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NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 145 TO FACILITY OPERATING LICENSE NO. NPF-21

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

NUCLEAR PROJECT NO. 2

DOCKET NO. 50-397

1.0 INTRODUCTION

By letter dated October 26, 1995, as supplemented by letters dated March 12, 1996, May 8, 1996, and May 16, 1996, the Washington Public Power Supply System (the Supply System, or the licensee) requested changes to the Technical Specifications (Appendix A to Facility Operating License No. NPF-21) for the WPPSS Nuclear Project No. 2. The proposed changes would revise the Technical Specifications (TS) to reflect replacement of the existing reactor recirculation (RRC) flow control (RFC) system with an adjustable speed drive (ASD) system. In addition, the proposed TS changes will reflect replacement of the existing analog-hydraulic flow control system with dual channel, variable frequency ASDs and a digital recirculation flow control system that would vary RRC flow by varying RRC pump speed. The letters dated March 12, May 8, and May 16, 1996, provided information that was not outside the scope of the notice of consideration of issuance of amendment.

2.0 BACKGROUND

The RRC system consists of two parallel loops which provide recirculation flow through the reactor core during normal operation and provide a means of controlling reactor power by varying the reactor coolant flow rate. Each loop contains an electric motor-driven pump, a flow control valve, and a flow control system. Currently, during plant startup and low power operation the RRC pumps are operated at slow speed (25 percent) with power supplied by two low frequency motor generator (LFMG) sets. After reactor power is sufficient to preclude flow control valve cavitation, the pumps are shifted to fast speed (100%). The RRC flow is varied at both pump speeds by varying the position of the existing flow control valves.

The ASD system will replace the RRC system flow control valves as a means of varying the RRC flow rate. The flow control valves and the LFMG sets will be deactivated in place. The analog-hydraulic flow control system will be replaced by a digital, dual channel, ASD system. The ASD system will provide variable frequency power to each RRC pump to vary pump speed from 25 percent to 105 percent of rated pump speed and thereby vary the RRC system flow.

The licensee's October 26, 1995, letter stated that they are replacing the existing RRC flow control system because the flow control valves have not,

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performed as reliably as desired, and have contributed to several reactor scrams and forced outages. The valves, in conjunction with a two-speed RRC pump, also restrict operational maneuverability during plant startup. This is due to the potential for cavitation and core instability restriction zones that must be avoided.

The ASD system is designed to regulate RRC pump speed based on a signal from the main control room. The ASD system is classified as non-safety-related in that the RFC system does not perform any active safety-related functions. The system has interlocks and setpoints which are intended to maintain plant availability and to prevent equipment damage during transients and abnormal events. These include interlocks which ensure that proper conditions are established before an RRC pump is started. The RRC system is also designed to limit the maximum pump speed and the rate of change of pump speed. In addition, the RRC pumps will be tripped off or they will be runback to a slower speed in response to selected transients and abnormal events. These trips and runbacks will be equivalent to those provided by the existing flow control system and will maintain the current level of protection for these scenarios. Table 1 lists the automatic actions provided by the system's trips, interlocks and limiters.

3.0 EVALUATION

Transient and Accident Analysis

The licensee analyzed postulated ASD system component failures and resultant plant events, including anticipated operational occurrences, off-design abnormal transients, and postulated accidents of low probability. There are two categories of anticipated operational occurrences that involve the RRC system: flow increase and flow decrease. The Final Safety Analysis Report (FSAR) Chapter 15 events primarily affected by the RFC system are "Reactivity and Power Distribution Anomalies" (flow increase) and "Decrease in Reactor Core Flow" (flow decrease).

For the flow increase category of events, the resultant power increase causes a decrease in the critical power ratio (CPR). The lower the initial core flow, the larger the potential flow increase. The flow-dependent Minimum CPR (MCPR) operating limit is therefore higher for lower flow conditions. The WNP-2 Core Operating Limits Report (COLR) includes a requirement that the operating MCPR must increase for core flow less than the maximum. The licensee, in its letter dated October 26, 1995, committed to change the COLR as appropriate to reflect the higher maximum flow capability of the RRC system after installation of the ASD system (new pump operating limit of 105 percent) and the resultant change to the MCPR curves. The two specific events from this category which involve the RRC system are RFC failure increasing flow and abnormal startup of idle RRC loop. The licensee analyzed both of these events for RFC failure. The analysis results showed that the events remained non-limiting transients and do not challenge the reactor coolant pressure boundary or fuel integrity.

