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December 19, 2005
LIC-05-0135

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

References:
1. Docket No. 50-285
2. NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004
3. Letter from OPPD (Harry J. Faulhaber) to NRC (Document Control Desk), Follow-up Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated August 31, 2005 (LIC-05-0101)

SUBJECT: Fort Calhoun Station Unit No. 1 License Amendment Request, "Reduce the Number of Required Operable Containment Spray Pumps"

Pursuant to 10 CFR 50.90, the Omaha Public Power District (OPPD) hereby transmits an application for amendment to the Fort Calhoun Station Unit 1 (FCS) Operating License. Attachment 1 provides the No Significant Hazards Evaluation and the technical basis for this requested change to the Technical Specifications (TS). Attachments 2 and 3 contain the marked-up and clean-typed Technical Specification pages reflecting the requested Technical Specifications and Basis changes.

The proposed change will revise FCS Technical Specification 2.4, "Containment Cooling," (and associated Bases) to reduce the required number of operable Containment Spray (CS) pumps from three to two in order to enhance net positive suction head (NPSH) margins. This change will be accomplished by disabling the containment spray actuation signal (CSAS) automatic start feature of CS pump SI-3C. This change will reduce the head loss across the containment sump strainers during the recirculation phase of a design basis accident (DBA) by reducing flow rates, and will improve NPSH available ($NPSH_A$). The enhancement in the NPSH performance will be

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realized due to a reduced sump strainer approach velocity, with an accompanying reduction in pressure drop across the strainer and a reduction in piping head loss. Additionally, two of the three CS pumps share a common suction line and reducing the number of CS pumps that operate in response to a DBA ensures that only a single CS pump will be using this common suction line thus reducing velocity and head loss in the piping which means increased NPSH margin for the SI-3B pump.

This license amendment request represents a portion of the actions required to satisfy the applicable regulatory requirements with respect to NRC Generic Letter (GL) 2004-02 (Reference 2) as it relates to the CS system. OPPD's full response to GL 2004-02 is contained in Reference 3. OPPD's response to NRC Request 2e in GL 2004-02 indicated that defeating the automatic start feature of one of the CS pumps would be a possible option to improve NPSH margin.

No commitments are made in this letter.

OPPD requests approval of the proposed amendment by September 1, 2006, with an implementation period of no later than the end of the 2006 Refueling Outage currently scheduled to begin September 9, 2006.

I declare under penalty of perjury that the foregoing is true and correct. Executed on December 19, 2005.

If you have any questions or require additional information, please contact Mr. T. C. Matthews at (402) 533-6938.

Sincerely,

R. T. Ridenoure
Vice President
Omaha Public Power District

RTR/RLJ/rlj

Attachments:
1. OPPD's Evaluation of the Proposed Change
2. Markup of Technical Specifications and Bases pages
3. Clean-Typed Technical Specification Page

c: Division Administrator – Public Health Assurance, State of Nebraska

ATTACHMENT 1
Omaha Public Power District's
Evaluation of the Proposed Change

Reduce the Number of Required Operable Containment Spray Pumps

1.0 DESCRIPTION

This letter is a request to amend Operating License DPR-40 for Fort Calhoun Station (FCS), Unit No. 1.

The proposed change will revise FCS Technical Specification (TS) 2.4, "Containment Cooling," (and associated Bases) to reduce the required number of operable containment spray (CS) pumps from three to two. This change will be accomplished by disabling the containment spray actuation signal (CSAS) automatic start feature of CS pump SI-3C, which is one of the two CS pumps that are associated with diesel generator DG-2. The automatic start feature for the remaining CS pumps (SI-3A and SI-3B), which are associated with DG-1 and DG-2, respectively, are not affected.

Evaluations have shown that the net positive suction head (NPSH) margin for the CS and high pressure safety injection (HPSI) pumps during the recirculation phase of a design basis accident (DBA) can be enhanced by reducing the flow to and through the containment sump strainers when the HPSI and CS pumps are operating in the recirculation mode in response to a DBA (the low pressure safety injection (LPSI) pumps are shut off following a recirculation actuation signal). This reduction in flow will be accomplished by reducing the number of CS pumps that automatically start during a DBA from three to two. The enhancement in the NPSH performance will be realized due to a reduction in pressure drop across the strainer, a reduction in piping head loss and a reduction in debris transport. This will provide additional margin for the NPSH available ($NPSH_A$) for the HPSI and CS pumps taking suction from the containment sump and will increase the time to the initiation of a recirculation actuation signal (RAS). Additionally, two of the three CS pumps share a common suction line; therefore, by reducing the number of CS pumps that operate in response to a DBA only a single CS pump will be using this common suction line which reduces velocity and head loss in the piping resulting in increased NPSH margin.

License Amendment 235 (Reference 7.9) provided temporary approval to revise the Technical Specification 2.4 Bases to include manually securing all but one containment spray pump following a loss-of-coolant accident (LOCA) when certain conditions are satisfied. This operator action would further increase the NPSH benefits noted above. This amendment was requested and implemented as a compensatory action associated with NRC Bulletin 2003-01 (Reference 7.10) and NRC Generic Letter (GL) 2004-02 (Reference 7.11).

OPPD anticipates that some action items required to satisfy the requirements of GL 2004-02 will not be completed prior to the implementation of the changes proposed in this license amendment request (LAR). The actions approved in temporary License Amendment 235 complement the proposed changes included in this LAR, and therefore will remain in effect until full compliance with GL 2004-02 is achieved.

2.0 PROPOSED CHANGE

The proposed change will remove CS pump SI-3C from the list of operable equipment required for Technical Specifications (TS) Limiting Conditions for Operation (LCO) 2.4(1)a.ii, "Containment Cooling." An exclusion to prevent SI-3A and SI-3B from being simultaneously inoperable is being added to the modification of minimum requirements in TS 2.4(2)a .

The following revisions to the basis of TS 2.4 are associated with the proposed change:

- Addition of a note to the basis section that discusses the engineered safeguards electrical buses to indicate that even though CS pump SI-3C is connected to the center bus, the pump is only available for manual operation;
- Revision of the discussion related to the limiting loss of coolant accident (LOCA) scenario to indicate that one of the two spray pumps, instead of "one of the three spray pumps," would be available to limit the containment pressure to below the design value without taking credit for the air coolers or the cooling capacity of the safety injection system; and
- Revision of the discussion related to failure of one diesel-generator during a DBA to reflect that one spray pump, rather than "at least one spray pump," would be connected to the available diesel-generator.

Additionally, the proposed change will also make the following revisions to the basis of TS 2.7:

- Revision of the discussion related to the loss of an entire 4.16 kV bus to reflect that if bus 1A3 is lost it would leave one CS pump available rather than two.

The proposed changes will be implemented through disabling of the automatic start logic for CS pump SI-3C. The disabling of the automatic start logic for CS pump SI-3C enhances the NPSH margins during a DBA by reducing the flow to and through the associated containment sump strainer when the HPSI and CS pumps are operating in response to a DBA. This reduction in flow reduces the debris transport to the strainer, reduces the pressure drop across the strainer and associated piping, maximizes the $NPSH_A$ for the pumps taking suction from the containment sump, and increases the time to the initiation of a RAS. Additionally, CS pumps SI-3B and SI-3C share a common suction line and disabling the automatic start logic for CS pump SI-3C ensures that only a single CS pump will be using this suction line in response to a CSAS. The reduction of flow in the common suction line will result in reduced velocity in the piping and reduced piping head loss which means increased NPSH margin for the SI-3B pump.

3.0 BACKGROUND

System Description

The design basis functions of the CS system and the description of the containment spray actuation signal are discussed in FCS Updated Safety Analysis Report (USAR) Sections 6.2 (Reference 7.1), 6.3 (Reference 7.2) and 7.3.2.4 (Reference 7.3).

The CS system consists of the safety injection and refueling water tank (SIRWT), three spray pumps, two heat exchangers (shutdown cooling heat exchangers) and all necessary piping, valves, instruments and accessories. The pumps discharge the borated water through the two heat exchangers to a dual set of spray headers and spray nozzles in the containment. One pump operation is sufficient to meet the capacity requirements in the event of a DBA. A CS valve interlock assures that one valve remains closed if only one spray pump is available, to prevent a pump run-out condition.

Two spray pumps (SI-3B and SI-3C) are located in one engineered safeguards room, along with one HPSI (SI-2B) and one low pressure safety injection (LPSI) (SI-1B) pump. The third spray pump (SI-3A) is located in the second engineered safeguards room with one LPSI (SI-1A) and two HPSI pumps (SI-2A and SI-2C). Each engineered safeguards room has a separate pump suction from both the SIRWT and the containment recirculation line inlet to ensure that the pumps in one room will have adequate suction if the suction line to the second room fails.

CS pumps SI-3B and 3C, LPSI pump SI-1B, and HPSI pump SI-2B are powered from diesel-generator DG-2 during a Loss of Offsite Power (LOOP). CS pump SI-3A, LPSI pump SI-1A and HPSI pumps SI-2A and 2C are powered from diesel-generator DG-1 during a LOOP. During a DBA, CS pumps SI-3B, and SI-3C and HPSI pump SI-2B are supplied through containment sump strainer SI-12A, and CS pumps SI-3A and HPSI pumps SI-2A and SI-2C are supplied through containment sump strainer SI-12B following the recirculation actuation signal (RAS). The RAS is generated when SIRWT level drops to 16 inches.

