Omaha Public Power District
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Fort Calhoun Station
P.O. Box 550
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April 4, 2008
LIC-08-0037

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

References:
1. Docket No. 50-285
2. Letter from OPPD (D. J. Bannister) to NRC (Document Control Desk), "Fort Calhoun Station, Unit No. 1 License Amendment Request (LAR), Uprate of Shutdown Cooling (SDC) System Entry Conditions," dated October 12, 2007 (LIC-07-0054) (Accession No. ML072890192)
3. Letter from NRC (M. T. Markley) to OPPD (D. J. Bannister), 'Fort Calhoun Station, Unit 1 – Request for Additional Information Re: License Amendment Request, "Uprate of Shutdown Cooling System Entry Conditions," (TAC No. MD6993),' dated February 27, 2008 (NRC-08-0025) (Accession No. ML080560007)
4. Letter from OPPD (R. P. Clemens) to NRC (Document Control Desk), "Response to Request for Additional Information Regarding License Amendment Request, Uprate of Shutdown Cooling System Entry Conditions (TAC No. MD6993)," dated March 22, 2008 (LIC-08-0028)

SUBJECT: Transmittal of Revised "Response to Request for Additional Information Re: License Amendment Request, *Uprate of Shutdown Cooling* [SDC] *System Entry Conditions* (TAC No. MD6993)" and Calculation FC05694

In the Reference 2 license amendment request (LAR), the Omaha Public Power District (OPPD) requested changes to the Fort Calhoun Station (FCS), Unit No. 1, Renewed Operating License No. DPR-40, to modify the plant design and licensing basis to increase the SDC system entry temperature from 300 degrees Fahrenheit (°F) to 350°F (cold leg), and the SDC entry pressure from 250 pounds per square inch absolute (psia) to 300 psia (indicated at the pressurizer). OPPD also requested changes to the design methodology described in the Updated Safety Analysis Report (USAR) as applied to the SDC heat exchangers. Reference 3 documents the NRC request for additional information (RAI).

In Reference 4, OPPD provided responses to the NRC RAI questions. OPPD calculation FC05694, "Calculation of Minimum Reactor Coolant Time Using Shutdown Cooling System," was subsequently transmitted to the NRC Sr. Project Manager to address RAI question E.1. There were follow-up communications between the NRC staff and OPPD concerning an administrative limitation proposed in the LAR. This was a 100°F temperature limitation with respect to the component cooling water (CCW) to the low pressure safety injection (LPSI) pump seal coolers when the reactor coolant temperature is greater than 300°F.

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OPPD has removed this administrative limitation based on re-evaluation of the limiting cooling water temperature to the LPSI pump seals. The evaluation was performed because it was discovered that the assumed seal water flow configuration to the seal coolers was misinterpreted by the pump vendor. This in turn resulted in overly conservative cooling water limitations being placed on the CCW inlet temperature to the LPSI pump seal coolers. The pump vendor has provided written verification that a 120°F CCW is acceptable. As a result, calculation FC05694 was revised (Revision 3, dated April 2, 2008), to reflect this information, and is attached per the NRC technical reviewer's request for use in compiling the NRC safety evaluation (SE).

As a result of the revision to calculation FC05694, OPPD's original responses to RAI questions C.1.a., E.1, and E.3.a. provided in Reference 4 were revised. These revised responses are provided in Attachment 1 and supersede the responses previously provided in Reference 4.

This letter contains no regulatory commitments.

If you should have any questions regarding this submittal or require additional information, please contact Mr. Thomas C. Matthews at (402) 533-6938.

I declare under penalty of perjury that the foregoing is true and correct. Executed on April 4, 2008.

Richard P. Clemens
Division Manager
Nuclear Engineering

RPC/dll

Attachments: (1) Revised Responses to RAIs
(2) Calculation FC05694, *Calculation of Minimum Reactor Coolant Time Using Shutdown Cooling System*

c: E. E. Collins, NRC Regional Administrator, Region IV (w/o Attachment)
M. T. Markley, NRC Senior Project Manager
J. D. Hanna, NRC Senior Resident Inspector (w/o Attachment)

Revised Responses to Request for Additional Information (RAI) Re: License Amendment Request (LAR), Uprate of Shutdown Cooling (SDC) System Entry Conditions

For ease of review and understanding, the NRC RAI questions and OPPD's revised responses are provided for only those items that have changed as a result of the calculation FC05694 revision. These responses supersede the OPPD RAI responses previously provided for RAI questions C.1.a., E.1., and E.3.a. in OPPD letter dated March 22, 2008 (LIC-08-0028).