For the flow decrease category of events, the ASD installation potentially impacts four events, including RRC pump trip, RFC failure decreasing flow, RRC

pump shaft break, and RRC pump shaft seizure. The inertia of the RRC pump is a key factor in the RRC pump trip event analysis. The inertia of the RRC pump is not impacted by the ASD installation, and therefore, the coastdown characteristics will remain similar to previous analysis of this event. There are small differences in the results of this analysis from the original FSAR analysis that resulted from changes in the initial conditions as a result of the power uprate (e.g., higher core thermal power) previously approved for WNP-2, and not due to ASD system installation.

The results of the RFC failure decreasing flow event show that the plant disturbance would be equal or less than that calculated for the corresponding RRC pump trip events. The RRC pump shaft break event continues to be bounded by the RRC pump shaft seizure event. The seizure of the pump shaft results in an instantaneous loss of pump speed and results in a reduction in the CPR. The CPR remains above the MCPR criteria applied to moderate frequency events and no boiling transition should take place. The small differences in the results of this analysis from the original FSAR analysis are due to changes in the initial conditions as a result of the power uprate (e.g., higher core thermal power) previously approved, and not due to ASD system installation.

Two other categories of events affected by the RFC system are "Decrease in Reactor Coolant Temperature" and "Increase in Reactor Pressure." Of these two categories of events, previous analyses showed that the generator load rejection with turbine trip and bypass failure event was the most limiting event. Since this event involved the RRC system, the licensee further analyzed this event as bounding for these categories of events. The ASD system indirectly affects this event through the RPT breaker response. Over the range of pump speeds with the ASD system, the total RPT delay time will vary from 185 milliseconds to 200 milliseconds. The RPT delay time with the current control system is 190 milliseconds. The licensee's analysis showed that the impact from this change in the RPT delay time was not significant.

The licensee also evaluated the impact of the ASD installation on the accident analysis, the containment analysis, the ATWS analysis, and the reactor core stability analysis. The limiting accident involving the RRC system is the design basis loss of coolant accident (DBLOCA). A slightly faster pump coastdown could result due to the potential for low initial pump speeds. The effect of this change would not result in a significant impact on the calculated fuel peak cladding temperature (PCT), and therefore the impact on the DBLOCA analysis is considered negligible. The change to the ASD design was also shown to have no significant impact on the containment response. The ATWS analysis showed that the additional 10 millisecond RPT delay time due to the ASD installation would result in an increase to the peak vessel pressure of less than 2 psi, and that this change would maintain adequate margin to the ATWS acceptance criteria. Regarding the reactor core stability analysis, the ASD installation will result in greater maneuverability of reactor power and flow and an increase of margin to regions of known low stability during controlled operations. Therefore, power oscillations are less likely to occur during normal controlled operations using the ASD system for RRC flow control.

Based on staff review of the above information, we conclude that the licensee has appropriately analyzed anticipated operational occurences, transients, and accidents for the ASD modification. The staff further finds that the results are acceptable for implementation of the ASDs.

Electrical Distribution and Harmonics

The ASD is a redundant gate turn off (GTO) induction motor drive system that consists of the following basic elements for each RRC loop:

1. The common power input transformer provides a 6.9 kV source voltage and electrically isolates each drive channel.

2. The source current converter rectifier has two channels with each channel supplying 6-pulse direct current (dc).

3. The dc link reactor smooths the dc input current to the inverter.

4. The load GTO inverter changes the dc current into variable frequency alternating current (ac) and filters or chops harmonics at low speeds.

5. The filter capacitor banks provide harmonic filtering of the ASD output waveform.

6. The input and output circuit breakers allow each channel to be electrically isolated either manually at the breaker for maintenance or automatically on an ASD fault.

7. The common load output transformer combines both channel outputs into a single 12-pulse ac current which is supplied to the induction motor.

8. The GE-Factory Automation Numeric Controls (FANUC) digital control system consists of redundant programmable microprocessors and input and output modules that vary the frequency of the output ac in response to either manual or automatic demand signals.

9. Each ASD contains two medium electronic modules (MEM) units. Each MEM unit is dedicated to an individual ASD channel control and consists of plug-in-cards in a 2 row x 12 slot module. The MEM central processing unit (CPU) digitally controls the firing of the ASD channel power converter silicon-controlled rectifiers (SCRs) and load inverter GTO SCRs for driving the motor. The MEM unit also provides various protective functions for the motor, converter/inverter, bridges, and SCR cooling controls.

The ASDs are a solid-state variable frequency power supply design that are capable of delivering the power required by each pump motor for normal operation over an output frequency range of approximately 15 Hz to 63 Hz to enable the pump to operate over the range of 25 percent to 105 percent of rated pump speed. The ASDs are a dual channel system. Each ASD channel has its own microprocessor controller that controls the channel and monitors the

ASD operating state. The microprocessor controller initiates alarms to inform the main control room operator when failures occur or when an ASD has been tripped due to a major fault. These features are discussed further in the instrumentation and control section of this SER.