CS System Design Basis Function

The function of the CS system is to limit the containment pressure rise and reduce the leakage of airborne radioactivity from the containment by providing a means for cooling the containment following a LOCA. This system reduces the leakage of airborne radioactivity by effectively removing radioactive particulates from the containment atmosphere. Removal of radioactive particulates is accomplished by spraying water into the containment atmosphere. The particulates become attached to the water droplets which fall to the floor and are washed into the containment sump. The iodine removal capability during the first 30 days of the DBA (Large Break LOCA) is discussed in FCS USAR Section 14.15, Safety Analysis – Loss-of-Coolant Accident (Reference 7.4).

Pressure reduction is accomplished by spraying cool, borated water into the containment atmosphere which provides a means for cooling the containment atmosphere. Heat removal is accomplished by recirculating and cooling the water through the shutdown cooling heat exchangers. The system is independent of the containment air cooling and filtering system. The CS system is designed for a heat removal capacity that is sufficient to maintain the peak containment pressure below the design limit as discussed in FCS USAR Section 14.16, Safety Analysis - Containment Pressure Analysis (Reference 7.4).

The minimum required hydraulic performance for a CS pump is calculated based on the credited CS flow in the LOCA containment pressure analysis for the one-pump, one-header operating mode as discussed in FCS USAR Section 14.16, Safety Analysis - Containment Pressure Analysis (Reference 7.4).

System Automatic Initiation

Containment spray operation is initiated by the same basic signals as safety injection, but in a different logic combination. The Containment Spray Actuation Signal (CSAS) results from coincidence of pressurizer pressure low and containment pressure high, both on a two-out-of-four basis. The CSAS brings the system to full operation. Initially, the pumps take suction from the SIRWT. Upon reaching low tank level the recirculation actuation signal (RAS) is initiated, automatically transferring the pump suction to the containment recirculation line inlet from the containment sump.

Reason for Proposed Change:

This license amendment request represents a portion of the actions required to satisfy the applicable regulatory requirements with respect to GL 2004-02 as it relates to the CS system. OPPD's response (Reference 7.14) to NRC Request 2e in GL 2004-02 indicated that defeating the automatic start feature of one of the CS pumps would be a possible option to improve NPSH margin.

Conditions That The Proposed Change Is Intended To Resolve:

The proposed change will improve NPSH margins for the CS and HPSI pumps. Evaluations have shown that the NPSH margin for the CS and HPSI pumps can be enhanced by reducing the flow to and through the containment sump strainers when the HPSI and CS pumps are operating in the recirculation mode in response to a DBA. This reduction in flow will be accomplished by reducing the number of CS pumps that automatically operate during a DBA from three to two. The largest benefit will be realized by reducing pressure drop across the strainer due to the reduced flow velocity. This will provide additional margin for the $NPSH_A$ for the HPSI and CS pumps taking suction from the containment sump pool. Additionally, CS pumps SI-3B and SI-3C share a common suction line; therefore, by disabling the automatic start logic for CS pump SI-3C only a single CS pump will be using this suction line in response to a CSAS. The reduction of flow in the common suction line will result in reduced velocity in the piping and reduced piping head loss which increases NPSH margin for the SI-3B pump.

Another benefit of the proposed change would be a delay in RAS and increased sump pool turnover time during a DBA. This change is beneficial in that it allows any accident generated debris that is transported to the containment sump pool more time to settle to the floor and thus be less likely to be drawn to the containment sump strainer following RAS. In addition, the sump pool flow velocity will be reduced also reducing debris transport.

Changes to Current Operation of the CS Pumps:

Currently, all three CS pumps are started by the CSAS via the auto-start sequencers. Following the proposed modification to the CS system, only two pumps (SI-3A and SI-3B) will be automatically started by the CSAS, one pump per train. CS pump SI-3C will remain connected to the electrical bus associated with diesel generator DG-2; however, it will have manual start capabilities only and is intended to be used to replace SI-3A when SI-3B is not running or replace SI-3B at any time.

Changes to Current Operation of the CS Spray Header Valves:

Currently, following a CSAS signal one spray header valve will open, with the second spray header valve opening only if CS pumps SI-3B and SI-3C start. This logic is to ensure that there will not be only one CS pump running with both spray header valves hand control valves (HCV-344 and HCV-345) open, which could result in run-out and potential inoperability of a single CS pump. Following the proposed modification, this same logic philosophy will be maintained; however, it will be accomplished in a different manner since CS pump SI-3C will no longer automatically start on CSAS. The logics for the spray header valves have been redesigned as follows:

- HCV-344 will open when CSAS is received and SI-3B is running. The HCV-344 solenoid is powered from 125V DC bus #1 (Train A) and SI-3B is powered from a Train B 480V AC Bus.
- HCV-345 will open when CSAS is received and SI-3A is running. The HCV-345 solenoid is powered from 125V DC bus #2 (Train B) and SI-3A is powered from a Train A 480V AC Bus.

Because the spray header valves are air operated valves and fail open on loss of DC power, a cross-train interlock has been provided, as noted above. This ensures that on any single failure associated with the CS system, or the AC or DC power systems, a single CS pump will not be running with two spray header valves open. It is acceptable to have one CS pump running with a single spray valve open or two CS pumps running with a single spray valve open.

The following provide examples of CS system response following a CSAS with the indicated single failure:

If 125V DC bus #2 (Train B) fails in conjunction with a CSAS, the following will occur:

- CS pump SI-3A will start on CSAS;
- CS pump SI-3B will not start due to the DC Bus #2 failure since the pump breaker requires DC power to close;
- Spray header valve HCV-345 will fail open due to loss of DC power to its solenoid; and
- Spray header valve HCV-344 will remain closed since CS pump SI-3B is not running.

If 125V DC bus #1 (Train A) fails in conjunction with a CSAS, the following will occur:

- CS pump SI-3B will start on CSAS;

- CS pump SI-3A will not start due to the DC Bus #1 failure since the pump breaker requires DC power to close;
- Spray header valve HCV-344 will fail open due to loss of DC power to its solenoid; and
- Spray header valve HCV-345 will remain closed since CS pump SI-3A is not running.

If Train A 480V AC Bus fails in conjunction with a CSAS, the following will occur:

- CS pump SI-3B will start on CSAS;
- CS pump SI-3A will not start due to loss of Train A AC power;
- Spray header valve HCV-344 will open due to CSAS signal and CS pump SI-3B running; and
- Spray header valve HCV-345 will remain closed since CS pump SI-3A is not running.

If Train B 480V AC Bus fails in conjunction with a CSAS, the following will occur:

- CS pump SI-3A will start on CSAS;
- CS pump SI-3B will not start due to loss of Train B AC power;
- Spray header valve HCV-345 will open due to CSAS signal and CS pump SI-3A running; and
- Spray header valve HCV-344 will remain closed since CS pump SI-3B is not running.

Because the CS pump discharge headers join into a common header upstream of the spray header valves, it does not matter which spray header valve opens for a particular CS pump running.

Technical Specifications LCO 2.4(2)c and 2.4(2)d discuss the operability of valves, interlocks and piping associated with the Containment Cooling System. LCO 2.4(2)c discusses those components directly associated with the equipment listed in LCO 2.4(1)a.i and ii; these components are required to meet the same requirements as the equipment listed in LCO 2.4(1)a.i and ii that they are directly associated with. LCO 2.4(2)d discusses those components not included in 2.4(2)c; these components are only allowed to be inoperable for 24 hours. Currently containment spray header valves HCV-344 and HCV-345 are related to the operation of CS pumps SI-3A, 3B, and 3C; however, due to their control logics, they fall under LCO 2.4(2)d. Following the proposed change, the HCV-344 spray header valve and associated logic will be directly related to CS pumps SI-3B; similarly HCV-345 spray header valve and associated logic will be directly related to CS pumps SI-3A. Since the spray header valves are directly related to the operation of the CS pumps they will fall under LCO 2.4(2)c, i.e., if a CS pump or associated spray header valve becomes inoperable, 7 days will be allowed to restore the component(s) in accordance with LCO 2.4(1)b and 2.4(2)c.

Temporary License Amendment 235 Allowances:

License Amendment 235 temporarily allows (for a portion of Cycle 22 and all of Cycles 23 and 24) operators to manually secure all but one containment spray pump following a loss-of-coolant accident (LOCA) when certain conditions are satisfied, in order to minimize the potential for containment sump clogging. As part of that amendment implementation, the Basis of TS 2.4 and USAR Section 6.3.4 were revised to include the acceptable bounding conditions for securing excess CS pumps. The use of this allowance would result in securing two of the three automatically started CS pumps.

Amendment 235 assumptions included the automatic start of three CS pumps and manual securing of two of those pumps. All of the conditions contained in Amendment 235 will be bounded and the intended results will be enhanced following the implementation of this LAR, because only two CS pumps will automatically start. Operators will therefore have one less CS pump to secure.

