing requirements. The Condensate, Heater Drain, and FW Systems are the BOP systems that are required to respond to these transient conditions.

The Condensate, Heater Drain, and FW Systems provide high-grade preheated water from the condenser and moisture separator/heater drains to the steam generators. This FW is further heated by the RCS to generate steam to power the high-pressure and low-pressure turbines.

There are two half-capacity centrifugal condensate pumps; both pumps are normally in operation. The condensate pumps take suction from the condenser hotwell and discharge to a single header. Condensate then flows through the air ejector condensers and the gland steam condensers. The common header then splits into two lines for the first three stages of FW heaters. Condensate flow returns to a single header after heater 13 and then divides to split flow through the fourth-stage heaters. A single header connects downstream of heaters 14 to the FW pumps suction. The FW pumps discharge flows through one stage of high-pressure heating and then to the steam generators.

Low-pressure FW heaters stages 1 through 4 (Heaters 11A/B, 12A/B, 13A/B, and 14A/B) are arranged in two strings. Each heater has a bypass line. This bypass is only required when one heater in a stage is out of service and power is greater than 75 percent (of prior to power uprate). If power level is below 75 percent (of prior to power uprate) then the one inservice heater can handle the entire condensate flow.

The FW System automatically maintains the steam generator water level during steady-state and transient operation. Two half-capacity, motor-driven, main FW pumps are provided with

common suction (condensate) and common discharge (FW) headers. One FW pump can provide approximately 60-percent capacity with two condensate pumps operating. (Analysis done in support of this power uprate indicates that post-power uprate operation up to 65-percent power with one FW pump is achievable [refer to subsection 8.3.3].) The number of running FW pumps must be equal to or less than the number of running condensate pump. The FW pumps discharge is split for the final stage of FW heaters (heater 15A/B), and rejoins a common header that splits flow to the steam generators. A control system regulates the FW flow to maintain a programmed steam generator level by automatically controlling the FRV. A flow control bypass valve is provided to control FW flow at low-power operation.

Drains from FW heater 15A/B, (which includes first point bleed steam and reheat steam), heater 14A/B, and the moisture separator drains are directed to a single-heater drain tank. Drains from the three remaining low-pressure FW heaters (heater 13A/B, 12A/B, and 11A/B) are cascaded back to the condenser.

Two half-capacity heater drain pumps take their suction from the heater drain tank and discharge into a common header. This discharge header connects to the Condensate System upstream of the FW pumps suction.

Heater drain flow into the condensate header is controlled to maintain heater drain tank level. During steady state full-power operation, the heater drain flow is approximately 30 percent of the total FW flow. Flow is controlled by varying the speed of the heater drain pumps based on heater drain tank level, thereby maintaining heater drain tank level within preset limits. A dump valve to the condenser is provided to divert heater drain flow during a high-heater drain tank level condition.

The Kewaunee Heater Drain System is designed such that the heater drain pump suction is subcooled by approximately 6°F. This is accomplished by providing approximately 100 gpm of condensate pump discharge flow to the heater drain pump suction to prevent loss of pump suction NPSH during changing load conditions. A 10-inch bypass line around the low-pressure FW heaters is provided. A normally closed motor operated valve in this line (C-13/MV-32024) will open on a low FW pumps suction pressure of 220 psig.

### 8.6.2 Transient Design Basis

The KNPP USAR addresses several load change scenarios. All of these scenarios involve a load change without a reactor trip. These include a step-load change of 10 percent (increase or decrease in load) or a ramp change in load of 5 percent per minute. These transients are not as severe as a major load rejection (50-percent rejection from 100-percent power) transient is. Therefore, this report section will discuss the major load rejection transient (design basis) analysis.

**50-Percent Load Rejection**

The maximum step-load decrease the plant is designed to accommodate without reactor trip is a step decrease of 50 percent of the plant-rated load. During a 50-percent step loss of load, the steam generator pressure rises approximately 100 psi above the full-load (100-percent power) steam pressure. Required FW flow is 96 percent of the full-power FW flow to prevent a reactor trip due to the shrink of steam generator water level as the steam pressure increases. For this transient, the major area of concern is maintaining system pump operation at required flow and pressure. The transient will cause the extraction steam pressure to decrease (and therefore, heater drain tank pressure to decrease). This causes the heater drain flows to initially flash and then be reestablished at a reduced rate. Therefore, the Condensate System flow will increase to provide the entire FW flow.

### 8.6.3 Description of Analysis

In order to evaluate the FW, Condensate, and Heater Drain System capability during load transients at the power uprate power level, the Condensate/FW System hydraulic flow model was used to determine the system hydraulic conditions using an iterative process. Several cases were run using the model to predict the system parameters based on the following bounding conditions:

- Steam generator pressure increase of 100 psi above power uprate full-power operating pressure

- FW flow of 96 percent of the power uprated full-power operating flow to the steam generator

- Complete loss-of-heater drain flow

The above bounding conditions are conservatively assumed to occur at the beginning of the transient. The limitations of the hydraulic analysis are that it is a steady-state snapshot at the most limiting conditions and does not predict the transient behavior as a function of time. Additionally, the evaluation is based on the assumption that the NSSS is not impacted as long as the 96-percent FW flow can be provided at the above bounding conditions during the load rejection. However, this approach is acceptable because it conservatively combines the bounding conditions expected during the transient.

The following conditions need to be satisfied to demonstrate that the 50-percent load rejection design basis can be supported:

- FW pumps can provide sufficient FW pump discharge pressure and flow to the steam generator (96 percent of full-load FW flow) with a 100-psi increase in steam generator pressure.

- Condensate pumps can provide sufficient condensate flow to make-up for the loss of heater drains and provide sufficient discharge pressure to satisfy FW pumps NPSH requirements. The condensate FW heater bypass line can be used to support this requirement. FW pumps NPSH must be maintained above 180 psig. The bypass line control valve is set to open at 220-psig FW pumps suction pressure. Adequate condensate pump NPSHa must also be maintained.

### 8.6.4 Results

Multiple cases of the hydraulic model were run. Based on these results a determination of capability of the FW flow control valves, FW pumps, and condensate pumps to support the large-load rejection transient was made.

**Feedwater Flow Control Valves**

For the 7.4-percent power uprate case, with the low-pressure FW bypass closed, the A FRV would not be able to pass the required flow. Additionally, the B FRV required Cv would be excessively large. The FW pumps suction pressure is calculated to be below the low-pressure heater bypass initiation setpoint (220 psig at the FW pumps suction). Therefore, it is expected in this scenario that the heater bypass would open to increase system pressure.

For the 7.4-percent power uprate cases with the low-pressure FW heaters bypassed, it is calculated that both FRVs will have adequate differential pressure to support operation. A Cv of approximately 875 would be required to support this operation. This is greater than the current FRV Cv of approximately 500. Therefore, the FRV trim would require modification to increase the valve Cv to support the large-load rejection at 7.4-percent power uprate conditions.

**Feedwater Pumps**

For the 7.4-percent Power increase transient case, the NPSHr is approximately 110 ft, the Condensate System also can not support this requirement with the low-pressure FW heater bypass closed. the FW pumps suction pressure will drop below 220 psig to allow condensate flow to bypass the low-pressure FW heaters to restore FW pumps suction pressure and ensure adequate NPSHa. Therefore, the model case with the low-pressure FW heaters bypassed reflects expected plant response to the large-load rejection transient.

For the 7.4-percent power uprate increase cases, with the low-pressure FW heaters bypassed, the Condensate System is able to maintain adequate FW pumps suction pressure to ensure FW NPSHa is greater than NPSHr. During the transient, FW pumps suction pressure is expected to drop below 220 psig. This will open the low-pressure FW heater bypass valve (C-13) and restore FW pumps suction pressure. Once this bypass is opened, the Condensate System will provide adequate pressure (NPSHa) to support continued FW pumps operation.

The FW pumps have adequate capacity to support the 7.4-percent power uprate normal and transient operations.

**Condensate Pumps**

The condensate pumps maintain adequate NPSHa. Therefore, the condensate pumps have adequate capacity to support power uprate transient conditions.

### 8.6.5 Steam Generator Level

Modifications are required to the Steam Generator Level Control System to support power uprate operation. Without these modifications, the steam generator level would exceed both the high-level turbine trip/FW isolation setpoint and the low level reactor trip during a 50-percent load rejection. With the proposed modification to the steam generator level control system and a FRV Cv of 732, acceptable level would be maintained throughout the transient.

### 8.6.6 Conclusions

For a 50-percent load rejection transient, the overall plant response will be similar to the current plant response to such an event. Heater drain pumps would have inadequate NPSHa to support pump operations. Therefore, the condensate pumps would "run-out" to maintain FW flow. The FRV would go to full open to maintain FW flow and steam generator water level at the increased steam generator pressures.

The current FRVs do not have sufficient flow capacity at either power uprate power level to support the power uprate required flow at the increased steam generator pressure. Modifications to the FRV trim to increase the Cv will be required for acceptable operation for the power uprate conditions.

The condensate and FW pumps have adequate capacity to support the required system flows for both power uprate power levels. The condensate pumps have adequate NPSH to support both power uprate power levels. The FW pumps will not have adequate NPSH unless the low-pressure FW heaters are bypassed during the transient. With the low-pressure FW heaters bypassed the FW pumps will have adequate NPSH for both power uprate levels.

With the recommended modifications to the FRV Cv and proper operation of the FW heater bypass, the Condensate/FW/Heater Drain Systems are adequate to support the design basis (50-percent load rejection from 100-percent power) transients for a 7.4-percent power uprate

from current power levels. The systems are also considered acceptable for less severe transients (including the 5-percent per minute load change) at power uprate levels.