The ASD design uses solid-state electronics, including diodes, transistors, and SCRs to change a constant frequency and ac voltage source input to a variable frequency and ac voltage output. This is accomplished by using an ac to dc rectifier followed by a dc link and then a dc to ac inverter. The ac to dc rectifier has an arrangement of SCRs for the positive and negative portions of each of the three phases of the input wave. One polarity inversion is needed for each sine wave cycle to rectify the ac power to dc. Power between the rectifier and the inverter sections of the ASD is transferred by means of a dc link. This link acts as a power bridge between the two sections to smooth the dc current to the inverter. The large dc link inductor limits the fault current to the inverter so that misfiring of the inverter power devices does not result in a shutdown. SCRs are also used in the inverter to convert the dc signal to a variable frequency ac signal. The inverter produces harmonics that can be fed to the RRC pump motor. If the motor is not specifically designed for the ASD application, these harmonics can increase RRC motor heating and may produce mechanical fatigue of the motor shaft. Filter capacitors are applied across the ASD output to filter the harmonics and avoid derating the motor due to harmonic heating. However, these filters are in parallel with the motor inductance and create an inductance-capacitance (L-C) circuit with a resonance frequency that can be excited by the ASD harmonics. If this resonance frequency is present, harmonic currents can be amplified. To eliminate this concern the inverter uses GTO SCRs to switch current on or off at appropriate times during a cycle. This allows the inverter current waveform to be notched or chopped in a specific pattern to eliminate selected harmonics. During acceleration, deceleration, and continuous operation on or through these resonant conditions the ASD control system turns the GTOs on or off at the appropriate time to minimize the harmonic currents. A GTO failure would initiate either an ASD alarm or fault which will be annunciated in the main control room. A GTO failure indication will be displaced at the local ASD printer and on the video display terminal in the main control room.

The existing RRC master controller and flux controller process control modules will be replaced with a digital RFC system. The flow in both RRC system loops will normally be manually controlled from a single control station with no automatic controls based on flow, neutron flux, or thermal power feedback signals. The operator will set the RRC pump speed from the manual master setpoint station located at the main control room operating panel. The manual ganged control station provides an ASD speed reference demand signal to the ASDs for both RRC loops. The demand signal adjusts the supply frequency in the recirculation flow rate. The two individual loop setpoint/bias stations allow the pump speed in each loop to be adjusted separately. A bias provides an adjustment up to ±5 percent for balancing loop flows. The MEM logic shuts down the ASD by interrupting the firing signals to the SCRs. Pre-trip signals from the 6.9 kV RRA/RRB breakers, source and load isolation breakers, and RPT breakers shutdown the affected ASD while breakers are opening to prevent

damage to the SCRs. To increase system reliability, the GE-FANUC control system uses redundant power supplies and the ASD control system uses a separate uninterruptable power supply.

The ASDs are required to drive the RRC pump motors up to 1871 rpm (62.4 Hz) which is 105 percent of the rated speed. This pump speed corresponds to an ASD output frequency of approximately 63 Hz and a pump horsepower of 9500 HP. To provide adequate margin, the ASDs are designed to provide an output frequency of 66 Hz and a pump horsepower of 11200 HP.

The ASDs will be connected between the existing 6.9 kV power supply feeder breakers and the recirculation pump trip (RPT) breakers. During shutdown and low thermal power operation, the "X" winding of TR-S startup transformer supplies power to the ASDs via the non-safety-related SH-5 and SH-6 buses, while the "Y" winding of TR-S transformer supplies power to the SM-1, SM-2, and SM-3 buses (which power safety buses SM-4, SM-7, and SM-8, respectively). In the generation mode, the main generator supplies power to the main step-up transformers (TR-M) which in turn, supply power to the 500 kV transmission system. In this mode, the main generator also supplies power to transformers TR-N1 and TR-N2. The SH-5 and SH-6 buses will be transferred from the TR-S transformer to the TR-N2 transformer and the SM-1, SM-2, and SM-3 buses (which continue to supply safety buses SM-4, SM-7, and SM-8, respectively) will be transferred to TR-N1. As described above, the SM-1, SM-2, and SM-3 buses are fed from a separate winding of the TR-S transformer during shutdown and low power operation and from a separate transformer (TR-N1) after the generator is connected to the grid. Thus, there will not be any direct electrical interface between the ASDs and the safety buses.