C. <u>**Review of TS Changes to Increase the SDC Entry Temperature and Pressure and the Associated Low Temperature Overpressure Protection (LTOP) Analysis**</u>

1. **Sections 3.2.2 and 3.3 indicated that the heat-transfer capacity of the SDC HX is adequate for the proposed range of the SDC temperature and pressure conditions, because a calculation verified that when a component cooling water (CCW) inlet temperature to the SDC HX is less than 110°F, the SDC/CCW system has the capability to cool down from the new initiation reactor coolant temperature of 350°F to 130°F at nominal full-power of 1500 megaWatts thermal (MWt) and normal service fouling level in the original design basis time of 24 hours. Based on the results, Section 3.3 indicated that for a loss-of-coolant accident (LOCA) during plant shutdown, the period during which automatic initiation of the emergency core coolant system is not available during the shutdown is bounded by the analysis of record (AOR).**

   a. **Please discuss the computer codes and/or methods used in the SDC HX capacity calculation, and reference the associated NRC safety evaluation (SE) that approved the codes and/or methods. Address if there have been any changes to the NRC-approved codes and/or methods used in the SDC HX capacity calculation, and justify that the changes are acceptable. Also, discuss the operating procedures that are used to control the CCW inlet temperature to the SDC HX within 110°F.**

<u>OPPD C. 1.a. Revised Response</u>:

With respect to the time the emergency core cooling system (ECCS) is not available, this change improves plant operations by enabling a more rapid normal cooldown, and reducing the amount of time that the ECCS is not available prior to cold shutdown. Cooldown with SDC is faster than with the steam generator (SG) at the lower reactor coolant temperatures.

The Technical Specification (TS) requirements as implemented in Technical Data Book (TDB)-III.42 for ECCS and containment cooling equipment operation in Mode 3, transition between Modes 3 and 4 and Modes 4 and 5 are not changed.

There were no computer codes used in the SDC HX capacity calculation FC05694, *Calculation of Minimum Reactor Coolant Cooldown Time Using Shutdown Cooling*. Standard thermodynamic equations, formulas, and ASME Steam Tables were used in the preparation of this calculation. This calculation was computed and tabulated using an Excel spreadsheet. The calculation, which is a revision to an existing calculation, was performed and qualified under Stone & Webster's Quality Assurance (QA) Program as documented in the calculation.

This calculation did not involve any new computer codes or methods requiring prior NRC approval; thus, there is no associated NRC Safety Evaluation (SE).

The CCW temperatures are administratively monitored and controlled in operating instructions OI-CC-1, "Component Cooling System Normal Operation," and OI-SC-1, "Shutdown Cooling Initiation." The existing temperature limitations are discussed in OI-CC-1, Precautions, Item No. 5:

In modes 1 or 2 nominal CCW temperature is 55°F to 110°F. CCW temperature must remain below 120°F. CCW temperature may fall below 55°F or exceed 110°F during testing periods, but the following parameters must be closely monitored to ensure the sudden temperature change does not induce an undesirable transient or violate a design limit:

- *Letdown – Maintain ≈120°F*
- *Spent Fuel Pool - Normally maintain greater than or equal to 45°F and less than or equal to 100°F. The design operating temperature for the Spent Fuel Pool and Storage Racks is 40°F to 140°F.*
- *Reactor Coolant Pumps - Maintain parameters within the limits specified in OI-RC-9, Tables 1-4. Monitor pump parameters closely to ensure the temperature change caused by testing does not adversely affect* [sic] *pump performance.*
- *Control Room Air Conditioner Waterside Economizer – Maintain Control Room ambient temperature less than 105°F.*

The LAR identified a 100°F temperature limitation to the LPSI pumps when the reactor coolant temperature is greater than 300°F. OPPD has removed this limitation based on re-evaluation of the limiting cooling water temperature to the LPSI pump seals. The evaluation was performed because it was discovered that the assumed seal water flow configuration to the seal coolers was misinterpreted by the pump vendor. This in turn resulted in overly conservative cooling water limitations being placed on the component cooling water (CCW) inlet temperature to the LPSI pump seal coolers. The pump vendor has provided written verification that a 120°F CCW temperature limit is acceptable.

Instruments TIC-493, TIC-494, TIC-495, and TIC-496 (located at the outlets of CCW heat exchangers AC-1A, AC-1B, AC-1C, and AC-1D, respectively) will alarm if the outlet temperature from the respective CCW heat exchanger exceeds 120°F. As these alarm settings are for <u>accident conditions</u>, and <u>not normal shutdown</u>, no adjustment to the alarm settings is required. The operator actions, in response to the alarms, are in the Alarm Response Procedure (ARP) for the indicated instruments. The maximum allowed CCW temperature post-LOCA is 160°F. The maximum calculated temperature post-LOCA is 156.4°F.