With a modified FRV Cv of 732 and adjustments to the Steam Generator Level Control System time constants and gains, the 50-percent load rejection transient for 7.4-percent power uprate conditions maintains an acceptable steam generator level.

### 8.6.7 References


1. PEPSE Heat Balance No. 13225-HB (D)-201-1, 1656 MWt NSSS Baseline Case, March 20, 2002.

2. PEPSE Heat Balance No. 13225-HB (B)-205-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 767 psia), March 20, 2002.

3. PEPSE Heat Balance No. 13225-HB (B)-205-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 782 psia), March 20, 2002.

4. PEPSE Heat Balance No. 13225-HB (B)-207-1, 1780 MWt NSSS Uprate Case (Main Steam Pressure 797 psia), March 20, 2002.

## 8.7 Programs

### 8.7.1 Generic Issues and Programs

The power uprate has the potential to affect programs that were developed and implemented by station personnel to demonstrate that topical areas and procedures associated with the program comply with various design and licensing requirements. The topical plant programs listed in Table 8.7.1-1 were identified for review. In addition to these topical plant programs based on previous experience, the plant Technical Specifications also address specific requirements for a number of programs, and these programs are identified in Table 8.7.1-2.

For the programs listed in Table 8.7.1-1, the associated procedures and processes along with key reference items within the associated procedures were reviewed. The extent of impact by the implementation of the power uprate was determined for the various topical programs. Table 8.7.1-3 identifies affected systems and specific process impacts.

Programs were categorized as either affected or not affected by the power uprate. Programs may not be affected by the power uprate if: the power uprate does not change key inputs to the program, or the program is based on information that exceeds the operating conditions that will result from the implementation of the power uprate. Specifically, the program may be based on system design values that exceed both the current operating conditions as well as those resulting from the implementation of the power uprate.

| Table 8.7.1-1<br>Topical Programs Reviewed for Effects of Power Uprate | | |
|---|---|---|
| | **Non-Affected** | **Affected** |
| Plant Simulator | | X[1] |
| Fire Protection (Appendix R) | X | |
| Check Valve Program | X | |
| MOV Program (GL 89-10) | X | |
| Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves (GL 95-07) | X | |
| Assurance of Equipment Operability and Containment Integrity during DBA Conditions (GL 96-06) | X | |
| AOV Program | | X |
| Heat Exchanger Program (GL 89-13) | | X |
| Inservice Inspection Program (ISI) | X | |
| Inservice Test Program (IST) | X | |
| Containment Integrity (Appendix J) | X | |
| HELB | X | |
| Human Factors | X | |
| Internal Containment Flooding | X | |
| Station Blackout (SBO) | X | |
| Internal Missiles | X | |
| ATWS | X | |
| FAC | | X |
| Crossunder and Crossover Piping | X | |
| EQ | | X |

Note:

1. Physical changes (scale changes and some meter change-outs) are captured by in-place design change procedures.

**Table 8.7.1-2**

**Technical Specification Programs Reviewed for Power Uprate**

| Program | TECH SPEC | Not Affected | Affected[1] |
|---|---|---|---|
| Technical Specification and Technical Specification Bases Control Program | N/A | X | |
| Ventilation Filter Testing Program | 3.6.c.1<br>3.6.c.2<br>3.8.a.9<br>3.12<br>4.4.c<br>4.4.d | X | |
| *Operational Safety Review Program: Calibration, Testing, and* Checking of Instrumentation and Logic Channels along with Equipment and Sampling Tests | 4.1<br>3.5 | X | |
| In-Service Testing and Inspection Programs. (for example, pump testing, RCP flywheel inspection, reactor containment vessel inspection, check valve inspections, etc.) | 4.2a | X | |
| Steam Generator Tube Surveillance Program | 4.2b | X | |
| Emergency Power Systems – Diesel Loading | 4.6a | X | |
| Testing and Surveillance of Shock Suppressers (safety-related only) | 4.14<br>3.14 | X | |
| Training and Replacement Training Program | 6.4 | X | |
| Procedure Program for Writing, Changing and Reviewing Procedures | 6.8 | X | |
| Reporting Program<br>1. Start-UpTest Report<br>2. Radiological Environmental Monitoring Report<br>3. Radioactive Effluent Release Report<br>4. Special Reporting | 6.9 | X | |
| Records Retention for RCS Transients | 6.10.b.6 | X | |
| Radiation Protection Program for Personnel Exposure and Iodine Monitoring | 6.11 | X | |
| System Integrity Program – Leakage Monitoring of Systems outside Containment | 6.12 | X | |
| Post-Accident Sampling and Monitoring Program | 6.14 | X | |
| Secondary Water Chemistry Program | 6.15 | X | |
| Quality Assurance Program for Effluent and Environmental Monitoring | 6.16a | X | |
| Radiological Effluent Controls Program | 6.16b | X | |
| Radioactive Environmental Monitoring Program | 6.16b | X | |
| Process Control Program for Processing and Packaging of Solid Radioactive Waste | 6.17 | X | |
| Offsite Dose Calculation Manual and Radiological Environmental Monitoring Manual | 6.18<br>6.16.b.2 | X | |
| Containment Leakage Rate Testing Program | 6.20 | | X |

Note:

1. In-place processes and procedures inherently capture any impact to the program caused by the power uprate.

**Table 8.7.1-3**

**System Process Impact and Program Review**

| System | System Process Impact | Discussion | Programs |
|---|---|---|---|
| AFW | CST Inventory Increased | Technical Specification 3.3.c.1 Requires a Minimum Volume of 39,000 gallons. Power Uprate Requires the Minimum Volume to be Increased to 41,500 gallons. | Appendix R, IST, SBO, Simulator |
| Containment Spray | No Impact | | |
| Reactor Containment Cooling | Heat Load Increase | Increased heat load is within the capability of the fan coil units to remove heat losses from equipment and piping within the containment. | Appendix R, GL 89-13, IST, Simulator |
| SI | No Impact | | |
| RHR | Heat Load – Increased for Cooldown and Post-Accident Operation. | Heat Exchanger Program Update<br>Procedure Review and Update<br>Computer/Simulator Review/Update | Appendix R, GL 89-13, ISI, IST, SBO, Simulator |
| RCS | Temperature $-T_{avg}$ and $\Delta T$ increased. | Scaling for RCS Instrumentation Sensitive to $T_{avg}$ and $\Delta T$ are Affected. | Simulator |
| CVCS | No Impact | | |
| RCS Sample | No Impact | | |
| CCW | Heat load – Increased for Normal Plant Cooldown and Post-Accident Operation | Heat Exchanger Program Update<br>Procedure Review and Update<br>Computer/Simulator Review and Update | Appendix R, GL 89-13, ISI, IST, Simulator |
| SW | Heat Load and Temperature Increase | UHS Temperature Remains Unchanged. Surveillance and Emergency Operating Procedures Reviewed for Impact and Update. | IST, Simulator |
| SPF Cooling | Heat Load and Temperature Increase | Minimal Increase of Normal Operating Temperature, but No Significant Change is Expected. | GL 89-13, IST, Simulator |

**Table 8.7.1-3 (Cont.)**

**System Process Impact and Program Review**

| System | System Process Impact | Discussion | Programs |
|---|---|---|---|
| MS | Flow Increased<br>Pressure Increased<br>Temperature Increased | Steam Generator and Main Steam Header Operate at a Higher Pressure<br>Impulse Pressure Increase for High-Pressure Turbine | Procedure review and update Check valve, MOV ISI, HELB, Internal Missiles, FAC, Simulator |
| Heater Drain | Flow Increased<br>Pressure Increased<br>Temperature Increased | Procedure Review and Update | FAC, Simulator |
| Condensate | Flow Increased | Pressure Decreased - Pump Discharge Pressure Will Decrease Resulting in Lower System Pressure<br>Velocity Changes May Require Update of FAC Program and Models<br>Procedure Review and Update<br>Computer/Simulator Review and Update | FAC, Simulator |
| FW | Flow Increased<br>Pressure Increased | Internals of FW Control Valves Modified for Increased Flow<br>Velocity Changes Require Update of FAC Program<br>Procedure Review and Update<br>Computer/Simulator Review and Update | Check valve, AOV, MOV, ISI, HELB, Simulator, FAC |
| Bleed Steam | Flow Increased<br>Pressure Increased<br>Temperature Increased | Velocity Changes May Require Update of Fac Program.<br>Procedure Review and Update<br>Computer/Simulator Review and Update | FAC, Simulator |
| SGB | No Impact | | |
| CW | No Impact | | |

### 8.7.2 Plant Procedures

The power uprate has the potential to affect plant procedures used to operate and maintain the facility in accordance with design basis and licensing requirements, and a procedure review activity was performed to determine specific power uprate impacts to plant procedures. Procedures that are affected will be identified, revised, reviewed, approved, and training conducted, where required, prior to implementation of the power uprate.

#### 8.7.2.1 Review Process to Identify Affected Procedures

The procedure indices for the various categories of plant procedures were obtained and screened based on the type of procedure and topic or title of the procedure. The screening criteria were keyed to identify those procedures that potentially may be impacted by the power uprate. A physical review of each procedure identified during the screening was conducted to determine the need for impact and revision. As expected, the majority of the revisions are minor in nature and do not change the intent of the procedure. Only clarification to address the power uprate conditions is necessary. However, a small number of procedures require setpoint changes, and these procedures may require additional reviews to fully implement the change.