The new ASD building is located outside of the turbine building and has no cable trays in areas associated with Class 1E safeguards systems or balance of plant control systems critical to power generation. At the 6.9 kV and 4.16 kV power level, most of the new power cabling associated with the ASDs will be located outside the main turbine building in the confines of the ASD input/output transformers and within the air conditioned ASD building that houses the solid state variable frequency drive units. Low voltage control, diagnostic, alarm, and trip signals originating at the ASD drive units and the ASD local communication cabinet will be run in twisted shielded pair wiring within rigid ferrous conduit to assure immunity to electromagnetic interference (EMI). In addition, the power cables between the ASDs and the RRC pump motors will be shielded to minimize EMI emissions.

Electronic drive systems such as the ASDs being proposed by the licensee will result in harmonic currents in the electrical distribution system. As described above, the drive systems convert ac to dc, and dc to ac. This conversion process causes a change in the sinusoidal waveform of the ac supply voltage to the drive system and produces multiples of harmonics of the fundamental electrical line frequency that can be injected back into the source ac bus. If the electrical distribution system and the ASDs share a common power supply, the harmonics currents would also be transmitted to the electrical distribution system. The harmonic currents may cause excessive heating in motors and may produce mechanical fatigue of motor shafts,

coupling, or frame, may cause regulating and control systems to operate erroneously, may cause metering and instrumentation to give erroneous information, or may cause failure or premature activation of protective relaying. Therefore, the staff evaluated the effects of harmonics on the supply sources and equipment.

IEEE Standard 519, 1992, "Recommended Requirements for Harmonic Control in Electrical Power Systems," recommends a total harmonic distortion value (THD) of 5 percent as described below. This standard has been developed to establish guidelines concerning the distortion of system voltage and current waveforms due to the behavior of non-linear load devices and primarily concerns itself with conditions at the point of common coupling between an industrial customer and the local utility system. The standard recommends that the total harmonic voltage distortion (THDv) at a general purpose bus be maintained at or below 5 percent. The standard allows 10 percent THDv for a bus serving solid state drive equipment. The IEEE conclusions and recommendations are based on the results of published quantitative analyses using established analytical techniques to determine the effects of harmonics on electrical power, control and metering equipment. In the absence of other available guidance in this area, the staff uses this standard as the basis for establishing the adequacy of installed electrical equipment at WNP-2 to operate in the presence of harmonic distortion. At WNP-2, SH-5 and SH-6 buses are not considered dedicated systems buses, therefore the total THD limits for these buses should not exceed 5 percent.

The licensee performed analyses to determine if operation of the ASD system had any significant impact on the main generator, the TR-M1, TR-M3, and TR-M4 main transformers (TR-M2 is disconnected and stored as spare), the TR-N1 and N2 normal auxiliary power transformers, the TR-S startup auxiliary power transformer, site switchyard equipment, the 500 kV and 230 kV grid, the RPT breakers, the RRC pumps and drive motors, the RRC system piping, and the reactor internals.

To evaluate the effects of injected harmonic currents on the WNP-2 plant electrical distribution system, the licensee performed a computer-based harmonic analysis. The analysis evaluated the response of the electrical distribution system to the harmonic currents injected by the ASD equipment under 44 different operating scenarios. The analyses were performed for the startup and generation modes of plant operation. The licensee evaluated five combinations of drive channels for each mode of operation. The licensee evaluated each drive channel mode for five ASD speeds (20, 40, 60, 80 and 100 percent). The magnitudes of the harmonic current components injected by the ASD units are related to the drive speed. As the drive speed and fundamental component of load current increase, the magnitudes of the lower harmonic components also tend to increase. Some of the higher frequency components reach maximum values at intermediate load levels, but the majority of the harmonic current components are greatest at full load.

The results of the analysis show that the highest THDv occurs on the SH-5 and SH-6 buses in start-up mode (connected to "X" winding of start-up transformer TR-S) and is expected to be less than 9.9 percent at full load. The highest current distortion (THDi) occurs in the TR-S transformer "X" winding in start-up mode and is expected to be less than 23 percent when operating one channel in each loop. Since the safety buses are connected to the separate "Y" winding of start-up transformer TR-S, there is no direct electrical interface. The highest voltage distortion on the safety buses is calculated to be less than 0.5 percent at full load when using the TR-S start-up transformer. However, during power operation the SH-5 and SH-6 buses are transferred to the TR-N2 transformer, while the safety buses are transferred to the TR-N1 transformer. Thus, the safety buses are further isolated from the SH-5 and SH-6 buses and the distortion is calculated to be less than 0.2 percent during normal plant operation. Since the ADSs would only be operated at 20 percent speed in the start-up mode, the highest THDv would be 2.5 percent on the SH-5 and SH-6 buses and 0.1 percent on the SMI, SM2 and SM3 buses.

