Table 7.6-1 Input Parameters for Fission Product Inventory Calculations	
Parameter	**Value**
Core Thermal Power (MWt)	3658.3 (3586.6*1.02)
Fuel Assembly Type	17 x 17 Vantage 5
Uranium Mass (MTU)	80.38
Equilibrium Cycle Length (MWD/MTU)	22795
Equilibrium Loading Pattern	See Table 7.6-2
Uranium Enrichments (wt % U-235)	Region A 4.754 Region B 4.617 Region C 4.250

Table 7.6-2 Equilibrium Fuel Cycle			
Region	**# of Assemblies**	**EOC Burnup (MWD/MTU)**	**Average Relative Power**
Feed Region A	36	27349	1.20
Feed Region B	44	30580	1.34
Feed Region C	1	31579	1.39
1 x Burned Region A	36	50810	1.02
1 x Burned Region B	44	52679	0.96
2 x Burned Region A	8	54573	0.26
2 x Burned Region B	16	53019	0.41
3 x Burned Region A	8	59353	0.23

Table 7.6-3 Input Parameters for Fission Product Inventory Calculation	
Parameter	**Value**
Core Thermal Power (MWt)	3658.3 (3586.6*1.02)
Fuel Assembly Type	17 x 17 Vantage 5
Uranium Enrichment (wt % U-235)	Region A 4.754 Region B 4.617 Region C 4.250
Uranium Mass (MTU)	80.38
Equilibrium Cycle Length (MWD/MTU)	22795
Initial Boron Concentration (ppm)	1214
Mixed Bed Demineralizer Resin Volume (ft^3)	30
Cation Bed Demineralizer Resin Volume (ft^3)	20(1)
Failed Fuel Fraction (%)	1.0
Reactor Coolant Mass (lbm)	5.461×10^5
Purification System Flow Rate (gpm)	118.3
Volume Control Tank total Volume (ft^3)	400
Nominal Volume Control Tank Temperature (°F)	109.7

(1) For the calculations described in this section, the cation bed demineralizers were not modeled. Therefore, it was unnecessary to consider a cation demineralizer DF.

Table 7.6.4

Reactor Coolant System (RCS) Sources

Nuclide	Specific Activity μCi/g		Specific Activity μCi/g
Kr-83m	4.39E-01	Fe-59	5.80E-04
Kr-85m	1.80E+00	Co-58	1.50E-02
Kr-85	7.11E+00	Co-60	1.90E-03
Kr-87	1.15E+00	Sr-89	2.75E-03
Kr-88	3.35E+00	Sr-90	1.20E-04
Kr-89	9.58E-02	Sr-91	4.64E-03
Xe-131m	3.31E+00	Sr-92	1.12E-03
Xe-133m	3.65E+00	Y-90	3.01E-05
Xe-133	2.51E+02	Y-91m	2.42E-03
Xe-135m	4.88E-01	Y-91	3.44E-04
Xe-135	7.72E+00	Y-92	8.95E-04
Xe-137	1.85E-01	Y-93	3.03E-04
Xe-138	6.63E-01	Zr-95	4.05E-04
Br-83	8.74E-02	Nb-95	4.06E-04
Br-84	4.59E-02	Mo-99	5.29E-01
Br-85	5.47E-03	Tc-99m	4.88E-01
I-127 (a)	6.39E-11	Ru-103	3.61E-04
I-129	3.78E-08	Ru-106	1.22E-04
I-130	3.29E-02	Rh-103m	3.57E-04
I-131	1.84E+00	Ag-110m	1.18E-03
I-132	2.43E+00	Te-125m	4.14E-04
I-133	3.35E+00	Te-127m	2.01E-03
I-134	6.04E-01	Te-127	9.77E-03
I-135	2.09E+00	Te-129m	6.85E-03
Rb-86	2.28E-02	Te-129	1.04E-02
Rb-88	4.21E+00	Te-131m	1.73E-02
Rb-89	1.93E-01	Te-131	1.17E-02
Cs-134	1.80E+00	Te-132	1.98E-01
Cs-136	2.89E+00	Te-134	2.95E-02
Cs-137	1.26E+00	Ba-140	2.62E-03
Cs-138	1.02E+00	La-140	7.66E-04
H-3	3.50E+00	Ce-141	3.99E-04
Cr-51	5.50E-03	Ce-143	3.65E-04
Mn-54	4.00E-04	Ce-144	2.92E-04
Fe-55	2.30E-03	Pr-143	3.84E-04

(a) Units are g/g of coolant

Table 7.6-5

Gas Decay Tank (GDT) Sources After Shutdown

Gas Decay Tank Isotope	Inventory (curies)
Kr-83m	2.38E+01
Kr-85	4.76E+03
Kr-85m	1.59E+02
Kr-87	4.01E+01
Kr-88	2.02E+02
Kr-89	1.93E-01
Xe-131m	9.69E+02
Xe-133	6.83E+04
Xe-133m	8.40E+02
Xe-135	9.65E+02
Xe-135m	7.01E+01
Xe-137	4.42E-01
Xe-138	5.44E+00

8.0 TURBINE GENERATOR (TG)

8.1 Introduction

The steam TG components and their designs, along with related auxiliary system designs, have been evaluated to determine their operability under uprated conditions. The following provides a summary of each TG element and sub-system's acceptability of performance under the proposed uprated conditions.

8.2 Input Parameters and Assumptions

The main turbine-generators have been evaluated for their ability to operate at the uprated inlet steam conditions that will be supplied by the nuclear steam supply system (NSSS) after the uprating. These design conditions corresponded to a revised maximum NSSS power level of 3600.6 MWt. Two sets of inlet conditions were identified as being required. This was necessary because Byron Unit 1 and Braidwood Unit 1 are operating with replacement BWI steam generators, but Byron Unit 2 and Braidwood Unit 2 are operating with the originally supplied D5 steam generators. Differences in the BWI and D5 steam generator designs resulted in two sets of design steam inlet conditions for the steam turbines.

8.3 Description of Analysis/Evaluation by Major TG Elements

8.3.1 High Pressure (HP) Steam Turbines

Evaluation of the existing turbine components consisted of a thermal design review and a mechanical evaluation of the existing components at the two uprated design steam inlet conditions. The results of the evaluation identified that certain component enhancements were required. The reasons for these enhancements fell into three categories:

- Steam flow capacity increase/thermal design/thermal efficiency
- Component reliability assurance at the uprated conditions
- Ability to ensure proper fit-up of components swapped among the four units during the multi-year, multi-unit uprating program

From the Units 1 thermal design and mechanical evaluation, the following steam turbine components were identified as requiring modification to accommodate a power uprating:

Component	**Action Required**
HP Rotor & External Shaft	Inspect to Requalify
1C Stationary Blading	Replace
2C Stationary Blading	Replace
3C Stationary Blading	Replace
1R Rotating Blading	Replace
6R Rotating Blading	Replace
7R Rotating Blading (Governor)	Replace
Horizontal Joint Bolting (Some)	Replace
Coupling Spacer & Sleeves	Replace, if required
Blade Ring Alignment Feature	Replace, if required

From the Units 2 thermal design and mechanical evaluation, the following steam turbine components were identified as requiring modification to accommodate a power uprating:

Component	**Action Required**
HP Rotor & External Shaft	Inspect to Requalify
Nozzle Block	Replace
Control Stage Blading	Replace
1C Stationary Blading	Remove
2C Stationary Blading	Replace
3C Stationary Blading	Replace
1R Rotating Blading	Remove
6R Rotating Blading	Replace
7R Rotating Blading (Governor)	Replace
Horizontal Joint Bolting (Some)	Replace
Coupling Spacer & Sleeves	Replace, if required
Blade Ring Alignment Feature	Replace, if required

In addition to the actual component modifications and/or replacements identified for both the Units 1 and Units 2 configurations, both configurations will also require turbine control system software alterations to change the control valve "minimum arc of admission" from the current 50% value to a revised 75% value.

All other HP turbine components meet the current Siemens Westinghouse design criteria for continuous service at the total NSSS power level of 3600.6 MWt.

8.3.2 Low Pressure (LP) Steam Turbines

8.3.2.1 LP Turbine Component Evaluation

Evaluation of the existing turbine components consisted of a thermal design review and a mechanical evaluation of the existing components at the two uprate design steam inlet conditions. The results of the evaluation identified the fact that certain component enhancements were required for reliability assurance at the uprated conditions.

The following steam turbine components were identified as requiring modification due to power uprating:

Component	**Action Required**
LP L-0 Segmentals	Addition of Stiffeners
LP L-1 Segmentals	Addition of Stiffeners
LP L-2 Segmentals	Addition of Stiffeners
LP L-3 Segmentals	Addition of Stiffeners

All other LP turbine components meet the current Siemens Westinghouse design criteria for continuous service at the total NSSS power level of 3600.6 MWt.

8.3.2.2 LP Turbine Missile Generation

Turbine Missile Reports have been prepared previously for each of the Byron and Braidwood LP rotors as listed in the references (Section 8.7).

In these reports, the probabilities of disc rupture and missile generation due to stress corrosion cracking (SCC) are summarized for each disc and the overall rotor in its present running condition. The procedures used for estimating the probability of disc rupture are based on the method approved by the Nuclear Regulatory Commission (NRC) in 1987. SCC has been found to be the dominant mechanism for determining the missile generation potential. The probability of missile generation by this mechanism is not to exceed 10^{-5} by NRC criteria.

These rotors were evaluated for the proposed units 1 and units 2 uprated conditions and their effect on missile generation. The primary parameters considered were disc exit (or keyway) temperature and whether the disc is exposed to wet steam conditions. Since the inception of moisture occurs at disc 2 for both current and uprated conditions, this factor does not change missile probabilities.

The amount of moisture formed in the blade path does change slightly with the uprated conditions in comparison to the original conditions. By the NRC approved Siemens Westinghouse probabilistic method, the effect of moisture is indirectly accounted for in the term "crack initiation probability". This term, which is design specific, is based on the number of discs that have cracked in our operating experience out of the total number of discs inspected. This historical data implies a certain distribution of moisture content throughout the blade path. The presence of moisture is one of the factors required in order for stress corrosion cracking to occur.

If the distribution of moisture had changed dramatically such that inception of moisture had shifted to a different disc location, it most likely would affect the crack initiation probability of that disc. Since the inception of moisture did not change disc location in these uprated conditions, no significant change in crack initiation probability was expected. Therefore, there is no effect on missile generation.

Therefore, the key parameter becomes disc exit temperature, which is summarized in Table 8.3.2-1 for each of the conditions.

Table 8.3.2-1 LP Rotor Disc Exit Temperature (°F)			
Disc	Current Configuration	Uprated Units 1	Uprated Units 2
1	358	368	358
2	271	268	271
3	224	222	224
4	184	187	187
5	176	179	179
6	180	179	179

After reviewing the original reports, performing sampling-basis verification analyses, and using engineering judgement, Siemens Westinghouse selected the LP rotor with rotor test number/serial number TN12249 as a representative bounding case. This is a light disc and key-plate (LDKP) design.

Probability of Missile Generation

The probability of generating a missile is the combined probability of rupturing a disc among those that would possess sufficient residual energy to perforate the turbine housing. The principal inputs to this risk assessment are critical flaw size, crack growth rate and the probability of crack initiation.

Critical flaw sizes were determined from maximum bore stresses, assuming conservative crack geometry in the bore and keyway areas, and from fracture toughness of the disc material. Fracture toughness (K_{IC}) values were obtained from a correlation with Charpy properties.

The crack growth rate model was formulated using regression analysis relating crack growth rate data from operating and laboratory experience to disc temperature and yield strength. Due to observed differences in crack growth rate between bores and keyways, different regression equations were developed for each.

The probability of crack initiation is statistically derived from in-service inspection results. The probability data are based on new crack initiation probabilities developed in 1999 from inspection results of the light disc and key-plate (LDKP) and heavy disc and key-plate (HDKP) rotor fleet over the years. With the absence of cracks in these upgraded discs, the crack initiation probabilities are lower resulting in lower overall probabilities. The spread between best to worst rotor is also much smaller now than before; the lower crack initiation probabilities diminish the effects of varying disc material and toughness properties.

Uprated Conditions

Analysis of the operating data for the uprated conditions of Byron/Braidwood Unit 1 and Unit 2 identified higher disc temperatures at some locations. Higher disc temperatures increase the probability of cracks, all other things being equal. Disc temperatures were selected as the higher from Table 8.3.2-1. Therefore, the resulting probabilities conservatively apply to any of these conditions. This permits maximum flexibility in swapping rotors to different LPs or even different units. It also allows immediate use without waiting for the uprate to be implemented.

Missile Probability Summary for LP Rotor TN12249

The overall probability of missile generation for the "worst case" LP rotor is summarized for nine different time intervals and for both rated speed and design overspeed. Figure 8.3.2-1 shows the overall probability of missile generation for the rotor.

In Figure 8.3.2-1, the two curves are defined as follows:

PROB (R) - Probability of missile generation at rated speed.

PROB (O) - Probability of missile generation at design overspeed. This number is generally lower than that corresponding to rated speed since it includes the probability for reaching design overspeed.

In summary, the probability of missile generation by this mechanism does not exceed the 10^{-5} NRC criterion until shortly after 70,000 operating hours since the last rotor disc inspection. The overall probabilities summarized are significantly lower at comparable operating hours in comparison to the original calculated values.

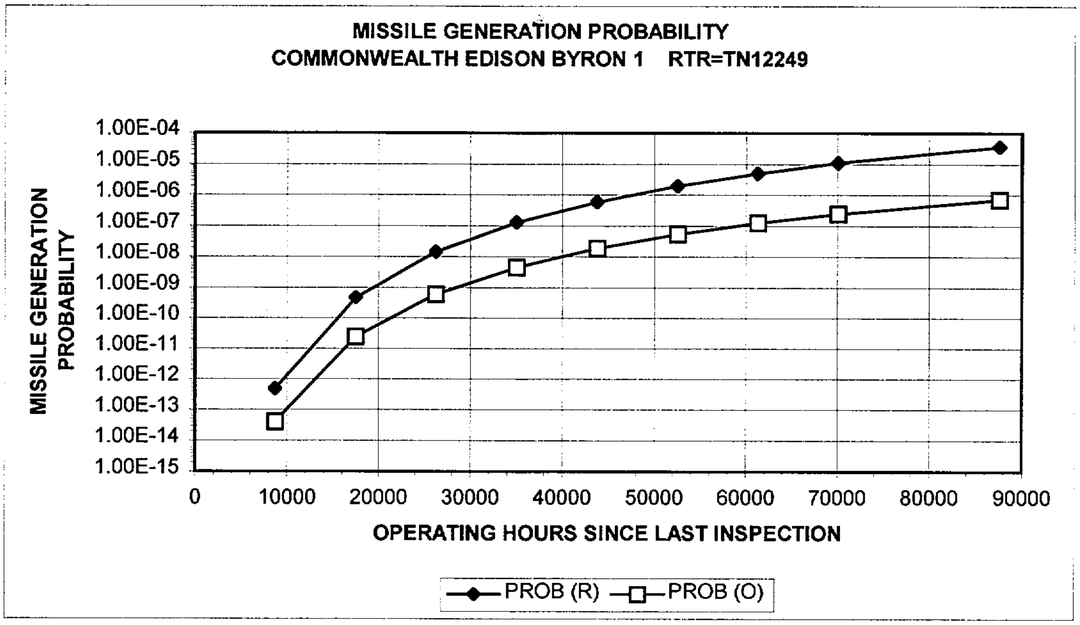

Figure 8.3.2-1

LP Rotor Missile Generation Probability

Increased missile generation probability is also directly related to the probability of turbine overspeed. The degree of overspeed protection for the turbine is a function of the entrapped energy at the time of the trip, the system design, and the turbine speed when the trip is initiated. If the final speed of the turbine following an overspeed trip does not exceed design overspeed, there is no increased probability of missile production due to overspeed.

The turbine control system closes the governor and interceptor valves when the turbine speed is greater than or equal to 103% of rated speed, and may re-open to maintain rated speed. At 108% of rated speed, the mechanical overspeed mechanism functions to trip the turbine. In addition, there is a secondary backup overspeed protection provided by the Digital Electro-Hydraulic (DEH) control system. The setpoint for this backup protection is also 108% of rated speed.

The design overspeed trip points were selected such that the unit should not achieve a final overspeed greater than the design overspeed of 120%. The energy available to the turbine immediately after a trip will carry the turbine speed beyond that of the trip device setting. The expected overspeed for the Byron and Braidwood plants upon a breaker opening, at the pre-uprate base load, is 3.15% above the trip device setting, or 111.15%. For the worst case uprated base load, it is 3.55% above the trip device setting, or 111.55%. These base calculations do not take into consideration any steam volumes in the piping or water in the heaters. During the balance of plant evaluation, the entrained energy values and limiting values for steam and water contained in the plant's extraction lines were reviewed. That review determined the maximum expected steam and water volumes both above and below the various extraction piping non-return valves. It has been determined that the expected additional entrained energy available within the extraction steam system would allow the steam turbine rotor train to reach a maximum of 114.9% of rated speed. Since this expected overspeed is less than the 120% design limit of the turbine, the design overspeed trip setting is still deemed to be acceptable at the uprated conditions.

8.3.3 Generator and Exciter

The Byron and Braidwood generator capability curve was reviewed to see if it is acceptable to operate the generators at the power uprate conditions without modifications. These generators have a rating of 1361 MVA. Therefore, no modifications to the generators are required for operation at 1242 MWe, or higher, if the MVAR reactive power output is adjusted to no more than the maximum specified by the capability curve. Since Commonwealth will operate these generators within the original capability curves, no modifications to the generator or exciter were determined to be required.

8.3.4 Moisture Separator-Reheaters (MSRs)

A review of the MSRs for the effects due to power uprating was performed. This was done by comparing predicted pressures and temperatures to design limits. At the power uprate conditions, all pressures and temperatures are within design parameters. Therefore the current MSRs will meet or exceed the requirements for the new plant heat balances, at the uprated NSSS power level of 3600.6 MWt.

8.3.5 Turbine Generator Coolers

All of the coolers were designed to accommodate the heat loads resulting from operation at the maximum capability of the generator. As such, they are by design adequate for operation at the power uprate conditions, provided that the cooling water flows and temperatures are adequate and the coolers are in good condition (i.e., performing close to design specifications).

During the TG detailed evaluation phase, the cooling water requirements for the various turbine and generator related coolers were identified as needing additional review due to the power uprate. The concern was that the power uprating could result in a higher heat load to some of the coolers, which would then require additional cooling water to eliminate the additional heat.

A review has shown that the heat load and the cooling water requirements for the majority of the TG system coolers will not change due to the power uprate. This review encompassed the following turbine generator coolers:

- Generator Hydrogen Coolers
- Exciter Air Coolers
- Seal Oil Coolers – Hydrogen Side
- Seal Oil Coolers – Air Side
- Generator Stator Water Coolers
- Main Unit Turbine Generator Lube Oil Coolers
- Feed Pump Turbine Lube Oil Coolers

The only coolers that could be affected by a power uprating are the generator's hydrogen coolers and stator water coolers.

The heat load generated is a mainly a function of the generator operating parameters of megawatts electric (MWe), volt-ampere reactance (VARs), and voltage. If the VARs and voltage are the same before and after the power uprate, the MWe increase will produce an increase in heat load on the coolers. However, if the VARs are reduced when the MWe is increased, a decrease in heat load is possible. By design both have adequate capacity to accommodate additional heat load due to power uprate.

8.4 Description of Analysis/Evaluation by TG Sub-systems

8.4.1 Turbine Gland Steam System

Evaluation of the Gland Steam (GS) System focused on the capacity of the HP turbine supply, spillover and leak-off systems. Each LP turbine gland has its own supply pressure regulator, supplied by the 140 psia header, and as such is not affected by the uprating. For that reason, the LP turbine gland steam supply/leak-off piping system was not evaluated as part of this study.

The service history of BB296 HP turbines indicates that the GS system is often at, or near, capacity at full load conditions. Piping modifications will be implemented to enhance the capability of the GS System to handle expected flow rates at the power uprate condition. These piping modifications enhance the capability of the system, though the operating characteristics remain unchanged from the current system operations.

The gland steam condensers (GSC) heat loads will increase as a result of power uprating, but the increase is not greater than the original design heat loads for these gland system components. As such, both GSCs (the "main" GSC and the "spare" GSC) will be able to perform adequately in the uprated condition, provided the above cooling condensate flowrate is maintained in the tubes.

8.4.2 Main Unit Lube Oil System

No changes to the lube oil system are required to uprate these TG units. Since the power uprate will not require any changes to the turbine generator bearings or lube oil supply, the lube oil system will not require any changes due the power uprate.

8.4.3 Turbine Control System

The effects of the power uprate on the Electro-Hydraulic (EH) control system will be minimal. The valve sequence will be altered to change the minimum arc of steam admission to the HP turbine from 50% to 75%. The original valve curves from the control settings drawing are entered in the DEH computer prior to startup. Final valve curves will be determined during initial unit start-up after the power uprate is implemented. Normal procedure is to install the final curves at the next unit outage. All changes required to the DEH control system can be accomplished by entering new values into the DEH computer.

Additionally, certain turbine instrumentation that provides input to the control system electronics will require replacement or re-scaling to the revised operating conditions.

8.4.4 Steam Generator Feed Pump Turbine Capacity

The capacity of the steam generator feed pump turbines has been reviewed. With continued proper maintenance, they will have adequate capacity for the power uprate conditions of the main turbines with only the low pressure control valves open.

8.5 Miscellaneous Turbine Components and Systems

8.5.1 Steam Admission Valves

All of the main steam and reheat steam admission valves were reviewed at the uprated conditions. Steam pressures, temperatures and velocities through the valves were compared to the valve design limits. No changes to any of the valves are required to operate at the power uprate conditions.

8.5.2 Main Steam Inlet and Extraction Piping

The temperatures and pressures of the HP inlet and extraction steam piping were compared to the pipe design limits. The steam velocities were calculated and compared to the pipe design limits. The main steam inlet piping, and HP and LP extraction piping, are acceptable by design for the power uprate conditions.

8.5.3 Crossover and Crossunder Piping

The temperatures and pressures of the crossover and crossunder steam piping were compared to the pipe design limits. The steam velocity was calculated and compared to the pipe design limits. Both the crossover and crossunder piping systems are acceptable by design for the power uprate conditions.

8.6 Results and Conclusions

The turbine-generator components and systems at Commonwealth Edison's Byron and Braidwood power plants were reviewed for the following areas:

- HP Turbines
- LP Turbines
- Generators
- Exciters
- Moisture Separator Reheaters

- Heat Exchangers (Generator Hydrogen Coolers, Exciter Air Coolers, Air and Hydrogen Side Seal Oil Coolers, Generator Stator Water Coolers, Lube Oil Coolers)
- Gland Sealing Steam Systems
- Lube Oil Systems
- Turbine Control Systems
- Steam Generator Feed Pump Turbines
- Steam Admission Valves
- Turbine Steam Piping Systems (Main Inlet, Extraction, Crossover, Crossunder)

The basis for this evaluation was a review of the above TG components and systems at the expected design steam conditions. Steam is to be supplied to the steam turbines by the NSSS at the uprated power level. These conditions were compared to the applicable design criteria to determine the acceptability of operation at the higher power level. Unit history records maintained by Siemens Westinghouse were reviewed to ensure that the latest TG conditions and configurations were evaluated.

The study results identified that certain TG components required either replacement or modification to operate acceptably at the designed 3600.6 MWt power uprating level. Those components will be upgraded over the course of implementing the Byron and Braidwood Power Uprate Project. All other related TG components and systems have been determined to be acceptable for the plants to operate satisfactorily at the uprated power level.

8.7 References

LP Missile Report References				
CT Report #	**Unit**	**LP**	**Rotor Test #**	**Date of Report**
CT-25276, Rev. 0	Byron 1	LPA	TN12249	July 1988
CT-25307, Rev. 1	Byron 1	LPB	TN10206	April 1996
CT-25308, Rev. 0	Byron 1	LPC	TN10668	February 1990
CT-25322, Rev. 0	Byron 2	LPA	TN10085	August 1990
CT-25277, Rev. 1	Byron 2	LPB	TN12266	November 1999
CT-25278, Rev. 0	Byron 2	LPC	TN12387	July 1988
CT-27254, Rev. 0	Byron	Spare	TN10912	March 1999
CT-25293, Rev. 0	Braidwood 1	LPA	TN10472	August 1989
CT-25327, Rev. 0	Braidwood 1	LPB	TN10190	October 1990
CT-25328, Rev. 0	Braidwood 1	LPC	TN11142	October 1990
CT-25317, Rev. 0	Braidwood 2	LPA	TN8993	March 1990
CT-25315, Rev. 0	Braidwood 2	LPB	TN8992	March 1990
CT-25316, Rev. 0	Braidwood 2	LPC	TN10207	March 1990
CT-27253, Rev. 0	Braidwood	Spare	TN8997	March 1999

9.0 BOP SYSTEMS, STRUCTURES AND COMPONENTS

9.1 Introduction

This section of the Licensing Report documents the evaluations conducted to assess the ability of and verify that the Balance of Plant (BOP) structures, systems, and equipment (SSCs) are structurally and functionally capable of safe, reliable operation at the power uprated conditions. Stone & Webster performed the detailed engineering evaluations. The study included a review of major components and systems typically impacted by a power uprate. The following are the core and NSSS power levels used in the evaluation.

Table 9.1-1
Current and Power Uprate Power Levels

Description	Core Power (MWt)	NSSS Power (MWt)
Licensed Power Levels (Existing)[(1)]	3,411	3,425
Power Uprate Levels (Stretch Rating)	3,586.6	3,600.6

(1) The current Engineered Safety Features (ESF) design ratings at the maximum calculated turbine rating and normal pump power are 3,579 MWt and 3,585 MWt, respectively. However 3,425 MWt (or 3,431) MWt was utilized in many of the UFSAR Chapter 15 Accident Analyses (Ref. UFSAR Table 15.0-2).

9.2 Approaches and Methodology

The methodology used for the evaluation of the BOP, in support of the power uprate, was the same as used successfully in many other power uprate projects. The first task was to identify the parameters and design inputs to be used to evaluate the BOP systems, structures, and components. Siemens-Westinghouse prepared heat balances were used to identify the operating parameters, based on design and performance conditions, expected for the uprated power level. The heat balance diagrams are contained in Section 9.3.1, Main Steam System and the Steam Dump System. Other key parameters and conditions, on which the BOP evaluations are based, are documented in each system subsection.

As part of the overall evaluation, plant walkdowns were performed to obtain plant parameters and record key control valve position. Additionally, interviews were conducted with personnel at various plant departments, including System Engineering, Performance Engineering, as well as, Maintenance and Operations personnel. The purpose of the interviews was to determine: if any plant conditions had changed, the availability of test data, or if observations had been noted indicating recent margin reductions or limitations that could impact the power uprate.

To demonstrate the capability of the BOP, evaluations and analyses were performed as documented herein. The impact of the power uprate on plant SSCs was evaluated by categorizing the SSCs into three areas:

- Bounded by existing analyses and design conditions - no further evaluation or analysis is required.

- Bounded by design with reanalysis - This category required evaluation or reanalysis (calculations or revision to existing calculations) to demonstrate the existing design is adequate with no modifications.

- Not bounded by analysis or design - This category required evaluation and/or analysis to justify operation of the SSCs at conditions beyond the existing design basis to accommodate the power uprate. A few cases in this category required minor hardware and/or setpoints modification.

The evaluations were performed based on the existing design and licensing basis documented in the UFSAR and Technical Specification Basis. When either the existing basis could not be met following power uprate, or a revised basis was used to demonstrate compliance to new criteria, justification for compliance and/or the revised basis is provided in the acceptance criteria used for the power uprate evaluation. In addition, calculations were performed in areas where existing documentation did not demonstrate capability at the power uprated conditions.

The BOP power uprate evaluations included the following general topics:

- BOP Systems and Components (over 35 plants systems were reviewed)
- BOP Radiological Review
- Instrumentation and Controls
- Electrical

- Structures
- Environmental Considerations
- Pipe Stress and Supports
- Generic Issues and Programs
- Plant Procedures

Power uprate evaluations investigated various aspects of the original plant design, current configuration, and operating conditions.

Results of the detailed BOP evaluations demonstrate that the Byron and Braidwood Units 1 and 2 are capable of providing safe and reliable operation at the NSSS power level of 3600.6 MWt with no major modifications.

9.3 BOP Systems and Components

9.3.1 Main Steam System and the Steam Dump System

9.3.1.1 Introduction

The Main Steam (MS) System transports steam from the steam generators (SGs) to the high pressure turbine and to various systems/components including the moisture separator reheaters, main condenser air ejectors, turbine-driven feed pumps, turbine bypass steam dump valves, and the turbine gland sealing steam system.

The Steam Dump System provides a means for the removal of heat when the main turbines are not available. The Steam Dump System is designed to accommodate the steam generated in excess of main turbine demand at times of sudden load reduction, and to provide MS pressure control during plant startup and cooldown periods. Steam is conveyed to the main condenser through the steam dump valves, or is conveyed to the atmosphere by the Power Operated Relief Valves (PORVs).

The MS system is safety-related from the SGs to the discharges of the Main Steam Isolation Valves (MSIVs), Main Steam Safety Valves (MSSVs), PORVs, and MSIV bypass valves. The remainder of the MS System and the Steam Dump System are non-safety-related.

9.3.1.2 Input parameters and Assumptions

The system and component design parameters utilized in the evaluations of the MS System are listed in Tables 9.3.1-1 through 9.3.1-4 and Figures 9.3.1-1,-2,and -3.

Table 9.3.1-1

SG Steam Outlet Parameters

	Current Power[1]		Uprate Power (2)	
Parameter	**Unit 1**	**Unit 2**	**Unit 1**	**Unit 2**
Pressure (psia)	997.55	922.53	1,035	910
Flow Rate (lb/hr)	15,076,638	14,970,548	16,026,608	15,958,134
Temperature (°F)	544.28	534.87	548.75	533.26

(1) Parameters recorded at Braidwood

(2) Steam generator operating condition which support heat balance of the uprated power conditions.

Table 9.3.1-2 Required MS Process Flow Parameters				
MS Flow to:	**Parameter**	**Current Baseline (Ref. 1)**	**Uprate Power Unit 1 (Ref. 2)**	**Uprate Power Unit 2 (Ref. 3)**
HP Turbine TVs	Flow (lb/hr)	14,318,324	15,154,804	15,260,975
	Pressure (psia)	960	1,004	869.1
	Max Moisture (%)	0.41	0.22	0.24
LP Turbine Inlet	Flow (lb/hr)	10,081,045	10,586,576	10,824,444
	Pressure (psia)	162.4	171.0	173.1
	Enthalpy (BTU/lb)	1,280.2	1,283.3	1,273.9
MSRs 2nd Stage Reheat Steam	Flow (lb/hr)	801,798	856,893	682,129
	Pressure (psia)	955.2	999.0	864.8
Turbine Driven Feed Pumps	Flow (lb/hr)	224,729	231,748	232,443
	Pressure (psia)	165.7	174.5	176.6
	Enthalpy (BTU/lb)	1,280.2	1,283.3	1,273.9
GS System (from Cross Tie Header)	Flow (lb/hr)	13,973	13,911	14,030
	Pressure (psia)	960.0	1,004.0	869.1
SJAE (from MS Cross Tie Header)	Flow (lb/hr)	1,000	1,000	1,000
	Pressure (psia)	960.0	1,004.0	869.1

Table 9.3.1-3 MS Design Parameters		
Component	**Design Parameter**	**Design Value**
Main Steam Isolation Valves (MSIV)	Pressure, psig	1,185
	Temperature, °F	600
	ΔP, psi (1)	1.0
	Power Uprate Flow Rate – Unit 1, lb/hr	4,006,652
	Power Uprate Flow Rate – Unit 2, lb/hr	3,989,534
MSIV Bypass Valves	Pressure, psig	1,185
	Temperature, °F	560
MSSVs	Pressure, psig	1,200
	Temperature, °F	650
PORVs	Pressure, psig	1,185
	Temperature, °F	600
Drip Leg Control Valves	Pressure, psig	1,060
	Temperature, °F	557

(1) Design ΔP is vendor calculated for design steam flow at 945 psig and 540°F.

Table 9.3.1-4 MSSV Capacity			
Parameter	**Current Power (Baseline)**	**Uprate Power Unit 1**	**Uprate Power Unit 2**
Total MS Flow, lb/hr	15,135,095 (Ref. 1)	16,026,608 (Ref. 2)	15,958,134 (Ref. 3)
Total MSSV Capacity, Lb/hr[1]	17,958,500	17,958,500	17,958,500
Total MSSV Capacity, % of Total MS Flow[2]	≈119	≈112	≈113
Total PORV Capacity, lb/hr[3]	1,661,000	1,661,000	1,661,000
Total PORV Capacity, % of Total MS Flow[4]	≈11.0	≈10.4	≈10.4

(1) Capacity at an accumulation pressure of approximately 1,293 psig (i.e., 110% of MS System design pressure minus an assumed pressure drop of 10 psid) and full valve open.

(2) Required percentage is 105%.

(3) Capacity at an inlet pressure equal to the zero-load pressure (approximately 1,107 psia).

(4) Required percentage is 10%.

9.3.1.3 Description of Analyses

The MS and Steam Dump System components are evaluated to ensure they are capable of performing their intended functions at power uprate conditions thereby ensuring the functionality of the MS and steam dump systems at power uprate conditions. Specifically:

- The design parameters of the MS system components are compared to power uprate conditions to ensure margin exists.

- The impact of operation at power uprate conditions on the ability of the MSIVs to close within a specified time is evaluated. Additionally, the changes in pressure drop through the MSIVs are reviewed.

- The MSSV and PORV setpoints and capacities are evaluated for acceptability at power uprate conditions utilizing existing design requirements/recommendations.

- The impact of operation at power uprate conditions on the ability of the steam dump valves to reposition is evaluated.

9.3.1.4 Acceptance Criteria

The design parameters of the MS and Steam Dump System components must bound the conditions at power uprate. Additionally, the following must be met:

- Adequate steam pressure/flow is required to satisfy the HP Turbine inlet conditions.
- MSSV capacity must be adequate to ensure the pressure does not exceed 110% of SG design pressure.
- PORVs must be capable of preventing unnecessary lifting of the MSSVs and are capable of supporting a plant cooldown rate of at least 50°F/hr.
- MSIVs must be able to close within 5 seconds at power uprate conditions.
- Steam dump valves must meet the original capacity and repositioning criteria at power uprate conditions.

9.3.1.5 Results

9.3.1.5.1 Main Steam Isolation Valves

The MSIVs provide protection against MS line breaks inside and outside of Containment, and prevent contamination of the secondary system in the event of a SG tube rupture. One MSIV is located on each of the four MS lines outside, but close to Containment. The MSIVs are downstream from the MSSVs to prevent MSSV isolation from the SGs by MSIV closure. Each MSIV is a hydraulically operated, double-disc gate which closes automatically on low MS line pressure, high negative MS line pressure rate, or high-high Containment pressure signals.

Per Westinghouse design criteria and as discussed in Section 4.2.3.1, the MSIVs are designed to cycle from fully open to fully closed in less than five seconds during abnormal operating conditions (i.e., steam break) with flow in either direction. This capability is retained as the SG flow restrictors, which limit steam flow during an MSLB accident, and the zero load conditions are not impacted by power uprate.