## 8.8 Radiological Assessments

This section of the licensing report is focused on assessing the radiological impact of a 7.4-percent power uprate at KNPP. The current licensing basis core power level is 1650 MWt. The power uprated core power level being evaluated is 1772 MWt. The power uprate NSSS power level is estimated at approximately 1780 MWt, based on the additional 8 MWt resulting from operation of the reactor coolant pumps. The current 18-month fuel cycle is expected to remain unchanged.

The radiological impact of power uprate was evaluated for the following:

- Normal operation dose rates and shielding
- Normal operation annual radwaste effluent releases
- Post-accident access to vital areas
- Radiological EQ

Radiological evaluations for accident related issues were assessed at a core power level of 1782.6 MWt to include a safety margin of 0.6 percent. Installation of improved FW measurement instrumentation used for the calorimetric power calculation allows the margin for instrument error to be reduced from the traditional 2 percent, as recommended in Regulatory Guide 1.49, *Power Levels of Nuclear Power Plants*, Revision 1, to 0.6 percent.

Except as noted, radiological evaluations for normal operation related issues were assessed for power uprate at a core power level of 1772 MWt. In accordance with regulatory guidance provided in NUREG-0017, Revision 1 (see subsection 8.8.2 for detail), the radwaste effluent assessment assumed a core power level of 1782.6 MWt to be consistent with the safety analyses, but utilized flow rates and coolant masses at the full NSSS power level of 1780 MWt.

The power uprate evaluations discussed in this section are based on scaling techniques. The radiation source terms utilized in the power uprate evaluations take into consideration operation with an 18-month fuel cycle. The estimated increase in radiation levels currently based on analyses reflect, in addition to the power uprated power level:

- The change in fuel cycle length

- The use of current computer codes, methodology, and nuclear data in developing the power uprate core/reactor coolant inventory (versus the methodology, computer tools, and nuclear data used in the development of the original licensing basis core/reactor coolant inventory).

For the most part, the percentage of the estimated increase that can be attributed directly to the power uprate is approximately the percentage of the core power uprate.

### 8.8.1 Normal Operation Dose Rates and Shielding

#### 8.8.1.1 Introduction and Background

Cubicle wall thickness is specified not only for structural and separation requirements, but also to provide radiation shielding in support of radiological EQ, and to reduce operator exposure during all modes of plant operation, including maintenance and accidents.

Conservative estimates of the radiation sources in plant systems and components form the bases of normal operation plant shielding and radiation zoning. These radiation source terms are primarily derived from conservative estimates of the reactor core and reactor coolant isotopic inventory and are referred to as "design-basis" source terms. Core power uprate will impact the isotopic inventory in the core. In addition, since the design basis RCS source term is based on 1-percent fuel defects, the power uprate will result in an increase in the design basis RCS concentration.

The expected radiation source terms in the coolant will also be impacted by core power uprate. Expected source terms are less than that allowed by the plant Technical Specifications and are usually significantly less than the design basis source terms.

The impact of the power uprate on the normal operation dose rates, and the adequacy of existing shielding was evaluated to ensure continued safe operation within regulatory limits. This section also discusses the impact of the power uprate on the normal operation component of the total integrated dose used for radiological environmental qualification.

### 8.8.1.2 Description of Analyses

Core power uprate from 1650 MWt to 1772 MWt will increase the activity inventory of fission products in the core by approximately the percentage of the power uprate. The radioactivity levels in the primary coolant, secondary coolant, and other radioactive process systems and components will also be impacted.

The original shielding design for KNPP was based on a core power level of 1721 MWt, a traditional 1-year fuel cycle and a design-RCS source term based on 1721-MWt/1-percent failed fuel. As part of the Power Uprate Project, and to reflect power uprate conditions, new radiological source terms were developed for the core and the RCS. The power uprate core inventory is based on 1782.6 MWt and an 18-month fuel cycle. The power uprate "design" RCS source term is based on 1782.6-MWt/1-percent failed fuel and an 18-month fuel cycle. The inclusion of the 18-month fuel cycle will serve to increase the inventory of the long-lived isotopes.

The assessment is divided into four parts and is summarized below:

- Areas near the reactor vessel/primary shield wall where the dose rate is dominated by the reactor core neutron flux during power operation and gamma radiation from the irradiated fuel and neutron activated sources during shutdown.
- Areas in containment adjacent to the RCS/secondary shielding where the dose rate is dominated by the high energy gammas associated with N-16.
- Areas near spent-fuel assemblies where the dose rate is dominated by the gamma radiation from the irradiated fuel.
- Areas outside the containment where the dose rate is determined by radiation sources derived from primary coolant activity.

**Dose Rates near Reactor Vessel /Primary Shield Wall**

Area dose rates during normal plant operation at 100-percent power bound that expected during all other modes of operation including shutdown and is, therefore, the basis of the dose estimates used for environmental qualification and shielding. Since the dose rates near the

reactor vessel at 100-percent power are dominated by neutron and gamma fluxes from the core fission process, the impact of the use of 18-month fuel cycle is insignificant.

The pre-power uprate calculations of neutron and gamma ray leakage from the KNPP reactor for the Radiation Source Manual were based on a design basis core configuration that included fresh fuel on the core periphery and an assumed core power level of 1721 MWt. This fuel management approach resulted in relatively high-power generation at the periphery of the core, thus maximizing the neutron and gamma radiation levels external to the reactor vessel. In actual operations, the Kewaunee reactor has transitioned to low leakage fuel management, which places burned fuel on the periphery of the core. This fuel management strategy acts to reduce radiation leakage by at least a factor of 2-to-4. The equilibrium fuel cycle defined for the Kewaunee Power Uprate Program also represents a low-leakage core design. Based on the application of low-leakage fuel management, the increase in reactor power from 1721 MWt (in the *Radiation Source Manual*) to 1772 MWt (an increase of 3 percent), or from the current operating power of 1650 MWt (an increase of 7.4 percent) is completely offset by the reduction in core leakage. Thus, the reactor power uprate will have no practical impact on the design basis of the primary shielding and the dose rates adjacent to the reactor vessel/primary wall.

**In-Containment Areas Adjacent to Reactor Coolant System/Secondary Shielding**

Area dose rates during normal plant operation at 100-percent power bound that expected during all other modes of operation including shutdown and is, therefore, the basis of the dose estimates used for environmental qualification and shielding.

The secondary shielding was designed to attenuate the radiation originating from the N-16 activity. N-16 is produced as the oxygen (of the water moderator) is exposed to the neutron flux present in the reactor core. The amount of activation is defined by the flux (or power) density of the core and the amount of time the moderator is resident in the core. After the moderator exits the core (and neutron field), decay of the N-16 will occur. The amount of decay at any given point in the coolant loop is defined by the time subsequent to exiting the core.

The radiation levels from N-16 source are essentially proportional to reactor power. Therefore, it is expected that the normal operation dose rate inside containment adjacent to RCS areas will increase from the observed values by the ratio of power uprate core power to the current core

power (that is, 1.074). Note that due to its short half-life, the N-16 activity level is not impacted by the use of 18-month fuel cycle.

During shutdown, the major radiation sources in the RCS components located within containment are the deposited corrosion products on the internal surfaces and the decayed/degassed/filtered primary coolant activity. The corrosion product activity used in the original shielding analyses was based on industry wide operating experience. A review of the power uprate RCS corrosion product activities provided by Westinghouse indicates that the activity of the dominating isotope, Co-60, has since been lowered and is bounded by the pre-power uprate condition.

Near-Spent Fuel Assemblies: This source depends on both the power level and, for the long-lived isotopes, on the fuel burnup. Unless a piece of equipment is specifically exposed to an "old" spent fuel assembly, the exposure will increase by approximately the percentage of the power uprate; that is, approximately 7.4 percent. Due to the 18-month fuel cycle, which will increase the inventory of long-lived isotopes, the percentage increase in dose rate from an old spent fuel assembly may be slightly higher than the percentage of power uprate. However, this is not a significant concern as the dose rate near the spent fuel pool is dominated by the freshly discharged spent fuel assemblies and/or corrosion products in the pool that form the basis of shielding design.

Outside Containment: In support of shielding provided outside the containment, where the radiation sources are either the reactor coolant itself or down-stream sources originating from coolant activity, a review was performed of the power uprate design primary coolant source terms (fission and activation products) versus the original design basis primary coolant source terms. A comparison was performed of the gamma energy emission rates by energy group for the equilibrium power uprate versus original primary coolant source terms. The sources evaluated included total primary coolant, degassed primary coolant and the primary coolant noble gas source. Due to the change in isotopic compositions and gamma energy spectrum between the original and the power uprate RCS fluid, the comparison was based on the dose rate shielded by 0, 1, 2, and 3 ft of concrete for representative source geometry. The power uprate evaluation reflects the difference of computer codes used in generating the source terms and shielding analyses, difference in nuclear libraries, and takes into consideration the conservative simplified modeling typically employed in shielding design. In addition, the

evaluation considers the operation limits imposed by the plant Technical Specifications on the primary coolant activity.

The dose rate ratios resulting from the power uprate source to the pre-power uprate source for the various design basis source term/shielding configurations discussed above ranged from 0.93 to 2.2. However, since the design basis power uprated primary coolant activity is a very conservative source term (that is, 1-percent defective fuel, which is equivalent to 4.5 µci/gm dose equivalent I-131), credit is taken for a more realistic but limiting upper bound primary coolant activity based on the plant Technical Specifications.