The results of the harmonic analysis for the generation mode show that the THDv at the SH-5 and SH-6 buses is expected to exceed 5 percent for drive speeds near 60 percent. The largest THDv expected on SH-5 and SH-6 for drive speeds of 100 percent with the drives operating in 12-pulse mode is 8.2 percent. THDv levels at the SM1, SM2, SM3 are not expected to be greater than 0.2 percent. The THDv levels expected in generation mode are slightly less than those expected in the corresponding start-up mode. This is due to the difference in the source impedance of the system. The source impedance is greater under the start-up mode and as a consequence its associated THDv levels are slightly higher.

The licensee states that the results of the above analysis are conservative for several reasons. First, the analysis assumes that all ASD harmonic contributions are in phase and additive, rather than random as would be expected under operation. Second, during startup, the licensee assumed that the ASDs were operating at 100 percent speed when supplied by the TR-S transformer when in reality the ASDs would normally be operating above 50 percent while connected to the TR-S transformer. Finally, the analysis assumes the ASDs are operated at the unit rating of 11200 HP rather than the maximum (63 Hz) RRC pump load of 9500 HP. A change in horsepower rating from 11200 HP to 10000 HP alone changes the calculated maximum generation mode THDv level at the SH-5 and SH-6 buses from 8.2 percent to 7.0 percent with a corresponding reduction at the 480 V buses (powered from SH-5 and SH-6 buses) from 6.5 percent to 5.5 percent when connected to the TR-N2 transformer.

The licensee performed onsite operational testing of the ASDs in June 1995. The ASDs were connected to a 7000 HP motor-generator unit and tested to verify proper operation during various speed and loading combinations. During the testing, the licensee monitored THDv at SH-6 (ASD power supply) and SM-1 (safety related bus power supply) with the plant connected to the TR-S startup transformer. With all four channels of the ASDs operating at approximately 30 percent load, the highest THDv was 5.2 percent as measured at SH-6, with a corresponding value of 0.7 percent measured at SM-1. These actual measured THDv values are higher than for comparable load due to the design and size

differences between the test motor and the RRC pump motor. In general, the measured THDv values increased with increasing ASD load and exhibited the same decreasing rate of change with increasing ASD load that was predicted by the analysis. Therefore, based on analysis and testing completed to date, the licensee contends that the ASD harmonics will not have a significant impact on the electrial equipment. Based on its review of the above information, the staff agrees with the licensee that since the safety buses at WNP-2 are powered from a separate winding of the TR-S transformer during startup and entirely from a separate transformer (TR-N1) after the generator is connected to the grid, the effect of harmonics on the safety buses is very low and therefore the safety related equipment for WNP-2 will not be adversely affected by harmonic distortion by the operation of the ASDs.

The staff also evaluated the effects of harmonics on the non-safety loads downstream and upstream of the SH-5 and SH-6 buses to assure that non-safety equipment subject to harmonic distortion operates satisfactorily and its premature failure does not create any plant transient. In particular, the staff was concerned about the effect of harmonics on the TR-S and TR-N2 transformers which supply power to the safety buses during low power and normal operation respectively. Furthermore, the results of the testing done so far indicate that the total harmonic distortion values during startup and power operation on non-safety buses SH-5 and SH-6, as well as these transformers and other non-safety-related equipment, exceeds the IEEE standard 519-1992 recommended value of 5 percent. By letter dated April 4, 1996, the licensee submitted an evaluation of harmonics related to the heating of the non-safety-related loads downstream and upstream of the SH-5 and SH-6 buses (the primary loads on the SH-5 and SH-6 buses are non-safety-related transformers and motors) which are tolerant of harmonics even above 5 percent. The effect of harmonics on these types of loads generally results in reduction in expected life due to additional winding heating as discussed below.

Non-sinusoidal voltages applied to rotating electric machines can cause overheating, pulsating torque, or noise if excessive levels exist. Rotor heating is usually the main concern associated with excessive THDv levels. NEMA Standard MG-1-1987," Motors and Generators," Part 17A, addresses motor application considerations for constant speed motors used on sinusoidal bus with harmonic content. This standard was used to calculate a derating factor for induction motors based on the calculated harmonic voltage factor (HVF). A HVF of 0.02779 was calculated for the 6.9 kV SH-5 and SH-6 buses for 100 percent speed in the startup mode of operation. The derating factor corresponding to this HVF is 1.0, which indicates that no derating is required for the motors. The HVF calculated for the SH-5 and SH-6 buses is considered worst case since these buses are closest to the ASD harmonic source. The HVF for the other non-safety-related motor loads downstream of the SH-5 and SH-6 would be lower due to the increased separation from the harmonic source. Therefore, the licensee concluded that no motor derating for the motors connected to the SH-5 and SH-6 buses is necessary. Based on its review of the above information, the staff agrees with the licensee's conclusion.