The maximum flow capability, and design pressure and temperature associated with the MSIVs bound the steam supply conditions at power uprate as shown in Table 9.3.1-3.

The MSIV bypass lines and valves enable warming of the MS System, and slowly pressurize the system during unit startup prior to opening the MSIVs. Each MSIV has one associated bypass valve, which is located outside but close to Containment. The bypass valves automatically close on the same signals as the MSIVs, and are closed during full-load operation.

As the MSIV bypass lines and valves perform their 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 their capability in performing these functions. Additionally, the design pressure and temperature of the bypass lines and valves bound the steam supply conditions at power uprate. (Refer to Table 9.3.1-3.)

9.3.1.5.2 Main Steam Safety Valves

Five MSSVs are located on each of the four MS lines, outside containment, upstream of the MSIVs (20 MSSVs total per Unit).

In accordance with the ASME Boiler & Pressure Vessel Code, the MSSVs are designed to ensure the MS pressure is limited to within 110% of its design. Additionally, as discussed in Section 4.2.3.1, Westinghouse recommends that the MSSVs be capable of passing 105% of the full load steam-flow at this pressure. Since the design pressure of the MS and the SGs does not change with power uprate, the MSSV setpoints and relieving capacity do not change with power uprate. Similarly, the maximum actual flow through an individual MSSV at the MS design pressure does not change with power uprate and remains within the allowable limit.

In terms of full-load operation at power uprate, the MSSVs are capable of relieving approximately 112% of the Unit 1 MS flow and approximately 113% of the Unit 2 MS flow at an accumulation pressure that ensures MS pressure is limited to within 110% of its design. (See Table 9.3.1.4.)

9.3.1.5.3 Power Operated Relief Valves

In order to limit unnecessary lifting of the MSSVs, one PORV is located on each of the four MS lines, outside Containment, upstream of the MSIVs (4 PORVs total per Unit). The PORVs can also be used for plant cooldown when the steam dump valves are unavailable.

Review of steam pressures and temperatures associated with power uprate (items 1 and 3 of Table 9.3.1-1) reveals that these conditions are bound, with margin, by the design of the PORVs. (See Table 9.3.1-3.)

The setpoint of the PORVs are based on the zero-load steam pressure and the set pressure of the lowest set MSSV. Additionally, the PORVs must be capable of modulating full stroke within 20 seconds over an inlet pressure range from 100 psig to the MS System design pressure. As the pressures defining the setpoints and operation of these valves don't change with power uprate, the PORV setpoint (1,125 psig) and operation are acceptable for power uprate conditions.

The PORVs are required to be capable of relieving 10% of the rated MS flowrate (i.e., full load operation) to support a plant cooldown rate of at least 50°F/hr. This is from the set pressure of the lowest set MSSV to the pressure corresponding to placing the Residual Heat Removal System (RHR) in operation. Each PORV is capable of relieving 415,250 lb/hr of steam at the zero-load pressure. Total capacity per unit is, therefore, 1,661,000 lb/hr, which exceeds the required 10% of full-load operation at power uprate with margin. (See Table 9.3.1-4.)

9.3.1.5.4 Main Steam Piping

With the implementation of power uprate, MS flow rate increases approximately 5.8% for Units 1 and 5.4% for Units 2, and SG steam outlet pressure increases approximately 4.5% for Units 1 and decreases approximately 8% for Units 2. The MS System design pressure of 1,200 psia bounds the Units 1 and 2 power uprate conditions of 1,035 and 910 psia, respectively. (See Table 9.3.1-1.)

During normal operation, the comparative pressure drop between the SG and the MS line crosstie for any two steam lines shall be no greater than 10 psi. Calculated pressure drops at power uprate steam conditions meet this requirement. Additionally, pressure drops between the SGs and the Main Turbine Throttle Valves will remain below the original design value of 30 psid.

MS line velocities were evaluated and found acceptable both for the current and power uprated conditions. The results of this evaluation will be incorporated into the ComEd Flow Accelerated Corrosion Program.

As shown in Table 9.3.1-5 the pressure required of the Throttle Valves (TVs) will be met at the power uprated SG operating condition.

Table 9.3.1-5
Power Uprate SG Outlet Pressures % MS System Overall Pressure Drops

Station	Unit	Loops	Required Pressure At TVs (psia)	Maximum ΔP (psid)	Minimum SG Outlet Pressure (psia)	Power Uprate SG Outlet Pressure (psia)
Braidwood	1	1 & 3	1,004	23.5	1,027.5	1,035
		2 & 4	1,004	24.4	1,028.4	1,035
	2	1 & 3	869.1	27.2	896.3	910
		2 & 4	869.1	28.4	897.5	910
Byron	1	1 & 3	1,004	23.2	1,027.2	1,035
		2 & 4	1,004	24.5	1,028.5	1,035
	2	1 & 3	869.1	26.0	895.1	910
		2 & 4	869.1	28.2	897.3	910

Notes:

1. Differences between pressure drops (observed through Braidwood MS piping and those listed above) are attributed to the differences in initial MS pressure (e.g., higher initial pressure yields lower pressure drops).

2. The pressure drops through the MSIVs that were calculated for use in determining the overall pressure drop across MS piping are approximately twice the value shown in Table 9.3.1-3.

The MS flows required by those systems/components for operation (i.e., Moisture Separator Reheater, Gland Steam System, Steam Jet Air Ejectors, Turbine-Driven Feed Water Pumps), which are small flows (<3%) in terms of the MS total flow, are not appreciably changed by implementation of power uprate. The operation of these systems/components, and their ability to perform their functions, are not affected by the power uprate.

The MS drains, which includes the drip leg control valves and flash tank, are capable of performing their intended function at power uprate conditions due to a decrease in maximum allowable steam moisture content. (See Table 9.3.1-6.) The steam pressures and temperatures associated with the power uprate (Table 9.3.1-1) are bound, with margin, by the designs of the drip leg control valves. (See Table 9.3.1-3.)

Table 9.3.1-6
MS Moisture Content

Parameter	Existing Condition	Power Uprate Condition	
		Unit 1	Unit 2
MS Flow Rate, lb/hr	15,135,095[(1)]	16,026,608[(2)]	15,958,134[(3)]
Maximum Moisture, %	0.41[(1)]	0.22[(2)]	0.24[(3)]
Total Drains, lb/hr	≈62,100	≈35,250	≈38,300

(1) Ref. 1 represents the revised baseline for current operating conditions at both Units 1 and 2.

(2) Ref. 2 represents Unit 1 heat balance at uprated operating conditions.

(3) Ref. 3 represents Unit 2 heat balance at uprated operating conditions.

9.3.1.5.5 Steam Dump System

The original recommended pressure drop between SGs and steam dump valves was that it be less than10% of SG outlet pressure. Calculated pressure drops at power uprate conditions are approximately 5% of SG outlet pressure and therefore the original recommendation is still satisfied.

As discussed in Section 4.2.3.2, the original sizing criteria recommends that the Steam Dump System be capable of passing 40% of rated steam flow. Based on the calculated pressure drops, the steam dump valves are capable of passing approximately 52% of the Unit 1 steam flow and approximately 44% of the Unit 2 steam flow at power uprate conditions.

Table 9.3.1-7

Steam Dump Valve Inlet Pressure and Flow Parameters at Power Uprate

			A	B	C	D	E	
Station	**Unit**	**Inlet Pressure (psia)**	**Power Uprate Flow @ 100% Open (Ref. 4) (Note 1)**	**Overall MS Flow (lb/hr) (Note 2)**	**% of Overall MS Flow (100 x 12A/B)**	**Required Flow (lb/hr) (Note 3)**	**% of Flow @ 100% Open (100 x D/A)**	**Approx.% Open (Ref. 4)**
Braidwood	1	985.6	700,000	16,026,608	52	534,220	76	94
Braidwood	2	853.6	580,000	15,958,134	44	531,938	92	98
Byron	1	985.9	700,000	16,026,608	52	534,220	76	94
Byron	2	854.1	580,000	15,958,134	44	531,938	92	98

Notes:
1. Flows are per steam dump valve (12 valves per unit).
2. Unit 1 and 2 power uprate overall MS flows are shown on References 2 and 3.
3. Flows are per steam dump valve and are based upon 40% of the total MS flows shown on References 2 (Unit 1) and 3 (Unit 2) i.e., . $D = \frac{0.4 \times B}{12}$

The maximum flow passed by the steam dump valves at an inlet pressure equivalent to the MS System design pressure (1,200 psia) is 890,000 lb/hr.

Additionally, the repositioning capabilities of the steam dump valves bound the power uprate conditions.

9.3.1.6 Conclusions

The MS and Steam Dump Systems are acceptable for the power uprate conditions. No equipment changes are required.

9.3.1.7 References

1. Siemens-Westinghouse Heat Balance WB-7329, dated April 22, 1999 (Revised Baseline conditions, applicable to Units 1 and 2)

2. Siemens-Westinghouse Heat Balance WB-7342 dated May 13, 1999 (Power Uprate conditions, applicable to Units 1)

3. Siemens-Westinghouse Heat Balance WB-7347 dated May 18, 1999 (Power Uprate conditions, applicable to Units 2)

4. Sargent & Lundy, "Analysis of Secondary Loop Systems for Operation at Vessel Hot Leg Temperatures of 600°F and 594°F Byron and Braidwood – Units 1 & 2", dated Apr. 1988

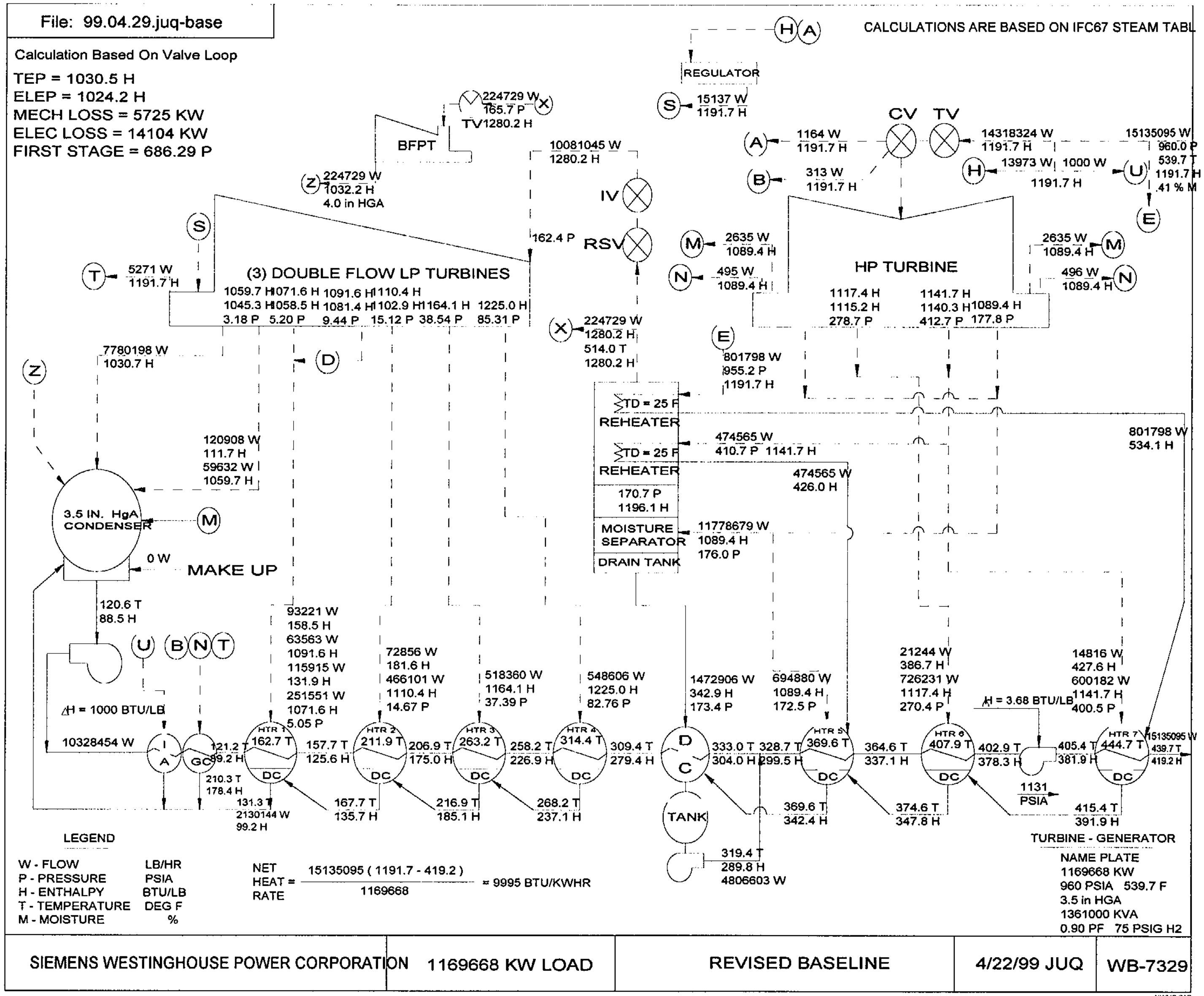

Figure 9.3.1-1

Revised Baseline Heat Balance (WB-7329)

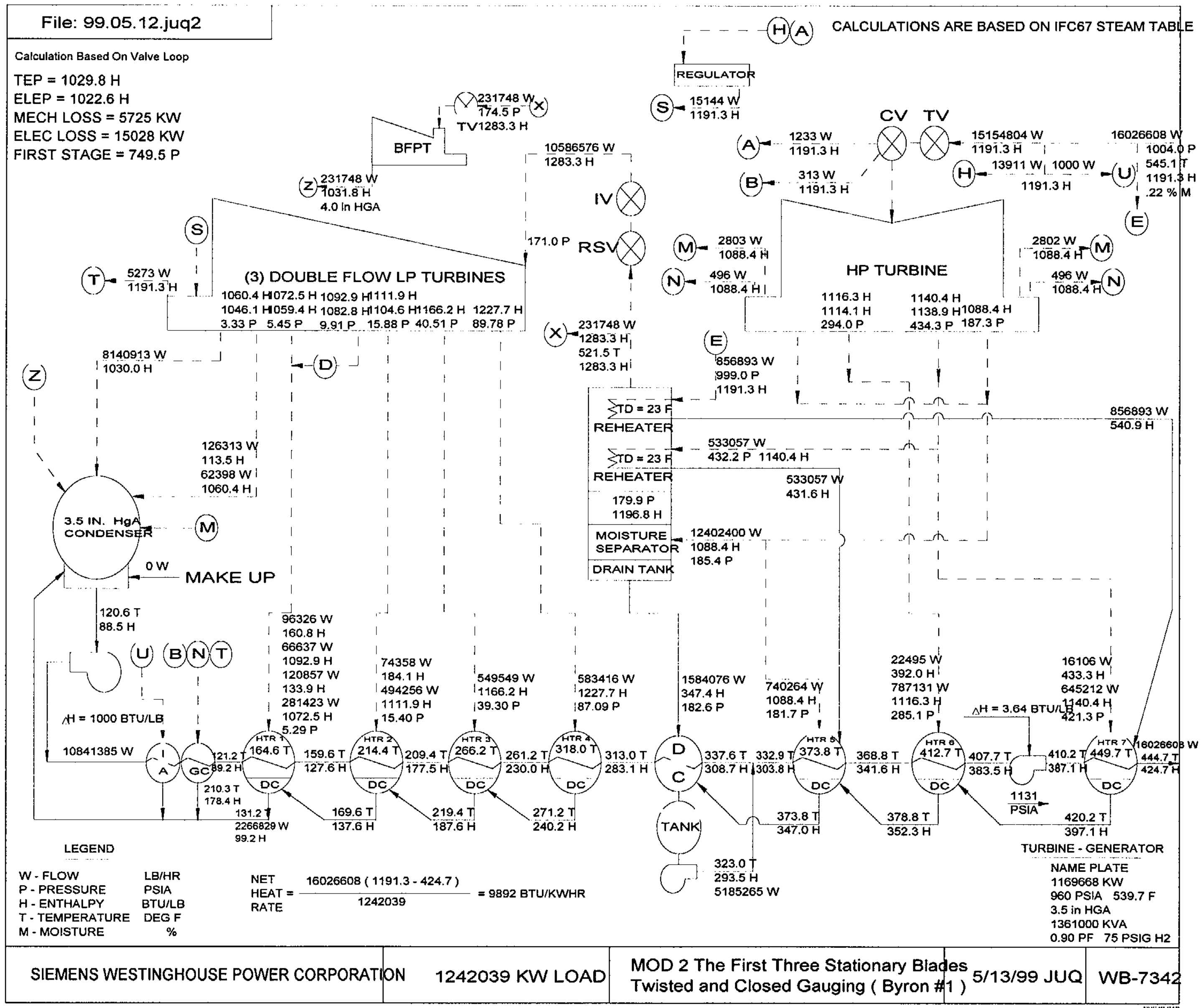

Figure 9.3.1-2
Power Uprate Conditions for Unit 1 (WB-7342)

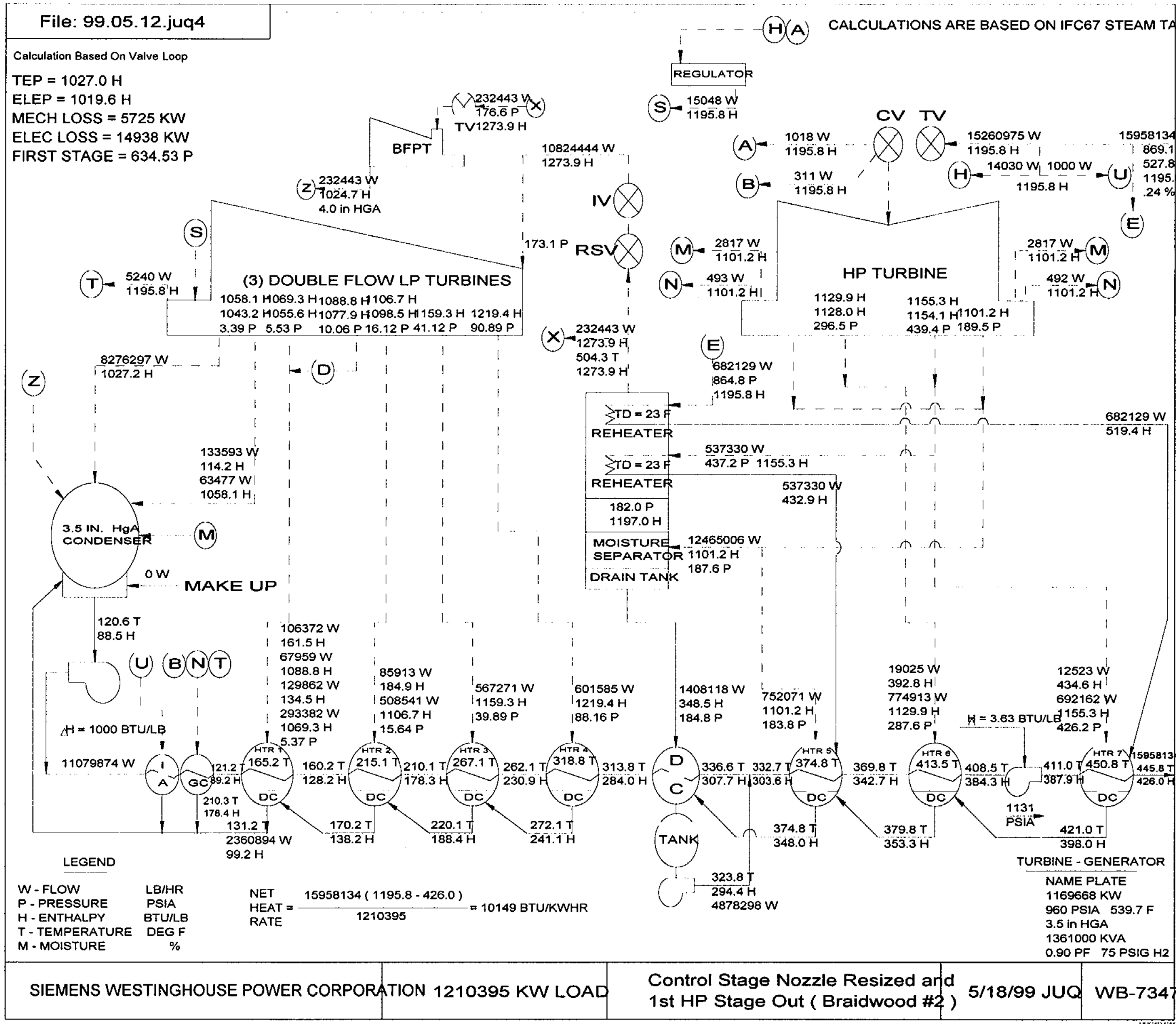

Figure 9.3.1-3

Power Uprate Conditions for Unit 2 (WB-7347)

9.3.2 Heater Drain System

9.3.2.1 Introduction

The Heat Drain (HD) System is a non-safety-related system that collects drains from the Feedwater (FW) heaters, drain coolers, reheaters and moisture separators.

The 1st stage low pressure FW heater strings consist of three parallel strings, four heaters and one drain cooler in each string (drain cooler 1 and heaters 1 through 4). The 2nd stage low-pressure FW heater strings consist of two parallel strings, two heaters and one drain cooler in each string (drain cooler 5 and heaters 5 & 6). The high-pressure FW heater strings consist of two parallel strings, with a single heater in each string (heater 7).

Liquid drains from heaters 4 and 3 cascade to the lower pressure heater in the string. Drains from FW heater 2 cascade to a flash tank where they mix with the drains from FW heater 1 and then drain through the separate drain cooler to the condenser. Flash steam from the flash tank goes to FW heater 1. Liquid drains collected in heaters 7, and 6 cascade successively downward to each lower pressure heater in the string. Drains from FW heater 5 flow through separate drain coolers into a single heater drain tank, which provides suction flow to the heater drain pumps. Drains from the four moisture separator shell drain tanks flow to the heater drain tank. Drains from the 1st stage reheater drain tanks (4) flow to FW heaters. Drains from the 2nd stage reheater drain tanks (4) flow to FW heater 7.

The heater drain tank has sufficient capacity to compensate for flow shortages during 10% load rejection. Emergency overflow from the heater drain tank back to the condenser is provided.

Liquid drains in the heater drain tank are pumped to the CD/FW system, by the heater drain pumps to a point between the 5th stage FW heater drain cooler and FW heater #5. Heater drain flow into the condensate header is normally controlled as a fixed ratio of total feedwater flow, thereby maintaining Steam Generator Feedpump NPSH above a preset minimum.

9.3.2.2 Input Parameters and Assumptions

Input parameters utilized in the evaluation of the HD system included Siemens Westinghouse heat balances WB-7329, WB-7342 and WB-7347. (Refs. 1, 2, 3)

The evaluation also utilized input parameters relative to HD level control valve position (i.e., % open position). Control valve position information was based on the following:

1. Walkdowns performed at Byron/Braidwood Units 1 and Units 2, in which actual control valve positions were determined at pre-power uprate conditions (i.e., existing normal operating conditions).

2. Results of a HD Level Control Valve Positions calculation performed at both pre-power uprate and power uprate conditions.

HD control valves for Byron and Braidwood Units 1 and Unit 2 are identical.

9.3.2.3 Description of Analysis

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

1. System pressure/temperature design.

2. Cascade heater drain flow in conjunction with HD system control valve design and operation.

3. HD pump operation (pump flow, TDH, etc.).

4. HD normal and emergency drain flow control valve operation.

5. Flow characteristics in HD gravity drain lines.

6. Flow Accelerated Corrosion (FAC) considerations were considered and are detailed in Section 10.0.

Additionally, a walkdown of all four units was performed to verify that control valve positions were approximately at positions predicted in the pre-power uprate analysis.

9.3.2.4 Acceptance Criteria

The HD system is considered acceptable under power uprate conditions provided the following criteria are met:

1. Power uprate pressure/temperature conditions are bounded by HD system piping and components pressure/temperature design.

2. HD system drain flows at power uprate conditions can be accommodated by HD system control valves (i.e., HD control valves have adequate margin as designed to accommodate drain flows at power uprate conditions).

3. HD Pump operation at power uprate conditions is within acceptable margin of pump design parameters. (i.e., flow, TDH, and NPSH).

4. HD gravity flow lines will operate fully flooded, in smooth, self-venting flow or in acceptable two-phase flow.

9.3.2.5 Results

The HD piping and component design bound the power uprate conditions for pressure and temperature.

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 HD system operation.

As a result of the power uprate conditions, the HD flow to FW flow ratio will remain essentially unchanged.

Table 9.3.2-1 provides HD system level control valve positions based on both calculated results and walkdown observations.

Table 9.3.2-1

Level Control Valve Positions

	EPN	Byron Walkdown Position (%Open) Unit1 / Unit2	Braidwood Walkdown Position (%Open) Unit1 / Unit2	Calculated Power uprate Position (%Open) Units 1 / Unit 2
1st Stage	HD002A	50 / 45	50 / 50	Power uprate flow < design flow
	HD002B	50 / 45	40 / 50	Power uprate flow < design flow
	HD002C	25 / 25	50 / 75	Power uprate flow < design flow
	HD002D	30 / 35	50 / 60	Power uprate flow < design flow
2nd Stage	HD005A	25 / 25	25 / Note 1	Power uprate flow < design flow
	HD005B	35 / 25	Note 1 / Note 1	Power uprate flow < design flow
	HD005C	25 / 25	Note 1 / Note 1	Power uprate flow < design flow
	HD005D	35 / 25	25 / Note 1	Power uprate flow < design flow
MSR Drain	HD099A	45 / 40	35 / 45	40 / 37
	HD099B	40-45 / 35-40	Note 1 / Note 1	40 / 37
	HD099C	95 / 80	70 / 15	75 / 67
	HD099D	70-75 / 45-50	Note 1 / Note 1	75 / 67
Heaters				
7A	HD008A	70 / 70	50 / 60	56 / 52
7B	HD008B	65 / 60	40 / 55	56 / 52
6A	HD011A	40 / 50	30 / 50	48 / 47
6B	HD011B	45 / 40	50 / 50	48 / 47
5A	No valve	NA	NA	NA
5B	No valve	NA	NA	NA

Table 9.3.2-1 Level Control Valve Positions				
	EPN	**Byron Walkdown Position (%Open) Unit1 / Unit2**	**Braidwood Walkdown Position (%Open) Unit1 / Unit2**	**Calculated Power uprate Position (%Open) Units 1 / Unit 2**
4A	HD020A	50 / 70	50 / 60	63 / 64
4B	HD020B	60 / 60	50 / 55	63 / 64
4C	HD020C	60 / 60	50 / 55	63 / 64
3A	HD023A	50 / 55	58 / 50	50 / 59
3B	HD023B	55 / 60	55 / 50	50 / 59
3C	HD023C	50 / 50	55 / 50	50 / 59
2A	HD026A	70-76 / 90	55 / 70	76 / 81
2B	HD026B	70 / 70	50 / 70	76 / 81
2C	HD026C	80-90 / 70	50 / 70	76 / 81
1A	No Valve	NA	NA	NA
1B	No Valve	NA	NA	NA
1C	No Valve	NA	NA	NA
Drain Coolers				
1A	HD029A	25 / 25	25 / 25	22 / 23
1B	HD029B	25 / 25	25 / 25	22 / 23
1C	HD029C	25 / 25	25 / 25	22 / 23

Notes:

(1) Position not accessible.

At Byron and Braidwood Stations, based on analysis, all of the normal HD control valves have sufficient margin for power uprate conditions. However, during field walkdowns at Byron and Braidwood, and as indicated in Table 9.3.2-1, it was observed that Byron valves 1HD099C and 1HD099D (normal drain valves from moisture separator shell drain tanks C and D, respectively) are currently at a greater open position than indicated by analysis. An evaluation was performed based on field (operating) conditions, and it was determined that these valves will be modified prior to power uprate. The modification will involve increasing the valve C_v to maintain these valves in the proper control range (approximately 75% open). Similarly at Byron Heater 12 and 22 drain valves 1HD026C and 2HD026A are also operating at 90% open. These valves are scheduled to be inspected at the next available outage to determine if valve position is correct and will be replaced with a larger C_v control valve prior to power uprate, if required.

Based on calculation results, all emergency control valves are acceptable for power uprate conditions. A few of the emergency control valves will operate at greater than 85% when in use but less than full open. However, because of their infrequent use changes to these valves are not necessary.

The emergency drain lines to the condenser from FW heaters 6 and 7 and from the heater 5 drain tank are not sized to carry full load flow. The absolute power level (i.e., MWt) at which the emergency drains reach their limit will not change due to the power uprate. The small reduction (Units 1) and increase (Units 2) in capacity, as a percent of the full load flow are inconsequential to the unit operation.

The heater drain pump design parameters of flow, TDH and corresponding NPSH have adequate margin to accommodate the power uprate condition, and therefore, associated HD system operation is acceptable. (Refs. 1, 2, 3)

The gravity drain lines from the 1st and 2nd stage reheaters to their drain tanks and from the MSR shell to the moisture separator shell drain tanks have adequate size for power uprate and should operate as self-venting gravity flow lines. The drain lines from FW heaters 5 to their separate drain coolers and the drain lines from FW heaters 1 to their flash tanks currently operate in low-velocity, 2-phase flow with demonstrated acceptable stability. The process conditions after power uprate are less severe and are enveloped by current operation.

9.3.2.6 Conclusions

Byron HD system control valves 1HD099C and 1HD099D will be modified to improve C_v characteristics and possibly 1HD026C and 2HD026A, as discussed in Section 9.3.2.5. The Byron/Braidwood HD systems, in conjunction with modifications to the Byron valves, are acceptable for power uprate conditions.

9.3.2.7 References

1. Siemens Westinghouse Power Corporation Heat Balance No. WB-7329, dated April 22, 1999 (Revised Baseline conditions, applicable to Units 1 and 2)

2. Siemens Westinghouse Power Corporation Heat Balance No. WB-7342, dated May 13, 1999 (Power Uprate conditions applicable to Units 1)

3. Siemens Westinghouse Power Corporation Heat Balance No. WB-7347, dated May 18, 1999 (Power Uprate conditions, applicable to Units 2)

9.3.3 Condensate and Feedwater System

9.3.3.1 Introduction

The Condensate (CD), Condensate Booster (CB) and Feedwater (FW) Systems (upstream of the feedwater isolation valves) are non-safety related. The feedwater piping from the FW isolation valves to the steam generators is safety related. The CD system condenser condenses steam exhausted from the low-pressure turbines. The CD and CB systems provide high-grade water, polished and deaerated, from the condenser hotwell to the FW system. The FW system supplies the Steam Generators (SGs) with heated water. In the SGs, Reactor Coolant System (RCS) heat transfer further heats the FW and then it undergoes a phase change to steam.

The FW system has two safety functions: (1) to isolate the containment following an accident and (2) to provide a flow path for the Auxiliary Feedwater (AF) to the SGs during transient and/or accident conditions. The portions of the FW system that serve these functions are designated as Safety Category I, Quality Group B.

The CD pumps take suction from the condenser hotwell and provide the motive force to drive the condensate through the Condensate Polishing System to the CB system. The Condensate Polishing System is partial-flow, and used intermittently (typically during startup and at times when water chemistry dictates).

There are four 1/3-capacity centrifugal CD pumps per unit with motor drives and common suction and common discharge headers. There are four 1/3-capacity CB pumps per unit with common suction and common discharge headers. A single motor drives each CD and CB pump set. Three sets of pumps are normally in operation. The fourth set of pumps automatically starts on low pressure at the FW pump suction to assure adequate flow to the FW pumps.

The FW system is a closed-type system, with deaerating accomplished in the condenser. The CD pumps take suction from the condenser hotwell and pump condensate through the air ejector and gland steam condensers to the suction of the CB pumps. The CB pumps pump the condensate through six stages of low-pressure feedwater heating to the FW pumps. The water discharge from the FW pumps flows through one stage of high-pressure heating into the SGs.

Low-pressure FW heaters stages 1 through 4 are 1/3-sized units arranged in three strings. Each string of these low-pressure FW heaters is provided with motor-operated shutoff valves. There is a single bypass line sized to handle the flow of one low-pressure feedwater string. These three strings and the bypass line discharge to a common header where flow continues through two strings of drain coolers and low-pressure heaters 5 and 6. Each of these two strings also has motor-operated shutoff valves. A bypass line is also provided for the stages 5 and 6 low-pressure FW heater strings.

The SG Water Level Control System automatically maintains SG water level during steady state and transient operation. There are three ½-capacity main FW pumps (FWP) common suction and common discharge headers. Two of the pumps are turbine-driven (TD) and the third is a standby motor-driven (MD) pump. The TD-FWP's supply FW to the SGs during normal operation and transient conditions. The MD-FWP is a backup to the TD-FWPs.

The FWPs pump the water through two strings of ½-capacity high-pressure FW heaters (7A and 7B). The discharge from the FWPs is recirculated to the condenser hotwell whenever pump discharge flow to the high-pressure heaters falls below a certain point. A control system regulates the FW flow to the SGs by:

- Positioning the FW regulator valves (FWRV) during normal operation and the FW regulator by-pass valves (FWRBV) during startup and low-power operation,
- Changing the speed of the TD-FWPs, and,
- Positioning the MD-FWP discharge control valve.

9.3.3.2 Input Parameters and Assumptions

The evaluation of the CD/CB and FW systems compared the heat balance parameters applicable to Units 1 and 2 at pre-power uprate conditions with heat balance parameters applicable to Units 1 and 2 for power uprate conditions. (Refs. 1, 2 & 3)

9.3.3.3 Description of Analysis

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

1. System design pressure/temperature
2. Flow rate
3. Transients

A FLO-SERIES model of the (CD), (CB), and (FW) systems was completed and then used to evaluate system performance under normal and transient conditions. The model analyses included runs to simulate existing plant conditions, and to evaluate Units 1 and 2 plant power uprate and transient conditions. The model was used to determine required TD-FWP speeds and feedwater regulating valve positions that would satisfy the power uprate conditions.

<u>Transient Review</u>

The CD/CB and FW system's capability to continue to support the plant during design basis load transient has been evaluated for the power uprate conditions. The capability of the CD/CB/FW and HD system pumps were reviewed to evaluate the impact of the increase flow demand and potential loss of heater drains during the 50% load reduction and reviewed the capability of the condensate system to provide adequate flow to match feedwater flow and maintain sufficient FW Pump NPSH.

The TD-FWP's electronic speed settings are being revised to allow operation up to 5,500 rpm to support operational transients at the uprated power level. The mechanical overspeed trip setpoint has sufficient margin above the uprate maximum speed so that it will not need to be reset.

9.3.3.4 Acceptance Criteria

The CD/CB and FW system is considered acceptable under power uprate conditions provided the following criteria are met:

1. CD/CB and FW system piping and components design pressure and temperature bound power uprate pressure and temperature conditions.

2. CD/CB and FW system flows at power uprate conditions can be accommodated by CD/CB and FW system control valves (i.e., CD/CB and FW control valves have adequate margin to accommodate flows at power uprate conditions).

3. CD/CB and FW pump operation at power uprate conditions is within acceptable margin of pump design parameters (i.e., flow, TDH, and NPSH).

9.3.3.5 Results

Condensate and Condensate Booster Pumps

The observed current flow rate is approximately 7,100 gpm per pump. The Unit 1 power uprates will require approximately 7,300 gpm and the Unit 2 power uprates will require approximately 7,500 gpm.