The current plant Technical Specifications restrict the primary coolant activity to a maximum of 0.2 µci/gm DE I-131 (Technical Specification, Section 3.1.c), which provides an inherent margin of more than a factor of 20 relative to the design basis primary coolant (that is, 4.5 µci/gm/ 0.2 µci/gm). Note that this margin will drop to 4.5 with a more typical Technical Specification limit of 1 µci/gm DE I-131. Regardless, the available margin due to the limits imposed by the Technical Specification will continue to bound the maximum calculated increase in the design basis source term (that is, 2.2) due to the power uprate.

Therefore, taking into consideration the limits on RCS concentrations imposed by the plant Technical Specifications, it is concluded that the shielding design based on the original design basis primary coolant activity remains valid at the power uprate condition.

#### 8.8.1.3 Results

The impact of the power uprate on shielding/radiation zones as they relate to personnel exposure and on the normal operation component of environmental qualification is summarized below.

##### 8.8.1.3.1 Impact of Power Uprate on Shielding/Radiation Zones: Personnel Exposure

The power uprate will impact the radiation source terms in the core and the expected radiation source terms in the coolant. The actual increase in radiation levels due to the power uprate will not significantly affect radiation zoning or shielding requirements in the various areas of the plant because it is expected that the increase due to the power uprate will be offset by the:

- Conservative analytical techniques typically used to establish shielding requirements

- Conservatism in the pre-power uprate design basis RCS source terms used to establish the radiation zones

- Plant Technical Specifications that limit the RCS concentrations to levels well below the design basis source terms

Regardless, individual worker exposures will be maintained within acceptable limits by the site As-Low-as-Is-Reasonably-Achievable (ALARA) Program that controls access to radiation areas.

**8.8.1.3.2 Impact of Power Uprate on the Normal Operation Component for Environmental Qualification**

Appendix C of the KNPP EQ Plan provides the radiological environmental dose, by zones or specific locations, to which the electrical equipment important to safety will be qualified.

**Radiological Environmental Levels Supporting Environmental Qualification Zones**

The estimated power uprate dose rate in each of the EQ zones identified in Tables C-1 to C-3 and C-5 to C-20 of the EQ Plan, is enveloped by the dose rate assumed in the EQ Plan to develop the existing 40 year integrated dose noted therein. Consequently, except as noted below, the current 40-year normal operation doses presented in the EQ Plan for the EQ zones remain valid for core power uprate.

The Containment Zone in the EQ Plan currently includes the pressurizer/steam generator/reactor coolant pump Vaults. Review of the survey dose rates for the pressurizer (below El 649' 6")/steam generator/RCP vaults indicates that at the current power level, the survey dose rates in the vaults are greater than the value used to establish the dose in the EQ Plan for the Containment Zone. The power uprate will exacerbate this problem. Based on discussions with KNPP, the EQ Plan will be updated by KNPP to include an exclusion area within the Containment Zone to address the referenced vaults; and the 40-year integrated dose in the vaults will be based on a dose rate of 50 R/hr, which will encompass the current survey data of 35 R/hr, and will also accommodate the potential 7.4-percent increase in radiation levels due to core power uprate.

**Radiological Environmental Levels at Specific Locations outside Containment**

The environmental conditions at each of the locations noted in Table C-22 of the EQ Plan, are still considered valid and are utilized by KNPP to obtain specific location dose information to aid in choosing appropriate locations for new equipment or relocating existing equipment.

A reasonably conservative estimate for the impact of the power uprate on the normal operation dose rate would be an increase in dose rates equivalent to the percentage of the power uprate (that is, 7.4 percent).

The 40-year normal operation radiation dose value following power uprate at locations 1-164, 1-183, 16221, 16222, 19528, 19529, 33302, and 33313 (see Table C-22) is changed to 3.5E3 rads based on recent plant survey data in that area and power uprate increase percentage of 7.4 percent.

#### 8.8.1.4 Conclusions

The power uprate has no significant effect on plant normal operation radiation zones and shielding requirements.

The impact of power uprate on the normal operation component of the total integrated dose used for radiological EQ is incorporated in the KNPP EQ Plan. A review of the KNPP EQ evaluation and review files has determined that power uprate will not impact the qualification of safety-related equipment in the EQ Plan.

### 8.8.2 Normal Operation Annual Radwaste Effluent Releases

#### 8.8.2.1 Introduction and Background

Liquid and gaseous effluents released to the environment during normal plant operations contain small quantities of radioactive materials.

- Liquid Radioactive Waste: Liquids from reactor process systems, or liquids that have become contaminated with these process system liquids, are considered liquid radioactive waste. These wastes are then processed according to their purity level (boron concentration, conductivity, insoluble solids content, organic content, and activity) before being recycled within the plant, discharged to the environment, or reprocessed

through the radioactive waste system for further purification until the dose guidelines of 10CFR50 Appendix I are met.

- Gaseous Radioactive Waste: Airborne particulates and gases vented from process equipment, and the building ventilation exhaust air is considered gaseous radioactive waste. The major source of gaseous radioactive waste (processing the reactor coolant by the gas stripper and the Cover Gas System) are decayed using gas decay tanks, filtered, and monitored prior to release to ensure that the dose guidelines of 10CFR50 Appendix I are not exceeded.

The power uprate will increase the activity level of radioactive isotopes in the primary and secondary coolant. Due to leakage or process operations, fractions of these fluids are transported to the liquid and gaseous radwaste systems where they are processed prior to discharge. As the activity levels in the primary and secondary coolant are increased, the activity level of radwaste inputs is proportionately increased. Regulatory guidance relative to methodology to be utilized to establish whether the radwaste effluent releases from a pressurized-water reactor (PWR) meet the requirements of 10CFR20/10CFR50 Appendix I is provided in NUREG-0017, Revision 1. It is noted that the NUREG-0017 methodology is independent of the length of the fuel cycle.

The liquid and gaseous radwaste systems' design must be such that the plant is capable of maintaining normal operation offsite releases and doses within the requirements of 10CFR20 and 10CFR50 Appendix I. (Note that actual performance and operation of installed equipment and reporting of actual offsite releases and doses continues to be controlled by the requirements of the *Offsite Dose Calculation Manual.*)

The *Kewaunee Annual Radioactive Effluent Release Reports* for 1996 through 2000 demonstrate that the current gaseous and liquid radwaste releases from the site are well within the release/dose limits set by 10CFR20 and 10CFR50 Appendix I. The impact of the power uprate on these releases is evaluated to ensure continued operation within regulatory limits. The evaluation takes into consideration that during the last 5 years, Kewaunee did not operate at its licensed power level due to limitations on the secondary side. In addition, in 2001, Kewaunee replaced its steam generators. Consequently, the power uprated system conditions utilized in this assessment reflect the replacement steam generators (RSGs), whereas the pre-power uprate values represent pre-RSG parameters.

### 8.8.2.2 Description of Analyses

Using the methodology outlined in NUREG-0017, the change in primary and secondary coolant activity due to power uprate is estimated using scaling techniques. The highest percentage change in activity level is applied to all effluents to bound the impact on offsite releases. The percentage change is applied to the offsite doses reported in the annual effluent reports for 1996 to 2000 to determine whether the estimated offsite doses following power uprate, although increased, continue to remain below the regulatory limits and the guidelines of 10CFR20/10CFR50 Appendix I.

The estimated impact of power uprate on normal operation radwaste effluents is summarized below.

The system parameters for power uprated conditions reflect the flow rates and coolant masses at an NSSS power level of 1780 MWt and RSGs, while the radiological source terms utilized represent a core power level of 1782.6 Mwt to include a 0.6-percent margin for power uncertainty.

The effluent reports for the KNPP for the years 1996 to 2000 were analyzed and doses for each pathway weighted by core power level to determine an average core power weighted dose impact for the 5 operational years. Effluent time for each cycle addressed both time at power, as well as down time for maintenance and refueling.

Using plant coolant system parameters for both pre-power uprate and power uprate, the maximum potential percentage increase in coolant activity levels for each chemical group was determined. Using the highest factor found for any chemical group (with the exception of noble gases, I-131, and I-133 activity concentrations, the only isotopes addressed are those with half-lives greater than 8 hours since there is a residence time for liquids of at least 1 day prior to release), the average doses, previously determined as representative of operation at pre-power uprate conditions, were adjusted by this factor to estimate the maximum potential increase in effluent doses due to the power uprate.

#### 8.8.2.3 Results

**Expected Reactor Coolant Source Terms**

The maximum expected increase in the reactor coolant source (associated with the chemical group with the largest percentage increase) is approximately 17.6 percent for noble gas activity. This increase is primarily a combination of the impact of core power uprate and reduction in RCS mass. Considering the accuracy and error bounds of the operational data utilized in NUREG-0017, this percentage change is well within the uncertainty of the existing NUREG-0017-based expected reactor coolant isotopic inventory used for radwaste effluent analyses and corrected for a facility with this power rating.

**Liquid Effluents**

As discussed above, there is approximately a 17.6-percent increase assumed for the liquid releases as input activities are based on the largest long-term RCS activity increase for any chemical grouping and on waste volumes which are essentially independent of power level within the applicability range of NUREG-0017. Tritium releases in liquid effluents are assumed to increase approximately 17.6 percent (production increase due to core power uprate would limit the actual increase to approximately 11.4 percent) since the analysis is identifying changes in an existing facility's power rating without changing its mode of operation. Strict adherence to NUREG-0017 methodology would have identified no change in tritium liquid releases as coolant activity would have been arbitrarily set at 1.0 µCi/ml.

**Gaseous Effluents**

For all noble gases (limiting chemical group), there will be a maximum 17.6-percent increase in effluent releases due to the core power uprate.