With regard to the effect of harmonics on TR-N2 and TR-S, the licensee performed an harmonic analysis on the 6.9 kV electrical system to determine

the effects of the harmonics imposed on the system by the operation of ASDs. The primary effect of power system harmonics on transformers is the additional heat generated by the losses caused by the harmonic currents. When high harmonic load current magnitudes are transformed, additional heat is generated in the transformer which may require load capability derating to remain within the transformer temperature rating. The primary loss components are winding I^2R losses, winding eddy-current losses, and stray losses. This additional heating will effectively reduce the nameplate rating of the transformers due to winding temperature limitations. Since the TR-S and TR-N2 transformers must carry additional harmonic currents during ASD operation, the licensee determined that transformers TR-S and TR-N2 must be derated by 4.47 percent and 9.43 percent respectively, based on their forced air (FA) rating, to reflect the additional winding heating and associated temperature rise caused by the harmonic currents. The licensee also determined that ASD loading must be limited while powered from the TR-S transformer at its derated capability. Consequently, the licensee stated that they will restrict ASD operation to two ASD operation at 50 percent speed or one ASD operation at 100 percent speed while connected to the TR-S transformer. The TR-N2 transformer is expected to be within its derated capability and therefore, no limitations on ASD or transformer operation should be necessary for TR-N2.

The staff was concerned that with the derating of the TR-S transformer which supplies offsite power to the safety-related buses during unit trip, startup and accident conditions, the licensee may not be within its orignal design basis with regard to the capacity and capability of the offsite power system to supply power to the safety loads to satisfy the requirements of GDC 17. The staff was also concerned that the derating of the TR-S transformer may unnecessarily challenge the undervoltage and degraded voltage relays during normal and accident loading conditions. The staff requested the licensee to re-analyze this aspect of the design. By letter dated May 16, 1996, the licensee submitted the results of an analysis of the current loading of these transformers for staff review. The results of the analysis demonstrates that the total loading on TR-S and TR-N2 transformers is still within the derated rating of the transformers, including the required fundamental and harmonic currents for ASD operation. Furthermore, the results of the analysis indicates that the minimum steady-state voltage drops established for the LOCA loads are above the maximum technical specification allowable values for the undervoltage and degraded voltage relay setpoints. Therefore, the safety-related 4.16 kV undervoltage and degraded voltage relays will not be inadvertently challenged during the normal or accident conditions. Based on its review of the above information, the staff concludes that derating of the transformer is acceptable for existing bus loadings. However, if additional loads are added to TR-N2 and TR-S transformers in the future, such that the loads exceed the derated KVA capacity of the transformer, the licensee would be required to justify, prior to adding the loads, the acceptability of the electrical distribution system to withstand harmonic distortion, including an evaluation of need for harmonic filters upstream of the ASD equipment to limit the harmonic distortion.

During normal power operation, the ASD system uses two channels (12 pulse mode) to control the RRC pump drive motors. In the event one channel is lost,

the operating mode is reduced from 12 to 6 pulse mode. The ASD system then begins operating in the current limit mode. One channel is not capable of supporting the power requirements for pump drive motor operation at a speed of 63 Hz (1871 rpm). Therefore the ASD control system automatically reduces ASD speed to the capability of the remaining channel which is approximately 52 Hz. At 52 Hz, the motor will be operating at current and voltage consistent for that operating speed. The staff was concerned that this capability of the ASD system has never been demonstrated by a test and whether the operational mode of changing of the ASD from 12 pulse mode to 6 pulse mode on a loss of one channel would really work.

By letters dated May 8 and May 16, 1996, the licensee committed to include in the power ascension testing program (1) a test to verify that on a loss of a single channel when operating in 12-pulse mode, the remaining operation channel will automaticaly runback from an initial speed to the 52.2 Hz speed and operates as designed, and (2) to monitor the harmonic levels and compare them to the previous results to assure that the THD levels will remain within established limits. Plant specific harmonic levels will also be used to recalculate the final derating factors for TR-S and TR-N2 transformers. Based on the above, the staff finds the ASD design to be acceptable and plans to perform confirmatory monitoring of the licensee's test results.

Instrumentation and Control

The ASDs are a dual channel system and each channel has its own nonredundant microprocessor controller that controls each ASD channel and monitors the ASD operating state. The microprocessor controller initiates alarms to inform the main control room operator when failures are detected or when an ASD has tripped. The microprocessor also includes self-test features and provides fault diagnostics and annunciator alarm information to the main control room via a video display terminal (VDT).