The CD and CB pumps have sufficient head and capacity margin to support the power uprated plant conditions. As determined in the power uprate analysis, the existing CD and CB pumps can provide the higher power uprate flow rate of approximately 7,500 gpm. The new operating points for the CD and CB pumps are within design parameters for flow, TDH and NPSH.

Feedwater Pumps

Two of the three FWPs are turbine driven. The speed of the turbine is controlled to maintain a programmed fixed pressure differential between the FWP discharge and the Main Steam (MS) header pressure to provide a constant differential pressure across the FWRVs. The third FWP is motor driven (constant speed). A control valve on the discharge side of the MD-FWP is automatically positioned to maintain the constant differential pressure across the FWRVs.

The FWPs have sufficient head and capacity margin to support the power uprated plant conditions. Higher turbine speeds will be necessary to provide the increased flow for the Unit 1 power uprate conditions. The FWPs currently operate at a capacity of approximately 18,000 gpm. The existing FWPs can provide the higher power uprate flow rate of approximately 19,000 gpm. The new operating point for the FWPs is within design parameters for flow, head and NPSH.

For Unit 1, a TD-FWP speed of approximately 5,200 rpm is required to support 100% power at power uprate conditions. A pump speed of approximately 5,500 rpm is required to support Unit 1 transient conditions. The higher operating speed for the Unit 1 FWPs will necessitate resetting the turbine electronic speed control setpoint (currently at 5,200 rpm). Resetting of the mechanical overspeed trip setpoint is not necessary (currently at 5,720 rpm).

For Unit 2 a TD-FWP speed of approximately 4,900 rpm is required to support 100% power at power uprate conditions. The Unit 1 FWP conditions bound Unit 2 and the proposed Unit 1 pump/turbine electronic maximum speed setpoint of 5,500 rpm is sufficient for the Unit 2 pumps at the uprate conditions. Also resetting the mechanical trip setpoint is not necessary for Unit 2.

Uprate impacts the loss of drains during the 50% load transients. Plant capability has demonstrated that heater drains are maintained for a 25% load rejection and the evaluation indicated a loss of heater drains occurs prior to the 50% load rejection. However, the condensate system has sufficient capacity with the start of the standby condensate and condensate booster pumps to prevent complete loss of FW flow and maintain FW pump NPSH when the heater drain flow is lost.

Feedwater Heaters

Shell side extraction steam flows at the current operating power level are below the design flows listed on the heater data sheets. At the uprated power level conditions the extraction steam flows, velocities, and pressure drops will increase but not exceed the heater(s) design.

Piping

The adequacy of the FW piping under power uprate conditions was reviewed to ensure that the operating pressure and temperature of the FW piping are within their design values and in compliance with applicable codes. The FW piping is designed in accordance with ANSI B31.1 up to the FWIVs and in accordance with ASME Section III Class 2 from the FWIVs to the inlet of the SG. Operating pressures in the CD and CB piping will decrease since the CD/CB pumps will operate further out on their performance curves for power uprate conditions. Operating pressures in the FW piping will increase for Unit 1 and decrease for Unit 2. This is due to the higher steam generator pressure (1,020 psig vs 990 psig baseline) for Unit 1 power uprate conditions and lower steam generator pressure for Unit 2 power uprate conditions (895 psig vs 990 psig baseline).

The system pressure at the power uprate both during normal operating and transient conditions are enveloped by the system design pressure. At the uprated power level conditions, CB, CD, end FW flows and velocities will increase but remain within the general guidelines of Reference 4.

Valves

The uprate analysis included evaluation of required turbine driven FW pump speeds and resultant FWRV positions. The analysis concluded that the existing FWRVs will support the power uprate plant conditions.

9.3.3.6 Conclusions

The CD/CB and FW systems are adequate for power uprate conditions.

9.3.3.7 References

1. Siemens Westinghouse Power Corporation Heat Balance No. WB-7329, dated April 22, 1999 (Revised Baseline conditions, applicable to Units 1 and 2)

2. Siemens Westinghouse Power Corporation Heat Balance No. WB-7342, dated May 13, 1999 (Power Uprate conditions, applicable to Units 1)

3. Siemens Westinghouse Power Corporation Heat Balance No. WB-7347, dated May 15, 1999 (Power Uprate conditions, applicable to Units 2)

4. MES-2.11 Rev. C, Sergant & Lundy Mechanical Dept. Standard "Recommended Allowable Velocities in Piping Systems"

9.3.4 Steam Generator Blowdown System

9.3.4.1 Introduction

The Steam Generator Blowdown (SD) System, a subsystem of the Liquid Radwaste System, utilizes a continuous blowdown flow to help maintain steam generator (SG) secondary side water chemistry within specified limits and remove impurities concentrated in the SGs. During normal operation, blowdown is conveyed to the main condenser hotwell. Blowdown flow may also be conveyed to the Unit 1 or Unit 2 condensate storage tank, the blowdown monitor tanks, or the radwaste monitor tanks.

The Unit 1 and Unit 2 SD systems can be cross tied upstream of the blowdown condensers (cross tie valves are normally closed).

The SD system is safety related from the SGs to the outermost containment isolation valves (1/2SD054A thru H).

9.3.4.2 Inputs, Parameters and Assumptions

Siemens-Westinghouse heat balances, WB-7329, WB-7342, and WB-7347 were used as input in the SD system evaluation. (Refs. 1, 2, 3)

9.3.4.3 Description of Analysis

The SD system is evaluated in terms of the effect of the power uprate on blowdown flow, design pressure and temperature.

9.3.4.4 Acceptance Criteria

The SD system is considered acceptable under power uprate conditions if the power uprate requirements are bounded by the system design.

9.3.4.5 Results

The SD system is designed based upon the highest set pressure of the Main Steam Safety Valves, which do not change with the power uprate. Additionally, operating temperatures at power uprate remain bounded by SD System design.

The maximum blowdown flow requirement will not be increased with the power uprate. The current range of normal blowdown flows in terms of percentage of SG steam flow remain within the recommended range of 0.2% to 1%. at power uprate.

9.3.4.6 Conclusions

Based on the above evaluation, the SD system is acceptable for the power uprated conditions. No equipment changes are required.

9.3.4.7 References

1. Siemens-Westinghouse Heat Balance WB-7329, dated April 22, 1999 (Revised Baseline conditions, applicable to Units 1 and 2)

2. Siemens-Westinghouse Heat Balance WB-7342, dated May 13, 1999 (Power Uprate conditions applicable to Units 1)

3. Siemens-Westinghouse Heat Balance WB-7347, dated May 18, 1999 (Power Uprate conditions, applicable to Units 2)

9.3.5 Extraction Steam System

9.3.5.1 Introduction

The Extraction Steam (ES) System conveys steam extracted from various stages of the high pressure and low pressure turbines to the shell side of the Feedwater (FW) heaters and to the tube sides of the first stage reheaters. The ES system also conveys the 4th pass vent and drain flow from both the 1st and 2nd stage reheaters to the FW heaters 5 and 7, or to the condenser.

Three common HP extraction lines, two reheating steam extraction lines, and each of three sets of 2nd, 3rd, and 4th point extraction lines 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 turbine water induction into the turbine.

The drains and vent steam from the 2nd stage reheater 4th pass outlets are directed to the No. 7 FW heater ES lines. The drains and vent steam from the 1st stage reheater 4th pass outlets are directed to the No. 5 FW heater ES lines.

9.3.5.2 Inputs Parameters and Assumptions

Siemens-Westinghouse heat balances WB-7329, WB-7342, and WB-7347 were used as input in the ES system evaluation. (Refs. 1, 2, 3)

The extraction steam MOV block valves are designed to have closure times fast enough to prevent water (due to a flooded FW heater) from entering the steam turbine. The calculated flooding rate was based on the FW heater tube and shell design pressures and temperatures.

Based on document review, the ES systems are identical among all four units.

The evaluation has been performed using input parameters for baseline conditions specific to Units 1 and 2 and input parameters for power uprate conditions specific to Units 1 and 2. (Refs. 1, 2, 3)

9.3.5.3 Description of Analysis

The ES system is evaluated/analyzed 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 as follows:

- ES piping system component pressure and temperature design.
- Extraction line pressure drops.
- Extraction line fluid velocities.
- The extraction line fluid flow regimes.
- Extraction steam line drainage provisions.
- Entrained energy at power uprate conditions compared with turbine OEM criteria.
- Required closure time for the extraction line shutoff valves.

9.3.5.4 Acceptance Criteria

The acceptance criteria for ES system design are as follows:

1. Piping System Component Pressure & Temperature Design - The ES component design conditions must equal or exceed the power uprate operating conditions.

2. ES Line Pressure Drop - Turbine to FW heater pressure drops affect efficiency of the steam turbine cycle (the values used in the turbine manufacturer's guarantee heat balance are part of their design basis, and deviations from them will effect the unit output at the guarantee throttle steam flow). The original Westinghouse heat balance uses a 3% drop, turbine flange to heater inlet for all extractions. Power uprate pressure drops must compare with the 3% Westinghouse pressure drop. Comparative pressure drops different than those on the turbine heat balance will result in generation different than calculated on the heat balance and will impact the process conditions elsewhere on the balance.

3. ES Line Fluid Velocities - ES system line velocities were checked against the HEI Closed Feedwater Heater nozzle sizing criteria. Nozzle sizing criteria are conservative for piping. Fluid velocity impact will be addressed as input to Flow Accelerated Corrosion (FAC) Program.

4. Fluid Flow Regimes - Fluid velocities and flow regime at full load should be sufficient to transport all moisture in the steam drawn from the turbine to the feedwater heaters without entering unstable flow regimes (slug or plug flow).

5. Drainage Provisions - At full load, no liquid collection should occur in the piping. Partial load, startup, and shutdown drainage provisions are not impacted by power uprate.

6. Entrained Energy for Turbine Overspeed Protection - The total energy stored in the extraction lines at full load, plus the energy restrained by any single non-return valve should be less than that necessary to accelerate the turbine beyond its design overspeed after a full load trip.

7. Isolation Valve Closure Times - The extraction isolation valve closure time should be fast enough to prevent water entry into the steam turbine following a design basis tube break in any feedwater heater accompanied by closure of the normal and emergency drain valves.

The item/system portion being evaluated is acceptable if there is no adverse effect due to the power uprate, or if the effect due to the power uprate is enveloped by current design.

9.3.5.5 Results

Component Design Pressures/Temperatures

The ES system steam pressures and temperatures predicted at the power uprate conditions are bounded by the system component design conditions, except for in a few cases. For portions of extraction lines to FW heaters 5, 6, and 7, and the reheater steam supply system, originally specified piping design temperatures will be exceeded at power uprate, (i.e., by less than 5°F). However, ES system maximum stress level and fatigue analysis results (at power uprate conditions of pressure, temperature, and flow) were reviewed, and it was determined that ES system meets appropriate criteria for the power uprated condition.

Extraction Line Pressure Drops

Turbine to feedwater heater steam pressure drops have a significant effect on the efficiency of the steam turbine cycle. The values used in the steam turbine heat balance are part of their design basis, and deviations will effect the unit output at the guarantee throttle steam flow. (Refs. 2, 3)

Based on comparison of Westinghouse original heat balance, the power uprate baseline heat balance, and the Units 1 and Units 2 power uprate heat balances, deviations from the turbine design basis value are considered insignificant. (Refs. 1, 2, 3)

Piping Velocities

The Braidwood and Byron line velocities at the FW heater inlets, are representative of the values in the system piping. Velocity values were compared with HEI nozzle sizing recommendations and are considered acceptable.

All units have experienced vibration problems in the 1st and 2nd stage reheater 4th pass vent and drain lines.

Subsequent to their original design, reheaters were modified to a "four pass" configuration. Currently, the drain flow leaves the reheater as a high pressure, saturated liquid and flashes continuously on its way to its receiver.

Power uprate will increase vent and drain flow from all reheaters at Units 1, will increase 1st stage vent and drain flows at Units 2, and will decrease 2nd stage vent and drain flows at Units 2. These lines will be monitored for vibration after the power uprate and appropriate evaluation will be performed as required.

Fluid Flow Regimes

With the exception of the 4th extraction, which is superheated steam, all extraction lines convey a two-phase flow.

A review of the ES system piping shows that it will support proper operation at the power uprate conditions. (i.e., moisture will be carried along with the vapor, the flow will remain adequately homogeneous, and no severe liquid partitioning will occur).

The 1st and 2nd stage reheater 4th pass "vent and drain" lines, with their high liquid loading were checked and found acceptable; no unsteady flow states are expected.

Drainage Provisions

The ES piping drawings were reviewed for drainage provisions. The flow regime analysis above indicates that at full load, all of the entrained moisture will be carried through to the FW heaters, and active line drainage is not required. The required drainage capacity is not impacted by power uprate.

Entrained Energy for Turbine Overspeed Protection

The turbine speed must be kept below its rotor design overspeed (i.e., 120% of rated speed). (Ref. 5)

NRVs, designed to limit the amount of steam that can expand through the turbine, have been provided at Braidwood and Byron on all extractions except No.1. The calculated overspeed following a worst case trip at the turbine overspeed trip setting, and considering a single NRV failure is less than the rotor design overspeed of the turbine. This is considered acceptable.

Isolation Valve Closure Times

The ASME Turbine Water Induction Prevention Standard (TDP-2) requires positive closure valves in the ES lines. The purpose of the valves is to prevent flooding of the turbine as a result of water accumulation due to ruptured tubes in a feedwater heater. Under TDP-2, NRVs can not be credited with prevention of water induction. Where a positive shutoff valve can not be installed, TDP-2 requires automatic isolation of the condensate or feedwater lines to and from the heater. (Ref. 4)

Braidwood and Byron ES systems are in conformance with TDP-2 and have automatic shutoff valves in the No. 2 through No. 7 extractions. They also include controls to automatically isolate the heater number one on high water level.

9.3.5.6 Conclusions

The ES system evaluation has determined that the ES system is acceptable for operation at the power uprated conditions.

9.3.5.7 References

1. Siemens-Westinghouse Heat Balance WB-7329, dated Apr 22, 1999 (Revised Baseline conditions, applicable to Units 1 and 2)

2. Siemens-Westinghouse Heat Balance WB-7342, dated May 13, 1999 (Power Uprate conditions, applicable to Units 1)

3. Siemens-Westinghouse Heat Balance WB-7347, dated May 18, 1999 (Power Uprate conditions, applicable to Units 2)

4. ANSI/ASME TDP-2-1985, "Recommended Practices for the Prevention of Water Damage to Steam Turbines Used for Electric Power Generation"

5. Siemens Westinghouse Letter No. BB12400.004, January 25, 2000, "Entrained Energy Values and Limiting Values for the Byron and Braidwood Turbines Under Power Uprate Conditions"

9.3.6 Circulating Water System

9.3.6.1 Introduction

The Circulating Water (CW) System for both the Byron and Braidwood Stations is non-safety-related and is used to reject heat from the turbine cycle. The power uprate will result in approximately a 5% increase in heat rejection duty to the CW system. The major components affected are the condensers for both Stations, the cooling towers for Byron, and the cooling lake for Braidwood.

<u>Byron Station</u>

The CW system at Byron Station is a closed loop cooling system designed to dissipate waste heat from the turbine cycle to the atmosphere using natural draft cooling towers, one tower for each unit. The CW system includes the following major components:

- Main Condenser
- Natural Draft Cooling Tower
- Cooling Tower Basin

- Three CW Pumps
- Circulating Water Treatment
- Makeup and Blowdown Systems
- Piping, Valves and Instrumentation

Cooling water from the cooling tower basin is pumped to the main condenser by the three CW pumps, each rated at 214,500 gpm, and returns to the cooling tower. CW flow varies between 697,900 GPM in the summer to 637,800 GPM in the winter. The Non-Essential Service Water System supply is also provided from the cooling tower basin and discharges back into the basin via the CW discharge header (see Section 9.3.8). Makeup water is pumped from the Rock River to the cooling tower basin by up to three CW makeup pumps to the common flume. Makeup flow is limited so as not to exceed 10% of normal river flow. A water treatment system provides periodic chlorination to control biological fouling of the condenser tubes and CW piping. Makeup water is treated with chemical addition to suppress organic growth in the cooling system and reduce the tendency of scale formation and silt deposit. Continuous blowdown from the cooling tower basin to the Rock River maintains control of dissolved solids.

The main condenser is a single pass, multizone (low-intermediate-high) unit consisting of four inlet and outlet water boxes. It utilizes type 304 stainless steel tubes, which are designed to condense 8,200,000 lbs. per hr of steam at full load, at an average backpressure of 3.5 in. Hg absolute, when provided with 632,000 gpm of cooling water at a supply temperature of 92°F. A cooling water temperature rise of 25°F can be expected under these conditions.

<u>Braidwood Station</u>

The CW system at Braidwood Station is a closed loop cooling system similar to that at Byron except that waste heat is rejected from the turbine cycle to a cooling lake. The CW system includes the following major components:

- Main Condenser
- Three CW Pumps
- Cooling Lake
- Make-Up and Blowdown Systems
- Piping, Valves and Instrumentation

The three CW pumps are each rated at 247,000 gpm. The Braidwood Unit 1 CW flow rate under summer conditions is 734,000 gpm, which provides 722,000 gpm to the main condenser after accounting for blowdown. The Braidwood Unit 2 CW flow rate under summer conditions is 715,200 gpm, which provides 703,000 gpm to the main condenser after accounting for blowdown.

The main condenser is a single pass, multizone (low-intermediate-high) unit consisting of four inlet and outlet water boxes. It utilizes type 304 stainless steel tubes, which are designed to condense 8,200,000 lbs. per hr of steam at full load, at an average backpressure of 3.5 in. Hg absolute, when provided with 729,800 gpm of cooling water at a supply temperature of 94°F. A cooling water temperature rise of 21.8°F can be expected under these conditions.

Discharge from the condenser is returned to the lake, where it is separated from the intake supply by diking. The non-essential service water is also returned to the lake via the CW discharge header. Makeup water to the lake is pumped from the Kankakee River. Makeup flow is limited to not exceed 10% of normal river flow. Water chemistry is controlled by continuous blowdown of the supply water to the condenser and makeup to the cooling lake.

9.3.6.2 Input Parameters and Assumptions

An increase in heat rejection to the main condenser of approximately 5%, which will cause slightly increased temperatures in the CW system. This will also result in a small increase in condenser backpressure.

Main condenser current operating data, including current CW flow rates, at summer weather conditions were used as input to the evaluation.

9.3.6.3 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 CW 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 Heat Exchanger Institute (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 tube wall thickness are considered.

9.3.6.4 Acceptance Criteria

The CW system is considered acceptable under power uprate conditions provided the following criteria are met:

1. CW temperature increase is bounded by CW system piping and component design and remains within UHS analysis limits.

2. Condenser backpressure increase remains below turbine manufacturer recommended limits.

3. Main condenser tube vibration and erosion analysis results remain within acceptable industry guidelines.

There are no Technical Specification limits associated with the CW system. However, the Braidwood cooling lake temperature is limited by the Technical Specification for the Ultimate Heat Sink as discussed in Section 9.3.11.

9.3.6.5 Results

The main condenser was evaluated at the power uprate conditions to verify that tube vibration would remain within acceptable limits. The existing maximum support plate spacing at Byron is 39.5 in. with alternate spans of 36.5 in. The algorithm predicted that for the proposed maximum power uprate conditions (considering all Units), unsupported tube spans of 39.5 in. would preclude damaging tube vibration.

Areas in the condenser receiving increased dump flows as a result of the power uprate may be subject to additional wear associated with the increased velocity. Adequate protection against flashing and high energy impingement is already a part of the existing design and the slight increases in power uprate flows does not impact this area.

Evaluation of Byron Station

The power uprate to the NSSS power level of 3,600.6 MWt can be performed without hardware modifications to the CW system.

The power uprate will result in approximately a 5% increase in low pressure turbine exhaust steam flow and a corresponding approximate 5% increase in heat rejection to the CW system.

The results of the analysis for the Byron Station are tabulated below:

Table 9.3.6-1
Byron Station – Circulating Water System

Parameter	Original Design	Current Operating Conditions (1)	Power Uprate (1)	
			BYR-1	BYR-2
Condenser Duty - BTU/hr	7.939E+09	7.633E+09	7.978E+09	8.084E+09
Condenser Back Pressure - in. Hga	3.5	3.8	4.1	4.0
CW Flow to Condenser - (gpm)	632,000	693,000	693,000	693,000
CW Temp. Rise - °F	25.2	22.2	23.2	23.5

(1) Based on nominal inlet temperature of 98°F.

CW system flow will remain essentially unchanged following power uprate, but condenser outlet temperature will increase. The increased levels of rejected heat, from an approximately 5% increase in turbine exhaust flow, will increase the CW outlet temperature by approximately 1°F.

This increase in temperature is bounded by the CW system design and can be accommodated by the cooling tower, although during periods of high temperature/humidity conditions a slight derate might be encountered as currently occurs. A slight increase in evaporation rates can also be expected, requiring an increase in makeup rates of approximately 1,000 gpm under maximum summer conditions. The makeup system has sufficient margin and is capable of providing this additional flow. (Ref. 1)

Performance of the condenser vacuum system and steam jet air ejectors is expected to remain unchanged. The aggregate performance effect of the existing tower and condenser will thus be a small increase in turbine backpressure.

The CW system will continue to support safe operation of the plant at the power uprate of 3,600.6 MWt. No modifications are required to the CW system or component including the cooling tower makeup, water treatment and blowdown systems. The CW and support systems will continue to perform within the existing NPDES permit limits. (Refer to Section 11).

Evaluation of Braidwood Station

The main condenser was evaluated at the power uprate conditions to verify that tube vibration would remain within acceptable limits. The existing maximum support plate spacing at Braidwood is 39.5 in. with alternate spans of 36.5 in. The algorithm predicted that for the proposed maximum power uprate conditions (considering all Units), unsupported tube spans of 39.5 in would preclude damaging tube vibration.

The power uprate to the NSSS power level of 3,600.6 MWt can be performed without hardware modifications to the CW system.

The power uprate will result in approximately a 5% increase in low pressure turbine exhaust steam flow and a corresponding 5% increase heat rejection to the CW system.

The results of the analysis for the Braidwood CW system are tabulated below.

Table 9.3.6-2 Braidwood Station - Circulating Water System				
Parameter	Original Design	Current Operating Conditions (1)	Power Uprate (1)	
			BRW-1	BRW-2
Condenser Duty - BTU/hr	7.939E+09	7.633E+09	7.978E+09	8.084E+09
Condenser Back Pressure - in. Hga	3.5	3.9	4.0	4.1
CW Flow to Condenser - gpm	729,800	722,000 BRW-1 703,000 BRW-2	722,000	703,000
CW Temp. Rise - °F	21.8	21.3 BRW-1 21.9 BRW-2	22.2	23.1

(1) Based on nominal inlet temperature of 98°F

While evaluation of the uprate condition with an appropriate allowance for tube plugging indicates that the condenser is adequate for the heat load, the condenser backpressure will increase under elevated CW temperatures. The heat load under the power uprate conditions will result in about a 0.12" Hg backpressure increase in the condenser and an approximately 1°F increase in temperature. The increase in backpressure may result in reduced output during extreme summer conditions. A 1°F increase in CW return temperature will have a negligible affect on the evaporation rate of the lake.

The operation of the CW system at the higher power levels is not expected to significantly impact the ability of the makeup, water treatment blowdown systems.

9.3.6.6 Conclusions

Power uprate increases the main steam flow and heat rejection to the main condensers and, therefore, slightly reduces the difference between the operating pressure and the required minimum condenser vacuum. The performance of the main condensers at Byron and Braidwood was evaluated for the power uprate based on a duty over a range of CW inlet temperatures. The increase in design power level to 3600.6 MWt will result in an increase in the temperature rise through the condenser of approximately 1°F.

Plant operational heat loads from the CW are rejected to the atmosphere by the cooling towers at Byron and the cooling lake at Braidwood. The cooling towers and cooling lake cools the CW to maintain proper condenser back pressure to meet turbine requirements and maintain peak station efficiency. This review confirmed that the condensers, CW systems, CW support systems, and cooling towers and cooling lake are adequate for operation at the uprated power level.

9.3.6.7 References

1. Byron/Braidwood UFSAR, Rev. 7, Dec. 1998, section 10.4

2. Byron/Braidwood UFSAR, Rev. 7, Dec. 1998, Table 10.4-1

3. Siemens Westinghouse Byron/Braidwood Baseline Power Uprate Heat Balance WB-7329, dated April 22, 1999

4. Siemens Westinghouse Byron/Braidwood Unit 1 Power Uprate Heat Balance WB-7342, dated May 13, 1999

5. Siemens Westinghouse Byron/Braidwood Unit 2 Power Uprate Heat Balance WB-7347, dated May 18, 1999

9.3.7 Essential Service Water System

9.3.7.1 System Description

The Essential Service Water (SX) System is designed to ensure that sufficient cooling capacity is available to provide adequate cooling during normal and accident conditions. The components served by SX for normal, LOCA, loss of offsite power (LOOP), or shutdown conditions are listed below:

- Component cooling heat exchangers
- Containment fan coolers (RCFC)
- Emergency Diesel-generator jacketwater coolers
- Diesel- and Motor-driven auxiliary feedwater pump lube oil coolers
- Diesel-driven auxiliary feedwater pump cubicle coolers

- Diesel-driven auxiliary feedwater pump diesel coolers
- Essential service water pump lube oil coolers
- Essential service water pump cubicle coolers
- Centrifugal charging pump cubicle coolers
- Safety-related suction source for the Auxiliary Feedwater Pumps
- Centrifugal charging pump oil coolers
- Safety injection pump oil coolers
- Safety injection pump cubicle coolers
- Positive displacement charging pump cubicle cooler
- Containment spray pump cubicle coolers
- Residual heat removal pump cubicle coolers
- Control room refrigeration units
- Spent fuel pit pump cubicle coolers
- Primary containment refrigeration units
- Alternate source for the Fire protection system

Safety-related heat transfer equipment is designed for a 100°F SX water supply temperature. At Byron, heat rejection from the SX system is to the essential service water cooling towers, both on a normal and on an emergency basis. At Braidwood, heat rejection from the SX System is to the essential service water cooling lake, both on a normal and an emergency basis. For the power uprate evaluation, the bounding case is one unit undergoing a LOCA and LOOP while the other unit is undergoing normal plant shutdown consistent with the design basis accident for the Ultimate heat Sink (UHS) as described in the UFSAR. The heat removal capability of the UHS to maintain the 100°F essential service water supply temperature is evaluated in the UHS Section 9.3.11.

The power uprate has a two-fold impact on the SX system. The direct effect of the power uprate is a higher decay heat that must be accommodated by the system. The decay heat will increase directly proportional with the power uprate. Using a nominal 5% core power increase will result in a 5% increase in decay heat. This decay heat will be absorbed by the SX system and rejected through the UHS. This results in higher heat loads from the RHR heat exchanger via the Component Cooling (CC) System for normal cooldowns as well as during sump recirculation modes following a postulated design basis accident. Also, during post-LOCA operations the Reactor Containment Fan Coolers (RCFCs) will experience a higher heat load.

The second effect on SX is an increase in the inventory required from the system as a safety related source of water to the Auxiliary Feedwater (AF) System.

9.3.7.2 Input Parameters and Assumptions

The following inputs are used in the SX system evaluation:

CC HX - minimum heat removal capability:

Minimum SX flow per HX - 5000 gpm

Maximum SX temperature - 100 °F

CC HX - maximum heat removal capability:

Maximum SX flow per HX - 20,044 gpm

Maximum SX temperature – 100°F

RCFC - minimum performance:

SX Temperature to RCFC - 100 °F

SX flow per RCFC - 2,660 gpm

RCFC - maximum performance:

SX Temperature to RCFC - 32 °F

SX flow per RCFC - 3,200 gpm

The power uprate post accident heat loads resulting from the containment re-analyses are used.

One Unit is assumed to be the accident unit undergoing a LOCA and LOOP. The other Unit is assumed to be undergoing a normal shutdown.

9.3.7.3 Description of Analyses

The Braidwood Station FLO-SERIES SX system model, developed to support the power uprate project, was used to evaluate SX flows to various components during six separate accident scenarios. The Byron Station system hydraulic model was used to evaluate SX flows to various components.

The operating parameters for the following components are affected by the power uprate and are considered to be critical to the SX and its reliable operation:

- Service Water Pumps
- Component Cooling Water Heat Exchangers
- Reactor Containment Fan Coolers (RCFCs)
- Auxiliary Feedwater Pumps

The other SX loads were reviewed and the power uprate did not impact the loads or the impact was bounded by existing heat loads and required SX flow.

The following SX system parameters and requirements were evaluated to assess the impact of the thermal power uprate:

- Flow adequacy to the CC heat exchangers and RCFC coils
- Heat Load removal capability
- Heat Load impact on the UHS maximum temperature
- SX Byron inventory for safety related source for AF pumps

The Braidwood flow model was used to evaluate several different cases to demonstrate the flow adequacy to the CC heat exchangers and the RCFCs post accident.

Similar cases were previously analyzed for Byron Station and were not impacted by the power uprate.

For normal RHR cooldown, the SX flow adequacy to the CC heat exchangers was evaluated.

9.3.7.4 Acceptance Criteria

The SX system must be capable of removing the heat duty during normal plant operation and post accident by supplying the required flow to system components. The SX system must provide the minimum SX flow at 100°F to satisfy the heat removal requirements of the various components.

9.3.7.5 Results

For Braidwood Station, the results from the SX system hydraulic model, show that the SX pumps have adequate capacity to supply the CC HX flow, and provide the minimum flow to the RCFCs. For Byron Station, the results from the SX system hydraulic model, shows that the SX pumps have adequate capacity to supply the CC HX flow and provide the flow to the RCFCs.

Refer to Section 9.3.13 for discussion of SX inventory required to provide a safety related source of water to the AF pumps.

The heat removal capability and temperature impact on the UHS are discussed in the UHS Section 9.3.11.

9.3.7.6 Conclusions

The existing SX system design is acceptable for the thermal power uprate to 3,600.6 MWt conditions. No hardware modifications to this system are required.

9.3.7.7 References

1. Byron/Braidwood UFSAR Section 9.2.1.2, Essential Service Water System, (Rev. 7), Dec. 1998

9.3.8 Non-Essential Service Water System

9.3.8.1 Introduction

The Nonessential Service Water (WS) System is a non-safety-related system which supplies cooling water for the turbine auxiliaries and other non-safety-related plant features. The WS system service has provided with three 35,000 gpm pumps to provide water to both units. Normally two pumps will be in operation with the third providing full capacity backup for either unit. Three 35,000 gpm strainers are provided downstream of the pumps. These may be used in any combination with the pumps to provide normal operation and full backup. Accordingly, the WS system is designated Safety Category II, Quality Group D. None of the loads serviced by this system affect the safe shutdown of the plant.

For the power uprate evaluation, the bounding case is both units operating at 100% power during weather conditions that result in maximum supply temperature (100° F) for the WS system. The heat rejected by the system is passed to the environment via the circulating water discharge header.

9.3.8.2 Input Parameters and Assumptions

The power uprate in NSSS power from 3425 MWt to 3600.6 MWt will result in demonstrable increases in the heat loads from the main generator hydrogen coolers, bus duct coolers and the stator cooling water system. Other loads may experience slight increases in heat loads. No heat load including those demonstrable increases will exceed the current design limits and are bounded by the existing design conditions.

9.3.8.3 Description of Analysis/Evaluation

Evaluations demonstrate that the overall capacity of the system is adequate for the power uprate condition. The potential for loss of the WS system has not increased over current levels. Operation of the WS system at power uprate power levels will not result in increased challenges to safety-related systems. The WS system can accommodate increased heat loads resulting from the power uprate.

The heat removal capability of the system is based on a design maximum WS supply temperature of 100°F.

9.3.8.4 Acceptance Criteria

The acceptance criteria for the evaluation of the WS system is to verify the specified cooler's design heat removal requirements and matching water tube side flowrate are adequate for the power uprate.

9.3.8.5 Results

The results of the evaluation performed shows that the design rating of the components will not be exceeded at the uprate conditions.

9.3.8.6 Conclusions

The WS system is adequate for the power uprate. There are no equipment changes required to the system.

9.3.8.7 References

None

9.3.9 Component Cooling Water System

9.3.9.1 Introduction

The Component Cooling (CC) System is required to provide cooling water to various plant components of either unit during normal operation, plant shutdown, and after an accident, and, to act as an intermediate system between the components being cooled and the Essential Service Water (SX) System.

The system consists of five pumps, three heat exchangers, two surge tanks and associated valves, piping and instrumentation. Two pumps, one heat exchanger, and one surge tank serve each unit. The remaining pump and heat exchanger are provided as backup equipment for either unit, e.g., during maintenance or shutdown of a unit. During normal operation, the CC system may be shared by both units or divided into separate unit operation, dependent on plant conditions.

During normal operation, one pump and one heat exchanger are required to accommodate the heat load for each unit. However, with a full spent fuel pool heat load an additional pump is required.

The component cooling system provides cooling water to the following equipment:

- residual heat removal (RHR) exchangers and pumps
- Chemical and Volume Control System CV letdown, excess letdown, and seal water heat exchangers, and, charging pump (positive displacement)
- reactor coolant pumps

- process sampling system coolers
- spent fuel pit heat exchangers
- waste gas compressors
- boron recycle evaporator condenser, distillate cooler, and vent condenser
- containment penetrations.

The UFSAR Table 9.3-4 provides the cooling flow requirements for the above components under the various modes of operation and post accident. During normal plant operation, essentially all of the components above require cooling, except the RHR heat exchangers. The RHR system requires cooling water both to remove the decay heat load, and to remove the heat required to cool down the Reactor Coolant System (RCS). Spent Fuel Pool Cooling (FC) is required for all modes of operation, normally the spent fuel pool heat load is not placed on the unit undergoing a Loss of Coolant Accident (LOCA).

Following a design basis accident, the CC/RHR systems in conjunction with the containment spray and fan coolers, maintain the containment peak temperature and pressure within design limits.

The limiting heat loads on the component cooling system occur for a simultaneous shutdown of one unit with the other unit undergoing a LOCA. This case assumes a loss of off site power, and a single failure (diesel generator) in the unit with the LOCA.

The design of this system is based on a maximum normal operating CC temperature of 105°F, maintained by SX cooling while removing the design heat loads. This temperature is allowed to reach 120°F for the first three hours of cooldown, following a unit shutdown. The CC system supply temperature limitations are dictated by the design of the reactor coolant pump thermal barrier cooling coils.

9.3.9.2 Input Parameters and Assumptions

Analyses have been performed for the reactor plant conditions, which define the CC performance requirements and the ability of the design to meet these requirements at the power uprate conditions. The reactor plant conditions which impose safety-related performance requirements on the CC system include the following:

1. Normal operation
2. Cooldown
3. Loss-of-Coolant Accident (LOCA)

The increased heat loads due to the power uprate are primarily due to the increased FC heat load, the increased RHR heat load during plant cool down and RHR heat load during post-LOCA recirculation mode. The power uprate FC heat loads are based on the following:

1. The background heat load for a full fuel pool.

2. The RHR normal plant cool down heat loads at the power uprated power level.

3. The post-LOCA power uprated heat loads from containment analyses.

The limiting cases include the following input parameters:

- SX temperature will be maintained at or below 100°F. for the CC heat exchanger:

- CC (shell side) flow rate = 3.19E+06 lb/hr (2.4E+06 lb/hr for one CC pump/one CC Hx operation)

- SX (tube side) flow rate = 9.96E+06 lb/hr (Minimum of 9,000 gpm for post-LOCA recirculation)

These inputs are consistent with the UFSAR Section 9.3.2, including Table 9.3-3.