Gaseous releases of Kr-85 in actuality will increase by approximately the percentage of power increase or approximately 11.4 percent. Isotopes with shorter half-lives will have increases slightly greater than the percentage increase in power level. The decrease in RCS mass (approximately 5 percent) contributes to the increased concentration of this chemical group in the RCS (the primary removal term for the non-Kr-85 noble gases is decay in the RCS) such that the impact of power uprate is conservatively approximated at 17.6 percent.

The impact of the power uprate on iodine releases is approximated by the power level increase. The other components of the gaseous release (that is, particulates via the building ventilation systems and water activation gases) are not impacted by power uprate using the methodology outlined in NUREG-0017. Tritium releases in the gaseous effluents increase in proportion to the increased tritium production, which is directly related to core power and is pathway allocated in this analysis in the same ratio as pre-power uprate releases.

For particulates, the methodology of NUREG-0017 specifies the release rate per year per unit per building ventilation system. This is not dependent on power level. Thus, there is no change calculated for power uprate. However, a 17.6-percent increase will be conservatively addressed.

**Appendix I Doses**

The maximum increase in doses for gaseous and liquid effluents is estimated to be 17.6 percent. The estimated doses are a very small fraction of that allowable under Appendix I.

**Solid Waste Effluents**

Only minor, if any, changes in waste generation volume are expected. However, it is expected that the activity levels for most of the solid waste would increase proportionately to the increase in long half-life coolant activity.

Thus, while the total long-lived activity contained in the waste is expected to be bounded by the percentage of the power uprate, the increase in the overall volume of waste generation resulting from power uprate is expected to be minor.

### 8.8.2.4 Conclusions

The power uprate has no significant impact on the expected annual radwaste effluent releases/doses (that is, all doses remain a small percentage of allowable Appendix I doses). It is, therefore, concluded that following power uprate, the liquid and gaseous radwaste effluent treatment system will remain capable of maintaining normal operation offsite doses within the requirements of 10CFR50 Appendix I.

### 8.8.3 Post-Accident Access to Vital Areas

#### 8.8.3.1 Introduction and Background

In accordance with NUREG-0578, 2.1.6.b and NUREG-0737, II.B.2, vital areas are those areas within the station that will or may require access/occupancy to support accident mitigation or recovery following a LOCA. In accordance with the above regulatory documents, all vital areas and access routes to vital areas, must be designed so that operator exposure remains within regulatory limits.

With the exception of determining the habitability of the Control Room and the Technical Support Center, Reference 1 is the current KNPP licensing basis for vital area access dose assessments.

Section 3.4 of Reference 1 discusses the vital area review and notes that per NUREG-0737 II.B.2, dose to personnel should not exceed 5 rem whole body or its equivalent. Section 3.4 of Reference 1 indicates that per licensee direction, a design criteria dose commitment of less than 3 rem for essential operations in a vital area was used by KNPP as a basis for any system modification, shielding or equipment relocation, and that this criterion was applied to all vital areas.

Though the vital area access review identified in Section 3.4 of Reference 1 covers several plant areas that will or may require post-accident occupancy, the report identified operator dose estimates only for the Control Room, the Technical Support Center, and the High Radiation Sample Room. An evaluation of accessibility to the MCCs is included but it focuses more on maintaining a reasonable dose margin relative to the regulatory criteria than estimating a specific operator dose.

As a result of the shielding review documented in Reference 1, several plant modifications were proposed. NRC acceptance of the evaluation completed in Reference 1, and confirmation that all of the proposed plant modifications were completed, is documented in the NRC *Safety Evaluation Report* (SER).

Power uprate impacts the equilibrium core inventory and, therefore, the post-accident radiological source terms. Additional factors that can impact the equilibrium core inventory are fuel enrichment and burnup.

KNPP is currently also going forward with the implementation of ASTs as outlined in 10CFR50.67, SRP 15.0.1 and Regulatory Guide 1.183 for the site boundary, Control Room, and Technical Support Center dose analyses. However, for the reason summarized below, the power uprate assessment for purposes of vital area access, excluding the Control Room and Technical Support Center doses, is based on TID 14844 source terms.

This approach is acceptable based on the AST benchmarking study reported in SECY-98-154, which concluded that results of analyses based on TID 14844 would be more limiting earlier in the event, after which time the AST results would be more limiting. The NRC SER for Fort Calhoun Station's implementation of AST referenced the SECY-98-154 study as the source for the conclusion that results of analyses based on TID 14844 would be more limiting for periods up to one to four months after which time the AST results would be more limiting. Post-LOCA access to vital areas usually occurs within the first one or two weeks when the original TID 14844 source term is more limiting.

#### 8.8.3.2 Description of Analyses

The impact of power uprate on the radiation doses received while accessing or occupying vital areas during post-LOCA conditions was evaluated based on a comparison of the original design basis source terms to the power uprate source terms.

The impact of power uprate on the post-LOCA gamma radiation dose rates at KNPP was evaluated based on a comparison of the gamma source terms developed based on the original core inventory used to develop the post-LOCA dose rates at KNPP to the gamma source terms developed based on the power uprate core inventory. The approach utilizes scaling techniques based on a source term comparison, rather than developing new dose rate estimates at the various locations, using the new core inventory.

Radiological source terms for both the pre-power uprate and power uprate cases are developed for the following post-accident sources.

- Containment atmosphere (100-percent core noble gases, 50-percent core halogens, and 1-percent of core remainder)
- Sump water (50-percent core halogens and 1-percent of core remainder)

- Reactor coolant liquid (100-percent core noble gases, 50-percent core halogens, and 1-percent of core remainder)
- Volume control tank source (noble gas only)
- Shield Building Ventilation System and Auxiliary Building Special Ventilation System Filters (halogens only)

For the unshielded case, the factor impact on post-accident gamma dose rates was estimated by ratioing the gamma energy release rates weighted by the flux-to-dose rate conversion factor as a function of time for the power uprate level to the corresponding weighted source terms based on the pre-power uprate level. Note that the unshielded case for sump water includes a thin shield of several inches of water to eliminate the weak photons that will not escape the self-absorption of sump water. In addition, the time intervals selected for this evaluation are those utilized in Reference 1, Section 3.4.5; that is, 1 hour, 4 hours, 8 hours, 24 hours, 145 hours, 168 hours, and 720 hours.

To evaluate the factor impact of the power uprate on post-LOCA gamma dose rates (versus time) in areas that are shielded, the pre-power uprate and power uprate source terms discussed above are weighted by the concrete shielding factors for each energy group. The concrete shielding factors for 2 ft of concrete (representative of moderate shielding) and 4 ft of concrete (representative of heavy shielding) provide a basis for comparison of the post-LOCA spectrum hardness of source terms with respect to time for both original design and power uprate cases.

Note that since the dose rate scaling factors will vary with time as well as shielding, to cover all types of analysis models/assessments, the maximum dose rate scaling factor at the time interval of interest is used as applicable for all source/receptor combinations.

Theoretically, with all things being equal, the power uprated gamma dose rates should be 1.098, that is, 1.06 (NSSS analysis uncertainty applied by Westinghouse to address variation in fuel design parameters such as enrichment) x 1782.6 MWt)/1721 MWt, times higher than the current calculated values. However, because the power uprate core reflects: extended burnup and the more advanced fuel burnup modeling/libraries utilized in development of the power uprate core, the calculated power uprate scaling factor values will deviate from the factor developed above.

The maximum gamma dose rate power uprate scaling factors with respect to time are as follows. Note that these values include the sump volume adjustment scaling factor of 1.03.

| Time after LOCA (hrs) | Gamma Dose Rate Scaling Factor |
|---|---|
| 1 | 1.13 |
| 4 | 1.16 |
| 8 | 1.20 |
| 24 | 1.26 |
| 145 | 1.55 |
| 168 | 1.56 |
| 720 | 1.57 |

The above dose rate scaling factors are utilized to evaluate the impact of power uprate on the operator dose estimates originally developed in Reference 1.

#### 8.8.3.3 Results

As documented in Section 3.4.2 of Reference 1, a design criteria dose commitment of less than 3 rem for essential operations in a vital area was used as a basis for any system modification, shielding or equipment relocation for all vital areas. Credit for the margin provided by this design criteria dose commitment relative to modifications is taken for the evaluation of MCC accessibility.

The impact of power uprate on some of the more specific conclusions of Reference 4 is discussed below:

**Control Room/Technical Support Center**

KNPP is currently going forward with the implementation of AST methodology and the dose estimates in the Technical Support Center and Control Room, based on power uprate conditions and AST methodology, have been developed by Westinghouse in a separate analysis. Consequently, this section will not address operator doses in the control room and Technical Support Center.

**High Radiation Sample Room**

The estimated dose to retrieve/analyze post-accident samples at pre-power uprate conditions (that is, a 1000 mr/hr dose rate at T=1 hr and a total access time of 101 minutes) is less than 1.7 Rem. The maximum power uprate dose rate scaling factor (SF) applicable during the time period between T=1 to T=4 hours after a LOCA is 1.16. Use of this SF results in an operator exposure dose estimate of 2 rem following power uprate. Note that although higher scaling factors are reported in subsection 8.8.3.2 of this report for later time periods, the maximum operator exposure in the sampling facility is encompassed by the exposure within the first 3 hours after the LOCA.

**Motor Control Centers**

Review of the MCC assessment indicates that all of the MCCs identified as critical were shielded or relocated resulting, at a minimum, in an inherent 67-percent margin to the dose limit of 5 rem imposed by regulatory guidance.