OPPD anticipates that some action items required to satisfy the requirements of GL 2004-02 will not be completed prior to the implementation of the changes proposed in this LAR. The actions approved in temporary License Amendment 235 complement the proposed changes included in this LAR, and therefore will remain in effect until full compliance with GL 2004-02 is achieved.

4.0 TECHNICAL ANALYSIS

The proposed TS change will allow disabling of the automatic start logic for CS pump SI-3C. This will enhance NPSH margin for the CS and HPSI pumps during the recirculation phase of a DBA by reducing the flow to and through the containment sump strainers. This reduction in flow reduces the debris transport to the strainers, reduces the pressure drop across the strainers and associated piping, and maximizes the $NPSH_A$ for the pumps taking suction from the containment sump. Additionally, CS pumps SI-3B and SI-3C share a common suction line; therefore, by disabling the automatic start logic for CS pump SI-3C only a single CS pump will be using this suction line in response to a CSAS. The reduction of flow in the common suction line will result in reduced velocity in the piping and reduced piping head loss which means increased NPSH margin for the SI-3B pump.

Another benefit will be a delay in the RAS. A delay in RAS allows any accident generated debris that is transported to the containment building floor to settle to the floor and thus be less likely to be drawn to the containment sump strainer following RAS.

<u>Benefits and Reliability Discussion</u>

The following benefits are associated with the disabling of the automatic start capability of CS pump SI-3C and having at most two CS pumps operating following a containment spray actuation signal:

- Increased $NPSH_A$ margin for Safety Injection System

  Following RAS, if a sufficient amount of debris accumulates on the containment sump strainer, the debris bed would reach a critical thickness at which the head loss across the debris bed could exceed the NPSH margin required to ensure the successful operation of the HPSI and CS pumps in the recirculation mode (the LPSI pumps are shut off following a RAS). A loss of NPSH margin for the pumps as a result of the accumulation of debris on the recirculation sump strainer, referred to as sump clogging, could result in degraded pump performance and eventual pump failure.

NPSH margin for the CS and HPSI pumps during the recirculation phase of a DBA can be enhanced by reducing the flow to and through the containment sump strainers. Evaluations have shown that a reduction in flow will result from minimizing the number of CS pumps that operate during a DBA. The enhancement in the NPSH performance will be realized due to a reduction in debris transport to the sump strainers (as a result of reduced approach velocity) with an accompanying reduction in pressure drop across the strainers and a reduction in piping head loss. This will provide additional margin for the $NPSH_A$ for the HPSI and CS pumps taking suction from the containment sump. Additionally, CS pumps SI-3B and SI-3C share a common suction line; therefore, by disabling the automatic start logic for CS pump SI-3C only a single CS pump will be using this suction line in response to a CSAS. The reduction of flow in the common suction line will result in reduced velocity in the piping and reduced piping head loss which means increased NPSH margin for the SI-3B pump.

- Delayed time to RAS

The depletion rate of the SIRWT is a direct function of the flow rate through the HPSI, LPSI, and CS pumps. CS pump flow rate is a significant contributor to the total pre-RAS flowrate from the SIRWT. Therefore, a reduction in the number of CS pumps that would automatically start in response to a CSAS from three to two would be beneficial, i.e., it would result in a delay in RAS actuation. A delay in RAS would allow any accident- generated debris transported to the containment sump pool additional time to settle to the floor and thus be less likely to be drawn to containment sump strainers following RAS. This reduces the probability of sump strainer clogging.

- Reduced debris transport

The amount of debris collected on the sump strainers is a function of strainer size, flow through the strainers, and overall inflow of debris into the containment sump area. A greater volumetric flow will result in a higher rate and probability of debris deposition on the sump strainers due to higher approach velocity in the sump pool, thereby increasing the strainer head loss. A reduction in flow rate, by reducing the number of CS pumps operating, will reduce the rate of sump strainer debris buildup and reduce the probability of strainer blockage, because the CS pump flow rate is a significant contributor to the total flowrate through the sump strainers. Sump pool turnover time is also increased, allowing more time for debris that bypassed the strainer to settle before reaching the strainer for the second time.

- Reduction in Diesel Generator DG-2 Loading

Disabling the automatic start of CS pump SI-3C will reduce the electrical loading on diesel generator DG-2 for those scenarios that result in the engineering safeguards loads being powered from the diesel generators. This will result in increased electrical loading margin for DG-2, and added margin for the diesel generator fuel oil storage system, i.e., the reduction in loading on DG-2 will extend the operation of the diesel generators while carrying safeguards loads using the Technical Specifications (TS) minimum fuel oil storage requirements of FCS TS LCO 2.7, Electrical Systems (Reference 7.12).

- Reduction in Size of Replacement Strainer SI-12A

  One of the planned actions to address GL 2004-02 requirements is replacement of the containment sump strainers with higher capacity strainers. The reduced flow associated with the proposed change in this LAR will allow reducing the size of the SI-12A strainer by reducing strainer approach velocity and head loss. This is advantageous because the available floor space to expand the strainer's foot print is much more limiting for this strainer compared to SI-12B.

Following the implementation of the proposed change, CS pump SI-3C will no longer automatically start on CSAS. CS pump SI-3C will be available for manual start for beyond design basis events, e.g., should both of the other CS pumps become unavailable; however, no credit will be taken for CS pump SI-3C since it will no longer be required to be operable by the Technical Specifications. The functionality of CS pump SI-3C as an "installed spare" will be maintained by appropriate maintenance and testing. The only control room operator actions for starting will be to turn the control switch to the start position. The reliability of starting CS pump SI-3C will not be reduced by this change. Only the method of starting the pump is changed. CS pumps SI-3A and SI-3B are redundant to each other, associated with separate engineered safeguards electrical buses, and the system is designed such that no single active failure will prevent the system from performing its safety function when required. Therefore, elimination of the automatic start feature for CS pump SI-3C will not adversely impact the availability, reliability, or capability of the CS system.

The following sections discuss the impact of the proposed change on the design and licensing basis for the plant.

Operator Actions

The proposed change will allow elimination of the automatic start feature for CS Pump SI-3C, and will not require any additional operator actions.

The conditional operator actions approved in temporary License Amendment 235 complement the proposed changes included in this LAR, and therefore will remain available until full compliance with GL 2004-02 is achieved. All of the conditions contained in Amendment 235 will be bounding and the intended results will be enhanced following the implementation of this LAR, because only two CS pumps will automatically start. Operators will therefore have one less CS pump to secure.

Administrative Controls

Manual Operation of CS Pump SI-3C

Even though CS pump SI-3C will no longer be available for automatic start following approval of the proposed change, it is OPPD's intention to maintain the pump available for use in beyond design basis situations, e.g., if one or both of the other CS pumps become unavailable after automatically starting in response to a CSAS (i.e., beyond single failure considerations). As stated previously, operation of a maximum of two CS pumps is a significant contributor to maintaining adequate NPSH for pumps that take suction from the containment sump. This assumption (i.e., two CS pumps running versus three) is being incorporated into the revised containment sump strainer design. Therefore, administrative controls will be incorporated into plant procedures to limit the use of CS pump SI-3C to when there are less than two CS pumps operating (and then only one pump utilizing containment sump strainer SI-12A) unless there are other extenuating circumstances which will be defined in the emergency operating procedures. Additionally, the FCS licensed operator training program will be revised to reflect the restriction on use of CS pump SI-3C. There would be a possibility that an operator could inadvertently start CS pump SI-3C following a CSAS actuation with the other two pumps operating. This situation is discussed in the Human Factors section below.

Periodic Testing of CS Pump SI-3C

Even though CS pump SI-3C will not be included in the Technical Specifications requirements for operability of the containment cooling system, it will be periodically tested to ensure that it remains functional. If a design basis event, a low probability event, were to occur concurrent with a loss of offsite power, CS pump SI-3C operating in test mode would trip due to loss of AC power and would not be restarted by the engineered safeguards sequencer. Consequently diesel generator loading assumptions would also not be impacted by periodic testing of this pump.

Human Factors

Human factors have been considered in the design change, administrative controls, operating procedures, emergency procedures and licensed operator training associated with the proposed change. As stated in earlier discussions above, during an event which generates a CSAS actuation of the CS system, no operator action is required, the system will respond as required, including considerations for single failures. Also as discussed above, operator error has been factored into the analysis of the proposed revised system. The situation related to a CSAS actuation occurring during testing of CS pump SI-3C has been fully evaluated as discussed in the Periodic Testing of CS pump SI-3C section above.

As identified in the Operator Actions section above, there is a possibility that the operator at the controls during an event that generates a CSAS could inadvertently or mistakenly start CS pump SI-3C even though pumps SI-3A and/or SI-3B are already running.

If the HPSI and LPSI pumps and CS pumps SI-3A and SI-3B are taking suction from the SIRWT when CS pump SI-3C is inadvertently started, the safety injection pumps and CS pumps will have adequate $NPSH_A$. The operator action would be to stop CS pump SI-3C as soon as practicable and preferably prior to RAS.