9.3.9.3 Description of Analyses

For normal plant operation, an analysis was performed to reflect the power uprate heat loads. The CC system as currently configured is able to remove the increased heat loads at the design system flow rates. For plant cool down, the analysis demonstrates that a two train cool down can remove the power uprate heat load while cooling the fuel pool. This will maintain the CC temperature at or below 120°F, utilizing 3 CC pumps and 2 CC heat exchangers on the unit cooling down, and allow one CC pump and one CC heat exchanger on the operating unit.

For post LOCA heat loads, the analysis demonstrates that SX could remove the power uprate heat load and still maintain CC at or below 120°F, as long as the SX flow rate is at least 9000 gpm. Calculations for Braidwood Station and for Byron Station demonstrate that this minimum SX flow rate will be maintained.

Additionally, the analysis verified that the increased heat loads can be removed. A calculation revision was performed to determine the increased cleanliness for the heat exchanger tubes to compensate for the tube plugging and still remove the design heat load.

9.3.9.4 Acceptance Criteria

The post power uprate heat loads will be removed with the CC system as currently configured.

The maximum CC temperatures shall remain as follows:

- for normal operation the CC temperature will not exceed 105°F
- for the plant cool down and post LOCA, the CC temperature will not exceed 120°F

9.3.9.5 Results

The CC system is able to remove the power uprate heat loads while maintaining existing limits on CC operating temperatures. The results of the evaluation at the power uprated power level are presented in Table 9.3.9 -1. The results demonstrate that the plant operation with two units at full power can be supported with three CC pumps and two CC heat exchangers. For a normal two train cool down on one unit, the cool down unit (with fuel pool heat load) can be supported with three CC pumps and two CC heat exchangers and the unit at operation can be supported with one CC pump and one CC heat exchanger. Also the analyses demonstrate that the CC system can provide adequate heat removal post accident with a single CC heat exchanger and support cool down of the non-accident unit with the fuel pool heat load on the shutdown unit.

Table 9.3.9-1 CS/SX Flows Required to Each CC Heat Exchanger for Power Uprate Heat Loads		
Mode of Operation	**CC Flow per CC Heat Exchanger (gpm)**	**SX Flow per CC Heat Exchanger (gpm)**
Normal Operation **both Units at power** (3 CC pumps, 2 CC HXs) Spent Fuel Pool heat load shared between units	6,376[(1)]	19,920[(1)]
Normal Operation **1 Unit at power** (1 CC pump, 1 CC HX)	4,800[(1)]	7,000[(1)]
1 Unit in shutdown at 4 hours (3 CC pmps, 2 CC HXs) Spent Fuel Pool heat load on shutdown unit	6,376	19,920[(2)]
Post LOCA **1 Unit post LOCA** (1 CC pump, 1 CC HX)	5,000	5,400 (min.) [(3)]
1 Unit at shutdown (3 CC pumps, 1CC HX) Spent Fuel Pool heat load on shutdown unit	6,376	19,920

Based on design fouling and no tube plugging for the CC HX

(1) maintaining CC temperature at or below 105°F

(2) maintaining CC temperature at or below 120°F

(3) Minimum SX flow to maintain required post-accident containment heat removal. However, to limit CC of 120°F, minimum SX flow is 9,000 gpm.

9.3.9.6 Conclusions

The limiting heat loads for the CC system occur for a simultaneous shutdown of one unit with the other unit undergoing a LOCA. The existing CC system capability is adequate for the power uprated conditions proposed with no equipment changes required. For normal operation the CC temperature will not exceed 105°F, and for the plant cool down, the CC temperature will not exceed 120°F as long as the minimum SX flow is maintained.

9.3.9.7 References

1. Byron/Braidwood UFSAR Section 9.2.2, Component Cooling System, (Rev. 7), Dec. 1998

2. Byron Technical Specifications, Sections 3.5.2, ECCS-Operating and 3.7.7, Component Cooling Water (CC) System), Amendment 111

3. Braidwood Technical Specifications, Sections 3.5.2, ECCS-Operating and 3.7.7, Component Cooling Water (CC) System), Amendment 104

9.3.10 Spent Fuel Pool Fuel Cooling

9.3.10.1 Introduction

The Spent Fuel Pool Cooling System (FC) is designed to remove decay heat generated by stored spent fuel assemblies from the spent fuel pool. This cooling is accomplished by taking high-temperature water from the pool, pumping it through a heat exchanger and returning the cooled water to the pool. A secondary function of the FC system is to clarify and purify spent fuel pool, transfer canal, and refueling water. A portion of the hot water discharged by the pump can be diverted through a water cleanup system and returned to the pool.

Refueling operations are routinely performed in either an approximate one-third core offload, a full core temporary offload where approximately two-thirds of the fuel assemblies are returned to the reactor vessel, along with the new fuel, prior to the end of the outage. A third refueling mode, back-to-back dual-unit discharge, would be an abnormal circumstance, but it is also considered in the analysis.

The FC system consists of two independent trains, each consists of one pump and one heat exchanger. Each cooling train is currently designed to service the spent fuel pool, with design spent fuel assembly loading, and to maintain the bulk fluid temperature of the pool below 138°F (Max. Pool Bulk) for the one-third core discharge, below 157°F (Max. Pool Bulk) for the full core discharge mode, and below 137°F (Max. Pool Bulk) for abnormal discharge.

For these two cases the discharge is assumed to be into a pool containing fuel from 34 previous discharges of approximately 84 assemblies.

Under normal refueling 84 fuel assemblies are discharged with a spent fuel pool water heat inertia (time to heat from 138°F to 212°F assuming no heat loss) of 8.4 hours. A full core discharge consists of 193 fuel assemblies discharged with a spent fuel pool water heat inertia of 3.8 hours. An abnormal discharge consists of 277 fuel assemblies being discharged with a spent fuel at 10.5 hours for first discharge (84 assemblies), 24.1 hours for the second discharge (193 assemblies), and 17 days between first and second discharge and 6 months to the previous discharge. The time to boil is 4.2 hours. (Refs. 4, 5)

The preceding discussion is based on the following assumptions and is consistent with UFSAR:

1. Spent fuel cooling system flow of 4,500 gpm and maximum temperature of 157°F (full core offload). (Refs. 4, 6)

2. Component cooling water (CC) flow to spent fuel pool heat exchanger of 5,440 gpm at a temperature of 105°F. (Ref. 6)

3. Core power level of 3411 MWt

The impact of the increase in core power from 3411 MWt to 3586.6 MWt was evaluated to determine the resulting maximum FC heat load, temperature, and heat-up times with the existing FC system.

9.3.10.2 Input Parameters and Assumptions

The following input parameters are used in the spent fuel pool system evaluation and are applicable at the power uprated conditions.

1. 1/3 Core Decay Heat Load
   @ 100 hours = 38.5 MBtu/hr

2. Full Core Decay Heat Load
   @ 100 hours = 61.4 MBtu/hr

3. CC inlet temperature = 105°F (Ref. 7)

4. CC flowrate = 2,720,000 lb/hr

5. FC flowrate = 2,230,000 lb/hr

6. FC water available = 3,800,000 lb

The following assumptions are used in the spent fuel pool system evaluation:

1. Normal refueling discharge (1/3 core) is into a pool containing fuel from 34 previous discharges of 84 assemblies. It is assumed that the total time period for the discharge of the 1/3 core is 10.5 hours. The discharge rate to the pool is assumed to be continuous and uniform with one spent fuel pool cooling train operating.

2. Full core refueling discharge is also into a pool containing fuel from 34 previous discharges of 84 assemblies. It is assumed that the total time period for the discharge of the full core is 24.1 hours. The discharge rate to the pool is assumed to be continuous and uniform with one spent fuel pool cooling train operating.

3. 17-day back-to-back abnormal discharge requires 410 hours between normal discharge and full core discharge with six months between the normal discharge and the previous discharge.

9.3.10.3 Description of Analyses

The thermal power uprate will increase the core power level from 3,411 MWt to 3,586.6 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 CC System and increased operating temperatures in the spent fuel pool. The power uprate is not expected to impact the impurity levels in the spent fuel pool and the design of the cleanup system will not be impacted. The spent fuel pool will operate at higher temperatures due to increased heat load. Note the demineralizer operation is restricted so as not to exceed 160°F. However based on two spent fuel cooling trains normally being available during refueling operations, the spent fuel pool is not expected to operate above 140°F during normal refuelings. This will allow maintenance to be performed during unit operations and ensure two trains will be available during refueling. (Ref. 10)

To determine the increased heat load for the power uprated power level, a calculation was performed using the maximum spent fuel pool decay heat load values. This calculation produced both the FC and CC water temperatures, times to boil for the fuel pool, and fuel pool boil-off rates for the following cases, which are consistent with UFSAR:

1. Power uprated Design Fouling Heat Load, 1/3 Core Offload (3,586.6 MWt), with one cooling train

2. Power uprated Design Fouling Heat Load, Full Core Offload (3,586.6 MWt), with one cooling train

3. Power uprated Design Fouling Heat Load, Back-to-Back Core Offload (3,586.6 MWt), with two cooling trains

4. Power uprated Design Fouling Heat Load, Full Core Offload (3,586.6 MWt), with two cooling trains

The spent fuel pool temperature is controlled by transferring the spent fuel pool heat load to the CC system via the spent fuel pool heat exchanger. To determine the increase in the spent fuel pool maximum operating temperature as result of the power uprate, calculations were performed for the following conditions:

Case 1 1/3 core Discharge – Design Basis

1/3 core offload beginning at 100 hours after shutdown, with one spent fuel pool cooling train operating

Case 2 Full core Discharge – Design Basis

Full core offload beginning at 100 hours after shutdown, with one spent fuel pool cooling train operating

Case 3 Back-to-back Discharge – Design Basis

1/3 core offload, followed by a full core offload 17 days later, with two cooling trains operating

Case 4 Full core Discharge – Normal Expected

Full core offload, beginning at 100 hours after shutdown, with two spent fuel pool cooling trains operating

9.3.10.4 Acceptance Criteria

The maximum spent fuel pool temperatures shall remain, per SRP 9.1.3 (Ref. 1) as follows:

1/3 Core Discharge - below 140°F with a heat load from a full core offload and a single failure resulting in one spent fuel pool train operating

Full Core Discharge - below 212°F with a heat load from a full core offload and a single failure resulting in one spent fuel pool train operating

Back-to-back Discharge - below 212°F with a normal heat load from a back-to-back offload with two spent fuel pool trains operating

The time to heat up the fuel pool to 212°F after a loss of all spent fuel pool cooling with a heat load from a full core discharge shall be sufficient to provide an alternative means of cooling.

The makeup rate to replace water due to boiling shall be equal to or greater than the calculated makeup rate at the highest pool heat loads.

9.3.10.5 Results

The results of the evaluation at the uprated power level are presented in the following Table 9.3.10-1:

Table 9.3.10-1 Spent Fuel Pool Cooling Evaluation Results			
Scenarios Evaluated	**Power uprate Heat Load (Btu/hr)**	**Power uprate FC Temp. (°F)**	**Time to boil (hours)**
1/3 Core Discharge (1 HX) 100 hours after reactor shutdown (Design Basis)	3.85×10^7	141.2	6.99
Full Core Discharge (1 Hx) 100 hours after reactor shutdown (Design Basis)	6.14×10^7	162.7	3.055
Full Core Discharge (2 Hx) 100 hours after reactor shutdown (Normal Expected)	6.14×10^7	133.8	4.85
Back-to-back Core Discharge (2 Hx) 100 hours after reactor shutdown (Design Basis)	7.32×10^7	139.4	3.77

9.3.10.6 Conclusions

The existing FC system capability is capable of removing the maximum heat load for the power uprated conditions proposed, while maintaining the spent fuel pool temperature near or below the required regulatory limits. In the event that all cooling to the spent fuel pool is lost, the system is capable of making up the inventory to more than compensate for the loss due to boil off.

In the event of a single failure resulting in one train operating, the calculated maximum spent fuel pool bulk temperatures are 141.2°F for a normal refueling (1/3 core) and 162.7°F for a full core discharge respectively. Although the 1/3 core discharge exceeds the Standard Review Plan (SRP) maximum temperature of 140°F, the full core discharge is well below the SRP maximum temperature of 212°F (boiling). The decay heat loads used in this analysis include conservative assumptions which, if removed would produce actual pool temperatures lower than those calculated for both 1/3 core and full core cases as expected. These assumptions take no credit for evaporative losses, heat losses to pool structures, heat removal by the residual heat removal (RHR) heat exchangers, and through heat exchangers between the water in the reactor cavity and the water in the fuel pool. The decay heat load calculation yields conservative results and the spent fuel pool temperatures are not expected to reach the results identified in Table 9.3.10-1.

With a complete loss of spent fuel pool cooling, the temperature would reach boiling in about 7 hours (1/3 core) and 3 hours (full core). These calculated times are considered conservative since they are based on the maximum heat generation rate at the very moment when all cooling capability is lost. In actuality, the heat generation rate will decrease with time due to reduced generation in the fuel. The makeup rates required to replace water loss due to boiling are approximately 79 gpm (1/3 core) and 126 gpm (full core). This makeup rate can be provided by one of two refueling water purification pumps from the Refueling Water Storage Tank, one rated at 150 gal/min and the other at 250 gal/min.

For the case of a back-to-back core offload, the maximum expected power uprated spent fuel pool temperature with two heat exchangers operable is 139.4°F. The conservative assumptions listed above for full core discharge apply here as well, making the probability of the spent fuel pool temperature actually reaching the calculated maximum of 139.4°F low. This is well below the SRP maximum of 212°F. Therefore the calculated temperature is considered acceptable.

In the event that only one heat exchanger is operable for a back-to-back core discharge (this is a beyond design basis transient), the maximum temperature 100 hours after shutdown would be 173.7°F. With complete loss of spent fuel pool cooling, the bulk fuel pool temperature would reach 212°F in about 2 hours. The required makeup rate to replace water loss due to boiling is approximately 151 gpm. Makeup to the spent fuel pool can be provided by one of two refueling water purification pumps from the Refueling Water Storage Tank, one rated at 150 gal/min and the other at 250 gal/min.

The FC system is designed to remain functional during and following a seismic event, and the fuel pool cooling system is designed for 200°F. The spent fuel pool is designed to withstand the stresses associated with a steady state gradient of 158°F. The impact of the spent fuel pool temperatures above 158°F on the structure is evaluated in Section 9.5.

9.3.10.7 References

1. Byron/Braidwood UFSAR Section 9.1.2.1, Design Bases, Rev. 7 Dec. 1998

2. Byron/Braidwood UFSAR Section 9.1.3.1, Design Bases, Rev. 7 Dec. 1998

3. Byron/Braidwood UFSAR Section 9.1.2.2, Facilities Description, Rev. 7 Dec. 1998

4. Byron/Braidwood UFSAR Table 9.1-1, Spent Fuel Pool Cooling System Design Parameters, Rev. 7 Dec. 1998

5. Byron/Braidwood UFSAR Table 9.1-1a, List of Cases Analyzed, Rev. 7 Dec. 1998

6. Byron/Braidwood UFSAR Table 9.1-2, Spent Fuel Pool Cooling System Component Design Parameters, Rev. 7 Dec. 1998

7. Byron/Braidwood UFSAR Table 9.1-4, Vaporization Rate from the Instant All Cooling is Lost, Rev. 7 Dec. 1998

8. Byron/Braidwood UFSAR Table 9.1-1a, List of Cases Analyzed, Rev. 7 Dec. 1998

9. Byron Technical Requirements Manual, Section 3.9.a, Rev. 4

10. Byron/Braidwood UFSAR Table 9.3-4, System Flow Conditions for Main Plant Operating Phases (One Unit), Rev. 7 Dec. 1998

11. Braidwood Technical Requirements Manual, Section 3.9.a, Rev. 4

12. Braidwood Technical Specification, Section 3.9.3, Containment Penetrations, Amendment 104

13. USNRC Standard Review Plan 9.1.3, "Spent Fuel Pool Cooling and Cleanup System", (NUREG-0800, Rev. 10)

9.3.11 Ultimate Heat Sink

9.3.11.1 Introduction

The Ultimate Heat Sink (UHS) provides a heat sink for processing and operating heat loads from safety related components during a transient or accident. In addition, the UHS provides the safety-related source of auxiliary feedwater when the Condensate Storage Tank (CST) is not available.

At Byron Station, the UHS is composed of two mechanical-draft cooling towers and the makeup system to these towers. Heat from the Essential Service Water (SX) system is rejected to the SX cooling towers. There are two mechanical-draft cooling towers of the counterflow design. Each of the two safety-related mechanical-draft cooling towers consists of a water storage basin, an antivortex duct, a trash rack, four fans, four riser valves, and two bypass valves. The cold water basins of the two cooling towers are connected by an overflow. The cooling towers must have a source of makeup water to compensate for drift losses, evaporation, and blowdown. The normal supply of makeup water comes from the Category II Circulating Water (CW) System. An emergency source of makeup water is provided by the Category I diesel driven makeup pumps. An additional source of makeup is provided by the Category II onsite deep well pumps.

The Braidwood Station UHS consists of an excavated essential cooling lake integral with the main Braidwood cooling lake. Makeup and blowdown of the essential lake is not required for fulfillment of its safety function. The SX cooling lake is sufficiently oversized to permit a minimum of 30 days operation with no makeup.

The UHS is capable of providing adequate cooling capability under the condition with a loss of coolant accident (LOCA) coincident with a Loss-of-Offsite Power (LOOP) in one unit and the unaffected unit undergoing a safe non-accident shutdown. The accident scenario also includes a single active failure.

9.3.11.2 Input Parameters and Assumptions

For LOCA coincident with LOOP in one unit and the unaffected unit undergoing a safe non-accident shutdown:

- Accident unit maximum containment heat load as a function of time
- Non-accident unit cooldown heat load as a function of time
- Miscellaneous heat loads from both units
- Emergency makeup to Auxiliary Feedwater (AF) system for one unit

Two-unit dual shutdown (two train cooldown on one unit and a single train cooldown on the other unit):

- Two train cooldown heat load for one unit with spent fuel heat load
- Single train cooldown of one unit without spent fuel heat load
- Miscellaneous heat loads from both units
- Emergency makeup to Auxiliary Feedwater (AF) System for both units

The following initial conditions are used in the UHS analyses:

Table 9.3.11-1
UHS Power Uprate Analysis Inputs

Initial Condition	**Byron**	**Braidwood**
Maximum UHS temperature (SX pump discharge)	96°F(1)	100°F
Minimum UHS Level	60%(2)	590 ft

Notes:

1. Used 96°F with 7 or more cooling tower fans running on high speed, used 90°F with two fans out-of-service

2. Used 60% with emergency SX makeup pumps, used 90% with makeup from deepwell pumps

9.3.11.3 Description of Analyses

At both stations, the power uprate in power from 3,411 MWt to 3,586.6 MWt causes an increased total heat load to the UHS as a result increased decay heat loads. A nominal 5% core power increase will result in an approximately 5% decay heat increase. This decay heat will be removed by the SX system and rejected to the UHS. This results in higher heat loads from the RHR heat exchanger via the Component Cooling System for normal cooldown as well as during sump recirculation modes following a postulated design basis accident. Also, during post-LOCA operations the Reactor Containment Fan Coolers will experience a higher heat load.

The design basis event for the Byron and Braidwood UHS is a loss-of-coolant accident (LOCA) coincident with a loss-of-offsite power (LOOP) in one unit and the concurrent orderly shutdown from maximum power to cold shutdown of the other unit using normal shutdown operating procedures. The accident scenarios analyzed various single active failures. These scenarios maximized heat supplied to the UHS and minimized UHS heat removal capability.

The UHS analyses maximize the accident unit containment heat load to the UHS by:

- Postulating scenarios with maximum heat removal from four RCFCs,
- Assuming higher SX water flow rates to the RCFCs,
- Assuming higher air flow rates for the RCFCs, and
- Assuming maximum heat removal from the RHR heat exchangers in the post-LOCA recirculation mode.

The containment heat load is based on the Unit 1 (replacement steam generators) double ended (RC) pump suction break with maximum ECCS and maximum heat removal assumptions and bounds Unit 2.

The design heat load from the nonaccident unit is conservatively calculated as the energy required to reduce the unit from maximum to zero power and reduce the reactor coolant temperature to cold shutdown conditions (<200°F). Additional heat load is placed on the SX System and UHS once residual heat removal is placed in operation (at approximately 350°F). Under normal conditions, the minimum time to reach this condition, assuming an orderly shutdown and cooldown from maximum power using normal operating procedures, would be eight hours.

Byron Analyses

SX cooling tower performance was calculated based on SX flow values, heat loads, and ambient wet-bulb temperature. Results of these calculations give the cooling tower thermal performance as a function of temperature and provide an SX cooling tower basin temperature. These calculations predicted the basin temperature as a function of time following the accident.

Time-dependent basin volume calculations were performed to determine the minimum acceptable SX cooling tower basin water levels to be maintained during normal operations and to verify the adequacy of the SX river makeup and deep well makeup pumps. Scenarios were run with makeup available from one SX river makeup pump or one deep well pump for the following initiating events:

a. LOOP/LOCA on one unit in conjunction with the safe shutdown of the other unit.

b. Two-unit plant trip from full power.

An adequate water volume is required in the SX cooling tower basins to accommodate the draw down of inventory until the makeup rate exceeds the inventory losses and the basins begin to refill. Both the SX river makeup pump and the deep well pump are able to provide sufficient water to maintain the basin levels for SX pump operation and support the availability of a 30-day cooling water supply.

Braidwood Analyses

Data and weather parameters giving maximum 5-day, 24-hour, and 30-day average temperatures were used as a design weather period of 36 days for maximum temperature analyses of the ultimate heat sink. Data and weather parameters giving maximum 30 day average net evaporative loss (actual maximum evaporation less precipitation) were used as a maximum design water loss period of analysis.

The Technical Specification allowable maximum plant intake temperature is used to predict the maximum UHS temperature and evaporative loses to ensure a minimum 30 days of operation following an accident with no makeup and provide adequate NPSH for the SX Pumps.

9.3.11.4 Acceptance Criteria

The Byron SX cooling tower performance is acceptable if the calculated basin temperature, hence the SX water temperature, is below the SX cooling tower basin design temperature of 100°F.

The SX cooling tower basin analysis cases that assume one makeup pump available are acceptable if the required minimum basin level is less than 60% (level required is less than the level available). The analysis cases that assume only one deep well pump are available are acceptable if the required minimum basin level is less than 90%.

The Braidwood UHS SX design temperature is ≤ 100°F with the increased power uprate heat load.

The drawdown of the UHS lake level limit meets the minimum SX system pump NPSH margin of 24.6 ft.

9.3.11.5 Results

Figure 1 contains the revised total heat load to the UHS for both the accident and non-accident unit based upon the power uprate.

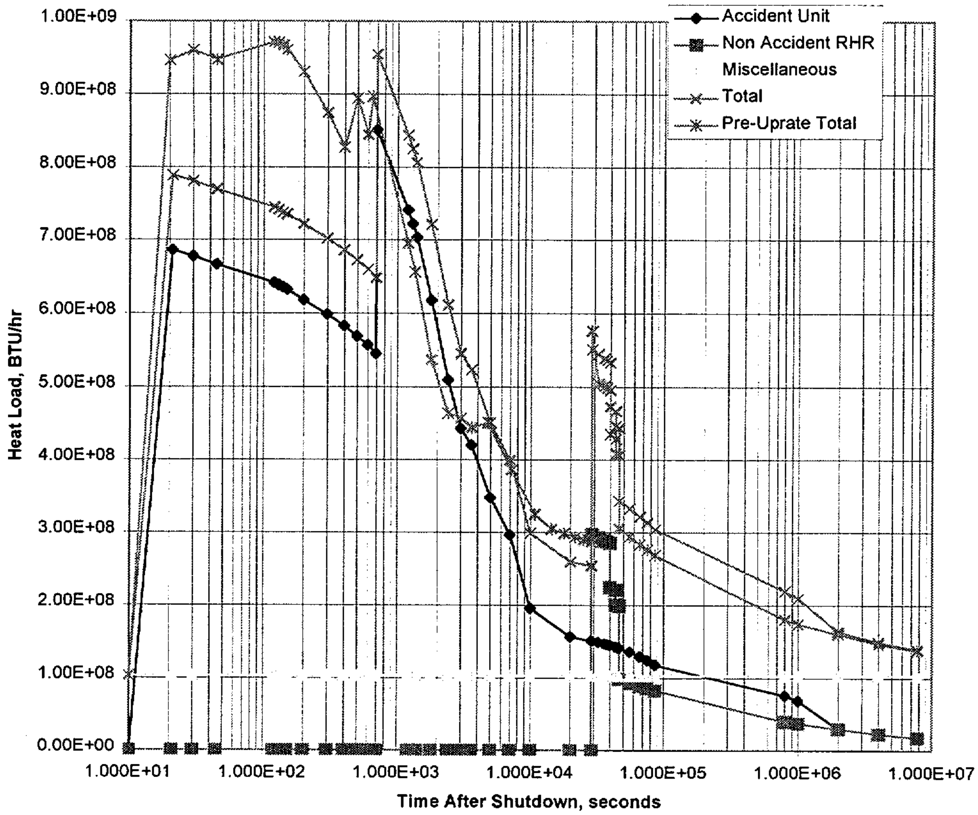

Figure 9.3.11-1
Total Heat Load to UHS

For the Byron Station, the power uprate heat load was applied to the limiting cases with one and two cooling tower fans out of service and a single failure of an additional fan was assumed. The cases with the initial condition of one fan out of service assume an initial cooling tower maximum Technical Specification temperature of 96°F. The cases with the initial condition of two fans out of service assume an initial cooling tower maximum Technical Specification temperature of 90°F. The results showed the post accident maximum basin temperature (SX inlet remains below 100°F. Further, the heat loads applied to the UHS are based on conservative assumptions (to maximize heat removal) and are well above that required to satisfy the containment peak temperature and pressure analyses and the RHR post-LOCA recirculation analyses. Due to the SX temperature remaining below 100°F for design basis cases and conservatism in the analyses, there is no impact on the function and performance of components cooled by the SX System.

The results of the Byron UHS cooling tower makeup analysis showed that starting with the minimum acceptable water levels and the existing makeup capability, basin levels would remain above the minimum acceptable usable water level for both the post-LOCA operation and the dual unit shut down operation.

The results showed that maximum post LOCA SX inlet temperature remains $\leq$ 100°F.

The Braidwood UHS is oversized and the additional evaporation lost due the power uprate heat load will not adversely impact the 30-day operation and NPSH of the SX system pumps.

Refer to the SX system Section 9.3.7 for discussion of flow rate impact resulting from power uprate.

9.3.11.6 Conclusions

The UHS is adequate for power uprate at both Byron and Braidwood stations. The existing UHS design at Braidwood and Byron will provide adequate heat removal and for the SX system to satisfy the conditions of having one unit at post accident condition and support an orderly shutdown of the unaffected Unit.

9.3.11.7 References

1. Byron Technical Specification 3.7.9, "Ultimate Heat Sink"
2. Braidwood Technical Specification 3.7.9, "Ultimate Heat Sink"
3. Byron UFSAR Section 9.2.5 "Ultimate Heat Sink", (Rev. 7), Dec. 1998
4. Braidwood UFSAR Section 9.2.5 "Ultimate Heat Sink" (Rev. 7), Dec. 1998

9.3.12 Reactor Containment Cooling System

9.3.12.1 Introduction

The Reactor Containment Cooling System under Normal Operating conditions consists of the Reactor Containment Fan Cooler (RCFC), Control Rod Drive Mechanism (CRDM), and Reactor Cavity Ventilation sub-systems.

Reactor Containment Fan Cooler (RCFC) Subsystem

During normal plant operation, the RCFC subsystem cools and dehumidifies the containment to maintain the operating environment required by the mechanical, electrical, and structural components at their required ambient temperatures listed below. Only one train (out of two redundant trains provided) is required to meet these conditions and each train consists of two RCFCs. (Ref. 2)

The RCFC Subsystem consists of four 50% capacity units. During normal operation, two of the four RCFCs are utilized with each RCFC providing 6.1×10^6 BTU/hr cooling capacity at 103,900 cfm utilizing a chilled water cooling coil assembly and 1.94×10^6 BTU/hr cooling capacity at 94,000 cfm utilizing a Essential Service Water (SX) cooling coil assembly. Thus the four RCFCs have the capacity to remove a total of 32×10^6 BTU/hr. (Refs. 1, 2, 4, and 5)

The RCFC subsystem, the emergency core cooling system (ECCS), and the containment spray system share in removing energy released following a postulated loss-of-coolant accident. While actuation of the emergency core cooling system takes first priority in initiation and in emergency power supply, the containment spray system takes second priority, and the RCFC system takes third priority following the initiation of the ECCS and the containment spray system. The containment spray system provides short-term cooling, while the RCFC system provides long-term cooling. (Ref. 9)

The reactor containment fan coolers provide the design heat-removal capacity for the containment following a loss-of-coolant accident, assuming that the core residual heat is released to the containment as steam. The system will accomplish this by continuously recirculating the air-steam mixture through cooling coils to transfer heat from containment to essential service water. Two redundant trains with two 50% capacity RCFC units each train is provided under a post-LOCA accident. Existing design for the four RCFC units is to provide 132 x 10^6 Btu/hr each heat-removal capability at 59,000 cfm utilizing a essential service water cooling coil assembly to maintain the containment pressure below the design value following a loss-of-coolant accident. (Refs. 9 and 10)

Control Rod Drive Mechanism (CRDM) Subsystem

The CRDM cooling system is a forced air cooling system provided for removal of heat from the CRDM magnetic coil housing during normal reactor operation. The system will maintain the temperature of the stationary and movable gripper and lift coils wiring insulation below 165°F (Max.) during normal operation.

The CRDM cooling system consists of four 50% capacity vaneaxial fans providing a reliable supply of cooling air. Only two of the four cooling fans (one train) will be in operation during normal operation and the two remaining fans are standby units that can be started manually by the control room operator. Each of the CRDM Supply Fans provide for a total heat removal of 90x10^6 BTU/hr and total air flow capacity of 37,500 cfm. (Refs. 2 and 3)

In the situation where the normal power supply is interrupted and the reactor is maintained at hot standby, the CRDM cooling system may be operable from the emergency power supply. This arrangement assures a minimum airflow to prevent economic damage to the CRDM components by limiting the maximum temperature in accordance with the rated life of the equipment. (Ref. 7)

Reactor Cavity Ventilation System

The Reactor Cavity Ventilation System provides ventilation in the reactor vessel cavity to remove thermal and gamma heat losses from the reactor vessel and thereby limit the maximum temperature of the primary shield wall to 150°F. In addition, the subsystem is designed to limit the normal maximum exhaust air temperature from the cavity and annulus areas to 124.7°F. (Refs. 3 and 7)

The Reactor Cavity Ventilation System consists of two 100% capacity fans, where each is designed to deliver 15,000 cfm. Operation of either fan draws relatively cool air (less than 100°F) from the above location and discharge is ducted to the reactor cavity where it flows into the following paths:

- through excore neutron detector cavities, then upward into the cable junction boxes, where the primary portion of airflow escapes through the sleeve space around the reactor nozzles and the balance of the airflow escapes out to the refueling cavity floor area

- or upward through the annular gap between the biological shield and the reactor vessel, where part of the flow will escape through the reactor vessel flange annulus and the balance of airflow will flow out through the sleeve space around the reactor nozzles. (Ref. 6)

The reactor cavity ventilation subsystem is not required to operate following a loss-of-coolant accident or for safe shutdown of the plant and therefore has no safety design basis. During loss of offsite electrical power, the reactor cavity ventilation subsystem will not be operable. (Ref. 6)

9.3.12.2 Input Parameters and Assumptions

The impact of power uprate on the Reactor Containment Cooling System is the increases in the amount of heat lost to the containment environment and the operating temperature of containment. The power uprate does not have an impact on the reactor cavity and control rod drive ventilation subsystems. The increase in heat load is in proportion to the increases in the operating temperature for piping and other hot fluid containing components.

The power uprate heat load is based on the following imputs:

Containment Initial Temperature	-	120°F
RCFC minimum performance	-	based on 100°F SX
RCFC maximum performance	-	based on 32°F SX
RCS Fluid temperature range	-	vessel outlet 608.0°F – 620.3°F
		vessel inlet 542.0°F – 555.7°F

Below are the inputs used for determining the RCFC capacities:

RCFC U Factor	-	4.09 ($BTU/hr/ft^2/F$) (1)
SX flowrate (tubeside flow)	-	2,650 GPM(1)

Post Accident Heat Loads - min. ECCS (2 RCFCs) 224.5 MBTU/hr @ 257°F

- max. ECCS (4 RCFCs) 686.5 MBTU/hr @ 262°F

(1) Technical specification 3.6.2.3 requires an essential service water coil flow of 2,660 GPM, however the vendor required flow 2,650 GPM is used as a conservative input.

For piping and equipment, the increase in heat load is the ratio of the ΔT between containment atmosphere and the process fluids or equipment at the current rating to the same ΔT at power uprate. The heat load from the RCPs and CRDMs is expected to increase for the power uprate, however, the existing design heat loads are based on the RCP design rating of 7000 HP and the CRDM heat load will increase about 1% due to increase in reactor coolant temperature. The increases in heat loads for NSSS equipment due to power uprate is about 1% and the differences between current and power uprate temperatures for fluids (e.g. main steam and feedwater) and equipment (i.e., reactor vessel, reactor coolant pumps, main steam and feedwater piping) in containment are minimal. In addition, increases in the heat loads for secondary system piping affect the total design basis heat load minimally due to their small contribution (<5%). A conservative 1% increase was added to existing heat loads for power uprate, which are listed below in Table 9.3.12-1.

Table 9.3.12-1
Containment Heat Losses

Source of Heat Loss	Heat Loss (Btu/hr)	1% Power Uprate Heat Loss (Btu/hr)
Heat Loss from piping	2,074,213	2,094,955
Heat Loss from valves	133,725	135,062
Heat Loss from pipe supports	1,861,431	1,879,985
Heat Loss from HVAC equipment		
- Containment Vent System	178,150	178,150(1)
- Containment Reactor Cavity System	12,725	12,725(1)
- Containment Charcoal Filter Fan	50,900	50,900(1)
- RCFC Fan System	633,603	633,603(1)
Heat Loss from electrical load	1,021,355	1,021,355(1)
Heat Loss from primary shielding	109,500	109,500(1)
Heat Loss from NSSS equipment		

Table 9.3.12-1 Containment Heat Losses		
Source of Heat Loss	**Heat Loss (Btu/hr)**	**1% Power Uprate Heat Loss (Btu/hr)**
- Reactor Vessel & Support	341,604	345,020
- Reactor Coolant Pump & Support	4,104,803	4,145,851
- Steam Generators & Support	708,892	715,981
- Pressurizer	124,300	125,543
- Control Rod Drive Mechanism	2,760,000	2,787,600
- Pressurizer Relief Tank	52,100	52,621
- Regenerative Heat Exchanger & Support	17,594	17,770
- Excess Letdown Heat Exchanger	3,430	3,464
- CRDM Exhaust Fan	374,200	374,200(1)
Heat Loss due to leakage	364,693	364,693(1)
TOTAL	**14,927,218**	**15,048,978**

(1)Not affected by power uprate

9.3.12.3 Description of Analyses

The Reactor Containment Cooling System evaluation consists of comparing the total heat load in containment due to power uprate with the total heat removal load provided by the Reactor Containment Cooling System and CRDM Coolers during normal operation. It also assures the Reactor Containment Cooling System can maintain the containment operating temperature at or below 120°F.