Taking into consideration a worst-case dose rate scaling factor of 1.16 at T=2 hrs (earliest time for access to the MCCs), the worst-case impact on the margin relative to the NUREG-0737 regulatory limit is a margin reduction from 67 percent to approximately 44 percent (that is, 5 / [3 X 1.16] =1.44).

### 8.8.3.4 Conclusions

Following the power uprate, the post-LOCA vital area operator dose estimates will remain within the regulatory limits of in NUREG-0578, Item 2.1.6.b and NUREG-0737 II.B.2 and II.B.3.

### 8.8.3.5 References

1. Doc. 23-7127-053, *Design Review of Post-accident Plant Shielding and Equipment Radiation Qualification,* Fluor Power Services, Inc., February 13, 1981.

### 8.8.4 Radiological Environmental Qualification

#### 8.8.4.1 Introduction and Background

In accordance with 10CFR50.49 safety-related electrical equipment must be qualified to survive the radiation environment at their specific location during normal operation and during an accident.

The impact of power uprate on the normal operation radiation environmental dose estimates supporting environmental qualification is summarized in subsection 8.8.1 of this report. The impact of power uprate on the post-accident radiation environmental dose estimates is discussed below. For completeness, this section will also include the conclusions of the normal operation evaluation developed in subsection 8.8.1.

Post-accident environmental doses are usually developed based on the equilibrium core inventory assuming full-power operation at the licensed power level plus margin, source term guidance available from regulatory documents relative to post-accident core releases, and plant-specific mitigation system design features/layout. power uprate impacts the equilibrium core inventory and, therefore, the post-accident radiological source terms. Additional factors that can impact the equilibrium core inventory are fuel enrichment and burnup.

KNPP is divided into various environmental zones as defined in the KNPP EQ Plan. The radiological environmental conditions noted for these zones are the maximum conditions expected to occur and are representative of the whole zone. Normal operation values represent 40 years of operation. Post-accident radiation exposure levels were determined for a 1-year or a 30-day period following a LOCA.

**Accident Environments**

A review of Appendix C of the EQ Plan indicates that the post-accident environmental radiation levels at KNPP are based on either the LOCA or a HELB.

**Environmental Levels Based on the Loss-of-Coolant Accident**

The KNPP EQ Plan indicates that, for the most part, the post-LOCA environmental gamma dose estimates listed in zone Tables C-1 to C-12, Table C-19 and location specific Table C-22 are

based on a Fluor Power Services Report documented in Reference 1. The other plant-specific references identified in the KNPP EQ Plan for the post-LOCA accident gamma radiation environments are Fluor Power Services letters issued during the same time frame as Reference 1. Since no other EQ source term document is identified in these letters, it is reasonable to assume, based on the similar vintage of the above references, and on the fact that the same organization was responsible for both the report as well as the letters, that the source terms used to support the post-LOCA doses provided via the letters, are the same as that discussed and summarized in the report (see Reference 1).

A review of Appendix C, Tables C-1 to C-12, Table C-19 and location-specific Table C-22 of the KNPP EQ Plan also indicates that the post-LOCA beta dose inside containment is assumed to be 2.0E8 Rads based on the DOR Guidelines for a PWR with a dry containment. There is no post-LOCA beta dose environment identified for any zone outside containment. The KNPP design basis position for equipment outside containment is that beta radiation outside containment is effectively attenuated to negligible values because the post-LOCA radioactive sources are mostly contained within system components or in the containment structure.

**Environmental Levels Based on the High-Energy Line Break**

The KNPP EQ Plan indicates that the post-accident radiation environment following a HELB is negligible and is, therefore, assumed to be the same as the normal operation dose.

**Normal Operation Environments**

As discussed in Section 8.8.1 of this report, the normal operation component of the total integrated dose presented in zone Tables C-1 through C-3 and C-4 through C-20 of the EQ Plan is based on assumed maximum dose rates that encompass plant survey data. However, the location specific environmental levels provided in Table C-22 could be based on calculations, radiation zone dose rate limits or plant surveys.

KNPP is currently also going forward with the implementation of AST as outlined in 10CFR50.67, SRP 15.0.1 and Regulatory Guide 1.183 for the site boundary, Control Room, and Technical Support Center dose analyses. However, for the reason summarized below, the power uprate assessment for the post-LOCA integrated doses for EQ purposes is based on TID 14844 source terms.

This approach is acceptable based on Section 1.3.5 of Regulatory Guide 1.183, which indicates that though EQ analyses impacted by plant modifications should be updated to address the impacts, no plant modification is required to address the impact of the difference in source term characteristics (that is, AST versus TID 14844) on EQ doses. The NRC staff is assessing the effect of increased cesium releases (associated with AST methodology) on EQ doses as a generic safety issue. Pending resolution of this issue, licensees may use either the AST or TID 14844 assumptions for performing the required EQ analyses.

The impact of power uprate on the post-accident component of the total integrated environmental dose is presented herein. As noted earlier, the assessment of the impact of power uprate on the normal operation environmental levels is presented in subsection 8.8.1 of this report.

#### 8.8.4.2 Description of Analyses

Appendix C of the EQ Plan indicates that the post-accident environmental radiation levels at KNPP are based on either the LOCA or aHELB. The impact of the core power uprate on the dose estimates reported in the EQ Plan is summarized below:

**Post-Accident Radiological Environments Based on the Loss-of-Coolant Accident**

- Gamma Dose

  The impact of power uprate on the post-LOCA environmental radiation dose levels at KNPP is evaluated based on a comparison of the gamma source terms developed based on the original core inventory used to develop the environmental dose levels to the gamma source terms developed based on the power uprate core inventory. The approach utilizes scaling techniques based on a source term comparison, rather than developing new dose estimates at the various locations, using the new core inventory.

  Radiological source terms for both the pre-power uprate and power uprate cases are developed for the following post-accident sources.

  — Containment atmosphere (100-percent core noble gases, 50-percent core halogens, and 1 percent of core remainder)

- Sump water (50-percent core halogens and 1 percent of core remainder)

- Reactor coolant liquid (100-percent core noble gases, 50-percent core halogens, and 1 percent of core remainder)

- VCT source (noble gas only)

- Shield Building Ventilation System and Auxiliary Building Special Ventilation System filters (halogens only)

For the "unshielded" case, the factor impact on post-accident gamma doses is estimated by ratioing the gamma energy integrated releases weighted by the flux-to-dose rate conversion factor, as a function of time, for the power uprate power level, to the corresponding weighted source terms based on the pre-power uprate power level. Note that for the unshielded case, the RCS liquid and sump water includes a thin shield of several inches of water to eliminate the weak photons that will not escape the self-absorption of sump water.

To evaluate the factor impact of the power uprate on post-LOCA gamma doses (versus time) in areas that are "shielded," the pre-power uprate and power uprate source terms discussed above are weighted by the concrete shielding factors for each energy group. The concrete shielding factors, for 2 ft of concrete (representative of moderate shielding), and 4 ft of concrete (representative of heavy shielding), provide a basis for comparison of the post-LOCA spectrum hardness of source terms with respect to time for both original design and power uprate cases.

Since the power uprate gamma dose scaling factors will vary with source, time, as well as shielding to cover all types of analysis models/assessments, the maximum dose scaling factor developed from all of the above assessments is recommended for use, for the most part, for all source/receptor combinations, with or without shields, and at all time periods after a LOCA.

Theoretically, with all things being equal, the power uprated gamma doses should be 1.098 (that is, 1.06 [NSSS analysis uncertainty applied by Westinghouse to address variation in fuel design parameters such as enrichment] x 1782.6 MWt )/1721 MWt) times higher than the current calculated values. However, because the power uprated

core reflects: extended burnup, and the more advanced fuel burnup modeling/libraries utilized in development of the power uprated core, the calculated power uprate scaling factor values will deviate from the factor developed above.

A maximum gamma dose power uprate scaling factor is 1.19. Note that this value includes a sump volume adjustment scaling factor of 1.03.

In addition to the above, scaling techniques were utilized to develop a 30-day post-LOCA gamma dose inside containment at power uprate conditions. This effort was undertaken to address the fact that many of the safety-related components within containment are only required to be functional for 30 days following a LOCA.

The pre-power uprate 30-day integrated post-LOCA in-containment gamma dose was generated using a scaling factor developed by ratioing the estimated pre-power uprate unshielded 30 days and 1 year, total integrated energy releases for the containment atmosphere (100-percent noble gases, 50-percent halogens, 1-percent remainder) source term, and applying that scaling factor on the pre-power uprate 1-year integrated post-LOCA dose.

- Beta Dose

Based on the current KNPP design basis, there are no power uprate scaling factors for beta radiation at KNPP. The KNPP EQ licensing basis for beta radiation in-containment is based on the DOR Guidelines that is independent of power level. However, a KNPP specific in-containment post-LOCA beta dose estimate at power uprate conditions has been developed. This analysis demonstrates that in the general areas of containment, the post-LOCA beta dose at power uprate conditions is bounded by the 2E8 rads value currently utilized based on the DOR Guidelines.

In addition, a beta radiation level is not addressed for locations outside containment. The KNPP design basis position for equipment outside containment is that beta radiation outside containment is effectively attenuated to negligible values because the post-LOCA radioactive sources are mostly contained within system components or in the containment structure. This licensing position is not impacted by power uprate.

**Post-Accident Radiological Environments based on the High-Energy Line Break**

Based on the current KNPP design basis, there are no power uprate scaling factors for the HELB at KNPP. As discussed in the KNPP EQ Plan, the post-accident radiation environment following a HELB is negligible and is assumed to be the same as the normal operation dose.