If CS pump SI-3C is started when the safety injection pumps and CS pump SI-3B is taking suction from the containment sump, and if CS pump SI-3C continues to run after RAS, the head loss for containment sump strainer SI-12A will increase. This will decrease the available NPSH for the pumps taking suction from containment sump strainer SI-12A; however, prompt operator action to secure CS pump SI-3C will reduce the adverse impact on available NPSH through strainer SI-12A. Strainer maximum head loss will occur some time after RAS, not immediately at RAS. If all three CS pumps are operated, both strainers SI-12A and SI-12B will be in service. Since each strainer is sized for 100% of the debris load, operation with both strainers will reduce the debris load to approximately 50% per train and will result in acceptable strainer head loss values.

Therefore, even in the unlikely event of an operator error, there is sufficient redundancy in the safety injection and CS systems and there will be adequate procedural controls and sufficient operator training, to ensure that the systems will continue to perform their intended safety related function and that the control room operator could recover in a timely manner.

Minimum / Maximum Safeguards

Engineered Safeguards is the designation given to systems and components provided to protect the public and plant personnel by minimizing both the extent and the effects of an accidental release of radioactive fission products from the reactor coolant system, particularly those following a LOCA up to and including a double ended rupture of the largest reactor coolant pipe. These safeguards function to localize, control, mitigate, and terminate such accidents and to hold off-site environmental exposure levels within the guidelines of 10 CFR Part 50.67.

The systems function to cool the core, limit the magnitude and duration of the pressure transient within the containment vessel following a LOCA, and provide long term post-accident cooling. Such an accident and a gross release of fission products could occur only as the result of an incredible series of failures and malfunctions.

Engineered Safeguards Equipment includes Engineered Safety Features Systems, Essential Auxiliary Support Systems, and Engineered Safeguards Controls and Instrumentation.

Full (or maximum) safeguards includes all of the equipment defined as Engineered Safeguards Equipment. Full safeguards would be available during a DBA if no single failures were to occur. In most accident analyses for FCS, the limiting single failure is the loss of an engineered safeguards electrical train. For this single failure concurrent with a DBA, an entire train of Engineered Safeguards would be unavailable for mitigation of the initiating event, however, the other redundant train of Engineered Safeguards would be available. The single train of Engineered Safeguards is termed as minimum Safeguards.

The CS system is an engineered safeguards system. The current plant configuration has three CS pumps for maximum safeguards and one CS pump for minimum safeguards. This system removes heat by spraying cool borated water through the containment atmosphere. Heat is transferred to the component cooling system through the shutdown heat exchangers. The FCS USAR currently assumes that all three CS pumps are available for operation. Therefore, many of the descriptions and analysis contained in the FCS USAR discuss three CS pumps.

The only FCS USAR safety analysis that currently assumes three CS pumps operating to mitigate an accident is the Containment Pressure Analysis for a main steam line break (MSLB) inside containment. The reason that all three pumps were assumed to be running was that a loss of offsite power is not the limiting condition for this accident and the limiting single failure is not a loss of an engineered safeguards electrical bus: therefore, it was assumed that all three CS pumps continued to operate. The impact of disabling the automatic start logic for CS pump SI-3C on the Containment Pressure Analysis for MSLB inside containment is discussed in detail in the Main Steam Line Break Containment Pressure Analysis Impact section below. However, the evaluation for this event has determined that operation of the CS system does not mitigate the peak containment pressure post MSLB inside containment and that the containment response is acceptable with less than three CS pumps operating.

The limiting design basis small break loss of coolant accident (SBLOCA) credits only one CS pump, since a loss of a diesel generator is assumed as the limiting single failure and this limiting single failure assumed that the two CS pumps fed from the same diesel generator would be unavailable. However, the limiting large break LOCA (LBLOCA) analysis determined that the limiting single failure was the loss of a single LPSI pump, not the loss of a diesel generator. The analysis of ECCS performance following a LBLOCA determines the minimum containment pressure that would be present during the accident; this analysis assumes maximum containment cooling is available, including all three CS pumps. Maximizing containment cooling following a LBLOCA minimizes containment pressure. Minimizing containment pressure following a LBLOCA adds conservatism to the ECCS performance since there is a direct dependence of core flooding rate on containment pressure. The impact of disabling the automatic start logic for CS pump SI-3C on the minimum containment pressure analysis for LBLOCA is discussed in detail in the LOCA Minimum Containment Pressure Analysis Impact section below. However, the evaluation for this event has determined that operation with one less CS pump improves ECCS performance.

Based on these evaluations, it is acceptable to disable the automatic start logic for CS pump SI-3C, thus reducing the number of CS pumps which are included within the definition of full or maximum safeguards. Following the modification, the minimum safeguards case will be unaffected and will include one CS pump and the maximum safeguards case will include two CS pumps.

FCS USAR Impact

In conjunction with this proposed license amendment request, a plant modification is being prepared to provide the design change documentation, evaluations, and implementation instructions associated with disabling the automatic start logic of CS pump SI-3C and modifying the logics of the spray header valves to prevent both valves opening when only one CS pump is running. As part of this design change package, a change to the USAR is being prepared to reflect the disabling of the automatic start logic of CS pump SI-3C and modifying the logics of the spray header valves.

The only USAR analysis that currently assumes three CS pumps operating to mitigate an accident is the current Containment Pressure Analysis for the MSLB inside containment. This analysis is being updated and is discussed further in the Main Steam Line Break Containment Pressure Analysis Impact section below. Appropriate USAR revisions will be made as part of the normal amendment implementation process following approval.

The following characteristics of the CS system will be maintained following implementation of the proposed change.

- The USAR contains a NPSH evaluation for the three CS pumps, which remains bounding for two pump operation.
- The minimum time that the Safety Injection and Refueling Water Tank (SIRWT) can be utilized as a water source for the injection pumps and CS pumps in response to a DBA prior to RAS will be longer with one less CS pump operating; therefore, the existing analysis remains bounding.
- The capability to use a CS pump to maintain the water level in the reactor vessel above the core during a DBA in accordance with the EOPs remains viable.
- The capability to prevent pump run-out with only one CS pump running is maintained by the revised logic for the spray header valve associated with this proposed change.
- The two CS pumps that are retaining their automatic start on CSAS capability, SI-3A and SI-3B, maintain their redundancy and physical separation.
- The ability of one CS pump to meet the capacity requirements in the event of a DBA is maintained.
- The ability of the CS system to perform fission product cleanup following a LOCA is maintained.
- The ability to meet FCS Design Criteria 41, Engineered Safety Features Performance Capability, is maintained for the containment heat removal systems (the containment spray system and the containment air recirculation system), i.e., a failure of a single active component in either system will be compensated for by the other system.
- The design basis analysis regarding potential accumulation of hydrogen in the containment following a hypothetical DBA LOCA is not affected by the change.

Accident Analysis Impact Summary

Evaluation of the accident analyses determined that:

- The ability of the CS system to maintain containment pressure below containment design pressure and provide cooling to reduce the post-accident containment pressure and temperature is maintained.
- The current LOCA analysis that credits only a single CS pump and CS header for active heat removal remains valid.
- The current LOCA analysis assumes that the single CS pump credited is last in the sequence of CS pumps automatically starting. CS pump SI-3C is currently last in the start sequence. This analysis remains conservative since the other CS pumps, SI-3A and SI-3B, start sooner in response to a CSAS.
- The LBLOCA analysis for minimum containment pressure impact on ECCS performance remains bounding with less than three CS pumps operating. See LOCA Minimum Containment Pressure Analysis Impact section below.

See additional discussion in the sections below related to LBLOCA analysis and containment pressure analysis.

LOCA Minimum Containment Pressure Analysis Impact

Standard Review Plan (SRP) Section 6.2.1.5, Minimum Containment Pressure Analysis for Emergency Core Cooling System Performance Capability Studies, provides the guidelines for conservatively evaluating ECCS performance following a LOCA. As stated in the SRP, following a LOCA the ECCS supplies water to the reactor vessel to reflood, and thereby cool the reactor core. The SRP continues by stating that the core flooding rate is governed by the capability of the ECCS water to displace the steam generated in the reactor vessel during the core reflooding period and that for pressurized water reactors (PWRs), there is a direct dependence of core flooding rate on containment pressure, i.e., the core flooding rate will increase with increasing containment pressure. Therefore, to provide a conservative evaluation of ECCS performance following a LOCA, the minimum containment pressure that could exist during the period of time until the core is reflooded following a LOCA must be included in the analysis. Note that this minimum containment pressure analysis done in conjunction with ECCS performance evaluation differs from the containment functional performance analysis, in that the conservatisms and margins are taken in opposite directions in the two cases. Therefore, the minimum containment pressure analysis required for ECCS performance evaluations is not intended to be representative of the peak containment pressure in the event of a LOCA.

SRP Section 6.2.1.5, which is associated with Branch Technical Position (BTP) CSB 6-1, Minimum Containment Pressure Model for PWR ECCS Performance Evaluation, delineates the calculational approach that should be followed to assure a conservative prediction of the minimum containment pressure that is used in the LOCA analysis. CSB 6-1 states that for Spray and Fan Cooling Systems, the operation of all engineered safety feature (ESF) containment heat removal systems operating at maximum heat removal capacity should be assumed, i.e., all CS trains operating at maximum flow conditions and all emergency fan cooler units operating.