Temperature increases for secondary system piping (main steam, feedwater) yield increases in heat loads of approximately 1%. The slight temperature and heat load increases have been used at other nuclear stations and found to result in minimal consequences. The changes are considered conservative. As was mentioned above, increases in the heat loads for secondary system piping affect the total design basis heat load minimally due to their small contribution. For the evaluation, a 1% increase in total heat load due to power uprate was used, as listed in Table 9.3.12-1.

During a loss-of-coolant accident all four essential service water cooling coils are designed to meet the cooling requirements, therefore the min./max. RCFC performance was evaluated against the essential service water system operation during LOCA to ensure that the parameters can be meet. The power uprate heat loads containment heat loads were also evaluated against the existing design specifications to ensure that the heat load in containment can be adequately removed during LOCA accident.

9.3.12.4 Acceptance Criteria for Analyses

The acceptance criteria for the evaluation is that the Reactor Containment Cooling System has sufficient margin to manage an increase in total heat load in containment during normal operation due to the power uprate and maintain the containment bulk ambient temperature at or below 120°F.

The acceptance criteria for a LOCA accident is that the four RCFC cooling coils has sufficient margin to manage an increase in total heat load in containment due to the power uprate. The RCFC should also be capable of maintaining a maximum containment temperature at or below 271°F, which is below the Containment design temperature of 280°F.

9.3.12.5 Results

At power uprate, the total normal full power heat load in containment is expected to result in less than a 1% increase above the existing total heat load, or approximately 15.05 x 10^6 BTU/hr, which is still below the existing design heat load capacity 16 x 10^6 BTU/hr. Where two RCFC provide total heat removal and cooling, sometimes the standby unit is also operated to supplement heat removal capability during peak periods. Experience at full power has shown no distinguishable change in containment temperature when at or near full power operation.

The final maximum heat load during a LOCA accident with Minimum ECCS (with 2 of 4 RCFCs) and 100°F essential service water is listed as 224.5 x 10^6 BTU/hr when containment is at 257°F. These expected values fall below the existing design heat load limits of 264 (132 x 2) x 10^6 BTU/hr at 271°F and containment analysis value of 249.25 x 10^6 BTU/hr at 271°F. This heat load is based on 2,650 gpm of essential service is supplied to the cooling coils.

9.3.12.6 Conclusions

No changes or equipment additions are necessary for the containment cooling system to support the power uprate. The existing components can safely remove the additional heat load due to the thermal power uprate and maintain the average containment temperature ≤120°F for normal operation and below 271°F following a LOCA accident. Therefore, all reactor containment cooling system components are still bounded by existing design limits.

9.3.12.7 References

1. ComEd Byron & Braidwood Stations UFSAR Section 6.2.2.1.1, Reactor Containment Fan Cooler (RCFC) System, Rev. 7, Dec. 1998

2. ComEd Byron & Braidwood Stations UFSAR Section 9.4.8.1.2, System Description, Rev. 7, Dec. 1998

3. ComEd Byron & Braidwood Stations UFSAR Table 3.11-2, Plant Environmental Conditions, Rev. 7, Dec. 1998

4. ComEd Byron & Braidwood Stations UFSAR Section 9.4.8, Containment Ventilation System, Rev. 7, Dec. 1998

5. ComEd Byron & Braidwood Stations UFSAR Table 9.4-23, Primary Containment HVAC System Equipment Parameters, Rev. 7, Dec. 1998

6. ComEd Byron & Braidwood Stations UFSAR Section 9.4.8.4, Reactor Cavity Ventilation Subsystem, Rev. 7, Dec. 1998

7. ComEd Byron & Braidwood Stations UFSAR Section 9.4.8.3, Control Rod Drive Mechanism (CRDM) Ventilation Subsystem, Rev. 7, Dec. 1998

8. ComEd Byron & Braidwood Stations UFSAR Section 9.4.8.4.2, System Description, Rev. 7, Dec. 1998

9. ComEd Byron & Braidwood Stations UFSAR Section 6.2.2, Containment Heat Removal System, Rev. 7, Dec. 1998

10. ComEd Byron & Braidwood Stations UFSAR Table 6.2-56, Reactor Containment Fan Cooler Design Characteristics, Rev. 7, Dec. 1998

11. ComEd Byron & Braidwood Stations Technical Specification Section 3.6.6

9.3.13 Auxiliary Feed Water System

9.3.13.1 Introduction

The function of the Auxiliary Feedwater (AF) System is to provide adequate cooling water to the steam generators in the event of a loss of offsite power coupled with various occurrences as discussed below. Either of the two auxiliary feed water pumps supplying the four steam generators provides enough feed water to cool the unit down safely to the temperature at which the residual heat removal (RHR) system can be utilized. The total amount of feed water required to replace the steam vented to the atmosphere and to compensate for shrinkage during cool down is less than 200,000 gallons for four steam generators. Unit 1 requires slightly more condensate than Unit 2 due to the increased reactor coolant system (RCS) volume and metal mass of the Unit 1 steam generators (SG). However, the total volume of 200,000 gallons is adequate to cool down to RHR conditions for either unit. There are 200,000 gallons in each Safety Category II condensate storage tank (CST).

Under emergency conditions, the AFWS is supplied with water from the Safety Category I essential service water system (SX). For Byron, SX makeup is available to replenish AFWS inventory taken from the SX cooling tower basins. For Braidwood, SX makeup is the ultimate heat sink (UHS) cooling lake. Therefore, an adequate supply would be available for meeting AFWS requirements.

The AF system must be capable of functioning for extended periods, allowing time either to restore normal feed water (FW) flow or to proceed with an orderly cool down of the plant to the RCS temperature where the RHR system can assume the burden of decay heat removal. The AF flow and the emergency water supply capacity must be sufficient to remove core decay heat, reactor coolant pump heat, and sensible heat during the plant cool down.

The AF consists of two subsystems. One subsystem utilizes an electric-motor-driven pump, which is powered from one of the emergency onsite power systems supplied from a diesel generator; the other subsystem utilizes a pump that is directly powered by a diesel engine through a gear increaser. Each of the two subsystems can deliver feed water to all four steam generators. The AF has been designed to provide adequate feed water to the unfaulted steam generators in the event of a main feed water or steam line break coupled with a single active or passive failure in the AF. Demineralized water is supplied to the AF pumps from the CST. The

Byron CST contains a volume of water equal to or greater than 60 percent of its volume, and the Braidwood CST contains a volume equal to or greater than 66 percent of its volume.

The reactor plant conditions, which impose safety-related performance requirements on the design of the AF, include the following:

a. Loss of main feed water transient,

b. Secondary system pipe breaks,

c. Loss of all a-c power,

d. Loss-of-coolant accident (LOCA), and

e. Cooldown.

Analyses have been performed for the limiting transients/accidents, which define the AFWS performance requirements and the ability of the design to meet these requirements. The limiting cases include the following:

a. Loss of main feed water (loss of non-emergency a-c power)

b. Break of a main feed water pipe, and

c. Main steam pipe inside containment.

Maximum and minimum flow requirements from the above transients meet the flow requirements of plant cool down. This operation, however, defines the basis for tank size, based on the required cool down duration, maximum decay heat input, and maximum stored heat in the system.

The AF pumps are sized so that each will provide sufficient flow against the steam generator safety valve set pressure (with 3% accumulation) to prevent water relief from the pressurizer. The same criterion is met for the loss of feed water transient where a-c power is available.

For a main steam line break (MSLB), AF is not needed during the early phase of the transient, but flow to the faulted loop will contribute to an excessive release of mass and energy to containment. Thus, steam line break conditions establish the upper limit on AF flow delivered to a faulted loop.

9.3.13.2 Input Parameters and Assumptions

Post power uprate AF volume required for 4 hour cooldown to RHR:

- CST minimum volume for Unit 1 – 198,619 gallons
- CST minimum volume for Unit 2 – 197,666 gallons
- Byron SX cooling tower basin volume – 183,927 gallons

Post power uprate AFWS flow rates following MSLB:

- To faulted SG – 938 gpm
- To intact SG – 280 gpm each

9.3.13.3 Description of Analyses

The evaluation consists of comparing the post power uprate AF minimum inventory requirements for the 4 hour cool down to RHR with the existing design and TS minimum volumes. This includes both the CST's and the Byron SX cooling tower basin.

The evaluation also compares the AF flow rates required for the power uprate conditions with the existing flows to determine whether the power uprate affects the AF capability to supply feed water to the SGs following a MSLB to accomplish reactor decay heat removal.

9.3.13.4 Acceptance Criteria

The acceptance criteria for this evaluation are that the AF and CST's are capable of supporting the following:

- The CST's and the Byron SX cooling tower water basin have sufficient useable capacity according to the existing Technical Specifications and those imposed by the plant design bases to meet the post power uprate cool down requirements.

- The post accident analysis AF flow requirements to the steam generators following a LOOP and MSLB are met by the existing AF design flows.

9.3.13.5 Results

The AFWS flows used in the power uprate analyses are bounded by the existing AFWS capability (Ref. 1, Tables 10.4-6 and 10.4-8) and no additional evaluation is required.

The minimum AFWS useable volume required to support the plant design basis, namely, that the plant be maintained at hot standby for 4 hours followed by a 4 hour cool down to RHR cut-in temperature (350°F) is calculated as198,619 gallons for the power uprate case and 195,211 gallons pre-power uprate. This represents an increase of 3,408 gallons, and is based on the same assumptions as the current design basis. Both Byron and Braidwood maintain their CST's at a minimum usable volume of 200,000 gallons (Refs. 1 through 5).

The minimum AF storage volume required to support the plant design basis in case of a Loss of Offsite Power (LOOP), from the power uprate analysis for the Byron SX cooling tower basin shows an increase of about 2,551 gallons to a total of 183,927 gallons. This volume is used as an input in the UHS makeup analyses described in Section 9.3.11.

9.3.13.6 Conclusions

The existing AF, CST and Byron cooling tower SX basin volumes are capable of providing the required AF flow rates and volumes needed to support the transients at plant thermal power uprate conditions.

9.3.13.7 References

1. Byron/Braidwood UFSAR, Section 10.4.9, Auxiliary Feedwater Systems, Dec. 1998
2. Byron Technical Specifications, LCO 3.7.6, Amendment 111
3. Byron Technical Specifications, Bases 3.7.6, Amendment 111
4. Braidwood Technical Specifications, LCO 3.7.6, Amendment 104
5. Braidwood Technical Specifications, Bases 3.7.6, Amendment 104

9.3.14 Combustible Gas Control

9.3.14.1 Introduction

Following a Loss of Coolant Accident (LOCA), hydrogen gas may be generated inside the containment by reactions such as zirconium metal with water, corrosion of materials of construction, and radiolysis of aqueous solution in the core and in the sump. Hydrogen may also be released from the break in the Reactor Coolant System (RCS).

The combustible gas control system, which is used to control the buildup of hydrogen within the containment, consists of the following four subsystems:

- a hydrogen recombiner system;
- a hydrogen monitoring system;
- a mixing system; and
- a post-LOCA purge system.

The following design bases were used for the combustible gas control system design:

1. The combustible gas control system is designed to prevent the concentration of hydrogen from exceeding the lower flammable limit of 4.0% by volume. This is accomplished by either of two redundant, 100% capacity recombiners.

2. The capability to monitor combustible gas concentrations within the containment has been provided. Two systems for monitoring hydrogen concentration in the containment atmosphere are available.

3. The capability to uniformly mix the containment atmosphere and prevent high concentrations of combustible gases from forming locally was considered in the system design.

4. Capability is provided to purge the containment as a backup means for the hydrogen recombiner system.

This report describes the recombiner and the post LOCA purge systems. The impacts of the power uprate which are to be evaluated are identified below:

1. Revised post LOCA containment temperature, which affects the corrosion of metals in containment by solutions used for containment spray.

2. Revised decay heat, which affects the radiolysis of the coolant in the core as well as the radiolysis of the water in the sump.

3. The core wide oxidation (CWO) of the zirconium fuel cladding and the reactor coolant is potentially affected.

9.3.14.2 Input Parameters and Assumptions

The calculation to determine the hydrogen concentration in containment post LOCA, was revised to reflect the power uprate conditions. The revised inputs included:

1. The post LOCA containment temperature curve, for the break producing the overall maximum containment temperature.

2. The new power level, which determines the power uprate decay heat values.

3. A new CWO maximum value of 1%, used to bound any possible increase calculated by Westinghouse. This value, the percent of the fuel cladding, which reacts with the coolant to release hydrogen, has been calculated by Westinghouse as 0.82% for the prepower uprate conditions. The analysis for the power uprate condition is based on 1% maximum. (Ref. 6)

The calculation to determine the time at which the post LOCA the containment purge system should be operational if neither of the hydrogen recombiners is available was revised for the power uprate conditions. The hydrogen generation rate was calculated for the power uprate conditions to be used as input to this purge calculation.

9.3.14.3 Description of Analyses

The amounts of hydrogen produced both at the current power level and at the uprated power level were calculated according to the method described in UFSAR 6.2.5.

The existing design is able to maintain the hydrogen concentration below 4% provided a single 65 scfm recombiner is operational 20 hours post accident and run continuously thereafter. These results do not include any effect due to post LOCA purge.

The power uprate design is also able to maintain the hydrogen concentration below 4% provided a single 65 scfm recombiner is operational 20 hours post accident and run continuously thereafter. The hydrogen concentration as a function of time for thirty days post accident was calculated. These results do not include any effect due to post LOCA purge.

Additionally, for the power uprate design, a purge rate was calculated based on the hydrogen generation rate just before the hydrogen concentration in containment reaches 4% with no hydrogen recombiner operating. The hydrogen concentration as a function of time for thirty days post accident was calculated based on operating the purge system at a minimum of 100 scfm starting at 5 days post accident and run continuously thereafter. This purge system is used in the event that neither recombiner is available. The results also show that the hydrogen concentration can be maintained below 4% by operating only the post LOCA purge system.

9.3.14.4 Acceptance Criteria

The ability of either a single hydrogen recombiner or the post-LOCA purge to maintain the hydrogen concentration below 4% by volume within the containment is evaluated for the increased production of hydrogen following a LOCA at the uprated power level. The 4% is required by Regulatory Guide 1.7. (Ref. 6)

9.3.14.5 Results

A comparison of the results pre and post power uprate is provided in Table 9.3.14-1 below. As can be seen, either a single 65 scfm recombiner or the 100 scfm post LOCA purge can maintain the hydrogen concentration in the containment below 4% following a LOCA. With redundant recombiners available per technical requirements, post-LOCA purge is not required to maintain hydrogen concentration post accident.

Table 9.3.14-1 Maximum H_2 Concentration in Containment		
	Current Power[(1),(3)] 3479 MWt Case	3658.3 MWt Case[(2)]
One 65 scfm recombiner operational at 20 hours and runs continuously. No purge.	3.78% at 11.6 days	3.93% at 12.7 days
To maintain H_2 concentration under 4%, purge operational at 5 days and runs continuously. No Recombiner	Not calculated	3.96%[(4)]

(1) Current power plus 2% (3,411 MWt + 2%)

(2) Power uprate power plus 2% (3,586.6 MWt + 2%)

(3) This case based on 0.82% core wide oxidation of zirconium.

(4) Assumes purge start at 5.0 days, purge rate at 100 scfm, 1% core wide oxidation of zirconium. Note the recommended purge rate is 150 scfm.

Figure 9.3.14-1 shows the containment hydrogen concentration percent as a function of time with and without the hydrogen recombiners at the uprated power level. Figure 9.3.14-2 shows the containment hydrogen concentration percent as a function of time with and without the post LOCA purge system at the uprated power level. Figure 9.3.14-3 shows the integrated amount of hydrogen produced vs. time, distinguished by the generation means.

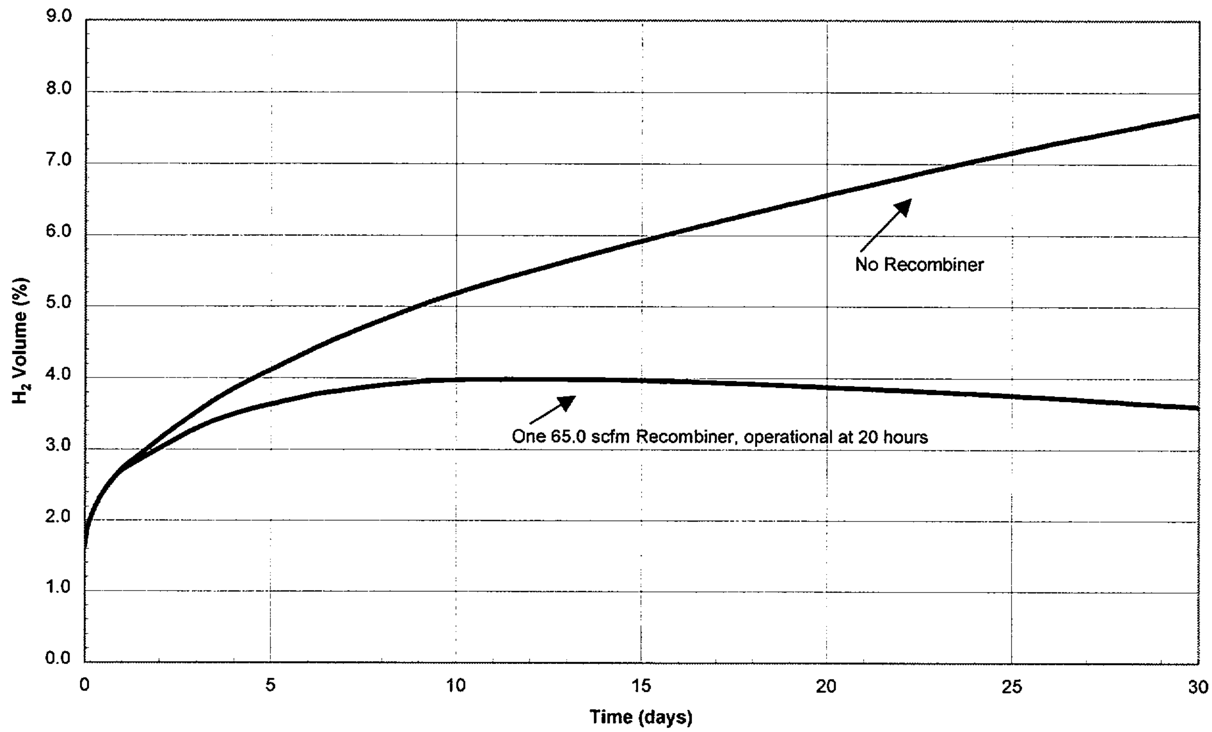

Figure 9.3.14-1

H_2 Concentration in Containment Uprate Bounding Values

1.0% Core Wide Oxidation of Zr

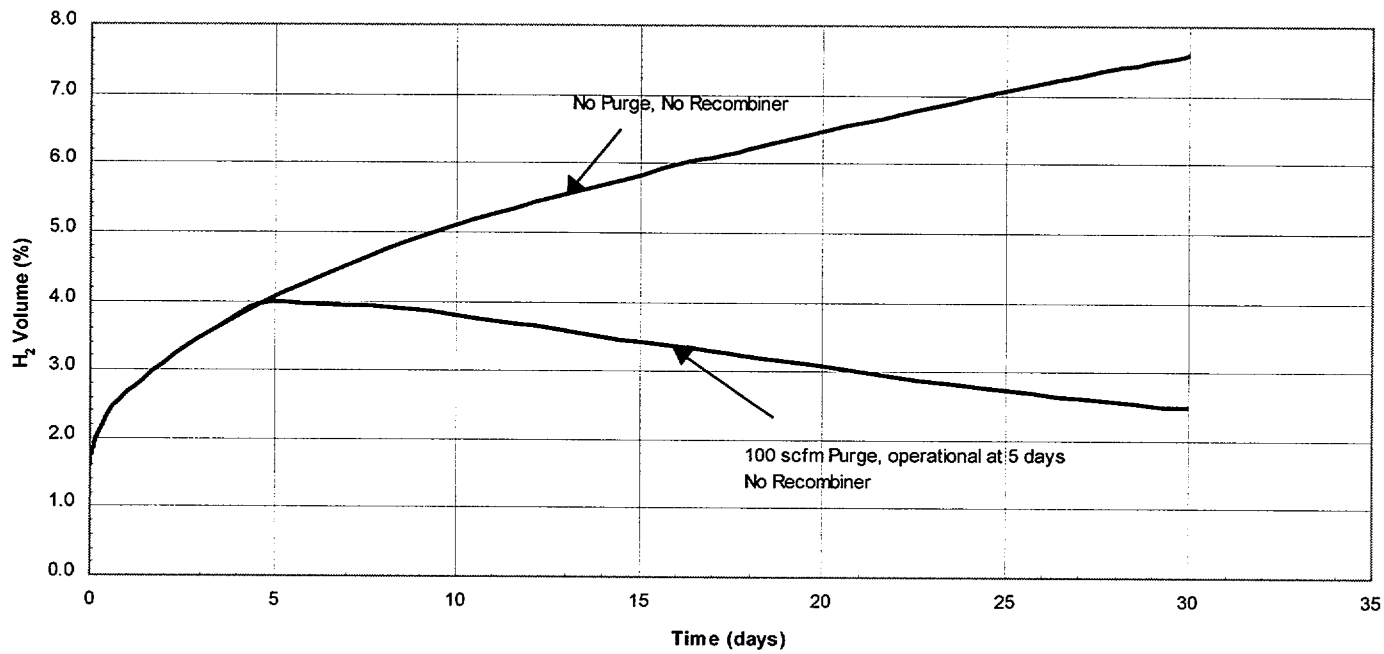

Figure 9.3.14-2

H_2 Concentration in Containment Uprate Bounding Values

1.0% Core Wide Oxidation

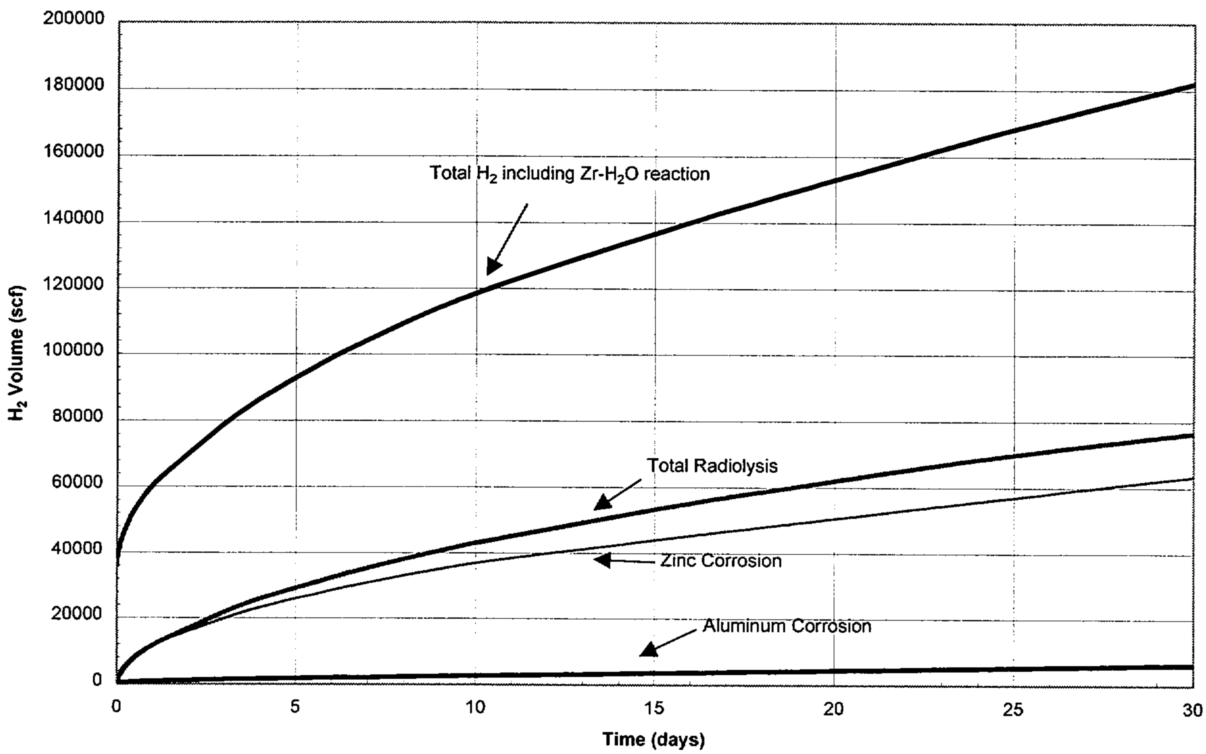

Figure 9.3.14-3

Total H_2 Generated in Containment Uprate Bounding Values

1.0% Core Wide Oxidation of Zr

9.3.14.6 Conclusions

Although the impact of the power uprate on the combustible gas control system is an increase in the maximum hydrogen concentration in containment post LOCA, the 4% limit is not exceeded. A single recombiner can maintain the concentration below the limit. The existing post-LOCA purge capability is able to maintain the containment hydrogen concentration below the maximum allowable limit of 4% by volume. The system is designed for 400 scfm and the 150 scfm recommended flow is within this design. (Ref. 1, 2)

The existing Technical Specification requirements, are met without modification. (Refs. 4 and 5)

The post-LOCA purge is not required for hydrogen control and no dose analysis is required as addressed in Section 6.7.8.1.

9.3.14.7 References

1. Byron/Braidwood UFSAR, Section 6.2.5, Combustible Gas Control in Containment, (Rev. 7), Dec. 1998

2. Byron/Braidwood UFSAR, Section 9.4.9.3, Post LOCA Purge System and Table 9.4-25, Primary Containment Purge System Equipment Parameters, (Rev. 7), Dec. 1998

3. Byron/Braidwood UFSAR, Section 15.6.5.5, Loss-of-Coolant Accident - Radiological Consequences of Containment Purging to Control Hydrogen and Table 15.6-10, Parameters Used in Analyses of Hydrogen Purging Following a LOCA, (Rev. 7), Dec. 1998

4. Byron Technical Specifications, Bases 3.6.8, Amendment 111

5. Braidwood Technical Specifications, Bases 3.6.8, Amendment 104

6. USNRC Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a Loss of Coolant Accident", (Rev. 2), Nov. 1978

9.3.15 NSSS/ECCS Support Systems

9.3.15.1 Introduction

The NSSS/ECCS Systems consists of the following:

- Reactor Coolant System (RCS)
- Chemical Volume & Control (CV) System
- Residual Heat Removal (RH) System
- Safety Injection (SI) System
- Containment Spray (CS) System

The mechanical systems that support the NSSS/ECCS Systems are the following:

- Reactor Containment Fan Cooler (RCFC) System
- Component Cooling Water (CC) System
- Essential Service Water (SX) System
- Ultimate Heat Sink (UHS) System
- Auxiliary Feedwater (AF) System, including Condensate Storage Tank (CST)

The above support systems are those systems that directly support the operation and performance of the NSSS/ECCS systems and were evaluated for impact as a result of the power uprate. The impacts of the power uprate that were evaluated are identified below:

1. Revised RCS operating temperatures resulting in increased heat loads for normal containment cooling.

2. Revised RCS/RHR systems decay heat load resulting in increased heat loads to the CC system and SX) system.

3. Increased RCS decay heat load resulting in increased inventory requirement for the CST and the UHS.

4. Revised containment analyses resulting in revised containment heat removal and RHR recirculation cooling requirements post accident.

5. Revised containment analyses resulting in revised containment sump conditions post accident for the RHR and CS pumps.

9.3.15.2 Input Parameters and Assumptions

Table 9.3.15-1
RCS Operating Temperatures

RC Temp.	Unit 1		Unit 2	
	Nominal	Range	Nominal	Range
Tavg °F	588	575 - 588	583	575 - 588
Thot °F	618	608 - 620.3	612.7	608 - 620.3
Tcold °F	558	542 – 555.7	553.7	542 – 555.7

- Power Uprate Core Power — 3,586.6 MWt
- Power Uprate NSSS Power — 3,600.6 MWt
- Containment Sump temperature, Max. — 260°F
- Post-Accident
  - Containment Water level, Min. — 8.94 Inches
- Post-Accident
  - Component Cooling Water Flow, Min. — 5,000 gpm
  - Essential Service Water Temp., Max. — 100°F

9.3.15.3 Description of Analyses

The existing design for reactor containment cooling system has the ability to maintain an average containment temperature ≤ 120°F (i.e., maximum normal operating containment temperature) utilizing two of the four Reactor Containment Fan Coolers (RCFCs). The effects of the NSSS power uprate to 3,600.6 MWt on containment results in less than a 1% increase in heat load to the containment. The RCFC capacity was evaluated to show that the existing design capacity is adequate for the increase in heat load. The evaluation of the RCFCs is contained in Section 9.3.12.

Following a Loss-of-Coolant Accident (LOCA), the existing design for each of the four RCFC units is to provide 132 x 10^6 Btu/hr of heat-removal capability utilizing an SX cooling coil assembly to maintain the containment temperature and pressure below the design values. The evaluation of the RCFCs is contained in Section 9.3.12. (Ref. 3)

The ability of the CC system to provide cooling to plant components, under both normal operating conditions and post accident, was evaluated for the increased heat loads at the power uprated power level. These increased heat loads are primarily from the FC system under all modes of operation, and from the RH system during plant cooldown, and under post accident conditions. These increased heat loads can be removed by the CC system at the current design flow rates, provided the minimum SX flow and the maximum SX supply temperature to the CC heat exchangers is maintained. The evaluation of the SX and CC systems are contained in Sections 9.3.7 and 9.3.9.

The power uprate in core power from 3,411 MWt to 3,586.6 MWt causes an increased total heat load to the UHS from increased decay heat loads. A nominal 5% core power increase will result in an increase of approximately 5% in decay heat. This decay heat will be removed by the SX system and rejected through the Ultimate Heat Sink (UHS). This results in higher heat loads from the RH Heat Exchanger via the CC system during normal cooldown as well as during sump recirculation modes following a postulated design basis accident. During post-LOCA operations the RCFCs will also experience a higher heat load as discussed above. The evaluation of the UHS is contained in Section 9.3.11.

The AF system flow and the emergency water supply capacity must be sufficient to remove core decay heat, reactor coolant pump heat, and sensible heat during the plant cooldown. The CST and the SX cooling tower water basin (for Byron) and SX cooling lake (for Braidwood) have sufficient useable capacity to meet the Hot Standby hold time and the subsequent cool-down requirements specified by the Byron and Braidwood Technical Specifications and plant design bases . The evaluation of the AF system and CST is contained in Section 9.3.13.

The power uprate does not affect operation of the RHR, CV, CS, and SI pumps during post-accident conditions. During the injection mode these pumps take suction from the Refueling Water Storage Tank (RWST) and the RWST conditions (level, temperature, and switchover setpoints) are not impacted. During the recirculation mode the RHR and CS pumps take suction from the containment sumps. The impact of the revised containment analyses on containment sump temperature and containment water level has been evaluated. The operation and NPSH of these pumps were evaluated to ensure the pump performance is not adversely impacted.

9.3.15.4 Acceptance Criteria

The Containment atmosphere temperature remains ≤ 120°F utilizing two of the four RCFCs. The existing design capacity of the RCFC remains adequate to provide containment heat removal following a design basis accident.

The CC supply temperature remains ≤ 105°F during normal operation and ≤ 120°F during shutdown and post-accident operation. The CC heat exchangers have sufficient capacity to remove the plant shutdown and post-accident heat loads based on minimum SX flow and maximum SX temperature.

The UHS temperature remains ≤ 100°F with the increased shutdown and post-accident heat loads. The UHS and SX design for temperature and inventory are not impacted.

The required useable volume of auxiliary feedwater from the CST or UHS remains below the existing Technical Specification Requirement of 200,000 gallons.

The containment sump minimum level at time of RHR pump switchover is ≥ 8.1 inches. At time of CS pump switchover the level is ≥ 8.4 inches. The available Net Positive Suction Head (NPSHa) for the RHR pumps and CS pumps remains greater that the required NPSHr of 19 ft. and 22.5 ft., respectively.

9.3.15.5 Results

The NSSS thermal power uprate to 3,600.6 MWt results in less than a 1% increase in heat loss to the containment piping and equipment. This results in a containment heat load increase from 14.9×10^6 BTU/hr to 15.05×10^6 BTU/hr. The existing design for reactor containment cooling is designed to remove 16×10^6 BTU/hr. Therefore, the increase remains within the existing design limits listed above. No changes or modifications are required and the power uprate heat load can safely be removed. Since the small increase in heat load can be safely removed the containment average temperature and pressure will be maintained within design limits. (Refer to Section 9.3.12)

The containment analyses for the power uprate utilizes the actual RCFC coil performance at a reduced a SX flow. The coil performance is based on 2,650 gpm of SX flow supplied to the cooling coils at 100 °F. Therefore, the effects of power uprate to reactor containment cooling during a LOCA accident remain bounded by existing design limits ensuring that both the heat load and containment post-accident temperature limits are satisfied. (Refer to Section 9.3.12)

The increased heat loads to the CC System are primarily from the FC System during all modes of operation, and from the RH System during plant cooldown, and under post accident conditions. These increased heat loads can be removed by the CC system at the current design flow rates, provided the minimum SX flow and the maximum SX supply temperature to the CC heat exchangers is maintained. To ensure the maximum CC supply temperature is not exceeded during post-accident operation the required SX flow to the CC heat exchanger will be increased above the minimum flow of 5,000 gpm to 9,000 gpm during the recirculation mode. The heat removal capability is based upon actual SX flows and a maximum SX supply temperature of 100°F. (Refer to Sections 9.3.7 and 9.3.9)

The Byron worst-case UHS scenarios, with the initial condition of two fans out of service and an SX cooling tower at the maximum Technical Specification temperature of 90°F demonstrate that the UHS temperature will remain below 100°F. The power uprated heat load was applied to the UHS at Braidwood assuming a proposed Technical Specification temperature limit of 100°F. This resulted in the maximum UHS inlet temperature (into the plant) below the maximum inlet temperature of 100°F. (Refer to Section 9.3.11)

The minimum CST useable volume that is required to be maintained to support the plant design basis to maintaining Hot Standby for 2 hours followed by a 4-hour cooldown to RHR cut-in temperature (350°F) is less than 200,000 gallons for the power uprate case. The power uprate analysis are based on the same assumptions for the current design basis, and also that the increase in decay heat is the most significant contribution to the increase in CST volume. The UHS power uprate analysis for the essential service water cooling tower basin make-up shows there is sufficient inventory to provide emergency source of water in the AF system. (Refer to Section 9.3.11 and 9.3.13).

The power uprate does not adversely impact the existing minimum containment sump water level or sump temperatures. The primary sources of water (RWST and RCS) are not changed as a result of the power uprate. The actual mass will differ slightly due to initial operating temperatures of the RCS, however the impact is negligible. The pump suction transfer, from injection to recirculation phase, times are not impacted by the power uprate. Differences in the RCS and RWST volumes and pump flow rates used in the existing flooding analyses with inputs used in the power uprate analyses may impact the recirculation sump levels at switchover times, however, the total water available for flooding the containment is not impacted. Based on the existing NPSH analyses, the containment sump temperature is not a factor since subcooling is not credited in the calculation of available NPSH. The calculation of the available NPSH for RHR and CS pumps with a minimum containment water level and pressure drop loss across the sump screens considering failed coating and debris resulted in NPSH margins of 5.66 ft. and 4.312 ft. respectively. Due to conservatism in the calculation of the minimum containment level, sump screen analyses considering the failed coating and debris, and the adequate pump NPSH margin at maximum flow rates, the performance of the ECCS System is not adversely impacted by the power uprate.