In its letter dated October 26, 1995, the licensee listed alarms that are annunciated in the control room. By letter dated March 12, 1996, the licensee provided additional discussion on these alarms. The two hardwired alarms from each of the ASD channels annunciated in the control room are "ASD ALARM" and "ASD FAULT." Various alarms are displayed on the video display terminal, including Bus A, B, and C Genius (the input/output communication bus controller) input/output (I/O) Trouble, and operating limit conditions - ASD Channel Failure, Rx Level Low, Recirc A or B High Flow Delta, and Delta T Cavitation.

The control input signal originates from a manual master setpoint station located at the main control room operating panel. This signal is used by the digital control system logic to adjust the frequency output of the ASDs for the desired speed for both pumps or as individually selected. Power to the RRC pump motor will be tripped off or reduced in frequency to runback the pump speed for selected transients or abnormal events. These trips and runbacks are either the same or equivalent to those provided by the existing analog-hydraulic flow control system.

The licensee's March 12, 1996, letter discussed the staff concern pertaining to the ASD overfrequency relays. A separate electromagnetic frequency relay is mounted on the 6.9 KV bus which feeds the RRC pump motor. If the frequency to the motor is greater than the relay trip setting, the relay will trip the ASD feeder breaker and the recirculation pump trip (RPT) breaker.

An overspeed trip is incorporated into each ASD channel MEM unit. If the frequency at the ASD output terminals exceeds the over speed trip setting, the ASD channel will be automatically tripped.

The existing master controller, flux controller, and flow controller process control modules will be replaced with a digital RFC system. The functions of the process control modules will be replaced with I/O modules operated by a software driven microprocessor CPU in the RFC system. The performance of the digital RFC system can be checked during plant outage maintenance periods by an externally connected "work master" station that can interrogate the system status. No software changes can be made without an authorized software access code that is keyed in at the "work master" station.

The licensee's March 12, 1996, letter discussed the staff concern regarding indications to the operator when the limiting functions in the Factory Automation Numeric Controls (FANUC) or Medium Electronic Module (MEM) units override the operators demand. When this occurs the following limits are annunciated which communicate to the operator that the ASD is in a "limit mode.": ASD Channel Failure; Rx Level Low; Delta T Cavitation; Recirc A or B High Flow Delta; Feedwater Pump Trip.

The licensee discussed the reliability of the FANUC MEM units. System failure rates of 1.25E-06 and 4.26E-06 per system demand were calculated for the RFC system GE-FANUC control logic and the entire ASD system, respectively. The licensee considers these failure rates low for non-safety-related systems. The licensee therefore predicts high system reliability. Additionally, the licensee provided information on the operating experience of the software. The software is programmed using modules which were developed, tested and verified through operating experience over the last 8 to 10 years. The failure rate information was derived from manufacturer information and industrial failure rate information.

The ASD system is placed in the "Ready" (meaning ready to start-up) mode locally once the source and load circuit breakers are closed. In the "Ready" mode, the control room operator can initiate a "Start" signal and the ASD microprocessor will ramp the ASD to the minimum frequency set by the RFC system frequency demand reference signal. This is referred to as a "soft start" because only a single channel of the ASD is required to provide the "break away" torque and provide 1 to 2 Hz to the RRC pump. At this point, the second channel ASD switches into range (15Hz). This design significantly reduces the starting current and motor winding heat-up and also eliminates the 25 percent to 100 percent speed transfer transient thereby increasing the induction motor life.

During normal startup, the master channel alone (6 pulse operation) will go through the normal start-up sequence until a minimum speed of 15 Hz is reached. Once the minimum speed is reached, the slave channel starts, synchronizes with the running motor and continues the start up sequences. The ASD is only capable of 6 pulse operation in 15 Hz. There is a 0.5 second delay associated with the slave channel such that the slave channel starts approximately 0.5 second after the initial start.

During normal operation, the ASD system uses two channels (12 pulse mode) to control the RRC pump drive motors. In the event one channel is lost, the operating mode is reduced to 6 pulse using the remaining channel. One channel is not capable of supporting the power requirements for pump drive motor operation at a speed of 63 Hz. Therefore, the speed is automatically reduced to the capability of the remaining channel which is approximately 52 Hz. Because of the large torque capacity of a single ASD system, the loss of one channel has a moderate effect at high reactor power and a negligible effect at low reactor power. The loss of a single channel at high pump speed is a power decreasing transient. The rate of decrease of pump speed is limited. The loss of a single channel at low to moderate speed is a minor transient in which the remaining channel assumes the pump load.

The licensee's March 12, 1996, letter discussed the manner in which the logic provides for continued acceleration if there is a failure of one of the ASD channels between 2 and 15 Hz. If a slave channel failure occurs during startup with the master channel operating, the master channel would continue the startup sequence. Since the slave channel design precludes synchronizing with the running motor at 15 Hz to provide 12 pulse operation, the master channel would continue in only 6 pulse operation. A failure of either the master or slave channel will be indicated to the control room operators by a fault annunciation. The GE-FANUC also automatically limits the maximum speed to 52 Hz for single channel operation.