In general, FCS is not licensed to the SRP. However, the FCS Large Break LOCA Peak Cladding Temperature (PCT) calculation is performed in accordance with the SRP Section 6.2.1.5 and the referenced BTP.

The Large Break LOCA analysis is performed using two single failure scenarios: (1) failure of one emergency diesel generator (EDG), and (2) failure of one LPSI pump to start/run. The first scenario results in the minimum containment heat removal systems (one CS pump/header and one train of containment fan coolers (CFCs)). The LPSI failure to start/run scenario results in the operation of all engineered safety feature containment heat removal systems (i.e., 3 CS pumps/2 headers and all CFCs). The LPSI failure scenario results in the highest calculated PCT of 1956°F and is therefore the limiting case. The EDG failure scenario, assuming operation of one CS pump/header and one train of CFC, results in a calculated PCT of 1948°F.

The analysis for the first case, EDG failure scenario, is not impacted by the proposed change since it already assumes only a single CS pump is operating. The second case, failure of one LPSI pump scenario, is impacted since it currently assumes that all three CS pumps are operating. However, as discussed above, the more containment cooling components that are assumed operating the more conservative the evaluation is. Therefore, if one less containment cooling component is operating, i.e., one less CS pump, then the performance of the ECCS is actually enhanced due to lower containment cooling capacity which results in higher containment pressure which equates to higher ECCS core reflood rate in response to a LOCA. Therefore, following the implementation of the proposed change, the current ECCS performance analysis will remain bounding and conservative. The Large Break LOCA analysis is documented in Framatone ANP Inc., EMF-2734, Revision 0, "Fort Calhoun Cycle 21 Large Break LOCA/ECCS Analysis with Reduced Reactor Coolant System Flow Rate", dated April 12, 2002 (FCS Updated Safety Analysis Report (USAR) Reference 14.15-34). The only impact on licensing basis documents regarding ECCS performance following implementation of the proposed change would be the possible reduction in the PCT for the LBLOCA analysis, if the above analysis is updated.

<u>Effects On The Containment Pressure Analysis</u>

The containment building and associated penetrations are designed to withstand an internal pressure of 60 psig at 305°F, including all thermal loads resulting from the temperature associated with this pressure, with a leakage rate of 0.1 percent by weight or less of the contained volume per 24 hours. To maintain containment pressure and temperatures within design limitations, and assure that the release of fission products to the environment following a design basis accident will not exceed regulatory guidelines, the following Engineered Safety Systems are incorporated into the FCS design:

a. Containment spray (CS) system with redundant features to remove heat from the containment and to provide for reduction of airborne particulate radioactivity following a LOCA; and

b. Containment fan coolers (CFCs) with redundant features to remove heat from the containment atmosphere.

The FCS licensing basis credits only one of the three CS pumps to limit the containment pressure to below the design value for a LOCA. Currently, the FCS licensing basis assumes three CS pumps operating during a MSLB; however, the CS system is not credited for limiting peak containment pressure for a MSLB since the peak pressure occurs before the spray is injected into containment. This is discussed further below in the Main Steam Line Break Containment Pressure Analysis Impact section.

The CFCs operate independently of the CS system to remove heat from the containment atmosphere. The CFCs consist of two redundant trains; each train with one air cooling and filtering unit and one air cooling unit, for a total of four cooling units. If all normal power sources are lost and one diesel generator fails to function, one train of CFCs will operate. Operation of the CFCs with a heat removal capacity of 200 x 10^6 BTU/hr is credited in the MSLB containment pressure analysis. The CFCs are not impacted by this proposed change.

LOCA Containment Pressure Analysis Impact

The limiting LOCA containment pressure analysis assumes operation of one CS pump and one CS header, with one spray nozzle missing and five spray nozzles per header blocked. An assumed CS flow rate of 1885 gpm takes into account pump degradation, instrument uncertainties and flow through the mini-recirculation lines. Following implementation of the proposed change at least one CS pump will be available to mitigate a LOCA, therefore, the proposed change will have no adverse effect on the peak containment pressure and temperature response following a LOCA.

Main Steam Line Break Containment Pressure Analysis Impact

The only FCS accident analysis that currently assumes three CS pumps operating to mitigate an accident is the Containment Pressure Analysis for a MSLB inside containment as documented in FCS USAR Section 14.16. It states:

"Although three containment spray pumps (SI-3A, SI-3B, and SI-3C) are credited in the analysis, the start time for all three is based on the SI-3C pump. This is conservative since SI-3C starts last and no credit is taken for starting the other two pumps earlier."

The reason that all three pumps were assumed to be running, was that a loss of offsite power was not the limiting condition for this accident and the limiting single failure was not a loss of an engineered safeguards electrical bus, therefore, it was assumed that all three CS pumps started and continued to operate.

Even though the current MSLB Containment Pressure Analysis assumes operation of all three CS pumps, it also shows that peak containment pressure occurs prior to the CS system starting, therefore, the CS system does not mitigate the peak pressure for a MSLB.

The reviews evaluated both existing analyses of record (AORs) and those analyses developed for the FCS replacement steam generator (RSG) project (these RSG analyses are pending final approval until implementation of the RSG project). The analysis which has been developed for the RSG project that evaluates the Containment Pressure Analysis for MSLB inside containment was reviewed for the impact of reducing the number of operating CS pumps from three to two. This review determined that the RSG analysis is impacted; however, it was determined by running various test cases that the existing AOR peak pressure is bounding following implementation of the proposed change. Therefore, the combination of the RSG project and the CS modification will not result in an increase in the currently documented peak containment pressure for an MSLB. The RSG evaluation will be updated as part of the implementation of the proposed change.

Therefore, the evaluation for the MSLB event has determined that the containment peak pressure is not affected by this change.

Supporting Analyses

Additionally, a review of other analyses that might be impacted by the reduction in the number of CS pumps available post accident was performed. This review determined that none of the other analyses are adversely impacted. Some of these analyses and the Containment Pressure Analysis for MSLB inside containment will be updated as part of the modification package that implements the proposed change. These updates are anticipated to produce results which are acceptable under 50.59 screening and will not require NRC reviews.

Radiological Consequences

LOCA

The FCS LOCA analysis demonstrates that, in the event of a postulated Large Break LOCA, core cooling is maintained and that severe damage of the reactor core will not occur. The analysis, summarized in the USAR Section 14.15, demonstrates that the limits of 10 CFR 50.46 are met assuming a worst-case single failure that limits core cooling. The FCS analysis assumes that one train of SI delivers the required flow to limit the consequences of a LOCA to within 10 CFR 50.46 limits. The LOCA radiological consequences analysis assumes, based on Regulatory Guide 1.183, that a certain level of core damage has occurred during the LOCA, and that fission products are released into the containment atmosphere in two stages over a period of 1.8 hours:

- Gap release phase which starts immediately following the LOCA and has a duration of 0.5 hours; and
- Core melt phase which starts at T=0.5 hours and continues for a duration of 1.3 hours.

Particulate fission products that are released into the containment are removed by the CS system. The water spray strips radioactive particles from the atmosphere where they fall to the floor and are washed into the containment sump. The radiological consequences analysis credits CS system operation for removal of particulates from the containment atmosphere during a LOCA. Credit for aerosol and elemental iodine removal via sprays is taken starting at T=185 seconds (spray initiation time based on minimum ESF case) and continued up to approximately T=5 hours after the LOCA; the proposed change does not affect this function.

The LOCA analysis source term is based on operation of minimum safeguards due to a worst-case single failure, and a presumption of core damage. The design basis radiological dose calculation credits the LOCA CS flow rates with degraded conditions.

Following implementation of the proposed change at least one CS pump will be available to mitigate a LOCA as currently assumed in the analysis, therefore, the proposed change will have no adverse effect on the radiological consequences following a LOCA.

MSLB

The analyses that establish the bounding radiological consequences impacts for the site are not impacted by this modification. The analyses are based on a LBLOCA with a single CS pump in operation. Single CS pump operation in response to this event bounds the plant configuration following the proposed modification.

Equipment Qualification

The electrical equipment qualification (EEQ) profile developed for the current plant configuration bound that associated with the upcoming RSG modification. Both the proposed CS system changes and the RSG projects are scheduled for implementation during the same refueling outage. The thermal lag analysis of equipment performed using the current plant configuration demonstrated a large margin between the equipment evaluated during the accident versus the conditions under which it was tested. The RSG modification will further increase this margin. As part of the RSG effort the EEQ analysis will be revised to address RSG issues and will include the changes to containment spray. As a result of the margins associated with the current analysis as well as increase in margin when the new analysis is implemented it is expected that the changes to the containment spray system will not produce an adverse result. All equipment will remain qualified to operate in the accident environment.

Summary

As discussed above, disabling the CSAS automatic start logic for CS pump SI-3C does not adversely affect the operation of the plant and does not result in unbounded conditions for the plant. The change will enhance the NPSH margins during a DBA by reducing the flow to and through the containment sump strainer SI-12A when the HPSI and CS pumps are operating in response to a DBA and the systems are taking suction from the containment sump. This reduction in flow maximizes the $NPSH_A$ for the pumps taking suction from the containment sump, reduces the velocity and pressure drop in the common suction lines for CS pumps SI-3B and SI-3C, reduces the debris transport to the associated strainer, reduces the pressure drop across the strainer and associated piping, and increases the time to the initiation of a RAS and the time for sump pool turnover. An ancillary benefit is a reduction in diesel generator DG-2 load in response to a design basis accident concurrent with a loss of offsite power.