9.3.15.6 Conclusions

The impact of the power uprate on the systems required to support the NSSS/ECCS systems do not adversely affect the ability of NSSS/ECCS systems to support power operation at the uprated power. The capabilities of the support systems to satisfy the safety analyses acceptance criteria at the uprated power level have been evaluated and are acceptable.

9.3.15.7 References

1. UFSAR Section 6.3 "Emergency Core Cooling System," (Rev. 7), 1998

2. UFSAR Section 6.5.2 "Containment Spray System," (Rev. 7), 1998

3. UFSAR Section 6.2.2, "Containment Heat Removal System," (Rev.7), 1998

9.3.16 Instrumentation and Controls

9.3.16.1 Introduction

In the following systems, instrumentation and control valves were reviewed to determine whether any changes to the existing design would be required as a result of power uprate conditions:

- Auxiliary Feedwater
- Auxiliary Steam
- Chilled Water
- Circulating Water
- Component Cooling
- Condensate Booster
- Condensate
- Containment Spray
- Diesel Generator
- Essential Service Water
- Extraction Steam
- Feedwater Heater Drains
- Feedwater
- Heating, Ventilation, and Air Conditioning
- Main Steam (including Steam Dump)
- Non-Essential Service Water
- Off Gas
- Reactor Containment Fan Cooling
- Reactor Coolant
- Spent Fuel Cooling
- Steam Generator Blowdown
- Area and Process Radiation Monitors

9.3.16.2 Input Parameters and Assumptions

Data for the existing and power uprated design conditions was reviewed based on current P&ID's, scaling and setpoint uncertainty calculations, heat balances, PCWGs, EWCS, vendor drawings, NDITs, and the above system evaluations. The following identifies the impact to existing instruments and control valves due to the new power uprate conditions.

9.3.16.3 Description of Analysis

The above systems and components were reviewed to determine whether setpoint/scaling changes, modifications, reanalysis, and/or calculation revisions were needed as a result of the new power uprate conditions. The instrumentation and controls for the systems and equipment fall into the following six cases:

Case 1

Existing instrumentation is adequate (scalable) to accurately measure the range and normal operating point of the process variables affected by the power uprate, but the existing calibrated range does not envelop the power uprated process variable. Therefore, these instruments may need to be re-calibrated to envelop the operating range of the power uprated process variable. This could also affect the scaling of the affected instrument loop. The affected instrument setpoint and/or instrument uncertainty calculations may need to be revised.

Case 2

Existing instrumentation is not adequate to accurately measure the range and normal operating point of the process variables affected by power uprate, because the instrument can not be calibrated to envelop the revised power uprated process variable. These currently installed instruments will be replaced with components having a greater overall range. The range of the new instruments will be scaled to envelop the operating range of the power uprated process variable. This will also affect the scaling of the affected instrument loop. If an instrument, needing replacement, has a redundant instrument in another loop not needing replacement as described for this case, then the scope of the power uprate will remain limited to only replacing the instrument needing replacement. The affected instrument setpoint and/or instrument uncertainty calculations may also need to be revised.

Case 3

Existing process instrumentation is adequate (scalable) to accurately measure the range and normal operating point of the process variables affected by the power uprate, but the range and green banded operating region need to change as a result of the revised power uprate process variable operational parameters. For these process indicators, the meter and/or the meter scale will be replaced. When the indicators and/or scales are replaced, the nominal operating range, green banding, will be revised to reflect the current operating range. The affected instrument setpoint and/or instrument uncertainty calculations may also need to be revised. These instruments loops may need to be re-calibrated to envelop the operating range of the power uprated process variable.

Case 4

Existing control valves that are not adequate to control the processes affected by power uprate will be replaced or modified. In most cases only the valve trim needs to be modified or replaced and not the valve body or actuator.

Case 5

Power uprate conditions may have impacts on environmental post-accident conditions. Therefore, reviews of the instrument scaling, setpoints, and uncertainties will be required for the post-accident conditions. Affected instrument setpoint and/or instrument uncertainty calculations that exist may need to be revised.

Case 6

Power uprate conditions may have impacts on Safety Analysis Limits (SAL). Therefore, reviews of the instrument scaling, setpoints, and uncertainties will be required to determine if adequate safety margin exists under the power uprate conditions. Affected instrument setpoint and/or instrument uncertainty calculations may need to be revised.

9.3.16.4 Acceptance Criteria

Instrumentation is considered acceptable and not needing revision as a result of the power uprate conditions when:

1. Power uprate conditions are enveloped by the "as installed" calibrated range and/or scale of an instrument or

2. Power uprate conditions exceed the installed calibrated range and/or scale of an instrument, but power uprate conditions are within the adjustable calibration limits of an affected instrument.

Control valves are considered acceptable and not needing revision as a result of the power uprate conditions when their operating flows, pressures, and temperatures, at the power uprate conditions, were determined to be enveloped by existing design conditions.

9.3.16.5 Results

The following summarizes the results of the instrument and controls review at the power uprate conditions:

Main Steam Instruments

The Main Steam System flow and pressure will increase as a result of the power uprate.

- The main steam flow transmitters have sufficient range to accommodate the power uprate conditions.

- The main steam pressure transmitters have sufficient range to accommodate the power uprate conditions.

- The HP Turbine first stage impulse pressure increased on Byron Unit 1. The range of the existing Byron Unit 1 transmitters is not sufficient for the power uprate conditions and will be replaced. The HP Turbine first stage impulse pressure decreased for Byron and Braidwood Unit 2 transmitters. The existing Byron and Braidwood Unit 2 transmitters ranges are sufficient for the power uprate conditions and will be rescaled.

Feedwater Instruments

The turbine-driven feedwater pump speed control circuitry will require revision to accommodate the expected power uprate flow increase requirements. The revised speed control setpoint will result in the Feedwater Regulating Valves maintaining the proper percent open position during steady state operation.

The existing settings of the feedwater pump NPSH protection circuit require changes due to the power uprate conditions.

The Steam Generator flow transmitters at Byron and Braidwood are suitable for the power uprate conditions.

Steam Generator water level transmitters for Unit 1 will be rescaled to account for the revised process temperatures and pressures of power uprate conditions.

Non-Essential Service Water Instruments

The control valve for regulation of non-essential service water flow to the generator hydrogen coolers is suitable for the power uprate condition.

Valves

The control valves were reviewed for suitability for the power uprate conditions. There are several valves impacted by the power uprate at Byron. These Heater Drain control valves will require a change in valve trim or valve replacement. All other valves were determined to be suitable at the power uprate conditions

NSSS Control Systems Setpoints

The NSSS control systems setpoints for Byron and Braidwood Units 1 and 2 were reviewed for the power uprate conditions as addressed in Section 4.3. Modifications will be made to the reactor control coolant average temperature program to maintain the desired programmed reactor coolant temperature. In addition, the following alarms setpoints will be modified:

- Insertion limit alarms
- High auctioneered Tavg temperature alarm
- Low steamline pressure alarm

The Low Temperature Overpressure Protection (LTOP) System Setpoint Analysis is addressed in Section 4.3.3. The remaining NSSS control system setpoints remain applicable for the power uprate conditions.

Calculations

Containment high pressure Safety Analysis Limit (SAL) setpoints 1, 2, and 3 were reviewed for the power uprate conditions. The containment high pressure SAL setpoint 1 and 2 did not change. The containment high pressure SAL setpoint 3 was lowered slightly. This results in a decrease in margin between the containment high pressure SAL setpoint 3 and the trip setpoint value. However, a positive margin is still maintained. Therefore, the pressure transmitters in containment are not effected by the 5% power uprate conditions.

The Main Steamline Low Pressure calculations were reviewed for increase in temperature and changes in the Safety Analysis Limit. The results showed a decrease in total allowance and a decrease in margin. However, a positive margin is still maintained. Therefore, the Main Steamline pressure transmitters are not impacted by the power uprate.

Revised Feedwater pump speed control instrument scaling calculations will be required due to the power uprated conditions.

Calculations and setpoint/scaling change requests (SSCRs) will be preformed to support implementation of the RCS temperature (T_{hot}, T_{avg}, T_{cold}) changes for the power uprate.

Area and Process Radiation Monitors

Containment Atmosphere and gross failed fuel process radiation monitors require alarm setpoint changes. The Control Room Air Intake radiation monitor setpoint at Byron will require revision.

Plant Process Computer

The Plant Process Computers will require rescaling and/or setpoint modifications for the analog inputs relating to instrument loops, indicated above, that are changed as a result of the power uprate.

Plant Simulator

The Plant Simulators will require modifications to the simulation software and/or simulator control panel hardware for the setpoints and components, indicated above, that are changed as a result of the power uprate.

9.3.16.6 Conclusions

Based on the instrumentation and control valve review it was concluded that the Byron and Braidwood instrument and control systems and control valve equipment will accommodate the power uprate with only minor modifications and changes being required.

9.3.16.7 References

None

9.3.17 Electrical Systems

9.3.17.1 Introduction

The systems evaluation for the power uprate was reviewed for impact on the electrical systems of each station. This section contains a complete evaluation of the individual system interfaces with the plant electrical distribution system where an impact has been identified. The following systems and components have been evaluated:

- Main unit generator
- Isolated phase bus ducts
- Main power transformers (MPTs)
- Unit auxiliary transformers (UATs)
- System auxiliary transformers (SATs)
- Non-segregated phase bus ducts
- Large loads and cables
- Emergency diesel generators
- Protective relay settings
- Grid stability

The review was to determine that the electrical systems and components would operate satisfactorily, and continue to perform their intended functions under the power uprate conditions.

The following discussions apply equally to the Byron and Braidwood Stations, unless otherwise noted.

9.3.17.2 Input Parameters and Assumptions

The main unit generator, the switchyard, and the medium-voltage switchgear loads (6,900 V and 4,160 V) comprise the electrical systems and components to be evaluated for power uprate. There are no changes to the DC systems and components because of the power uprate. The review was based on Unit 1 loads (because the Unit 1 loads at each station are either identical to or bound the corresponding Unit 2 loads) as shown on the Byron Station Unit 1 and Braidwood Station Unit 1 Station One-Line Diagrams. Only components and large loads that are expected to experience a load change (Power Uprate Load) from present loading requirements are documented in this report.

The present loads on the 6900 V and 4160 V medium-voltage switchgears are listed on the Electrical Load Monitoring System (ELMS) Loading Calculations and Diesel-Generator Loading Calculations, for the plant operating conditions (startup, normal, LOCA). The Power Uprate Loads are tabulated in the new Electrical Load Lists, along with the corresponding ELMS and Diesel loads where applicable.

The Power Uprate Loads are incorporated into the ELMS load flow models for Byron and Braidwood Stations, Units 1 and 2. The program generates Special Load Flow Studies for load summaries by bus, connection loading, voltage profile, and short circuit values. The reports were used to evaluate those portions of the electrical systems and components affected by the load changes.

Transmission system grid stability analyses were used as inputs.

Existing equipment sizing calculations were reviewed for power uprate, when applicable.

9.3.17.3 Description of Analysis

The primary electrical distribution system was examined to establish the impact that the increased main unit generator power output under power uprate conditions would have on the electrical systems and components. Increased generator output (MW) means an increase in generator output power delivered to the transmission grid, and a change in required BHP/kW loading for some large auxiliary loads. It was therefore, necessary to establish that the electrical distribution system and components have the capacity to carry any increased current, and that the loads will operate satisfactorily while the transmission system grid remains stable at the power uprate conditions.

<u>Main Unit Generator</u>

The main unit generator was evaluated to ensure that the generator rating of 1361 MVA will not be exceeded and that the generator operates within the generator capability curve.

Evaluations were performed to determine the maximum generator MVAR output at the worst case/bounding conditions, such that the calculated heat load to the generator coolers does not exceed the heat load based on the generator nameplate. The adequacy and margin of the present generator coolers (hydrogen cooling equipment and stator water cooler) for operation under the power uprate conditions were evaluated.

Isolated Phase Bus Ducts

The rated capacity of the main generator isolated phase bus duct connection to the MPT and the isolated phase bus duct taps for the UATs were evaluated for capacity and margin under the power uprate conditions.

The adequacy and margin of the present isolated phase bus duct cooling equipment for operation under the power uprate conditions were evaluated.

Main Power Transformers

The existing sizing calculation for the MPT bank was reviewed to confirm that the MPTs have sufficient capacity and margin to handle the electrical power requirements under the power uprate conditions.

The adequacy of the present MPT cooling system for operation under the power uprate conditions was evaluated.

Unit Auxiliary Transformers

A review was performed to confirm that the UAT bank at each unit has sufficient capacity and margin to handle the electrical power requirements under the power uprate conditions.

The adequacy of the present UAT cooling system for operation under the power uprate conditions was evaluated.

System Auxiliary Transformers

A review was performed to confirm that the SAT bank at each unit has sufficient capacity and margin to handle the electrical power requirements under the power uprate conditions.

The adequacy of the present SAT cooling system for operation under the power uprate conditions was evaluated.

Non-segregated Phase Bus Ducts

The rated capacities of the non-segregated phase bus ducts, that connect the UATs and SATs and their respective switchgears, were compared to the anticipated load of associated switchgear under power uprate.

Large Loads and Cables

System evaluations were performed to determine the anticipated effect of the power uprate conditions on the large medium-voltage loads for the plant operation conditions (startup, normal, LOCA).

Where a load increase (BHP/kW) was identified, its impacts on the equipment performance and associated cable ampacity were evaluated. Accelerated aging and reduction in design life was also considered when the motor may be required to operate at a load exceeding its nameplate rating (i.e., the Reactor Coolant Pump under cold loop operation).

Emergency Diesel Generators

The ESF bus loading under power uprate and LOOP/LOCA was evaluated to determine if it is within the design and licensed ratings of the diesel generator, and that the diesel generator would remain capable of performing its safety-related functions during a LOOP/LOCA.

Protective Relay Settings

Station protective relay schemes and setpoints were evaluated for any impact as a direct result of power uprate.

Grid Stability

The ComEd T&D Planning department prepared dynamic and transient stability analyses for each station, to study stability issues for operation under the power uprate conditions. The criteria used are in accordance with the MAIN (Mid-American Interpool Network) Guide No. 2 as stated in the Byron/Braidwood UFSAR, Section 8.2.2. The results of these studies were used to evaluate the impact of power uprate on the transmission system grid stability under normal expected operating conditions for double line contingency events and faults. The studies were also used to determine operating limitations, and modifications were proposed to resolve the stability issues, as required to support power uprate conditions.

9.3.17.4 Acceptance Criteria

The acceptance criteria for the evaluation of the Electrical Systems under power uprate conditions are:

- The main unit generator is capable of operating satisfactorily at the anticipated power output level, with the reactive power (MVAR) limit such that the generator does not exceed its nameplate output rating (1,361 MVA) and will operate within the capability curve. Also, the generator coolers are adequate and have proper capacity to accommodate the power uprate.

- The electrical distribution system is able to accommodate power uprate requirements without exceeding equipment ratings. In particular, the isolated phase bus duct cooling equipment and MPT cooling equipment are adequate and have proper capacity for the increased power uprate duty.

- The large station auxiliary loads will continue to perform their intended functions satisfactorily.

- The emergency diesel generator loading is within the design and licensed ratings.

- The bounding steady-state voltages, motor starting voltages and short circuit values remain within acceptable limits.

- There is no impact on relay trip setpoints for loss of voltage or degraded grid voltage protection schemes due to power uprate.

- Power uprate has no negative impact on the stability of the transmission system grid.

9.3.17.5 Results

Main Unit Generator

The generator hydrogen cooling and its relationship to both the nameplate generator rating and "off nameplate" operating conditions have been evaluated. The "worst case/bounding condition" has been determined to occur in the summer months, with the unit operating at an uprated power of 1247 MW, generator voltage of 26 kV (not the rated 25 kV), and holding the generator "heat load" constant while varying the MVAR output in various increments. The maximum generator MVAR limit under this condition has been established at 530 MVAR, which results in machine operation at less than the nameplate output rating (1355 MVA). Also, the calculated heat load to the generator coolers does not exceed the heat load for the generator nameplate rating for operation under the power uprate conditions.

Isolated Phase Bus Duct

The existing isolated phase bus ducts have sufficient capacity and margin to support the output of the main unit generator at power uprated conditions. Since the design rating of the isolated phase bus duct is not exceeded, the existing cooling design is considered adequate for the power uprate.

Main Power Transformers

Calculation 4391/19-AX-1, for sizing of the MPTs, has been revised for power uprate. The conclusion indicates that the existing MPTs have sufficient capacity and margin to support the output of the main unit generator at power uprated conditions. Since power uprated output is still within the MPT rating, the existing MPT cooling design is adequate for the power uprate.

Unit Auxiliary Transformers

Evaluation of the connection loading summaries has determined that the existing UATs have sufficient capacity and margin to support operation at power uprated conditions without modification. Since power uprated output is still within the UAT rating, the existing UAT cooling design is adequate for the power uprate.

System Auxiliary Transformers

Evaluation of the connection loading has determined that the existing SATs have sufficient capacity and margin to support operation at power uprated conditions without modification. Since power uprated output is still within the SAT rating, the existing SAT cooling design is adequate for the power uprate.

Evaluation of the running voltage summaries also confirm that bus voltages are essentially unchanged at power uprate loading conditions. Accordingly, plant operation at power uprate conditions has no effect on loss of voltage or degraded grid voltage protection schemes, and motor starting scenarios.

In addition, evaluation of the short circuit summaries confirm that short circuit values are essentially unchanged at power uprate loading conditions.

Non-segregated Phase Bus

Evaluation of the switchgear bus loading summaries has determined that the existing non-segregated phase bus ducts have sufficient capacity and margin to support operation at power uprated conditions without modification.

Large Loads and Cables

System evaluations have determined that some of the large medium-voltage motors experience a BHP/kW load change (increase or decrease) at power uprated conditions. However except for the reactor coolant pump (RCP), the BHP remains within the nameplate rating of the motors. The ampacity of the motor cables remain adequate, since cable sizing is typically based on equipment nameplate ratings.

The cold loop rating of the RCP at power uprate exceeds the nameplate cold loop rating of the motor. An analysis indicates that this increase will cause the motor temperature rise to exceed the NEMA specified limit during cold loop operation, accelerate the motor aging, and reduce the design life of the motor by approximately one month. The ampacity of the RCP motor cables remains adequate.

Emergency Diesel Generators

System evaluations have determined that some of the large safety-related medium-voltage motors experience a BHP/kW load decrease at power uprated conditions. The present diesel generator loading analysis bounds the power uprate diesel generator loading. Therefore, the diesel generators will remain capable of performing their safety-related functions during a LOOP/LOCA.

Protective Relay Settings

The existing station protective schemes and setpoints are not affected by operation under the power uprate conditions. This is because the data upon which protective relay settings are typically based (equipment nameplate ratings, motor and cable thermal data, and short circuit studies) are essentially not affected by power uprate conditions.

Grid Stability

Byron Station: The ComEd T&D Planning department has completed dynamic and transient stability analyses for Byron Units 1 and 2. The power uprate condition has identified new modifications (including unit trip schemes, reduction of the existing local breaker back up timer settings, and installation of a power system stabilizer (PSS) on Byron Unit 2) required to maintain stability in the transmission system grid.

Braidwood Station: The ComEd T&D Planning department has completed dynamic and transient stability analyses for Braidwood Units 1 and 2. The power uprate condition has identified a reduction of the existing local breaker backup timer settings required to maintain stability in the transmission system grid.

9.3.17.6 Conclusions

The main unit generator is capable of providing the additional power within its nameplate rating without any modifications to the present generator cooling systems.

The electrical distribution system will be able to accommodate the power uprate requirements without exceeding equipment ratings.

The large station auxiliary loads will continue to satisfactorily perform their intended functions.

The emergency diesel generator will not be impacted by power uprate.

The bounding steady-state voltages, motor starting voltages and short circuit values remain within acceptable limits.

There is no impact on relay trip setpoints for loss of voltage or degraded grid voltage protection schemes due to power uprate.

Modifications are proposed and will be implemented prior to power uprate to maintain the Byron and Braidwood transmission system grid stability. Modifications for Byron Station include revising the unit trip schemes and installation of a PSS on Byron Unit 2, with reduction of the existing LBB timer settings. Braidwood Station includes a reduction of the existing LBB timer settings.

9.3.17.7 References

None

9.3.18 Heating, Ventilation, and Air Conditioning System

9.3.18.1 Introduction

The power uprate in NSSS power from 3,425 MWt and 3,600.6 MWt at Byron and Braidwood Units 1 and 2 will result in demonstrable increase heat loss to environment that house, main steam, generator blowdown, and feedwater piping. Other heat loss may experience a slight increase.

The following Heating, Ventilation, and Air Conditioning (HVAC) Systems were evaluated to ensure that sufficient margin and capability exist to operate satisfactorily to support the plant thermal power uprate to 3,600.6 MWt:

- Control Room HVAC system
- Spent Fuel Pool Area Ventilation system
- Auxiliary Building and Radwaste Area Ventilation systems
- Turbine Area Ventilation system
- Engineered Safety Features Ventilation systems

- Pump House Ventilation systems
- Off-gas and Miscellaneous Tank Vent Filter system
- Containment Ventilation system
- Primary Containment Purge system
- Miscellaneous HVAC system

The subject HVAC systems cool, heat, ventilate, and 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 both units operating at 100% power during weather conditions that result in maximum supply temperatures for the heating, ventilation, and air conditioning system.

9.3.18.2 Input Parameters and Assumptions

The impact of power uprate on the HVAC systems listed above is the increase in the amount of component heat lost to the environment. This increase is in proportion to the new electrical load for motors and other equipment (i.e. electrical/control panels, cables, etc.) and/or increases in the operating temperature of piping and other hot fluid containing components.

For piping and equipment, the increase in heat load is the ratio of the temperature differential between the environment and the process fluids or equipment at the current rating to the same temperature differential at power uprate.

9.3.18.3 Description of Analysis

The HVAC evaluation consisted of determining the impact of the 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.

The electrical load increase at power uprate conditions for electrical equipment does not impact the HVAC 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.

In addition, no new cables, electrical/control panels, or motors have been identified as a result of the plant thermal power uprate.

Consequently, the following HVAC systems serve areas containing electrical equipment and are not impacted by the plant thermal power uprate to 3,600.6 MWt:

- Control Room HVAC system
- Radwaste & Remote Shutdown Control Room HVAC system (part of Auxiliary and Radwaste Area Ventilation System)
- Diesel Generator Room Ventilation system
- Miscellaneous Electrical Equipment Room Ventilation system (part of ESF Ventilation System)
- Switchgear Heat Removal system (part of ESF Ventilation System)
- Control Room Offices HVAC system (Part of Misc. HVAC System)

Similarly, the power uprate will not increase the operating temperature of piping and other hot fluid containing components, or necessitate the addition of new equipment, in the areas served by the Radwaste Building and Laboratory Ventilation Systems (part of Auxiliary and Radwaste Area Ventilation System). Therefore, these systems are not impacted by the power uprate to 3600.6 MWt.

For the Spent Fuel Pool Area Ventilation System, the power uprate does not impact the system ventilation equipment capability in providing the minimum number of air changes per hour required to maintain the negative pressure with respect to atmosphere.

The Auxiliary Building HVAC System (part of ESF ventilation) utilizes cubicle coolers, cooled with the Essential Service (SX) Water System, for supplemental cooling, for the equipment identified above. It has been shown in that with SX system water greater than 100°F the cubicle coolers will be capable of maintaining the respective rooms below the design temperature limits provided the coolers are maintained in a satisfactory manner.

The turbine building ventilation systems are non-safety-related. Information was found to determine that fans in the turbine building ventilation system have satisfactorily met their design flowrate requirements. The turbine building ventilation system is not affected by power uprate, since the incremental expected increase in heat loss to the turbine building will be small in comparison to the total existing heat loss. The condensate booster pump motor at Braidwood has been identified as problem area in that the condensate pumps motor has elevated temperatures in the motor winding area. However, it is not significantly impacted by the power uprate.

The diesel generator rooms ventilation system is unaffected by power uprate because only non-safety-related loads are impacted and none of the affected loads have access to the diesel-backed 4,160 v buses.

The pump house ventilation systems are unaffected by power uprate because none of the equipment in the pump houses are affected by power uprate.

The Off-gas and Miscellaneous Tank Vent Filter System is unaffected by power uprate. The Off-gas portion is designed to filter potential radioactive particulate and iodine from the exhaust gases of priming and hogging vacuum pumps air separator tanks, steam jet air ejector, and gland steam condensers. None of these components are affected by power uprate. The Miscellaneous Tank Vent Filter portion is designed to filter potential radioactive particulate and iodine from the vent gases from various tanks, filters, process units, pumps and heat exchangers from the auxiliary building. None of these components are affected by the power uprate.

The Containment Ventilation System is unaffected by the power uprate, except for the increase in heat load to the entrainment which is addressed in Section 9.3.12.

The Primary Containment Purge System consists of the three subsystems as follows: miniflow purge, normal purge, and post-LOCA purge. The miniflow portion is required during normal operation to purge containment to keep maintenance personnel exposures to ALARA levels. The normal purge only functions during planned reactor shutdowns. The post-LOCA purge is designed as a backup to the hydrogen recombiners for purging the containment atmosphere to reduce the hydrogen buildup. None of the Containment Purge System is required for temperature control and therefore is not affected by power uprate.

The Main Steam Pipe Tunnel & Safety Valve Enclosure Areas are unaffected by power uprate. The piping systems that are routed through this area are main steam, steam generator blowdown, and feedwater systems. The temperature of 550°F for the main steam and blowdown systems power uprate conditions, changed from the current temperature of 544°F. The thermal analyses for these systems each utilizes a fluid temperature of 560°F for main steam and 567°F for blowdown; and therefore, power uprate changes will not increase the design temperatures for main steam or for blowdown.

At power uprate, the normal operating feedwater temperature is 446°F. This is a change from the current temperature of 440°F. Power uprate changes will not increase the design temperature of 567F° for feedwater. These changes, therefore will not impact the area temperatures from the power uprate conditions.

The tendon access tunnel ventilation and the fuel handling building train shed ventilation systems are both non-safety-related and are unaffected by power uprate.

9.3.18.4 Acceptance Criteria for Analyses/Evaluation

The acceptance criteria for the HVAC evaluation is that power uprate does not impact the subject systems' ability to maintain the operating environment temperature at or below the respective maximum normal operating temperature.

9.3.18.5 Results

The Main Steam Pipe Tunnel & Safety Valve Enclosure Areas Ventilation Systems (part of Misc. HVAC System) are unaffected by power uprate. The piping systems that are routed through this area are main steam, steam generator blowdown, and feedwater systems. The maximum temperature 550°F for the main steam and blowdown systems power uprate changed negligibly with power uprate compared to the current temperature of 544°F. The thermal analyses for these systems each utilizes a fluid temperature of 560°F, and the power uprate changes will not increase the design temperatures for the main steam or blowdown systems. Since the fluid temperatures after the power uprate will be less than the design basis temperature, there is margin in the system design in managing the heat loss at power uprate. Consequently, additional system design margin is obtained.

At power uprate condition, the normal operating feedwater temperature will be 446°F. This is a negligible increase from the current temperature of 440°F. Power uprate changes will not increase the design temperature of 567°F for feedwater. These changes will not impact the area temperatures from the power uprate conditions.

9.3.18.6 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 3,600.6 MWt.

9.3.18.7 References

1. UFSAR Section 9.4, "Air Conditioning, Heating, Cooling, and Ventilation Systems, " (Rev. 7), December 1998

2. UFSAR Section 6.5.1, "Engineered Safety Feature (ESF) Systems," (Rev. 7), December 1998

9.3.19 Miscellaneous Systems

9.3.19.1 Introduction

A review of Byron & Braidwood Units 1 and 2 Miscellaneous Systems was performed to determine the impact of power uprate. Systems reviewed were Auxiliary Steam, Condenser Off Gas, Emergency Diesel Generator, Boric Acid Processing, and Chilled Water.

<u>Auxiliary Steam System</u>

Each unit has a separate non-safety related Auxiliary Steam (AS) System. The AS system supplies 50 psig steam for various systems/components including the following major systems/components:

- Turbine Gland Sealing System (during plant startup/shutdown)
- Station Heating System heat exchangers
- Radioactive Waste and Boric Acid Processing

During normal plant operation, steam is supplied by the Extraction Steam system. During plant shutdown and plant operating loads below approximately 40%, steam is supplied by the Auxiliary Boilers.

Condenser Off Gas System

Each Byron and Braidwood unit has a separate non-safety related Condenser Off Gas System. The OG system removes non-condensable gases to help maintain condenser vacuum. The OG system consists of steam air ejectors and mechanical hogging vacuum pumps.

Each condenser is equipped with four 100% two-stage steam jet air ejectors with inter- and after-condensers that utilize condensate for condensing entrained vapor. Two high capacity mechanical vacuum pumps are also available for plant startup and to assist the steam units if necessary.

Emergency Diesel Generator System

In the event of a complete loss of offsite electrical power, the safety related Emergency Diesel Generator (DG) system provides power for electrical loads required for reactor shutdown, which may include loads required to minimize the effects of a design basis Loss of Coolant Accident (LOCA).

Each unit contains two diesel-generators. Each diesel-generator consists of a diesel engine, an electrical generator, and support systems (fuel oil storage and transfer system, cooling water system, starting system, lubrication system, and combustion air intake and exhaust system). Each diesel-generator is capable of supplying one train of its units' engineered safety features (ESF) and emergency shutdown loads.

Additionally, in the event of a station blackout, the DG system of the unaffected unit serves as an alternate power source for safe shutdown of the affected unit.

Boric Acid Processing System

In conjunction with the Boric Acid Processing (AB) System, the boron recycle system receives and recycles reactor coolant effluent for reuse of the boric acid and makeup water. The system decontaminates the effluent by means of demineralization and gas stripping, and uses evaporation to separate and recover the boric acid and makeup water.

The recycle evaporators are components in this system, and are no longer used for boric acid recovery. At Byron, the nonessential service water supply to parts of the recycle evaporator skid has been abandoned permanently.

Chilled Water Systems

A. Containment Chilled Water Systems

The Containment Chilled Water System provides chilled water to the Byron and Braidwood Units 1 and 2 Reactor Containment Fan Cooler (RCFC) chilled water coils, during normal plant operating conditions. A separate chilled water system is provided for each containment. The system is designed to provide an adequate quantity of chilled water to the RCFC units at a temperature of 42°F from the refrigeration unit with a ΔT of approximately 8°F across the refrigeration unit. The system cooling capacity is based on heat losses from piping and valves, equipment, reactor pressure vessel, and inadvertent steam leakage.

Each of the Unit 1 and 2 containment chilled water systems consist of two, 100%-capacity chilled water circuits, each comprised of one chilled water pump, one centrifugal refrigeration unit, chilled water coils located in the reactor containment fan coolers, and associated piping and instrumentation. The containment chilled water system works in conjunction with the primary containment ventilation system to meet the cooling requirements inside the containment.

B. Service Building Chilled Water Systems

The Service Building Chilled Water System is designed to provide sufficient quantity of chilled water to cool the supply air for the areas served by the service building HVAC system, laboratory HVAC system, control room offices HVAC system, turbine building future offices HVAC system, and secondary sample room HVAC system.

Each service building chilled water system consists of one chilled water compressor tank and air separator and two 100%-capacity chilled water circuits each comprised of one primary chilled water pump, one booster pump, and one centrifugal refrigeration unit. The system cooling capacity is based on cooling the supply air to each air handling unit in the systems listed in the previous paragraph.

C. Auxiliary Building Chilled Water Systems

The Auxiliary Building Chilled Water System is designed to provide an adequate quantity of chilled water to the auxiliary building HVAC system chilled water coils at a temperature of 55°F from the refrigeration unit with a ΔT of 16°F across the refrigeration unit.

Each Auxiliary Building Chilled Water System consists of a compression tank, air separator, two (Byron) and three (Braidwood) 50%-capacity chilled water circuits; each comprised of one chilled water pump and one centrifugal refrigeration unit. These circuits serve two chilled water coils banks of the auxiliary building HVAC system. The system capacity is based on cooling the auxiliary building HVAC system supply air (100% outside air) from 95°F to 70°F.

D. Control Room Chilled Water Systems

The Control Room Chilled Water System is designed to provide an adequate quantity of chilled water to the control room HVAC system chilled water coils at a temperature of 42°F from the refrigeration unit with a ΔT of 10°F across the refrigeration unit.

Each control room chilled water system consists of two 100%-capacity independent subsystems. Each subsystem consists of a chilled water pump, one refrigeration unit, chilled water coils, one air separator, one chilled water compressor tank and associated piping, valves, and instrumentation.

9.3.19.2 Input Parameters and Assumptions

Siemens-Westinghouse heat balances, WB-7329, WB-7342, and WB-7347 were used as input in the AS, OG, and DG system evaluations. (Refs. 1, 2, 3)

It is assumed that the Byron/Braidwood Unit 1 and Unit 2 AS, OG, DG, AB and CW systems are identical.

Evaluations have been performed on the applicable plant chilled water systems to define the amount of chilled water flow required for all refrigeration coils to maintain associated cooling capacities. The cooling capacity needs are based on the applicable calculated room heat loads. The preceding discussion is based on the following assumptions and are consistent with the Byron and Braidwood UFSAR:

Containment Chilled Water System:

1. Containment chilled water refrigeration unit (2) capacity – 12.54 x 10^6 Btu/hr each

2. Containment chilled water pump (2) capacity – 3,000 gpm each

Service Building Chilled Water System:

1. Service building chilled water refrigeration unit (2) capacity – 5.46 x 10^6 Btu/hr each

2. Service building chilled water pump (2) capacity – 1,380 gpm each

Auxiliary Building Chilled Water System:

1. Auxiliary building chilled water refrigeration unit (2 Byron / 3 Braidwood) capacity – 2.76 x 10^6 Btu/hr each

2. Auxiliary building chilled water pumps (2 Byron / 3 Braidwood) capacity – 900 gpm each

Control Room Chilled Water System:

1. Control room chilled water refrigeration unit (2) capacity – 2.76 x 10^6 Btu/hr each

2. Control room chilled water pump (2) capacity – 555 gpm each

9.3.19.3 Description of Analysis

Auxiliary Steam System

The analysis compared current conditions with power uprate conditions with respect to the AS system design operating parameters (i.e., flow pressures and temperatures requirements, etc.)

Condenser Off Gas System

The analysis compared current conditions with power uprate conditions with respect to condenser backpressure, steam jet air ejector capacity, vacuum pump removal capacity, and design pressure and temperature requirements for the vacuum removal equipment.

Emergency Diesel Generators System

The DG system capability is evaluated in terms of the effect of power uprate on the loading on the diesel generators during a loss of offsite power event coincident with a LOCA.

Boric Acid Processing System/Boron Recycle System

The basis of this analysis is provided in Section 4.1.7.

Chilled Water Systems

The study consisted of evaluating the impact that the power uprate will have on the plant chilled water systems cooling capacities. All room heat loads were evaluated and only the containment will be impacted by the power uprate. Therefore, an evaluation was performed on this system only. All related cooling requirement calculations were reviewed to determine if the power uprate would require additional chilled water. As described in Section 9.3.12, the current design basis for the containment cooling system is 16.0 x 10^6 BTU/hr.