While operating in the 12 pulse mode above 52 Hz, a loss of one ASD channel results in the following system responses: (1) the speed reference of the GE-FANUC controls and the maximum speed limit of the operating ASD channel immediately drops to 52 Hz; and (2) upon transferring from the 12 to 6 pulse mode on the loss of one ASD channel, the remaining ASD channel will begin operating in the current limit mode. The current to the RRC pump motor will be reduced approximately 70 percent. The motor will begin to ramp down in speed to 52 Hz, but not as fast as the normal coast down rate of the pump/motor. Just before reaching 52 Hz, the motor current load will be below the current limit of the ASD channel. At 52 Hz, the motor will be operating at a current and voltage consistent with that operating speed. Thus, there would be no adverse effects on the system as a result of motoring from 60 Hz to 52 Hz.

Multilayered diagnostic and troubleshooting capability is included in the drive power and electronic circuitry. Some of the main elements of this capability are: (1) self testing of critical microcomputer systems elements every time the control is reset or power applied, (2) a memory type fault monitor which displays the cause of shutdowns in a printed message at the

printer, and (3) lights on the front of cards provide overcurrent, overvoltage, and overspeed indication in the electronics module.

The licensee discussed the ASD quality assurance (QA) program including software QA, validation and verification, and configuration management. The ASDs, including the software, were manufactured under a General Electric (GE) quality assurance program. Verification and validation and configuration control practices were performed according to International Organization for Standardization (ISO) 9000 standards.

GE Fanuc Automation in Charlottesville, Virginia manufactured the GE FANUC hardware. The FANUC hardware was manufactured under a quality control management program which was standard for the industry in 1992, when the equipment was shipped to WNP-2. GE Drive System (GEDS) in Salem, Virginia manufactured and configured the MEM unit.

The licensee maintains software configuration management for the GEDS control through use of a standard firmware design which cannot be modified in the field by the user. A field change notice is issued to Product Service to order and ship new PROMs to the job site to correct identified problems.

GE-Nuclear Engineering (GE-NE) in San Jose, California configured the GE FANUC software. The software, which can be modified in the field by the user, was designed under the GE quality control program. If any changes are made to the software during installation or testing, GE will issue a design change and revised controlled document. The licensee has implemented an error and change reporting program to correct errors and to make changes to the GEDS.

The licensee did not perform a QA audit of GEDS or GE-FANUC. However, the GEDS QA program was reviewed by an independent third party. The staff considers that the measures taken comply with ISO 9000 standards and are appropriate and consistent, given the system's importance to safety.

The RFC system GE-FANUC digital equipment is to be installed in the main control room. The GE-FANUC equipment is designed to perform in industrial environments and, as such, the equipment was tested to meet test standards for EMI emissions and immunity in excess of those anticipated. The licensee's EMI analysis showed that the GE-FANUC equipment will have no impact on the electromagnetic environment in the control room.

Based on its review of the above information, the staff considers the ASD instrumentation and controls acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Washington State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

Pursuant to 10 CFR 51.21, 51.32 and 51.35, an environmental assessment and finding of no significant impact was published in the Federal Register on April 1, 1996 (61 FR 14337).

Accordingly, based upon the environmental assessment, the Commission has determined that issuance of this amendment will not have a significant effect on the quality of the human environment.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

Attachment: Table

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TABLE 1

ASD SYSTEM AUTOMATIC ACTIONS

	SENSED CONDITION	ACTION
1)	Rate of speed change demanded is too high in either the increase or decrease direction.	Limit rate of change until desired speed setpoint is reached.
2)	Frequency demanded is too high.	Limit frequency to max frequency.
3)	One feedwater pump tripped and reactor water level less than or equal to +31.5 inches (Level 4).	Reduce speed to 45%.
4)	Reactor water level less than or equal to +13 inches (Level 3).	Reduce speed to 25%.
5)	Temperature difference between the vessel steam dome and the pump suction is less than 9.9 °F.	Reduce speed to 25%.
6)	One ASD channel is tripped. capacity of the remaining	Reduce speed to the load channel.
7)	Turbine trip and/or generator load reject event	Pump trip
8)	Suction or discharge block valves less than 90% open	Pump trip
9)	Pump motor or ASD (both channels in a loop) electrical system protection logic	Pump trip
10)	High reactor pressure (>1076psig) or low level -50 inches (Level 2)	Pump trip
11)	ASD output overfrequency	Pump trip