5.0 REGULATORY SAFETY ANALYSIS

5.1 No Significant Hazards Consideration

The proposed change will revise the Technical Specifications to reduce the number of containment spray (CS) pumps that are required to be operable from three to two, in order to enhance net positive suction head (NPSH) margin for the high pressure safety injection (HPSI) and CS pumps during a design basis accident (DBA). This change will be accomplished by disabling the Containment Spray Actuation Signal (CSAS) automatic start feature of CS pump SI-3C.

This change will enhance NPSH margin for the CS and HPSI pumps during the recirculation phase of a DBA by reducing the flow to and through the associated containment sump strainer. The enhancement in the NPSH performance will be realized due to a reduction in debris transport to the strainer (as a result of reduced strainer approach velocity) with an accompanying reduction in pressure drop across the strainer and a reduction in piping head loss. This will provide additional margin for the NPSH available ($NPSH_A$) for the HPSI and CS pumps taking suction from the containment sump. Additionally, CS pumps SI-3B and SI-3C share a common suction line and, by disabling the automatic start logic for CS pump SI-3C only a single CS pump will be using this suction line in response to a CSAS. The reduction of flow in the common suction line will result in reduced velocity in the piping and reduced piping head loss which means increased NPSH margin for the SI-3B pump.

This license amendment request (LAR) represents a portion of the actions required to satisfy the applicable regulatory requirements with respect to NRC Generic Letter (GL) 2004-02 as it relates to the CS system. OPPD's response (Reference 7.14) to NRC Request 2e in GL 2004-02 indicated that defeating the automatic start feature of one of the CS pumps would be a possible option to improve NPSH margin.

OPPD has evaluated whether or not a significant hazards consideration is involved with the proposed amendment(s) by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," as discussed below:

1. **Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?**

   Response: No.

   The Containment Spray (CS) system is not an initiator of any accident previously evaluated at the Fort Calhoun Station (FCS); the CS system is an accident mitigation system. The CS system's licensing basis functions are to limit the containment pressure rise and reduce the leakage of airborne radioactivity from the containment by providing a means for cooling the containment following a loss-of-coolant accident (LOCA) or main steam line break (MSLB) inside containment. The proposed change disables the CSAS automatic start feature of one of the three CS pumps.

   The only FCS safety analysis that currently assumes three CS pumps operating to mitigate an accident is the Containment Pressure Analysis for a MSLB inside containment. Even though this analysis assumes operation of all three CS pumps, it also shows that peak containment pressure occurs prior to the CS system starting, therefore, the CS system does not mitigate the peak pressure for a MSLB. The reviews evaluated both existing AORs and those analyses developed for the Steam Generator Replacement (RSG) project. The analysis developed for the

RSG project that evaluates the Containment Pressure Analysis for MSLB inside containment was reviewed for the impact of reducing the number of operating CS pumps from three to two. This review determined that the RSG MSLB analysis will be acceptable and will continue to be bounded by the analysis currently documented in USAR. AOR peak pressure is unaffected by implementation of this proposed change. Therefore, the combination of the RSG project and this containment spray modification will not result in an increase in the currently documented peak containment pressure for an MSLB. Therefore, the evaluation for the MSLB event has determined that the containment pressure response is acceptable with less than three CS pumps operating.

The LOCA analysis source term is based on operation of minimum safeguards due to a worst-case single failure. The minimum safeguards configuration is unchanged by this modification. Following implementation of the proposed change at least one CS pump will be available to mitigate a LOCA as currently assumed in the analysis, therefore, the proposed change will have no adverse effect on the radiological consequences following a LOCA. The analyses that establish the radiological consequences for the site are based on a Large Break LOCA with a single CS pump in operation, therefore, single CS pump operation during a MSLB inside containment is bounded by the LOCA analysis.

Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. **Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?**

   Response: No.

   The proposed change will reduce the number of operable CS pumps from three to two; however, previous accident analyses will remain valid. No credible new failure mechanisms, malfunctions, or accident initiators not considered in the design and licensing basis have been created and none of the initial condition assumptions of any accident evaluated in the safety analysis are impacted.

   Therefore, the proposed change does not create the possibility of a new or different kind of accident from any previously evaluated.

3. **Does the proposed amendment involve a significant reduction in a margin of safety?**

   Response: No.

   The containment building and associated penetrations are designed to withstand an internal pressure of 60 psig at 305°F, including all thermal loads resulting from the temperature associated with this pressure, with a leakage rate of 0.1 percent by weight or less of the contained volume per 24 hours. The CS System and the Containment Fan Coolers are credited for maintaining containment pressure and temperatures within design limitations, and assure that the release of fission products to the environment following a design basis accident will not exceed regulatory guidelines. The FCS licensing basis credits only one of the three CS pumps to limit the containment pressure to below the design value for a LOCA. Currently, the FCS licensing basis credits three CS pumps for a MSLB, however, the CS system is not credited for limiting peak containment pressure for a MSLB.

The EEQ profile developed for the current plant configuration bounds those associated with the upcoming RSG modification. Both the proposed CS system changes and the RSG projects are scheduled for the same refueling outage. The thermal lag analysis of equipment performed using the current plant configuration demonstrated a large margin between the equipment evaluated during the accident versus the conditions under which it was tested. The RSG modification will further increase this margin. As part of the RSG effort the EEQ analysis will be revised to address RSG issues and will include the changes to containment spray. When the margins associated with the current analysis as well as increases in margin when the new analysis is implemented it is expected that the changes to the containment spray system will not produce an adverse result. All equipment will remain qualified to operate in the accident environment.

Additionally, the CFCs operate independently of the CS system to remove heat from the containment atmosphere. The CFCs consist of two redundant trains; each train with one air cooling and filtering unit and one air cooling unit, for a total of four cooling units. Operation of the CFCs is credited in the MSLB containment pressure analysis. The CFCs are not impacted by this proposed change. During the MSLB containment spray takes place after the peak containment pressure occurs. Therefore, the licensing basis capabilities of the Containment Cooling System, which consists of the CS and CFCs, is not adversely affected by the proposed change; the ability to maintain containment peak pressure and temperature and long term containment pressure and temperature will be maintained.

Particulate fission products that are released into the containment following a DBA are removed by the CS system for those events that result in CS actuation. The water spray strips radioactive particles from the atmosphere where they fall to the floor and are washed into the containment sump. The radiological consequences analysis credits CS system operation for removal of particulates from the containment atmosphere during a LOCA. The LOCA analysis source term is based on operation of minimum safeguards due to a worst-case single failure, and a presumption of core damage. Minimum safeguards corresponds to one CS pump and one CS header operation and take into account pump degradation, and instrument uncertainties. The analyses that establish the radiological consequences for the site are not impacted by the proposed modification. These analyses are based on a Large Break LOCA with a single CS pump in operation. Therefore, single CS pump operation bounds the plant configuration following the proposed modification.

The Large Break LOCA assumes that there will be three CS pumps operating when evaluating the effects of containment pressure on ECCS performance. The analysis assumes three CS pumps, which minimizes containment pressure, to conservatively evaluate ECCS performance in response to a LOCA. The use of two CS pumps versus three improves ECCS performance and thus increases margin to 10 CFR 50.46 limits on peak clad temperature.

In summary, following implementation of the proposed change:

- Peak containment pressure for analyzed DBAs will not be increased;
- The assumptions used in the environmental qualification of equipment exposed to the containment atmosphere following a DBA remaining bounding; and
- The radiological consequences for the bounding DBA remains unchanged.
- The currently calculated peak clad temperature following a LOCA remains bounded by existing analysis.

Therefore, the proposed change does not involve a significant reduction in a margin of safety.

Based on the above, OPPD concludes that the proposed amendment presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of "no significant hazards consideration" is justified.

5.2 Applicable Regulatory Requirements/Criteria

In OPPD's license amendment request (Reference 7.6) that resulted in the NRC issuing Amendment 235 (Reference 7.9), OPPD proposed the actions necessary to provide the interim compensatory measures to reduce risk associated with the potentially degraded or non-conforming ECCS and CS Recirculation functions due to adverse post-accident debris blockage, as required by NRC Bulletin 2003-01. This current license amendment request represents a portion of the actions required to satisfy the applicable regulatory requirements with respect to NRC Generic Letter 2004-02 as it relates to the CS system.