**8.8.4.3 Results**

For completeness, the discussion provided below includes the conclusions developed in subsection 8.8.1 of this report relative to impact of power uprate on the normal operation radiation environments utilized for environmental qualification.

The doses reported in Tables C-1 through C-20, and Table C-22 in the KNPP EQ Plan will be updated to reflect power uprate using appropriate normal operation/accident scaling factors as discussed below:

- Per subsection 8.8.1, and except as noted in subsection 8.8.1.3.2, the normal operation environmental levels noted in zone Tables C-1 to C-20 will remain unchanged due to existing margin in the current dose levels.

- Per subsection 8.8.1, and except as noted in subsection 8.8.1.3.2, the normal-operation environmental levels noted in location-specific Table C-22 will increase by 7.4 percent due to power uprate.

- Post-accident environmental levels in areas where the gamma dose is based on the LOCA will increase by the worst-case power uprate dose scaling factor of 1.19

- Post-accident in-containment beta doses will remain unchanged as the current values are based on the DOR guidelines and are independent of power level. In addition, a KNPP-specific in-containment post-LOCA beta dose estimate at power uprate conditions has been developed. This analysis demonstrates that in the general areas of containment, the post-LOCA beta dose at power uprate conditions is bounded by the 2E8 rads value currently utilized based on the DOR Guidelines. (Note that there are no beta doses currently reported in the EQ Plan for areas outside containment. The KNPP design basis position is that beta radiation outside containment is effectively attenuated

to negligible values because the post-LOCA radioactive sources are mostly contained within system components and in the containment structure.)

- Post-accident environmental levels in areas where the gamma dose is based on the HELB will remain unchanged, since the KNPP current design basis concludes that the post-accident radiation level following a HELB is negligible and the same as the normal operation dose.

Note that the above scaling factors were utilized to develop power uprate environmental conditions. In addition, the 30-day integrated post-LOCA in-containment gamma dose at power uprate conditions is estimated to be 4.3E7 rads.

#### 8.8.4.4 Conclusions

KNPP has completed a review of all of the EQ evaluation and review files and determined that all the components in the EQ Program are qualified to the power uprate radiation environmental levels.

#### 8.8.4.5 References

1. Doc. 23-7127-053, *Design Review of Post-Accident Plant Shielding and Equipment Radiation Qualification" Fluor Power Services*, Inc., February 13, 1981.

## 8.9 Equipment Qualification

### 8.9.1 Introduction and Background

EQ was evaluated for the power uprate impact on plant environmental parameters (pressure, temperature, humidity, and radiation) used for equipment qualification. The EQ environmental areas that are impacted by the power uprate are those areas that the post-accident environmental temperature and pressure are revised as a result of a LOCA or MSLB inside containment and a HELB outside containment. No significant new or revised heat loads have been identified as a result of the power uprate, and therefore, the normal environmental conditions are not impacted. The radiological EQ impact is addressed in Section 8.10 of this report.

The power uprate will result in revised containment pressure and temperature profiles for the LOCA and MSLB events. The outside containment MSLB event will also result in revised temperature profiles for the Auxiliary Building.

### 8.9.2 *Description of Analysis*

The electrical equipment within the scope of 10CFR50.49 was evaluated to ensure qualification for the normal and accident conditions expected in the area where the devices are located. Applicable conservatisms in accordance with IEEE 323 were applied to the environmental parameters as required.

The inside containment revised temperature/pressure profiles were compared for the bounding LOCA and MSLB. The post-accident containment peak pressure and temperature for the power uprate are 60.6 psia and 267.2°F, respectively.

The peak temperature and pressure for the Auxiliary Building compartments for the power uprate were compared to the existing (EQ Plan) EQ compartment parameters. Where the power uprate peak temperature increased above existing conditions identified in the EQ Plan, additional thermal lag analysis was performed to determine the maximum temperature for specific components located in the impacted area.

The plant internal flooding impact was evaluated for the HELBs as a result of the power uprate. The flooding due to moderate energy lines was reviewed and was determined not to be

impacted, since the moderate energy system operating conditions (pressure and temperature) do not change so as to result in any new HELBs, and the inventory sources for flooding have not increased. Therefore, the internal flooding evaluation was limited to existing HELBs for the impact on the submergence levels identified in the EQ plan. The FW line break outside containment is the bounding break for determining the maximum flood (submergence) levels. The areas flooded and the associated submergence levels are based on specified break locations determined by the HELB criteria contained in the USAR Appendix 10A and Fluor Power Services letter KPS-6601, *Kewaunee Nuclear Power Plant Submergence Elevations-High-Energy Line Breaks.* The break locations for the FW lines are not impacted since the locations of peak pipe stress are not impacted and the physical line arrangements (terminal ends, branch connections, etc.) have not changed. These inputs are not impacted and are bounded by the existing evaluation. In addition, the maximum flood levels in all compartments, except the basement levels, are controlled by physical plant features such as doors and curb plates. Therefore, the submergence levels in these areas are not impacted by the power uprate.

### 8.9.3 Results

There is a slight increase above the current inside containment temperature and pressure profile curves, however, the peak temperature and pressure remains below the peak temperature of 293°F and peak pressure of 60.7 psia and are considered bounded by the existing qualification. However, the long-term temperature profile results in higher containment temperatures as a function of time. The EQ equipment inside containment will be evaluated to demonstrate the affected equipment is qualified for the EQ long-term temperature.

For the steam line break outside containment, where the power uprate peak temperature increased above existing conditions identified in the EQ Plan, additional thermal lag analysis was performed to determine the maximum temperature for specific components located in the impacted area. For those components where the thermal lag temperatures exceeded the equipment qualification temperature, the EQ equipment required for HELB outside containment will be evaluated to demonstrate the affected equipment is qualified for the EQ thermal lag temperatures.

The flooding (submergence) levels remain the same and are not impacted as a result of the power uprate.

The radiological EQ impact is addressed in subsection 8.8.4.

The equipment located inside and outside the containment that performs an important-to-safety function was evaluated to demonstrate that they remain qualified for the revised accident temperature and pressure environments at the power uprate conditions. The following actions were required to document the environmental qualification of components impacted by a MSLB outside containment:

1. Identify EQ components whose existing equipment qualification is not bounded for the revised power uprate EQ profiles.

2. Evaluate the thermal lag temperature conditions for use in qualification of the equipment identified in Item 1.

3. Determine components identified in Item 1 that are not required for the MSLB outside containment and annotate EQ binder to document component qualification not impacted for MSLB outside containment.

4. Determine components identified in Item 1, which functions prior to steam generator FW or main steam isolation and are not required to function following isolation. Identify environmental conditions at time of isolation and perform evaluation of qualification based on these conditions. Review industry data and/or vendor data to demonstrate that these components will not fail in an adverse manner to impact safety-related equipment required for mitigation of a MSLB outside Containment.

For remaining components identified in Item 1, EQ binders and industry data were reviewed to determine equipment impacted for the revised power uprate EQ profiles or thermal lag temperatures.

### 8.9.4 Conclusion

The equipment located inside and outside the containment that performs an important-to-safety function was evaluated to demonstrate that they remain qualified for the revised accident temperature and pressure environments at the power uprate conditions.

Qualification of the EQ equipment inside containment affected by the higher containment EQ long-term temperature profile will be performed prior to implementing the power uprate.

For those components where the thermal lag temperatures exceeded the equipment qualification temperature, the EQ equipment required for HELB outside containment will be qualified for the EQ thermal lag temperatures.

## 8.10 Environmental Impact Assessment

### 8.10.1 Introduction and Background

The Environmental Impacts Review examined the environmental effluent discharge permit limits to assess the impact of the power uprate to 1780-MWt NSSS power. BOP radiological evaluations are addressed separately in Section 8.8 of this document.

The assessment included determining whether the power uprate will cause the plant to exceed the permits' effluent discharge limitations and other conditions associated with operation of the plant. This review is based upon information contained in the State of Wisconsin, Department of Natural Resources (WDNR), WPDES Permit No. WI-0001571-06-0 and the Final Environmental Statement for the KNPP. The WPDES permit was effective beginning on August 1, 2002, and expires June 30, 2005.

If a system that discharges effluents to the environment is affected by the power uprate, the effect on the permit must be evaluated. WPDES Permit requirements were categorized by systems and reporting requirements. For the systems that are affected by the power uprate, an evaluation of the specific requirements was completed.

### 8.10.2 Description of Analysis and Evaluation

There are no requirements in the Environmental Permit impacted by the power uprate.

CW outlet temperature rise increases by approximately 1.5°F due to the power uprate. The total temperature rise across the condenser was found to be 16.7°F. No change in CW flow is required due to the power uprate.

### 8.10.3 Conclusions

No further actions are needed for power uprate as a result of this evaluation.

## 9.0 TURBINE GENERATOR

### 9.1 Generator

#### 9.1.1 Introduction and Background

The power uprate study on the Kewaunee Nuclear Power Plant (KNPP) turbine generator was done to determine the generator capability for operation with turbine upgraded to 1780-thermal MWt, 616.615-MW shaft power, assuming as-designed, as-new generator and exciter component conditions. At 616.615-MW shaft power, the generator active output is equal to 607.9 MW, which is 8.5 percent higher than the original generator rating (560.15 MW).

#### 9.1.2 Input Assumptions

The power uprate analysis was performed assuming the unit is as-designed, as-new, since it is not possible to model degraded conditions. "As-designed" means as specified by unit configuration records, drawing, and exception documents. "As-new" means without any material or component degradation.