9.3.19.4 Acceptance Criteria

The AS, OG, and AB systems are considered acceptable under power uprate conditions if the power uprate requirements are bounded by the system design.

This DG system is considered acceptable at power uprate if the diesel-generators have adequate capacity to provide power to the loads on the 4,160V ESF buses during a loss of offsite power event coincident with a LOCA at power uprate conditions.

The acceptance criterion for the plant chilled water evaluation is that an adequate amount of chilled water is supplied to all refrigeration units to maintain areas at current design temperatures.

9.3.19.5 Results

The AS supply pressure and flow requirements remain unchanged for power uprate.

The steam jet air ejectors exceed the minimum capacities recommended by the Heat Exchanger Institute "Standards for Steam Surface Condensers" for both the current and power uprate conditions. As a result of power uprate condenser duty will increase approximately 5% which in turn will result in slightly higher backpressure (less than a 0.3 in. Hg. increase). This increase in backpressure is negligible and will not affect operation or performance of the OG system.

The design ESF and emergency shutdown loads listed in the current diesel-generator loading calculations bound the loads at power uprate conditions. DG system operation and fuel oil consumption will not change with power uprate. Additionally, operation of systems supporting DG system operation (i.e., 125V dc Power, Diesel-Generator Facilities Ventilation, Essential Service Water) will not change with power uprate.

The temperature of the letdown fluid diverted to the AB system during load changes or boron concentration changes is not affected by the uprating since the diverted letdown occurs downstream of the letdown heat exchanger. The volume of letdown diverted is dependent upon the magnitude and frequency of boron concentration changes in the RC system. These are a function of plant operations, not plant power levels. Power uprate has no effect on the AB system.

Relative to chilled water systems, at power uprate conditions, the total heat load in the containment is expected to result in less than a 1% increase above the existing total containment heat load from normal operation, or approximately 15.05×10^6 BTU/hr. This is below the design heat load capacity of 16×10^6 BTU/hr. Because the total heat load for containment is below the design basis no further evaluation is required on the containment chilled water system. The remaining plant chilled water systems are not impacted by power uprate. Therefore, the systems are bounded by their current design basis and no further evaluation is required. (Ref. 5)

9.3.19.6 Conclusions

The AS, OG, DG, and AB systems are considered acceptable at power uprate conditions. No equipment changes are required.

The only plant chilled water system impacted by the power uprate is the containment chilled water system. The impact results in less than a 1% increase above the existing heat load but still meets the current design basis. Therefore, the impact is negligible and no modifications to existing system components are required. The remaining chilled water systems are not impacted by the power uprate and are bounded by the existing design basis.

9.3.19.7 References

1. Siemens-Westinghouse Heat Balance WB-7329, dated 4/22/99 (Revised Baseline conditions, applicable to Units 1 and 2)

2. Siemens-Westinghouse Heat Balance WB-7342, dated 5/13/99 (Power Uprate conditions, applicable to Units 1)

3. Siemens-Westinghouse Heat Balance WB-7347, dated May 18, 1999 (Power Uprate conditions, applicable to Units 2)

4. Byron/Braidwood UFSAR Table 9.3-7, Plant Chilled Water System Equipment Parameters, Rev. 7, Dec. 1998

5. Byron/Braidwood UFSAR Table 9.4-23, Primary Containment HVAC System Equipment Parameters, Rev. 7, Dec. 1998

9.3.20 Piping and Supports

9.3.20.1 Introduction

The purpose of the piping and support review is to evaluate balance of plant (BOP) piping systems for the effects resulting from thermal power uprated conditions to demonstrate design basis compliance. Operation at the thermal power uprated conditions may increase piping stresses caused by slightly higher operating temperatures, pressures and flow rates.

Additionally, BOP pipe supports and equipment nozzles may be potentially subjected to slightly increased loadings due to the thermal power uprate condition.

The specific piping systems evaluated for thermal power uprated conditions are as follows:

Safety Related Piping Systems

- Auxiliary Feedwater
- Chemical and Volume Control
- Component Cooling Water
- Containment Spray
- Essential Service Water
- Feedwater
- Fuel Pool Cooling
- Main Steam
- Residual Heat Removal
- Reactor Coolant
- Reactor Coolant Sampling
- Safety Injection
- Steam Generator Blowdown
- Non-Safety Related Piping Systems
- Auxiliary Steam
- Chilled Water
- Circulating Water
- Condensate
- Condensate Booster
- Condenser Off Gas
- Extraction Steam
- Heater Drains
- Non-Essential Service Water

9.3.20.2 Input Parameters and Assumptions

Design input data (i.e., pre-power uprate and thermal power uprate temperatures, pressures, and flowrates conditions as applicable) for each safety-related and non safety-related system affected by the thermal power uprate was obtained and evaluated to document piping system acceptability for thermal power uprate conditions. Existing pipe stress calculations and new or revised systems power uprate calculations were used for evaluation of piping systems under uprate conditions.

9.3.20.3 Description of Analysis/Acceptance Criteria

The piping system evaluations for the thermal power uprated conditions were performed as follows:

1. Pre-power uprate and thermal power uprate system operating data (i.e., operating temperature, pressure, etc.) were obtained.

    a. For piping which experiences no temperature increase or less than a 10°F increase, the thermal "change factor" was based on the ratio of the thermal power uprate to pre-thermal power uprate operating temperature. That is, thermal change factor is $(T_{uprate}\text{-}70°F)/(T_{pre\text{-}uprate}\ \text{-}70°F)$. Using this method for the thermal change factor determinations resulted in a reasonable approximation of the thermal impact on piping stresses and loads subjected to relatively small temperature increases. The calculated change factors are virtually identical to those determined using the applicable mean coefficients of expansion, due to the 10°F temperature increase limit.

    b. For piping which experiences a 10°F or larger temperature increase, the thermal "change factor" was based on using ratios determined by considering the mean coefficients of expansion for the thermal power uprate and pre-power uprate operating temperatures. That is, thermal change factor is $(\alpha_{\ uprate})(T_{uprate}\text{-}70°F)/(\alpha_{\ pre\text{-}uprate})(T_{\ pre\text{-}uprate}\text{-}70°F)$. This method resulted in a reasonable approximation of the thermal impact on piping stresses and loads subjected to temperature increases of 10°F and larger.

c. The pressure "change factor" was determined by ($P_{uprate}/P_{pre-uprate}$) ratio.

2. For the Main Steam and Feedwater piping systems which experience only higher fluid flow rates for thermal power uprate conditions, a flowrate assessment was performed in their respective piping system evaluations.

9.3.20.4 Acceptance Criteria

Based on the thermal and pressure change factors determined from above, the following engineering activities were performed or conclusions reached:

- For thermal or pressure change factors less than or equal to 1.0 (that is, the pre-thermal power uprate condition envelops or equals the thermal power uprate condition), no further review was required and the piping system was concluded to be acceptable for the thermal power uprated conditions.

- For thermal or pressure change factors of 1.0 through 1.05 (that is, a one to five percent increase in thermal expansion and/or pressure stress effects), this minor increase was concluded to be acceptable by engineering judgement since these increases are offset by conservatisms in analytical methods used to calculate the existing thermal stresses and loads. Conservatism includes the enveloping of multiple thermal operating conditions and not considering pipe support gaps in the thermal analyses. Pressure effects are always considered in conjunction with other loading conditions (e.g., weight, seismic) thus the overall effect of the pressure change factor is reduced.

- For thermal or pressure change factors of 1.05 or greater, additional evaluations were performed to address the specific increase in pressure, flow and/or temperature in order to document design basis compliance. The evaluations included reviews of pipe stress levels, pipe support loads and equipment nozzle loads, as required.

- Main Steam and Feedwater fluid flow rates effects from these flow increases are considered in conjunction with other loading conditions (e.g., weight, seismic) thus the overall effect of the fluid flow rates change factor is reduced.

9.3.20.5 Results

The results of the piping systems reviews for the safety and non-safety-related systems are summarized as follows:

- All piping systems affected by the thermal power uprate were determined to have **a thermal "change factor"** of 1.05 or smaller. Based on the acceptance criteria described in Section 9.3.20.3, the piping systems were concluded to be acceptable.

- All piping systems affected by the thermal power uprate were determined to **have a pressure "change factor"** of 1.05 or smaller. Based on the acceptance criteria described in Section 9.3.20.3, the piping systems were concluded to be acceptable.

- The main steam and feedwater piping systems were determined to have flowrates "change factors" greater than 1.05. Additional assessments were performed in their respective piping system evaluations and were concluded to be acceptable.

9.3.20.6 Conclusions

The piping systems review concluded that all piping systems remain acceptable and will continue to satisfy design basis requirements in accordance with ASME Section III 1974 Edition up to Summer 1975 Addenda and ANSI B31.1 1973 Edition, as applicable, when considering the temperature, pressure, and flow rate effects resulting from the thermal power uprate conditions. The evaluations also document that no piping or pipe support modifications are required as a result of the increased power level.

9.3.20.7 References

None

9.3.21 Equipment Qualification

9.3.21.1 Introduction

The power uprate will result in revised containment pressure and temperature profiles for the Loss of Coolant (LOCA) and Main Steam Line Break events. The outside containment MSLB event will also result in revised temperature profile for the main steam piping tunnels and associated valve enclosures.

9.3.21.2 Input Parameters and Assumption

The design basis for Equipment Qualification (EQ) at the Byron and Braidwood Stations is provided in Design Basis Document (DBD) PMED-EQ-DVD-00. These documents provide the associated environmental conditions envelopes for which the EQ equipment is qualified to.

Containment temperature/pressure response to LOCA and MSLB events are provided in Sections 6.4.3 and 6.5.4.

9.3.21.3 Description of Analysis

The electrical equipment within the scope of 10CFR50.49 was evaluated to assure qualification for the normal and accident conditions expected in the area where the devices are locaed. Applicable conservatisms in accordance with IEEE 323 were applied to the environmental parameters as required.

The Containment revised temperature/pressure profiles were compared to the existing bounding profiles as shown in Figure 9.3.21-1 and to determine that existing profiles remain bounding.

9.3.21.4 Acceptance Criteria

The electrical equipment located inside and outside the containment which performs a safety-related function must remain qualified for the accident temperature, pressure, and humidity environments at the uprate power conditions.

9.3.21.5 Results

There is a slight increase above the current profile temperature curve, however it remains below the peak temperature and is considered bounded by the existing qualification. The revised outside containment temperature profiles (Section 6.4.3 and 6.5.4) show that the peak temperature (413.5°F) prior to Main Steam isolation exceeds the current maximum of 373°F but remain below the temperature of 419°F previously used to demonstrate qualification.

The peak long term temperature used for evaluation of post accident monitoring equipment outside containment in the Steam tunnels and valve rooms exceeded the current peak temperature of 515.25°F by 3°F.

The Radiological EQ impact is addressed in Section 9.4.

The final results for the MSLB outside containment are provided in Section 6.5 and summarized as follows:

Tables 6.5.5-4 through 6.5.5-7 show the compartment peak temperature results for Byron/Braidwood Units 1. The peak temperature prior to steamline isolation (SLI) is seem to be 396.0°F from Case 70-C with a MSIV failure (which is a 0.3 ft^2 break case) and the overall peak compartment temperature is 518.4°F from Case 102-L with a MSIV failure (which is a 1.2 ft^2 break case).

Tables 6.5.5-8 through 6.5.5-11 show the compartment peak temperature results for Byron/Braidwood Units 2. Case 70-D with a MSIV failure (which is a 0.4 ft^2 break case) yields the peak temperature prior to streamline isolation of 413.5°F. The overall peak compartment temperature was 502.5°F for Case 102-M with a MSIV failure (which is a 1.4 ft^2 break case).

9.3.21.6 Conclusions

The revised LOCA/MSLB containment temperature/pressure profiles compared to the bounding EQ profile are shown on Figure 9.3.21-1 and -2.

The revised containment temperature/pressure profiles remain bounded by the existing EQ profile and except as noted in above; however, there is no impact on the equipment qualification as a result of the power uprate.

The safety evaluation (BRW-SE-1997-201/6G-97-0105) supporting UFSAR DRP 7-040 states that "Qualification of the safe shutdown equipment is not a concern since the revised safe shutdown temperature is less than the previous temperature of 419°F used to demonstrate qualification." "The revised analysis also determined that the peak temperature was reduced to 515.25°F (515°F). Although lower than previously determined, the qualification acceptability of the Regulatory Guide 1.97 equipment affected by the MSLB revised peak temperature is summarized in the attached evaluation."

The above results increased the peak temperature for safe shutdown to 413.5°F, but remains less than the 419°F previously evaluated. The peak long term temperature increased to 518.4°F; however, the same evaluation performed at 515°F demonstrates that the increased temperature of 518.4°F is also acceptable. Therefore, the uprate will not impact qualification of affected equipment; however, revisions to the UFSAR, DBD, and the existing safety evaluation are being performed to support uprate implementation.

9.3.21.7 References

None

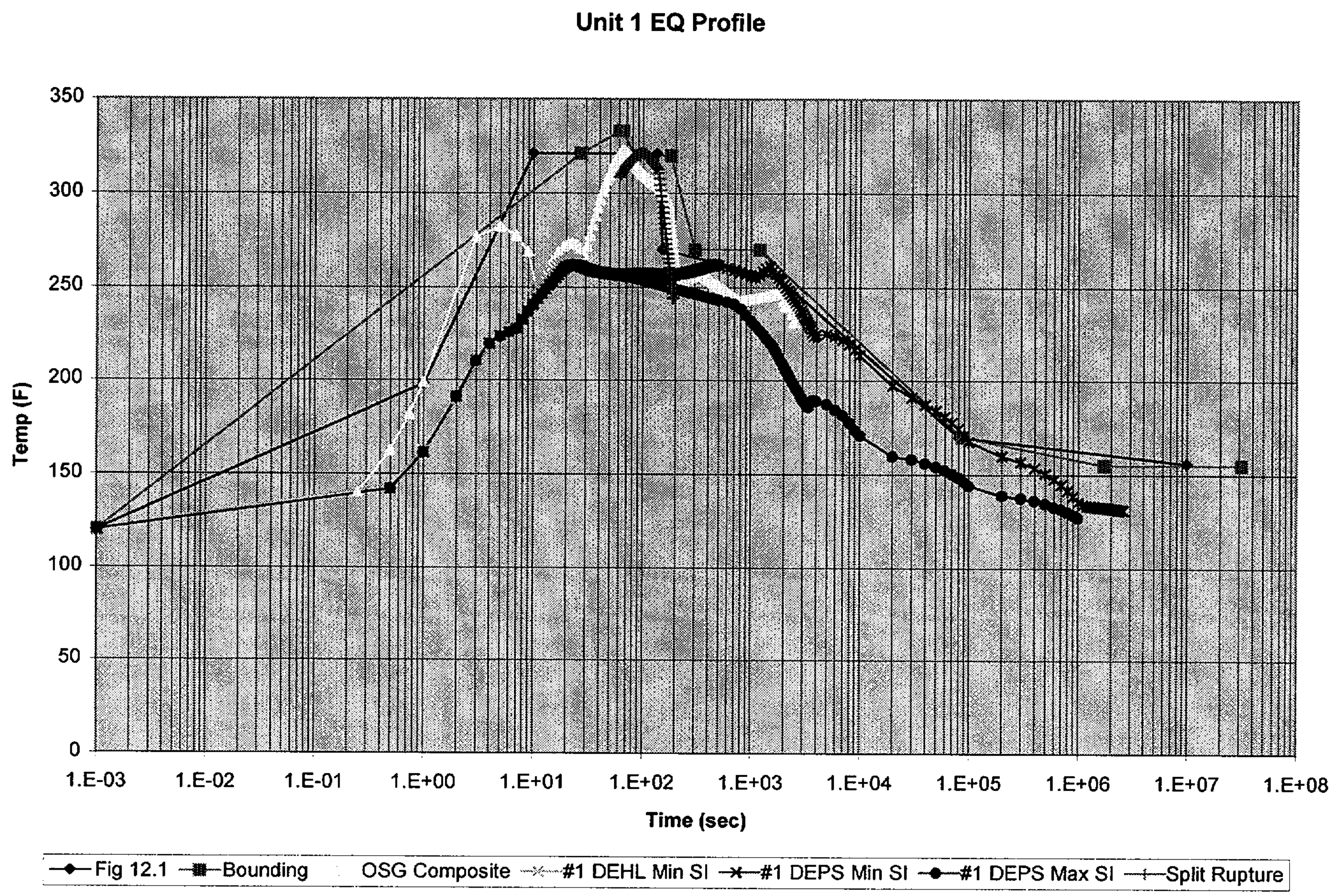

Figure 9.3.21-1
EQ Profile

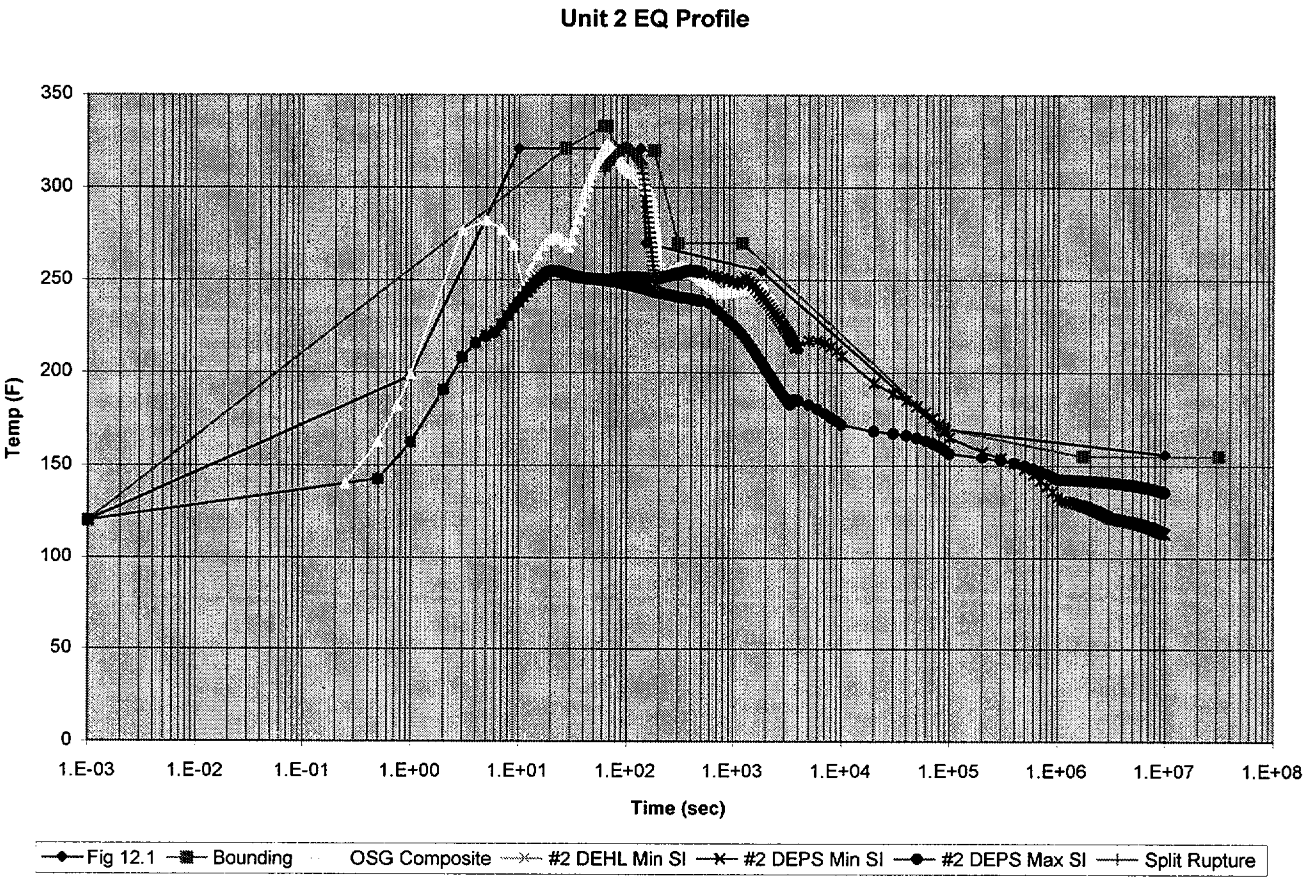

Figure 9.3.21-2
EQ Profile

9.4 Radiological Evaluations

This section of the licensing report is focused on assessing the radiological impact of a 5% power uprate at the Byron and Braidwood Units 1 and 2. The current licensing basis core power level is 3,411 MWt. The power uprated core power level is 3,586.6 MWt.

Radiological evaluations for normal operation-related issues were assessed, for power uprate, at the base power uprated core power level of 3,586.6 MWt. Radiological evaluations for accident related issues were assessed, for power uprate, at a core power level of 3,658.3 MWt, to include the 2% instrument error margin addressed in Regulatory Guide 1.49, Revision 1.

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 Environmental Qualification (EQ) for safety-related equipment in the Byron/Braidwood EQ Program.

The impact of the power uprate on post-accident exclusion area boundary doses and control room habitability has been evaluated by Westinghouse and is documented in Section 6.7.

9.4.1 Normal Operation Dose Rates and Shielding

9.4.1.1 Introduction

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

The impact of the power uprate on the normal operation dose rates, and adequacy of shielding, was evaluated to ensure continued safe operation within regulatory limits. This information was also utilized to assess the impact of the power uprate on the normal operation component of the total integrated dose used for radiological EQ.

9.4.1.2 Input Parameters and Assumptions

The following input parameters were used in this evaluation:

1. The original Byron and Braidwood Units 1 and 2 shielding and normal operation dose estimates are based on a core power level of 3,565 MWt, and a design normal operation reactor coolant source term based on 1% failed fuel and documented in Reference 1.

2. The power uprated core power level is 3,586.6 MWt.

3. The power uprated design reactor coolant source terms developed by Westinghouse are based on 1% failed fuel.

The following assumption was used in this evaluation:

1. Following power uprate, the operation and layout/arrangement of plant radioactive systems will remain consistent with original design.

9.4.1.3 Description of Analyses

The power uprate from 3,411 MWt to 3,586.6 MWt will increase the activity inventory of fission products in the core by approximately the percentage of the power uprate. The design source terms for primary coolant, secondary coolant, and other radioactive process systems and components may also be impacted. These increases will be bounded by the data used in the original analyses, or modest increases in estimated source terms, doses, and releases might result.

The original shielding design was based on a core power level of 3,565 MWt (i.e., approximately 0.6% less than the power uprated power level) and a design reactor coolant system source term based on 1% failed fuel.

The impact of the power uprate on normal operation design dose rates/shielding is divided into three parts:

- areas near the reactor vessel and spent fuel, where the dose rate is dominated by the reactor core neutron flux and/or the irradiated fuel gamma radiation

- areas in containment adjacent to the Reactor Coolant System (RCS), where the dose rate is dominated by the high energy gammas associated with N-16
- the rest of the plant, where the dose rate is determined by radiation sources derived from primary coolant activity.

9.4.1.4 Acceptance Criteria

Normal operation dose rates/shielding must meet the requirements of 10CFR20 related to allowable operator exposure and access control. (Ref. 1 and 2)

9.4.1.5 Results

During normal operation, the radiation source in the reactor core is made up of the neutron and gamma fluxes, which are approximately proportional to the core power level. The radiation sources during shutdown are the decay gamma fluxes in the core and the activation activities in the reactor internals, pressure vessel, and primary system walls, which also vary approximately in proportion to the reactor power. With regard to the spent fuel assemblies, the major radiation source is the fission product inventory, which again, is approximately proportional to the reactor power.

The current design basis shielding and normal operation design dose rate (including shutdown) calculations for the reactor core source, as well as the spent fuel source, are based on a core power level of 3,565 MWt, i.e., about 0.6% less than the uprated power level. This small percentage is well within the uncertainty of the calculated results in the existing design basis analyses, considering the accuracy of nuclear data and the conservatism present in computation model simplification utilized in the current shielding analyses.

During normal operation, the major radiation source in the reactor coolant system components, located within containment, is N-16 since the available transit times from the core to the components are not sufficient for the N-16 to decay to negligible levels. The N-16 source, used in current design basis shielding analyses, is based on a power level of 3,565 MWt. Since a 0.6% power uprate is not expected to change the transit times significantly, the N-16 activity leaving the core is expected to increase only by the percentage of the power uprate (i.e., 0.6%). This small percentage increase of the N-16 source is well within the uncertainty of the calculated results in the existing design basis analyses, considering the conservatism present in computation model simplification utilized in the current shielding analyses. During shutdown, the major radiation sources in the reactor coolant system components located within containment are the deposited corrosion products on the internal surfaces and the decayed primary coolant activity. The deposited corrosion product activity used in the original shielding analyses is based on industry wide operating experience and is applicable for power uprate.

To evaluate the 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) vs. the original design basis primary coolant source terms. A comparison was performed of the gamma energy emission rates by energy group for the power uprate vs. original primary coolant source terms with 0 hr, 1 day, 1 week, 1 month, and 1 year decay to represent different process equipment/streams. The evaluation considered unshielded and shielded dose rates. The sources evaluated included total primary coolant, degassed primary coolant, primary coolant noble gas source, cumulative halogen and fission product sources in primary coolant, and the cumulative corrosion product source in primary coolant. The unshielded and shielded dose rates, based on the power uprate design primary coolant source terms, were either comparable to, or slightly less than, the dose rates developed based on the original design basis primary coolant source terms. This is primarily due to the conservatively low water mass used in the base case analysis vs. the more realistic value utilized for the power uprate evaluation. It is therefore concluded that the current design basis analyses supporting shielding/design dose rates outside containment bound the impact of the power uprate.

9.4.1.6 Conclusions

The power uprate has no significant effect on plant normal operation radiation zones and shielding requirements. In addition, the normal operation component of the total integrated dose used for radiological EQ is not affected by the power uprate.

9.4.1.7 References

1. Byron and Braidwood Units 1 and 2 UFSAR Section 12.2, "Radiation Sources"

2. Code of Federal Regulations, Title 10, Part 20, "Standards for Protection Against Radiation"

9.4.2 Normal Operation Annual Radwaste Effluent Releases

9.4.2.1 Introduction

Liquid and gaseous effluents released to the environment during normal plant operations contain small quantities of radioactive materials. As noted in Byron and Braidwood Units 1 and 2 UFSAR Section 11, the original plant analyses demonstrate that radioactive releases from the site are within the release/dose limits set by 10CFR20 and 10CFR50, Appendix I. The impact of the power uprate on these releases was evaluated to ensure continued operation within regulatory limits. (Refs. 1 & 2)

9.4.2.2 Input Parameters and Assumptions

The original effluent release and Appendix I dose analyses (i.e., input to the PWR-GALE program / NUREG 0017, Rev 0), were based on a core power level of 3,565 MWt, and plant parameters (including gaseous and liquid waste system operation data) as noted in UFSAR Table 11.2-2. Included in the list of parameters utilized for the assessment were the following: (Refs. 3, 4, 5 & 6)

-	Core Power Level:	3,565 MWt
-	Mass of Coolant in Primary System:	2.42 E8 gms
-	Total Steam Flow Rate:	1.5 E7 lb/hr
-	Mass of steam in each Steam Generator:	9,100 lb
-	Mass of Liquid in each Steam Generator:	117,000 lbs

Except as noted below, all parameter values provided in UFSAR Table 11.2-2 remain unaffected by the power uprate:

-	Core Power Level:	3,586.6 MWt
-	Mass of Coolant in Primary System:	2.477 E8 gms
-	Total Steam Flow Rate:	1.604 E7 lb/hr
-	Mass of steam in each Steam Generator:	6,039 lb
-	Mass of Liquid in each Steam Generator:	114,465 lbs

The following assumption was used in this evaluation:

a. Following power uprate, the Byron and Braidwood Units 1 and 2 radwaste system operation/ and availability will remain consistent with the original design.

9.4.2.3 Description of Analyses

In evaluating the impact of the power uprate on radwaste effluents, the methodology in NUREG 0017 was used to establish the relative change in expected reactor coolant activities. The percentage change in the expected coolant concentrations was estimated to be less than or, equal to the percentage change in core power.

For liquid releases, the magnitude of the activity concentration after the power uprate is directly proportional to the change of coolant activity over the base case. For the gaseous releases, the analysis is more complex as gaseous effluents are composed of two components:

- non-containment leakages from the RCS or secondary-plant steam and the normal operation gaseous waste effluents, which are coolant concentration-based, and
- effluents from the gaseous waste system during shutdown sequences and the reactor coolant leakage into containment, which are coolant inventory based.

An upper-bound analysis for the potential impact of the power uprate indicates that the increase in releases/dose impact is bounded by the percentage change in power uprate. Note that the original analyses were performed at a core power level of 3,565 MWt (i.e., approximately 0.6% less than the uprated power level).

An evaluation was performed, using scaling techniques, to assess the impact of the power uprate on normal operation annual effluent releases and, Appendix I doses.

9.4.2.4 Acceptance Criteria

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).

9.4.2.5 Results

Expected Reactor coolant source terms:

Based on a comparison of original vs. power uprate input parameters and the methodology outlined in NUREG 0017, the maximum expected increase in the reactor coolant source is limited to the percentage of the power uprate, i.e., 0.6%. Note that, with the exception of the long-lived Kr-85, the noble gases have a lower coolant concentration in the power uprate case. This is primarily due to the conservatively-low water mass used in the base case analysis vs. the more realistic value utilized for the power uprate evaluation. Considering the accuracy and error bounds of the operational data utilized in NUREG 0017, this small percentage is well within the uncertainty of the existing NUREG 0017 based expected reactor coolant isotopic inventory used for radwaste effluent analyses.

Gaseous and Liquid Effluent Releases:

There was approximately a 0.6% increase in the liquid effluent release concentrations, as this activity is based on the long-term RCS activity, which is proportional to the power uprate percentage increase, and on waste volumes, which are essentially independent of power level within the applicability range of NUREG 0017. Tritium releases in liquid effluents remain unchanged due to power uprate as the coolant concentration is set by the NUREG 0017 methodology.

Gaseous releases for Kr-85 increase by the 0.6% power increase. However, isotopes with shorter half-lives have either reduced releases or only slight increases, compared to the percentage power increase. For example, releases of Xe-133 will increase about 0.2%. The impact of the power uprate on iodine releases is limited to the 0.6% power level increase. The other components of the gaseous release (i.e., particulates via the building ventilation systems and water activation gases) are not impacted by power uprate. All of the incremental tritium production due to the power uprate is assumed to be released via the gaseous pathway resulting in an approximate 0.8% increase in tritium releases via gaseous effluents.

Considering the accuracy and error bounds of the operational data utilized in NUREG 0017, these small percentage changes are well within the uncertainty of the calculated results in the existing NUREG 0017-based expected gaseous and liquid release isotopic inventory presented in UFSAR Tables 11.2-4 & 11.3-7. (Refs. 7 & 8)

Appendix I Doses:

Since the maximum increase due to the power uprate, relative to the liquid releases, is approximately 0.6%, the increase in the estimated Appendix I doses via the liquid pathway, will also be bounded by this value.

With respect to the gaseous pathway, the noble gases, iodines and particulates contribute to over 90% of the Appendix I dose, whereas the tritium contribution to dose is less than 10%. Based on the discussion provided earlier, the impact of uprate on the noble gas, iodine and particulate contribution to the Appendix I doses will be less than 0.6%. Though the incremental dose contribution due to the increase in tritium releases due to uprate is 0.8%, it is a small contributor (<10%) to the total Appendix I dose from gaseous effluents. Therefore, the overall increase in offsite dose due to the gaseous pathway is estimated to be less than 0.6%.

Considering the accuracy and error bounds of the operational data utilized in NUREG 0017, this small percentage change is well within the uncertainty of the calculated results in the existing NUREG 0017 based Appendix I dose estimates documented in UFSAR Tables 11.2-3 & 11.3-9. (Ref. 9 & 10)

Solid Waste Generation:

Per regulatory guidance for a "new" facility, the estimated volume and activity of solid waste is linearly related to the core power level. However, for an existing facility that is undergoing power uprate, the volume of solid waste would not be expected to increase proportionally, since the power uprate neither appreciably impacts installed equipment performance, nor does it require drastic changes in system operation. Only minor, if any, changes in waste generation volume are expected.

As the estimated coolant activity does not change appreciably, the calculated specific activity of the solid waste would not be expected to change as maintenance and operational practices are not expected to be affected by the power uprate. Therefore, the power uprate has no significant impact on the solid waste estimates.

9.4.2.6 Conclusions

The power uprate has no significant effect on the estimated annual radwaste effluent releases/doses. Therefore, the liquid and gaseous radwaste system design remains capable of maintaining normal operation offsite releases and doses within the requirements of 10CFR20 and 10CFR50, Appendix I.

9.4.2.7 References

1. Code of Federal Regulations, Title 10, Part 20, "Standards for Protection Against Radiation"

2. Code of Federal Regulations, Title 10, Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Reasonably Achievable" for Radioactive Material in Light Water Cooled Nuclear Power Reactor Effluents"

3. FSAR Sections 2.3, 11.1, 11.2 and 11.3"

4. FSAR Sections 2.3, 11.1, 11.2 and 11.3"

5. UFSAR Table 11.2-2, "Parameters Used in the GALE-PWR Computer Program," Rev. 7, Dec. 1998

6. NUREG 0017, April 1976, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors"

7. UFSAR Tables 11.2-4 "Comparison of Expected Liquid Effluent Concentrations to 10CFR20 Limits" (Separate tables for Byron & Braidwood), Rev. 7, Dec. 1998

8. UFSAR Tables 11.3-7 "Comparison of Maximum Offsite Airborne Concentrations with 10CFR20 Limits" (Separate tables for Byron & Braidwood), Rev. 7, Dec. 1998

9. UFSAR Tables 11.2-3 "Pathway Doses from Liquid Effluents" (Separate tables for Byron & Braidwood), Rev. 7, Dec. 1998

10. UFSAR Tables 11.3-9 "Expected Individual Doses from Gaseous Effluents" (Separate tables for Byron & Braidwood)

9.4.3 Post-Accident Access to Vital Areas

9.4.3.1 Introduction

In accordance with NUREG 0737, II.B.2, vital areas are those areas within the station that will or may require occupancy to support accident mitigation or recovery following a Loss of Coolant Accident (LOCA). (Ref. 1)

Appendix E of the Byron and Braidwood Units 1 and 2 UFSAR, identifies the control room, remote shutdown panels, technical support center, the sampling station, and the hydrogen recombiner panels as post-LOCA vital areas. Dose rate maps (UFSAR Appendix E Dwg E.20-1 through E.20-7) are provided to show the radiation environment expected at these vital areas, and areas essential for access to these vital areas, at 1 hour, 1 day, and 1 week following a LOCA. The maps outline zones with boundaries as follows: >500 R/hr, 100-500 R/hr, 10-100 R/hr, 1-10 R/hr, 0.1-1 R/hr, 0.015-0.1 R/hr, and 0-0.015 R/hr. The zone maps address both the pressurized and the de-pressurized LOCA. This information is utilized to demonstrate that, following a LOCA, vital areas requiring continuous occupancy are in a less than 15 mrem/hr zone. Also, Appendix E indicates that adequate occupancy times are available for typical operator actions in the vital areas requiring infrequent access. This latter determination appears to be based on a qualitative assessment of the dose rate maps in conjunction with application of the post-accident 5 R whole body limit imposed by NUREG 0737 and 10CFR50, Appendix A, GDC 19. (Refs. 1, 2, and 3)

The post-accident radiation dose rate maps are based on an equilibrium core inventory assuming full power operation, source term guidance relative to post-accident core releases as discussed in NUREG 0578 and NUREG 0737, II.B.2, 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. (Refs. 1 and 4)

The impact of the power uprate on the post-accident radiation dose rate maps, referenced above, was evaluated. The results of this evaluation determine the impact of the power uprate on post-accident access to vital areas.