The proposed change will revise the Operating License to reduce the number of CS pumps that are required to be available, for the containment cooling system to be considered operable, from three to two in order to enhance the performance of the containment sump strainers during a DBA. The proposed change does not affect commitments to FCS design criteria presented in the USAR Appendix G, accident analysis, approved methodologies, Regulatory Guides, or NUREGs. The only FCS safety analysis that currently assumes three CS pumps operating to mitigate an accident is the Containment Pressure Analysis for a MSLB inside containment. Even though this analysis assumes operation of all three CS pumps, it also shows that peak containment pressure occurs prior to the CS system starting, therefore, the CS system does not mitigate the peak pressure for a MSLB. The AOR for the Containment Pressure Analysis for MSLB inside containment was reviewed for the impact of reducing the number of operating CS pumps from three to two on long term cooling. This review determined that the analysis is impacted as discussed in Section 4, "Main Steam Line Break Containment Pressure Analysis Impact", however, it was determined by running various test cases that the existing analysis remains bounding following implementation of this proposed change. Therefore, the evaluation for the MSLB event has determined that the containment pressure response is acceptable with less than three CS pumps operating. The proposed change will not change any assumptions previously made in evaluating radiological consequences or affect any fission product barriers, nor does it increase any challenges to safety systems. Therefore, the proposed change does not increase or have any impact on the consequences of events described in Section 14 of the FCS USAR.

10 CFR 50.46, Acceptance Criteria For Emergency Core Cooling Systems For Light-Water Nuclear Power Reactors, requires in part that the calculated maximum fuel element cladding temperature shall not exceed 2200°F following a postulated LOCA. The FCS Large Break LOCA analysis includes a minimum containment pressure analysis for ECCS performance following a LOCA; it currently assumes that all three CS pumps are operating. This is conservative since the more containment cooling capacity that is available following a LOCA the lower the performance of the ECCS will be due to the lowered containment pressure; following the guidance in SRP 6.2.1.5 and BTP CSB 6-1. In general, FCS is not licensed to the SRP, however, the FCS Large Break LOCA Peak Cladding Temperature (PCT) calculation is performed in accordance with the SRP Section 6.2.1.5 and BTP CSB 6-1. Specifically, the Large Break LOCA analysis is performed using two single failure scenarios; one of the scenarios has three CS pumps operating and the other scenario has a single CS pump operating. The scenario with three CS pumps operating results in the highest calculated PCT of 1956°F. The scenario with a single CS pump operating results in a calculated PCT of 1948°F. The single CS pump operating scenario is unaffected by the proposed change. The multiple pump scenario is impacted since there will be at most two CS pumps operating rather than three. The reduction in the number of CS pumps operating will result in a lower calculated PCT due to the increase in ECCS performance caused by the resultant higher containment pressure. Therefore the existing analysis continues to be bounding and the requirements of 10 CFR 50.46 will continue to be met.

In conclusion, based on the considerations discussed above, (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.

6.0 ENVIRONMENTAL CONSIDERATION

The proposed amendment is confined to changes to the logic in the containment spray system. The changes meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9) for the following reasons:

1) As demonstrated in Section 5.0, the proposed amendment does not involve a significant hazards consideration.

2) The proposed amendment does not result in a significant change in the types or increase in the amounts of any effluents that may be released offsite. Also, the change does not introduce any new effluents or significantly increase the quantities of existing effluents. As such, the change cannot significantly affect the types or amounts of any effluents that may be released offsite.

3) The proposed amendment does not result in a significant increase in individual or cumulative occupational radiation exposure. The proposed change does not result in any physical plant changes, only control logic changes. No new surveillance requirements are anticipated as a result of these changes that would require additional personnel entry into radiation controlled areas. Therefore, the amendment has no significant affect on either individual or cumulative occupational radiation exposure.

Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

7.0 REFERENCES

7.1 FCS Updated Safety Analysis Report (USAR) Section 6.2, Engineered Safeguards, Safety Injection System

7.2 FCS Updated Safety Analysis Report (USAR) Section 6.3, Engineered Safeguards, Containment Spray System

7.3 FCS USAR Section 7.3.2.4, Instrumentation and Control, Engineered Safeguards, Controls and Instrumentation, Containment Spray Actuation Signal (CSAS)

7.4 FCS USAR Chapter 14, Safety Analysis

7.5 FCS Technical Specifications and Basis 2.4, Containment Cooling

7.6 Letter from OPPD (Ralph L. Phelps) to NRC (Document Control Desk), Fort Calhoun Station Unit No. 1, License Amendment Request, "Incorporation of Allowance to Secure Containment Spray Pumps During a Loss-of-Coolant-Accident to Minimize the Potential for Containment Sump Clogging", dated May 21, 2004 (LIC-04-0050)

7.7 Letter from OPPD (Ross T. Ridenoure) to NRC (Document Control Desk), Response to Request for Additional Information Regarding License Amendment Request, "Incorporation of Allowance to Secure Containment Spray Pumps During a Loss-of-Coolant-Accident to Minimize the Potential for Containment Sump Clogging", dated September 16, 2004 (LIC-04-0095)

7.8 Letter from OPPD (Ross T. Ridenoure) to NRC (Document Control Desk), Response to Request for Additional Information Regarding License Amendment Request, "Incorporation of Allowance to Secure Containment Spray Pumps

During a Loss-of-Coolant-Accident to Minimize the Potential for Containment Sump Clogging", dated December 14, 2004 (LIC-04-0125)

7.9 Amendment 235 to Renewed Facility Operating License No. DPR-40 for the Fort Calhoun Station, Unit No. 1, (TAC MC3217) (NRC-05-0064) dated May 23, 2005

7.10 NRC Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors," dated June 9, 2003 (NRC-03-114)

7.11 NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004

7.12 FCS Technical Specifications and Basis 2.7, Electrical Systems

7.13 Letter from OPPD (Richard P. Clemens) to NRC (Document Control Desk), Fort Calhoun Station Unit No. 1, 60 Day Response to NRC Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors," dated August 8, 2003 (LIC-03-0105)

7.14 Letter from OPPD (Harry J. Faulhaber) to NRC (Document Control Desk), Follow-up Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated August 31, 2005 (LIC-05-0101)

Markup of
Technical Specifications
&
Bases Pages

2.0 LIMITING CONDITIONS FOR OPERATION
2.4 Containment Cooling

Applicability

Applies to the operating status of the containment cooling systems.

Objective

To assure operability of equipment required to remove heat from the containment during normal operating and emergency situations.

Specifications

(1) Minimum Requirements

a. The reactor shall not be made critical, except for low-temperature physics tests, unless all the following are met:

i. The following equipment normally associated with diesel-generator DG-1 (4.16-kV bus 1A3 and associated non-automatically transferring 480-Volt bus sections) is operable, except as noted:[1]

Raw water pump	AC-10A
Raw water pump	AC-10C
Component cooling water pump	AC-3A
Component cooling water pump	AC-3C
Containment spray pump	SI-3A
Containment air cooling and filtering unit	VA-3A
Containment air cooling unit	VA-7C

ii. The following equipment normally associated with diesel-generator DG-2 (4.16-kV 1A4 and associated non-automatically transferable 480 Volt bus sections) is operable, except as noted.[1]

Raw water pump	AC-10B
Raw water pump	AC-10D
Component cooling water pump	AC-3B
Containment spray pump	SI-3B
Containment air cooling and filtering unit	VA-3B
Containment air cooling unit	VA-7D
~~Containment spray pump~~	~~SI-3C~~

iii. Four component cooling heat exchangers shall be operable.

iv. All valves, piping and interlocks associated with the above components and required to function during accident conditions are operable.

(1) Reactor may be made critical with one inoperable raw water pump. LCO action statements shall apply.

2.0 **LIMITING CONDITIONS FOR OPERATION**
2.4 Containment Cooling (Continued)

b. During power operation one of the components listed in (1)a.i. and ii. may be inoperable. If the inoperable component is not restored to operability within seven days, the reactor shall be placed in hot shutdown condition within 12 hours. If the inoperable component is not restored to operability within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

c. For cases involving Raw Water pump inoperability, if the river water temperature is below 60 degrees Fahrenheit, one Raw Water pump may be inoperable indefinitely without applying any LCO action statement. When the river water temperature is greater than 60 degrees Fahrenheit, an inoperable Raw Water pump shall be restored to operability within 7 days or the reactor shall be placed in a hot shutdown condition within 12 hours. If the inoperable Raw Water pump is not restored to operability within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

(2) Modification of Minimum Requirements

a. During power operation, the minimum requirements may be modified to allow a total of two of the components listed in (1)a.i. and ii. to be inoperable at any one time. (This does not include: 1) One Raw Water pump which may be inoperable as described above if the river water temperature is below 60 degrees Fahrenheit.) or, 2) SI-3A and SI-3B being simultaneously inoperable. Only two raw water pumps may be out of service during power operations. Either containment spray pump, SI-3A or SI-3B, must be operable during power operations.) If the operability of one of the two components is not restored within 24 hours, the reactor shall be placed in a hot shutdown condition within 12 hours. LCO 2.4(1)b. shall be applied if one of the inoperable components is restored within 24 hours. If the operability of both components is not restored within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

b. During power operation one component cooling heat exchanger may be inoperable. If the operability of the heat exchanger is not restored within 14 days, the reactor shall be placed in a hot shutdown condition within 12 hours. If two component cooling heat exchangers are inoperable, the reactor shall be placed in hot shutdown condition within 12 hours. If the inoperable heat exchanger(s) is not restored to operability within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

c. Any valves, interlocks and piping directly associated with one of the above components and required to function during accident conditions shall be deemed to be part of that component and shall meet the same requirements as for that component.