The power uprate analysis included an evaluation of the design of all the generator stator and rotor components, hydrogen coolers, and excitation system to determine if these components can be uprated to a higher capability. A review of original design calculations, manufacturing records, service records, and engineering drawings was also performed.

#### 9.1.3 Acceptance Criteria

The acceptance criteria for the windings and core are the temperature limits per ANSI C50.13.

#### 9.1.4 Descriptions of Component Evaluations and Results

When generator components are not identical in design to a reference generator of higher rating, evaluations are done by creating computer program models or hand calculations for these specific components. This is defined as a quantitative evaluation. Even though the design of the stator and rotor windings of the reference machine are identical in dimensions to the KNPP generator, the stator and rotor windings and stator core end packs were evaluated using a quantitative approach. In addition, the generator hydrogen coolers and exciter were

evaluated quantitatively, because their designs for the KNPP generator are different than those used for the reference generator.

Some of the generator components are evaluated by comparing the generator to components of another generator of the same frame size (reference generator). For this type of evaluation to be valid, the reference generator must have the identical component dimensional and material design. Also, the reference generator must have a nameplate rating of equal or higher capability than the KNPP generator. In this way, the evaluation can take advantage of the reference generator's operating experience. This is defined as a qualitative evaluation. A qualitative evaluation was performed for the main loads for torsional analysis.

#### 9.1.4.1 Stator Winding

The stator winding evaluation was performed for 607.9 MW at nameplate power factor. The stator winding average and hot spot rise and discharge gas rise were evaluated for the as-designed and as-new condition. The stator winding evaluation showed that the stator coils' maximum temperature calculated was within the Class B temperature limit (120°C for hot spot).

#### 9.1.4.2 Rotor Winding

The rotor winding hot spot rise and average temperature rise at 607.9 MW at nameplate power factor were evaluated. Once again, models were created for the as-designed and as-new condition. No data under operation were available to calibrate the computer models, because the generators of this vintage are equipped with brushless exciters and do not allow for measurements of rotor winding average temperature by the resistance method. The calculated average and hot spot temperature rises are within the Class B temperature limits for inner-cooled rotor windings. The calculated J-strap, radial, and axial lead temperatures at the power uprated conditions do not exceed the thermal limit for Class B insulation system.

#### 9.1.4.3 Exciter

KNPP has a brushless exciter with a nameplate rating of 2600 kW, 500 V. The revised requirements do not exceed the original exciter rating and voltage, therefore, the exciter is acceptable for the generator uprating.

#### 9.1.4.4 Stator Core End Packs

The stator core end pack (step iron) temperatures have been calculated. The calculated temperatures are within the Class B temperature limit.

#### 9.1.4.5 Parallel Rings and Bushings

The calculated parallel rings and bushing temperature does not exceed the Class B limit.

#### 9.1.4.6 Current Transformers

The existing current transformers have a current ratio of 25,000:5. According to standard, the generator should be capable of operating within +/-5 percent of the rated voltage. At 95-percent voltage, the stator current is 105 percent of the rated value. This is the highest current for the current transformer. At these conditions, the stator current does not exceed 25,000 amps, therefore, the current transformers can support the generator uprating.

#### 9.1.4.7 Hydrogen Coolers

The original Kewaunee hydrogen coolers have finned tubes with 10 fins per inch (1.125-inch fin diameter, 0.875-inch outside diameter Admiralty brass tubing). The cooler study has been performed at the tubeside fouling factor of 0.00035, which is recommended for tubes in the 7- to 12-fin/inch range and tubeside water velocity below 7 ft/sec, to keep the pressure drop through the cooler unchanged.

The hydrogen cooler thermal-hydraulic analysis indicates that the original cooler design can be used at uprating conditions if cooling water inlet temperature does not exceed 86°F (30°C).

#### 9.1.4.8 Main Leads

The main leads have the same design and ventilation scheme as the reference unit. The main lead capability depends on the hydrogen flow rate throughout these components, and in turn the differential pressure across the exciter end and lead box.

Based on the shop ventilation test of the reference unit, stator current should be limited to 19,024 amps (659 MVa) to keep the main leads temperature within the temperature limit.

#### 9.1.4.9 Torsional Analysis

The conclusion of the torsional analysis is that there are no torsional concerns at the uprated load.

### 9.1.5 Conclusions

The generator can operate at the power uprate conditions based on the recommendations included in this section.

## 9.2 Turbine

### 9.2.1 Introduction and Background

KNPP is a nuclear-cycle steam turbine with a steam supply generated by a Westinghouse Pressurized Water Reactor (PWR) System. The turbine train is composed of a double-flow BB95A turbine, and two double-flow BB80 low-pressure (LP) turbines. Each end of the high-pressure (HP) turbine path has nine stages of blading, with the stationary blades installed in two blade rings. The steam for the HP heater is extracted from a zone between the HP turbine blade rings. Steam from the HP turbine exhausts through crossunder pipes into the moisture separator reheaters, where moisture is removed and the steam is superheated. The superheated steam flow through crossover pipes into two double-flow LP turbines. Each end of each LP turbine blade path has 11 stages of blading. The cycle features five feedwater heaters and feed pump.

In addition to a mechanical evaluation, a comprehensive thermal evaluation was successfully performed.

### 9.2.2 Assumptions

The evaluations were based on the intent of maintaining the existing turbine configuration. These mechanical evaluations are based on the equipment being in a clean and new condition.

### 9.2.3 Acceptance Criteria

The mechanical load on existing components was checked to ensure that the Siemens-Westinghouse mechanical design criteria were met.

### 9.2.4 Description of Analysis and Evaluations

#### 9.2.4.1 High-Pressure Turbine

##### 9.2.4.1.1 Nozzle Blocks

The existing nozzle block was evaluated for the worst-case design condition for the nozzle block. Resulting stresses were analyzed at the deflector groove wall, hook fit, and nozzle vane areas. All of these stresses were found to be below allowable; therefore, the nozzle block is acceptable at the uprated condition.

##### 9.2.4.1.2 Control Stage Blading

Analysis of the existing control stage was performed at the uprated condition and found to be acceptable.

##### 9.2.4.1.3 High-Pressure Rotating Reaction Blading

The existing HP rotating blades were analyzed at the uprated condition and found to be acceptable at the uprated condition.

##### 9.2.4.1.4 High-Pressure Stationary Reaction Blading

The existing HP stationary blades were analyzed at the uprated condition. These stationary blades are acceptable at the uprated condition.

##### 9.2.4.1.5 High-Pressure Outer Cylinder and Stationary Parts

As part of this uprating study, the outer cylinder and blade rings were checked to maximum fleet and building block limits, where applicable. The uprated conditions were found to be adequately below these limits; hence the outer cylinder and blade rings were acceptable.

##### 9.2.4.1.6 High-Pressure Rotor and Couplings

The HP turbine rotor, couplings, and coupling bolts were evaluated and are adequate for the uprated load.

#### 9.2.4.1.7 Outer Cylinder Horizontal Bolting

Due to the high loading condition imposed by the uprated condition, a recommendation is made to modify the HP outer cylinder joint bolting.

### 9.2.4.2 Low Pressure Turbine

#### 9.2.4.2.1 Low-Pressure Rotating Blades

The LP rotating blades were evaluated for the uprated conditions by comparing strength to stress ratios. Upfront blade rows were evaluated qualitatively based on comparison to existing fleet units that have operated satisfactorily at the same uprated conditions. Backend rows were evaluated quantitatively at the uprated conditions. Results are summarized in the following table. The LP rotating blades are acceptable.

#### 9.2.4.2.2 Low-Pressure Stationary Blades

All stationary rows in the LP turbine meet the mechanical design criteria at the uprated condition. Upfront blade rows were evaluated qualitatively based on comparison to existing fleet units that have operated satisfactorily at the same uprated conditions. Backend rows were evaluated quantitatively at the uprated conditions.

#### 9.2.4.2.3 Low-Pressure Stationary Parts

The inlet flow guide, blade rings, inner cylinders (No. 1 and No. 2), and outer cylinders are within design limits at the uprated condition.

The exhaust end loading at the uprated conditions increases. At this loading the exhaust flow guide bolting may be affected. If desired, upgraded bolting can be installed.

#### 9.2.4.2.4 Low-Pressure Rotors

The LP rotor shafts and couplings were evaluated. Current allowable stresses will be satisfied at the uprated condition.

#### 9.2.4.2.5 Low-Pressure Coupling Bolts

Due to the high loading, a recommendation is made to replace the LP-to-jackshaft and LP-to-generator coupling bolts with higher strength material.

### 9.2.4.3 Additional Systems and Evaluations

Additional evaluations were performed for Electro-Hydraulic System, coolers, Gland Steam System, consenser, moisture separators/reheater, and crossunder/crossover piping.

Enhancements and inspections were provided for all the systems, so that corrosion and vibration issues will be minimized.

The rotor configurations remain the same, and there are no changes in torsional frequencies at the uprated load. Therefore, there is no effect on the torsional analysis.

Comparison of the current heat balance diagrams with the uprated heat balance diagrams indicate that steam temperatures are equal to or less than the original values used in the missile analysis. Therefore, the uprated conditions will not adversely affect the existing turbine missile analysis.

Torsional analysis and turbine missile analysis are unaffected by the uprating.

The overspeed trip setting will be reset to compensate for the overspeed from uprated conditions.

## 9.2.5 Conclusions

The KNPP turbine generator has been shown to satisfy all applicable mechanical and electrical acceptance criteria at power uprate conditions. This conclusion is based on the engineering evaluations and analysis performed and summarized herein.