9.4.3.2 Input Parameters and Assumptions

The following input parameters were used in this evaluation:

a. The original analyses supporting the development of the post-LOCA radiation dose rate maps for vital access utilized a reactor core inventory based on a core power level of 3411 MWt.

b. The power uprated equilibrium core inventory developed by Westinghouse is based on a reactor core power level of 3658.3 MWt and is obtained from. This includes the 2% instrument error margin required by Regulatory Guide 1.49. (Ref. 5)

The following assumption was used in this evaluation:

a. Following power uprate, the operation, and layout/arrangement of plant radioactive systems which will remain consistent with original design

9.4.3.3 Description of Analyses

The impact of power uprate on the radiation doses received while assessing 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 approach utilized was to estimate a scaling factor impact based on a source term comparison rather than on developing actual dose rate estimates at various locations/times using the new core inventory.

The power uprated core inventory was used to develop the post-LOCA gamma energy release rates (Mev/sec) per energy group vs. time, for containment atmosphere, sump water (or de-pressurized recirculating fluid), and pressurized recirculating fluid.

For the "unshielded" case, the factor impact on-post accident gamma dose rates was estimated by ratioing the gamma energy release rates as a function of time for the uprate power level, to the corresponding source terms for the original design basis power level.

To evaluate the factor impact of the power uprate on post-LOCA gamma dose rates (vs. time) in areas that are "shielded," the current as well as power uprate source terms discussed above were weighted by the concrete reduction factors for each energy group. The concrete reduction factors, for 1, 2 and 3 feet of concrete, provided 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.

9.4.3.4 Acceptance Criteria

Demonstrate compliance with the dose rate/dose limits noted in NUREG 0737, II.B.2 and committed to in Appendix E of Byron and Braidwood Units 1 and 2 UFSAR, i.e.;

- vital areas requiring continuous occupancy are located in a <15 mrem/hr zone.
- adequate occupancy times remain available for typical operator actions in vital areas requiring infrequent access.

9.4.3.5 Results

The original analysis that developed the post-LOCA radiation dose rate maps (UFSAR Appendix E Dwgs E-20-1 through E.20-7) was developed to provide an indication of the radiation levels at plant vital areas and areas essential to access those vital areas. Conservative assumptions were made in determining the dose rates from the various post-accident sources. For example, all dose rate estimates were based on simplified, but conservative models. Dose rates were always calculated at the midpoint of each source, regardless of the relative elevation of the source. Concrete walls were conservatively modeled assuming a density of 140 lbs/cu. ft, (note that ordinary concrete has a density closer to 145 lb/cu ft). Contact dose rates with the floor or ceiling were used for sources above or below the floor of interest.

A selected number of dose points were evaluated, to determine the original zone maps. Some error in boundary location was expected when drawing the zone boundaries through the limited number of dose points evaluated. An iterative technique was utilized to facilitate the determination of zone boundaries in areas with multiple sources. An uncertainty of approximately 20% was expected because of the nature of the interpolating polynomials. The tolerance in the zone boundaries, when not defined by structural walls, was expected to be plus or minus several feet. However, due to the conservative assumptions used in developing the dose rate from each source, the radiation level in every area of the plant was expected to be less than that indicated on the maps.

For the power uprate evaluation the unshielded/shielded power uprate gamma dose rate scaling factors for the various post-LOCA radiation sources (containment atmosphere, sump water, and pressurized recirculating fluid), at 1 hour, 1 day, and 1 week following a LOCA were determined to be 1.15.

Based on the conservative, approach utilized in determining the original zone maps and the tolerance expected in the zone boundaries, it was concluded that the original dose rate mapping remains representative for power uprate.

9.4.3.6 Conclusions

The existing post-accident dose rate maps are adequate for power uprated conditions, and variances from existing calculated values are insignificant. The power uprate has no significant impact on post-accident access to vital areas.

9.4.3.7 References

1. NUREG-0737, "Clarification of TMI Action Plan Requirements", Nov. 1980

2. UFSAR Appendix E, "Requirements Resulting from TMI-2 Accident," (Rev. 7), Dec. 1998

3. Code of Federal Regulations, Title 10, Part 50, Appendix A, GDC 19, "Control Room"

4. NUREG-0578, "TMI-2 Lessons Learned Task Force Status Report and Short Term Recommendations", July 1979

5. Regulatory Guide 1.49, Revision 1, "Power Levels of Nuclear Power Plants"

9.4.4 Radiological EQ for Equipment in the Byron/Braidwood EQ Program

9.4.4.1 Introduction

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. (Ref. 1)

The Byron and Braidwood nuclear stations are divided into various environmental zones as defined in UFSAR Table 3.11-2. The radiological environmental conditions noted for these zones are the maximum conditions expected to occur and are representative of the whole zone. When the qualification level of a specific component is less than that of the zone in which it is located, specific radiation calculations have been generated based on the component specific location. Normal operation values represent 40 years of operation. Post-accident radiation exposure levels are determined for a one-year period following a LOCA. A 10% margin is addressed for the accident contribution. (Ref. 2)

The post-accident EQ radiation dose is based on an equilibrium core inventory assuming full power operation, source term guidance relative to post-accident core releases (as provided in NUREG 0588), 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. (Ref. 3)

The impact of power uprate on the post-accident component of the total integrated dose was evaluated. Based on Section 9.4.1.6, the normal operation component of the total integrated dose used for radiological EQ qualification remains unimpacted by the power uprate.

9.4.4.2 Input Parameters and Assumptions

The following input parameters were used in this evaluation:

a. The original analyses supporting the development of the post-LOCA radiation dose contribution at each of the plant environmental zones, defined in UFSAR Table 3.11-2, utilized a reactor core inventory based on a core power level of 3565 MWt.

b. The power uprated equilibrium core inventory developed by Westinghouse is based on a reactor core power level of 3658.3 MWt and is obtained from Reference 6. This includes the 2% instrument error margin required by Regulatory Guide 1.49. (Ref. 4).

The following assumption was used in this evaluation:

a. Following power uprate, the operation and layout/arrangement of plant radioactive systems will remain consistent with original design

9.4.4.3 Description of Analyses

The impact of power uprate on the post-LOCA EQ radiation doses was evaluated based on a comparison of the original design basis source terms to the power uprate source terms. The approach utilized was to estimate a scaling factor impact based on a source term comparison rather than developing actual integrated dose estimates at the various zones/component-specific locations, using the new core inventory.

The power uprated core inventory was used to develop the post-LOCA gamma integrated energy releases (Mev-hr/sec) per energy group vs. time, for containment atmosphere, sump water (or de-pressurized recirculating fluid), and pressurized recirculating fluid.

For the "unshielded" case, the factor impact on post-accident gamma doses was estimated by ratioing the integrated gamma energy releases as a function of time for the uprate power level to the corresponding source terms for the original design basis power level.

To evaluate the factor impact of the power uprate on post-LOCA gamma doses (vs. time) in areas that are "shielded", the current and power uprate source terms discussed above were weighted by the concrete reduction factors for each energy group. The concrete reduction factors, for 1, 2 and 3 feet of concrete, provided 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.

To evaluate the impact of the power uprate on unshielded post-LOCA beta doses (vs. time), the power uprated core inventory was used to develop the post-LOCA beta integrated energy releases (Mev-hr/sec) vs. time, for containment atmosphere, sump water (or de-pressurized recirculating fluid), and pressurized recirculating fluid. The factor impact on the post accident beta dose was estimated by ratioing the integrated beta energy releases as a function of time for the uprate power level, to the corresponding source terms for the original design basis power level.

The above scaling factors were applied to the post-LOCA zone as well as component/location-specific environmental dose estimates.

9.4.4.4 Acceptance Criteria

The equipment in the Byron/Braidwood EQ Program must be qualified to actively function, and/or not impair other equipment relied on to perform an active safety function (or certain Regulatory Guide 1.97 activities), in the radiation environment to which they are exposed to during normal operation as well as for the duration of the accident.

9.4.4.5 Results

The unshielded/shielded power uprate gamma and beta dose scaling factors for the various post-LOCA radiation sources (containment atmosphere, sump water, and pressurized recirculating fluid), were calculated. The maximum gamma and beta dose scaling factors are those associated with sump fluid and are determined to be 1.078 and 1.04, respectively. The containment atmosphere beta dose scaling factor is 1.02.

Based on Section 9.4.1.6, the normal operation component of the total integrated dose (TID) used for radiological equipment qualification remains unimpacted by the power uprate.

Relative to the environmental radiation zones, a comparison of the power uprated TID doses to the original environmental dose established for each zone (see UFSAR Table 3.11-2) indicates that the existing values have sufficient margin to envelope the impact of the power uprate.

For Safety-Related equipment for which location specific environmental doses had been utilized, the power uprated doses were compared to the qualification dose used for the individual component or equipment. This comparison shows that sufficient margin is available to accommodate the increase due to the power uprate without compromising equipment qualification.

9.4.4.6 Conclusions

The power uprate has no significant impact on radiological equipment qualification.

9.4.4.7 References

1. Code of Federal Regulations, Title 10, Part 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants"

2. UFSAR Table 3.11-2, “Plant Environmental Conditions,” (Rev. 7), 1998

3. NUREG-0588, “Interim Staff Position on Environmental Qualification of Safety Related Equipment”, Revision 1

4. Regulatory Guide 1.49, (Rev. 1), “Power Levels of Nuclear Power Plants”

9.5 Structures

9.5.1 Containment

Among the loads that the Byron and Braidwood containment buildings are designed to withstand are the effects associated with postulated piping ruptures taking place within the structure including Loss of Coolant Accident (LOCA) and Main Steam Line Break (MSLB) events. The impact of the core power uprating was evaluated for the containment structures on the design basis parameters comprising the peak containment pressure, peak liner temperature, and the peak concrete temperature.

The containment is designed for an internal pressure of 50 psig. The containment liner and concrete design temperatures for accident conditions are 280°F (short term inside face of liner,) and, 208°F (inside face of concrete). (Ref. 1)

9.5.1.2 Input Parameters and Assumptions

Westinghouse provided results for LOCA events using the Unit 1 B&W replacement steam generator (SG) design which bounds the originally installed Unit 2 Westinghouse D-5 SGs.

Existing MSLB results with the power uprate peak pressures and temperatures resulting from eight postulated MSLBs for the original SGs and the replacement steam generators were provided by Westinghouse as input. The review of this input concluded that the existing MSLB analysis results are greater than those for the power uprate.

The peak pressure and peak temperature are treated as coincident static loads in the design that is, the peak liner temperature occurs simultaneously with the peak pressure without consideration of dynamic effects.

9.5.1.3 Description of Analysis

As discussed in Section 9.5.1.2 the existing results for MSLBs in the containment are above those calculated for the power uprate. Therefore, no changes result from the power uprate.

The peak power uprate pressures and steam temperatures resulting from each of the transient analyses for the LOCA scenarios were compared to the design basis peak values provided in (Refs. 1 and 2). Where only steam temperatures are available in (Ref. 3), they are used as surrogates for the maximum containment liner temperatures.

9.5.1.4 Acceptance Criteria

The specific acceptance criteria associated with the containment structure(s) are that they withstand the effects associated with the postulated effects associated with piping ruptures taking place within the structure including LOCA. Specifically, the pressures and temperatures resulting from piping ruptures in the containment must not exceed the internal pressure of 50 psig, and the containment liner and concrete design temperatures for accident conditions of 280°F (short term inside face of liner,) and, 208°F (inside face of concrete).

9.5.1.5 Results

The results of the analyses are summarized below:

LOCA SCENARIO	PEAK PRESSURE PSIG	PEAK STEAM TEMPERATURE, °F
Double Ended Hot Leg Break - Minimum ECCS, 13 Second Diesel Delay, 100°F SX Temp	42.8	264.5
Double Ended Pump Suction Break – Minimum ECCS	41.8	262.3
Double Ended Pump Suction Break – Maximum ECCS	40.8	261.5

The calculated pressures are less than the 50 psig, the containment design basis pressure.

The peak steam temperature is less than the design basis temperature for the inside face of the containment liner. The peak concrete temperature is based on a maximum liner temperature of 280°F. The lower liner (steam) temperatures will result in lower concrete temperatures.

9.5.1.6 Conclusions

The power uprate postulated LOCA conditions are less than the design basis parameters for the containment design. Therefore, the power uprate does not result in changes to the containment design basis.

9.5.1.7 References

1. UFSAR Table 3.8-4, Definitions Of Structural Terminology, (Rev 7), 1998

2. UFSAR Table 6.2-66, Liner And Concrete Design Temperatures, (Rev. 7), 1998

9.5.2 Steam Pipe Tunnels and Valve Rooms

The effects of power uprate on the structural design of the Safety Valve Rooms (MSIV), Main Steam Tunnel (MST) and Auxiliary Feed Tunnels (AFT) and associated rooms are assessed in this section. The structural design loads affected by power uprate are the peak differential pressurization, the corresponding temperature, and impingement loads resulting from a main steam pipe rupture. These forces act on the walls and slabs comprising the compartments of the MSIV, MST, and AFT.

9.5.2.2 Input Parameters and Assumptions

The structure has been modeled as a series of interconnected volumes or compartments separated by intermediate walls and slabs. The input parameters for this analysis are the pressure time histories for each volume, the corresponding temperature time histories, and the local impingement loads where applicable. For walls and slabs exposed to the exterior environment the design differential pressure is determined directly from the pressure transient for the affected volume and atmospheric pressure. The design pressure for the walls and slabs dividing the interior into compartments is determined from the pressure time histories for the adjoining volumes.

In the absence of pressure time histories, and assuming that the pipe break mechanism and the break opening remain the same as in the design basis calculation, the mass and energy release time history for core power uprate may serve as a surrogate for the pressures previously described. The mass and energy releases are the input data required to calculate the pressures and temperatures in each volume of the model.

9.5.2.3 Description of Analysis

The increase in the Main Steamline rupture mass and energy release rate associated with core power uprate is not expected to exceed 10 percent. The pressures resulting from a MS line break are, therefore, not expected to exceed 10 percent using the mass and energy release as a surrogate for the pressure.

Attachment C3.6, Table 1 of the UFSAR identifies the design margins for the concrete MSIV, MST, and AFT structure. These margins are greater than 10 percent at all locations except for Volume Number 14.

The approach used in engineering calculations treated the pressurization as a dynamic loading and calculated the frequency spectrum for the pressure transients associated with each volume comprising the structure. A dynamic load factor equal to the maximum spectrum amplitude was then used to factor the pressure without consideration of the structure frequency.

Calculations address the Spectral Analysis of the MS Line break pressure T.H. in the first quadrant tunnel node. For this case the maximum spectral amplitude is 1.6 and is used to factor the differential pressure and obtain the design pressure. The peak spectral amplitude calculated for the pressurization time history associated with the MS Line break, occurs at a period of 10 Hz.

For 3 ft. thick slabs and walls and the spans encountered for this structure the resonant frequency is between 33 Hz and 60 Hz. The maximum value of the spectral amplitude in this frequency range is 1.2. Due to the conservative amplification factor used in the original design, a margin of 1.6/1.2 or 33 percent is available to support the higher pressures resulting from core power uprate. The resulting stresses will remain within the plant design basis code allowable stresses.

9.5.2.4 Acceptance Criteria

The Main Steam Tunnels were evaluated for changes in the accident conditions resulting from the RSG. The pressure time histories were analyzed at the required locations in the MSIV, MST, and AFT to establish the amplification (dynamic load) factor for the pressure loadings. The pressure amplification factor is determined as a function of the structure frequency and the peak value is used to increase the calculated pressure. The structure frequencies are greater than those at which the maximum amplification occurs. A comparison of the peak differential pressures resulting from RSG with the original design pressures and their comparisons show the RSG results are bounded by the original design pressures.

The pressure transients resulting for the RSG were calculated and the values are tabulated and correspond to those in Attachment C3.6, Table 1 of the UFSAR. It uses the mass-energy release transient provided in Attachment C3.6, Table 4 of the UFSAR to determine these pressures. The mass and energy release transient associated with main steamline break for power uprate conditions does not exceed the time history in Table 4 of UFSAR Attachment C3.6.

9.5.2.5 Results

As discussed in Section 9.5.2.3, the design of the MSIV, MST, and AFT structures uses a conservatively estimated differential pressure. Eliminating the conservatively estimated dynamic load factor and using a more appropriate value results in design pressures less than those used to establish the margins in UFSAR Attachment C3.6 Table 1.

9.5.2.6 Conclusions

The calculated peak pressures at power uprate are still bounded by the design peak pressures of the MSIV, MST, and AFT structures.

9.5.2.7 References

None

9.5.3 Spent Fuel Pool

9.5.3.1 Introduction

Power uprate will result in higher temperatures in the fuel bundles removed from the reactor core. The Spent Fuel Pool structure is evaluated to ensure that the higher concrete temperatures and structural loading imposed by the temperature increase, thermal gradients and resulting stress analysis will not result in exceeding the design acceptance criteria.

9.5.3.2 Input Parameters and Assumptions

The Spent Fuel Pool temperatures have increased for the power uprate as documented in Section 9.3.10. The limiting scenario and the results of the temperature analysis are summarized as follows:

- Full Core Discharged 100 hours after shutdown. Power uprate Conditions Only

- 1 HX train available and operating - peak pool water temperature is 162.7°F

The interior concrete temperature is assumed to be equal to the water temperature and the exterior concrete temperature is taken as 70°F.

An evaluation of power uprate with the existing procedure is provided in this assessment and the potential impacts of the other scenarios is also discussed.

9.5.3.3 Description of Analysis

The analysis of the spent fuel pool structure for increased temperatures is used as a basis to determine the consequences of higher spent fuel pool temperatures due to power uprate. The increased temperatures reflecting these conditions are evaluated using latest plant analysis and Reference 1.

The latest plant analysis identifies the thermal expansion (axial expansion) of the walls and slab as the load contributing to the maximum (and limiting) bending moment in the pool walls. Assuming that this moment is proportional to the increase in the average temperature of the wall (the thermal gradient is treated separately) the maximum rebar stress is estimated for the case when the peak temperature is 162.7°F for full core discharge.

a. The increase in the average concrete wall temperature is (158°F - 70°F)/2 or 44°F and the maximum rebar stress is 50.9 ksi.

b. The increase in the average concrete wall temperature for the power uprate conditions only is 46.4°F. This is an increase in the average temperature of 5.45%. A proportionate increase in the maximum stress results in a stress of 53.7 ksi.

Thermal gradients are evaluated and do not change the reinforcement stresses when cracking of the cross-section is considered.

The average concrete temperatures of the walls (and slab) for these peak pool water temperatures is determined by averaging the interior and exterior temperatures and are less than 150°F.

9.5.3.4 Acceptance Criteria

Reference 1 provides the following limitations for "normal operations or other long term period. The temperatures shall not exceed 150°F ... except for local areas... which are allowed to have increased temperatures not to exceed 200°F. The definition of normal operations of the spent fuel pool is discussed in UFSAR Section 9.1.3.1, "Spent Fuel Pool Cooling". A full core off load is a temporary condition. Refueling operations are routinely performed in either an approximate one-third core offload or a full core temporary offload where approximately two-thirds of the fuel assemblies are routinely returned to the reactor vessel, along with new fuel, prior to the end of the outage. Since the heat load of the fuel (i.e., spent fuel pool heat load) decays exponentially, the SFP temperature remains below 150°F for long term operations.

The allowable stress for grade 60 reinforcement is 54,000 psi.

9.5.3.5 Results

The maximum temperature of 162.7°F in the spent fuel pool only occurs for a full core offload. Since this is considered a temporary offload, the spent fuel temperature for the long term remains below 150°F. The power uprate scenario for the full core offload results in the maximum temperature condition. The revised maximum steel reinforcing stress is 14.9% higher than the previous analysis, however, the design margin for the allowable stress is greater than

1.0 and this revised loading condition is acceptable. These local overstresses do not significantly reduce the factor of safety for the pool structure.

The maximum concrete temperature will be less than the 200°F limit for local areas during normal operations.

9.5.3.6 Conclusions

The changes in the spent fuel pool temperature loading due to power uprate result in concrete temperatures and reinforcement stresses which meet the structural acceptance criteria.

9.5.3.7 References

1. ACI 349-97, Nuclear Safety Structures, Commentary on Appendix A - Thermal Considerations

10.0 PROGRAM REVIEWS

The power uprate has the potential to affect programs that were developed and implemented by station personnel to demonstrate that topical areas comply with various design and licensing requirements. Based on previous experience with other power uprate projects, the topical plant programs listed in Table 10-1 were identified for review. In addition to these topical programs, the Technical Specifications also address specific programs that were reviewed. These programs are identified in Table 10-2, "Technical Specification Programs Reviewed for Affects Resulting From Implementation of Power Uprate."

10.1 Review Process for Programs

For the programs listed in Table 10-1, the controlling procedures for the programs and key reference items within the procedures were reviewed. Program sponsors, implementing organization personnel and other cognizant individuals were interviewed regarding the conduct of the program and how changes to the program or changes to the key inputs to the program were identified and incorporated. Based upon the review of this information, the extent of impact by the implementation of the power uprate was determined for the various programs.

For the programs listed in Table 10-2, the Technical Specifications and Technical Requirements Manual Sections associated with the programs were reviewed to identify any areas affected by power uprate. Based upon this review, the extent of impact was determined to be limited to the identification of the peak calculated containment internal pressure (P_a) calculated for the design basis loss of coolant accident. Technical Specification 5.5.16, "Containment Leakage Rate Testing Program" and Technical Requirements Manual (TRM) Appendix P, "Containment Leak Rate Testing" require revision to replace the value specified with that calculated based on uprate conditions. The review process resulted in three groupings; not affected; affected but changes would be captured by in-place processes and procedures; and affected but no in-place processes or procedures to ensure that the power uprate information would be incorporated into the affected programs. Under the first category, programs may not be affected by power uprate if, a) the program is indeed not affected by power uprate because the power uprate does not change key inputs to the program or, b) 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.

In the last category, where programs will be affected by the power uprate but no existing processes or procedures exist to ensure that this information is factored into the programs, special steps were taken during the design process to transmit, in a controlled manner, the required information to the program sponsors.

10.2 Conclusions

The overall review process was effective in identifying programs that are impacted by implementation of the power uprate and identifying those where no current processes or procedures are in-place to ensure that changes are incorporated into the program. Further, the review indicated that no programs are dramatically or extensively affected, nor will the affects be of such a nature to compromise the current programs status.

Table 10-1 Programs Reviewed for Affects Resulting From Implementation of Power Uprate			
Program	**Not Affected**	**Affected[1]**	**Affected[2]**
Plant Simulator			X[3]
Fire Protection (Appendix R)	X		
Check Valve Program	X		
Motor Operated Valve (MOV) Program (GL 89-10)	X		
Air Operated Valve (AOV) Program	X		
Heat Exchanger Program (GL 89-13)			X
Inservice Inspection Program		X	
Inservice Test Program		X	
Containment Integrity (Appendix J)		X	
High Energy Line Break (HELB)		X	
Special HELB in Turbine Building	X		
Human Factors		X	
Internal Containment Flooding	X		
Station Blackout		X	
Internal Missiles	X		
Anticipated Transient Without Scram (ATWS)		X	
Flow Accelerated Corrosion (FAC)			X

1 In-place processes and procedures capture program affected by the power uprate and changes.

2 Program affected by power uprate and changes provided to program sponsor via controlled transmittals.

3 Physical changes (scale changes, greenbanding) are captured by in-place design change procedures, system performance characteristics and responses to transients are transmitted to simulator staff.

Table 10-2 Technical Specification Programs Reviewed for Affects Resulting From Implementation of Power Uprate			
Program	**Not Affected**	**Affected[4]**	**Affected[5]**
Offsite Dose Calculation Manual (ODCM) and Radiological Controls Reports and Program	X		
Primary coolant sources outside containment		X	
Post-Accident Sampling Program		X	
Radioactive Effluent Controls Program		X	
Transient Monitoring Program	X		
Containment Tendon Surveillance Program	X		
Reactor Coolant Pump (RCP) Flywheel Inspection Program	X		
In-Service Testing (IST) Program		X	
Steam Generator Tube Surveillance Program	X		
Secondary Water Chemistry Program	X		
Ventilation Filter Testing Program	X		
Explosive Gas and Storage Tank Radioactivity Monitoring Program	X		
Diesel Fuel Oil Testing Program	X		
Integrated Technical Specification (ITS) Bases Control Program	X		
Safety Function Determination Program (SFDP)	X		
Containment Leakage Rate Testing Program			X[6]

4 In-place processes and procedures capture program updates for the power uprate changes.

5 Program affected by power uprate and changes provided to program sponsor via controlled transmittals.

6 Technical specification change is required to support power uprate.

11.0 ENVIRONMENTAL IMPACTS REVIEW

The Environmental Impacts Review examined the environmental effluent discharge permit limits to assess the impact of the power uprate to 3,600.6 MWt. Radiological release changes are addressed separately in Sections 6.7.6 and 9.4.

The beneficial aspects of this power uprate are that collectively, the four units will provide an expected increase of 226 MWe additional electric power generation to service commercial and domestic loads for the COMED grid. This thermal power uprate is needed to help meet the annual growth in the COMED system while avoiding major capital expenditures for new generating capacity. The power uprate program will result in direct displacement of higher cost fossil fuel generation with lower cost nuclear fuel generation.

An alternative to this power uprate would be "no action" with respect to the proposed amendments. No action would also prevent the four units from generating the additional expected increase of 226 MWe that is needed for current and projected needs.

11.1 Introduction

The assessment included determining whether the power uprate will cause the plants to exceed the permits' effluent discharge limitations and other conditions associated with operation of the plants. This review is based upon information contained in the Environmental Report and the latest National Pollutant Discharge Elimination System Permits (NPDES) (Ref.1, 2).

The Byron and Braidwood NPDES Permits are scheduled to be renewed on August 1, 2000 and September 1, 2000, respectively. The NPDES Permits cover discharge limitations, monitoring, and reporting requirements for the two stations. The Permits include restrictions on various normal plant operations and effluent limitations including cooling tower blowdown, wastewater treatment, and operation of the radwaste treatment system.

11.2 Input Parameters and Assumptions

The following discussion addresses the NPDES requirements potentially impacted by the power uprate.

11.2.1 Byron Permit Requirements

The current Byron NPDES Permit requires, in part, that the following effluent of discharge(s) to the Rock River be monitored in accordance with the permit conditions.

a. Cooling tower blowdown
b. Non-Essential SW blowdown & strainer backwash
c. Essential SW blowdown & strainer backwash
d. Demineralizer regenerant waste
e. Sewage treatment plant effluent
f. Wastewater treatment plant effluent
g. Radwaste treatment system effluent
h. Stormwater runoff basin
i. Secondary steam system (non-rad) process water

Additionally, the discharge of wastewater from the facility must not, alone or in combination with other sources, cause the receiving stream to violate the following thermal limitations at the edge of the mixing zone:

1. The maximum temperature rise above natural temperature must not exceed 5°F (2.8°C). Where natural temperature is considered the ambient or upstream intake river temperature.

2. Water temperature at representative locations in the main river shall not exceed the following maximum limits during more than one (1) percent of the hours in the 12-month period ending with any month (i.e., 87.6 available excursion hours in one year). Moreover, at no time shall the water temperature at such locations exceed the maximum limits in the following table by more than 3°F (1.7°C).

Table 11.2.1-1 Rock River Temperature Limits					
Parameters	**Jan.**	**Feb.**	**Mar.**	**Apr. – Nov.**	**Dec.**
Temp. - °F	60	60	60	90	60
Temp. - °C	16	16	16	32	16

11.2.2 Braidwood Permit Requirements

The current Braidwood NPDES Permit requires, in part, that the effluent of the Cooling Lake Blowdown Line that discharges to the Kankakee River and consists of the following discharge(s) be monitored in accordance with permit conditions.

a. Condenser cooling water
b. House service water
c. Essential service water
d. Demineralizer regenerant waste
e. Wastewater treatment plant effluent
f. Radwaste treatment plant effluent
g. House service water strainer backwash
h. Essential service water strainer backwash
i. Sewage treatment plant effluent
j. Water treatment system filter backwash
j. River intake screen backwash
k. Cooling lake intake screen backwash

Additionally the discharge of wastewater from the facility must not, alone or in combination with other sources, cause the receiving stream to violate the following thermal limitations at the edge of the mixing zone:

1. The maximum temperature rise above natural temperature must not exceed 5°F (2.8°C). Where natural temperature is considered the ambient or upstream intake temperature.

2. Water temperature at representative locations in the main river shall not exceed the following maximum limits during more than one (1) percent of the hours in the 12-month period ending with any month. Moreover, at no time shall the water temperature at such locations exceed the maximum limits in the following table by more than 3°F (1.7°C).

Table 11.2.2-1
Kankakee River Temperature Limits

Parameters	Jan.	Feb.	Mar.	Apr. – Nov.	Dec.
Temp. - °F	60	60	60	90	60
Temp. - °C	16	16	16	32	16

As noted above normal blowdown is via the cooling pond blowdown line to the Kankakee River.

11.3 Description of Analysis and Evaluations

11.3.1 Byron Analysis and Evaluation

The Circulating Water (CW) system at Byron Station is a closed loop cooling system designed to dissipate waste heat from the turbine cycle to the atmosphere using natural draft cooling towers, one tower for each unit. The three CW pumps per unit pump cooling water from the cooling tower basin in the main condenser and back to the cooling tower. Tower blowdown is accomplished by diverting flow from the circulating water system downstream of the CW pumps and upstream of the condenser and Tower. The maximum temperature is the tower basin temperature. The Non-Essential Service Water System supply is provided from the cooling tower basin and discharges into the CW system. Two 24,000 gpm cooling tower makeup pumps, one provided for each tower, pump makeup water from the Rock River to a common flume. A third pump is provided as a backup supply for either tower.

The cooling tower heat-duty increase associated with the power uprate is mainly associated with the CW system and will be approximately 5 percent higher than at the present power level. This will result in a 1°F CW temperature increase. The current CW temperature rise is approximately 14°F at 100% power. Although the NPDES Permit does not specify a maximum cooling tower blowdown temperature, the plant has determined that under a worst-case scenario, cooling water blowdown temperature could be approximately 120°F while meeting the temperature requirement at the edge of the mixing zone and sets 120°F as an administrative limit. Normally, with a summer river supply temperature of 70°F – 90°F and a cooling tower blowdown temperature of 96°F there is no jeopardy that the proposed power uprate will impact this administrative limit. Continuous blowdown from the cooling tower basin to the Rock River maintains control of dissolved solids in the Tower basin.

Under most circumstances, the two-unit Byron Station is capable of operating at full load with cooling tower consumption losses supplied by a net withdrawal rate no greater than 10% of the Rock River flow. The limits are:

a. Limit water withdrawal for make-up to a maximum of 125 cfs.

b. Limit net water consumption to no more than 9% of the Rock River's flow when the flow is at or below 679 cfs, the one-day ten-year low.

The average cooling tower makeup rate is between 30,000 - 35,000 gpm (both towers combined) while the average blowdown rate is 14,000 gpm. This makeup rate is approximately 6.6% of the 2-day average minimum river water flow rate of 1,187 cfs (533,000 gpm) and less than 2% of the 2-day average rate of 4,575 cfs (2.05 E6 gpm). Additionally, the Byron Station, must discharge less than 0.5 billion BTUs/hour, in accordance with Title 35, Subtitle C, Chapter 1, Section 302.21(f) regulations. The requirement will continue to be met following uprate.

11.3.2 Braidwood Analysis and Evaluation

The Circulating Water (CW) System at Braidwood Station is a closed loop cooling system similar to that at Byron except that waste heat is rejected from the turbine cycle to a cooling lake. Three CW pumps per unit pump cooling water from the lake to the main condenser. Discharge from the condenser is returned to the lake, where it is separated from the intake supply by a dike.

Makeup water to the lake is pumped from the Kankakee River. Under most circumstances, the two-unit Braidwood Station is capable of operating at full load with cooling lake consumption losses supplied by a maximum withdrawal rate no greater than 160 cfs of the Kankakee River. The limits are:

a. To limit withdrawal of Kankakee River water to a maximum of 160 cfs.

b. To stop withdrawing water from the Kankakee River when the flow in the river is 442 cfs (7-day 10 year low flow) or less, and not to withdraw water such that the flow of the river is diminished below 442 cfs.

The plant currently operates at a withdrawal rate of approximately 110 cfs for makeup and blows down at the rate of approximately 28 cfs. Water chemistry is controlled by continuous blowdown of supply water to condenser and the makeup to the cooling lake.

The heat duty increase associated with power uprate is mainly associated with the CW System and will be approximately 5 percent higher than at the present power level. This will result in a 1°F increase to the CW temperature rise, which is now approximately 21.8°F at 100% power. The increase will nominally increase the lake temperature as the lake temperature is primarily influenced by climatic conditions. Current cooling lake makeup and blowdown requirements should remain acceptable and within NPDES limits following power uprate.

The NPDES permit contains a blowdown heat rejection limit to the river that requires blowdown discharge be less than 0.5 billion BTUs/hr, in accordance with Title 35, Subtitle C Chapter 1 Section 302.211(f) regulations.

11.4 Acceptance Criteria and Results

11.4.1 Byron Acceptance Criteria and Results

The acceptance criteria are that there are no adverse impacts or significant changes to the NPDES Permit as a result of the power uprate.

No significant changes are required.

11.4.2 Braidwood Acceptance Criteria and Results

The acceptance criteria are that there are no adverse impacts or significant changes to the NPDES Permit as a result of the power uprate.

No significant changes are required.

11.5 Conclusions

The non-radiological environmental impacts related to the proposed power uprate have been reviewed and there are no major issues with the current NPDES Permits or other plant administrative limits.

11.6 References

1. NPDES Permit No. IL0048313 Dated September 29, 1995 for Byron Nuclear Power Station (expiration Aug. 1, 2000)

2. NPDES Permit No. IL0048321 Dated Aug. 28, 1997 for Braidwood Nuclear Power Nuclear Power Station (expiration September 1, 2000)

12.0 STATION PROCEDURES IMPACT

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. Procedures that are affected must be identified, revised, reviewed, approved, and training conducted, where required, prior to implementation of the power uprate.

12.1 Review Process to Identify Affected Procedures

For each station, electronic copies of procedure indices were obtained and screened-based on the type of procedure and topic or the title of the procedure. The screening criteria was keyed to identify those procedures which may potentially be impacted based on previous power uprates. A physical review of each procedure identified, during the screening, will be conducted to determine the need for revision. Those procedures will be revised to incorporate the changes. For example, changes due to modifications, operator response times, setpoint changes will result in revisions to existing procedures.

12.2 Revision of Affected Procedures

Procedures that are identified as being affected by the power uprate will be revised prior to implementation. They will be reviewed and approved in accordance with station procedures. Prioritization will be given to those operational procedures that require operating training.

12.3 Conclusions

All procedures that are affected by the power uprate will be revised and all required training will be conducted prior to the implementation of the power uprate.