2.0 **LIMITING CONDITIONS FOR OPERATION**
2.4 Containment Cooling (Continued)

d. Any valve, interlock or piping associated with the containment cooling system which is not included in the above paragraph and which is required to function during accident conditions may be inoperable for a period of no more than 24 hours. If operability is not restored within 24 hours, the reactor shall be placed in a hot shutdown condition within 12 hours.

Basis

A full capacity diesel-generator is connected to each of the two engineered safeguards 4.16-kV buses. Three engineered safeguards 480-Volt double-ended load centers are provided; of the six transformers, three are connected to each of the two 4.16-kV buses. Two load centers are operated as two-bus-section units; the third is provided with a center bus manually transferable to either associated end section. The center bus section supplies HPSI Pump SI-2C, CS Pump SI-3C and Charging Pump CH-1C any of which can thus be supplied from either 4.16-kV bus if required (note that CS Pump SI-3C is connected to the center bus, however, this pump is available for manual operation only). The containment sprays initially take coolant from the safety injection and refueling water (SIRW) tank. Before this supply of water is exhausted (at least 24 minutes)[2] the spray system is transferred to the recirculation mode and the pumps take suction from the containment sump. One shutdown cooling heat exchanger is sufficient to satisfy the spray system requirements during the long-term containment cooling period.[3] In addition, in the unlikely event of the component cooling water supply being lost, raw water can be utilized for direct cooling of certain engineered safeguard components.[4]

The containment spray system is independaent from the containment air cooling and filtering unit for the containment cooling function.[5] For the limiting Loss of Coolant Accident (LOCA) scenario, one of the two ~~three~~ spray pumps would limit the containment pressure to below the design value without taking credit for the air coolers or the cooling capacity of the safety injection system.[6] [7] For the limiting Main Steam Line Break (MSLB) scenario, a heat removal contribution is credited from the air coolers in the mitigation of containment peak pressure.[7] Credit is taken for iodine removal by the containment spray system.

The cooling equipment provided to limit the containment pressure following a DBA is divided between the independent power supply systems. The raw water and component cooling water pumps are similarly distributed on the 4.16-kV and 480 Volt buses. In the event of a DBA, loss of normal power sources and failure of one diesel-generator to operate, a minimum of ~~at least~~ one spray pump, and two air coolers would be connected to the available diesel-generator. This would provide adequate containment cooling equipment to limit the containment pressure below the design value for the limiting one pump, one spray header LOCA event. The limiting MSLB event in which off site power is available, is not affected by the loss of one diesel generator.

2.0 **LIMITING CONDITIONS FOR OPERATION**
2.7 Electrical Systems (Continued)

Basis

The electrical system equipment is arranged so that no single failure can inactivate enough engineered safeguards to jeopardize the plant safety. The 480 V safeguards are arranged on nine bus sections. The 4.16 kV safeguards are supplied from two buses.

The normal source of auxiliary power with the plant at power for the safeguards buses is from the house service power transformers being fed from the 161 Kv incoming line with on-site emergency power from either one of two diesel generators and off-site standby power via the unit auxiliary transformers.[1] The loss of the 161kV incoming line renders the house service transformers (T1A-3 and T1A-4) inoperable in that the transformers cannot supply power to the 4.16kV safeguards buses 1A3 and 1A4. Inoperability of the house service transformer(s) or loss of the 161kV incoming line is not reportable pursuant to 10 CFR 50.72 criteria; however, the NRC will be promptly notified of these events via the NRC Operations Center.

The two emergency diesel generators on site do not require offsite power for start up or operation.

Upon loss of normal and standby power sources, the 4.16 Kv buses 1A3 and 1A4 are energized from the diesel generators. Bus load shedding, transfer to the diesel generator and pickup of critical loads are carried out automatically.[2]

When the turbine generator is out of service for an extended period, the generator can be isolated by opening motor operated disconnect switch DS-T1 in the bus between the generator and the main transformer, allowing the main transformer and the unit auxiliary power transformers (T1A-1 and T1A-2) to be returned to service.[3] The auxiliary power transformers are not considered inoperable during these normal plant startup/shutdown realignments.

Minimum requirements are implemented prior to raising the RCS temperature above 300°F to assure availability of engineered safety features.

The time allowed to repair an inoperable inverter is based upon engineering judgement, taking into consideration the time required to repair an inverter and the additional risk to which the unit is exposed because of the inverter inoperability. In the event of inverter failure, the load on the inverter is automatically transferred to its safety related bypass source. The associated 120 V a-c instrument bus is considered OPERABLE when it is being powered from its bypass source and during the short time it takes to manually or automatically transfer between sources.

Equipment served by 4.16 kV and 480 V auxiliary buses and MCC's is arranged so that loss of an entire 4.16 kV bus does not compromise safety of the plant during DBA conditions. For example, if 4.16 kV bus 1A3 is lost, two raw water pumps, one low pressure safety injection pump, two high pressure safety injection pumps, one auxiliary feedwater pump, two component cooling water pumps, one containment spray pump and two containment air fans are lost. This leaves two raw water pumps, one low pressure safety injection pump, one high pressure safety injection pump, one component cooling water pump, one ~~two~~ containment spray pump~~s~~ and two containment air fans which is more than sufficient to control containment pressure below the design value during the DBA.

**Proposed
Technical Specifications
&
Bases Pages (Retyped)**

2.0 LIMITING CONDITIONS FOR OPERATION
2.4 Containment Cooling

Applicability

Applies to the operating status of the containment cooling systems.

Objective

To assure operability of equipment required to remove heat from the containment during normal operating and emergency situations.

Specifications

(1) Minimum Requirements

a. The reactor shall not be made critical, except for low-temperature physics tests, unless all the following are met:

i. The following equipment normally associated with diesel-generator DG-1 (4.16-kV bus 1A3 and associated non-automatically transferring 480-Volt bus sections) is operable, except as noted:[(1)]

Raw water pump	AC-10A
Raw water pump	AC-10C
Component cooling water pump	AC-3A
Component cooling water pump	AC-3C
Containment spray pump	SI-3A
Containment air cooling and filtering unit	VA-3A
Containment air cooling unit	VA-7C

ii. The following equipment normally associated with diesel-generator DG-2 (4.16-kV 1A4 and associated non-automatically transferable 480 Volt bus sections) is operable, except as noted.[(1)]

Raw water pump	AC-10B
Raw water pump	AC-10D
Component cooling water pump	AC-3B
Containment spray pump	SI-3B
Containment air cooling and filtering unit	VA-3B
Containment air cooling unit	VA-7D

iii. Four component cooling heat exchangers shall be operable.

iv. All valves, piping and interlocks associated with the above components and required to function during accident conditions are operable.

(1) Reactor may be made critical with one inoperable raw water pump. LCO action statements shall apply.

2.0 LIMITING CONDITIONS FOR OPERATION
2.4 Containment Cooling (Continued)

b. During power operation one of the components listed in (1)a.i. and ii. may be inoperable. If the inoperable component is not restored to operability within seven days, the reactor shall be placed in hot shutdown condition within 12 hours. If the inoperable component is not restored to operability within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

c. For cases involving Raw Water pump inoperability, if the river water temperature is below 60 degrees Fahrenheit, one Raw Water pump may be inoperable indefinitely without applying any LCO action statement. When the river water temperature is greater than 60 degrees Fahrenheit, an inoperable Raw Water pump shall be restored to operability within 7 days or the reactor shall be placed in a hot shutdown condition within 12 hours. If the inoperable Raw Water pump is not restored to operability within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

(2) Modification of Minimum Requirements

a. During power operation, the minimum requirements may be modified to allow a total of two of the components listed in (1)a.i. and ii. to be inoperable at any one time. (This does not include: 1) One Raw Water pump which may be inoperable as described above if the river water temperature is below 60 degrees Fahrenheit or, 2) SI-3A and SI-3B being simultaneously inoperable. Only two raw water pumps may be out of service during power operations. Either containment spray pump, SI-3A or SI-3B, must be operable during power operations.) If the operability of one of the two components is not restored within 24 hours, the reactor shall be placed in a hot shutdown condition within 12 hours. LCO 2.4(1)b. shall be applied if one of the inoperable components is restored within 24 hours. If the operability of both components is not restored within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

b. During power operation one component cooling heat exchanger may be inoperable. If the operability of the heat exchanger is not restored within 14 days, the reactor shall be placed in a hot shutdown condition within 12 hours. If two component cooling heat exchangers are inoperable, the reactor shall be placed in hot shutdown condition within 12 hours. If the inoperable heat exchanger(s) is not restored to operability within an additional 48 hours, the reactor shall be placed in a cold shutdown condition within 24 hours.

c. Any valves, interlocks and piping directly associated with one of the above components and required to function during accident conditions shall be deemed to be part of that component and shall meet the same requirements as for that component.

2.0 LIMITING CONDITIONS FOR OPERATION

2.4 Containment Cooling (Continued)

d. Any valve, interlock or piping associated with the containment cooling system which is not included in the above paragraph and which is required to function during accident conditions may be inoperable for a period of no more than 24 hours. If operability is not restored within 24 hours, the reactor shall be placed in a hot shutdown condition within 12 hours.

Basis

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2.0 **LIMITING CONDITIONS FOR OPERATION**
2.7 Electrical Systems (Continued)

Basis

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