E. **In the LAR, the licensee states in order to ensure adequate pump seal and bearing cooling, the CCW inlet temperature at the seal cooler must not exceed the design value of 100°F when the RCS temperature is between 300°F and 350°F. The evaluation refers to the CCW inlet temperature to the SDC HX of 110°F would result in an approximately 26 percent increase temperature difference and an increased decay heat load. The evaluation refers to a calculation that verifies the SDC/CCW system has the capability to cool down the RCS from 350°F to 130°F at full nominal power of 1500 MWt in the original design basis time of 24 hours. Assuming the CCW supplied to the pump seal and bearing cooling is the same CCW being supplied to the SDC HX, then CCW cannot be supplied to the SDC at 110°F when the RCS is between 300°F and 350°F (i.e., limited to 100 degrees). The application refers to procedure controls to ensure the limit is not exceeded.**

1. **Considering the design basis maximum for river water temperature is 90°F (with a limit of the outlet of the CCW HX to less than 100°F, not 110°F) and future power uprate to 1765 MWt, what would be the effect on the SDC HX's ability at these limits and constraints to remove the required design heat load at 350°F and achieve a cooldown of the RCS in the time required?**

<u>OPPD E.1. Revised Response</u>:

The purpose of revising Calculation FC05694 "Calculation of Minimum Reactor Coolant Time Using Shutdown Cooling System," was intended to be informative; cooldown of the RCS by the SDC system is not a safety related function.

Updated Safety Analysis Report (USAR) Section 14.15 states that the reactor coolant is reduced from 300°F to 140°F in about 24 hours with the event being Loss-of-Coolant-Accident during shutdown. The 24-hour time frame is not a limiting DBA analytical limit. The 24-hour limit is a sizing criteria established by CE. [Contract No. 750, CEND23866]. The TS limits to be in cold shutdown are: 6 hours to hot shutdown and cold shutdown within the next 30 hours [TS 2.0.1 (1) & (2)]. There are no safety limits with respect to cool down for DBA [full LOCA at power]. The revision to calculation FC05694 shows that the reactor can be cooled from 350°F to 130°F within 24 hours with 90°F raw water.

The LAR response identified a 100°F temperature limitation to the LPSI pumps when the reactor coolant temperature is greater than 300°F. OPPD has removed this limitation based on re-evaluation of the limiting cooling water temperature to the LPSI pump seals. The evaluation was performed because it was discovered that the assumed seal water flow configuration to the seal coolers was misinterpreted by the pump vendor. This in turn resulted in overly conservative cooling water limitations being placed on the component cooling water (CCW) inlet temperature to the LPSI pump seal coolers. The pump vendor has provided written verification that a 120°F temperature limit CCW is acceptable.

Revised calculation FC05964 reflects the current licensed full power rating of 1500 MWt. Future extended power uprate to 1765 MWt is not being addressed under this submittal.

3. **The current design temperature limit for the LPSI pumps seals is 300°F (reference USAR, page 13 of 31 in Section 6.2). The LAR implies that the LPSI pumps are currently rated for 350°F (Table 1 on page 5 and discussion for LPSI pumps on page 7).**

    a. **The licensee is requested to explain the difference in ratings when the seals are usually encompassed with the pump ratings. Additionally, the licensee is requested to provide an evaluation of whether the pump seals can safely operate at the new proposed operating limits with an adequate safety margin, considering the higher temperature and pressure, including uncertainties.**

<u>OPPD E.3.a. Revised Response</u>:

The following evaluations were performed to address the impact of the increase in the process fluid temperature on the pump performance and integrity including the seals. In every case, except the hold-down bolts, the LPSI pump parts are within original design without modification.

Shutdown Cooling Mode of Operation:

<u>LPSI Pump and Cooler Pressure and Temperature Evaluation</u>

The LPSI pumps and coolers have been evaluated for the conditions of the 600 psig and 350°F by Flowserve in evaluation TR-2007-09 (FC07096). The new conditions were found to be within the maximum working pressures and temperature for the pump parts (volute, suction/discharge flanges, main casing bolting and suction bracket).

As documented in the evaluation, the rerating of the LPSI pumps to 600 psig and 350°F requires the replacement of the current pump hold-down bolting with bolting composed of a stronger material. This was the result of increased nozzle loads as calculated in the piping analysis. The stresses within the nozzles themselves were within allowable values. These bolts are scheduled to be replaced during the 2008 RFO via modification EC 35639.

The design pressure and temperature of the LPSI pump coolers of 5140 psig and 800°F bound the rerate conditions of 600 psig and 350°F. Note: While the system rerate is to 550 psig and 350°F, the LPSI pumps were conservatively evaluated to 600 psig and 350°F.

LPSI Pump NPSH Evaluation

As a result of the SDC system rerate, the static pressure and vapor pressure at the LPSI pump inlets during SDC system operation will change. This will impact the available net positive suction head (NPSHA) of the pumps during initial SDC system operation.

The design flow rate of the SDC system is 3000 gpm, based on 1500 gpm per each LPSI pump. The current LPSI pump NPSH calculation for the SDC operating mode is performed at the design flow rate of 3000 gpm. The required net positive suction head (NPSHR) for the LPSI pumps at a flow rate of 1500 gpm is 14.5 feet.

The table below compares the parameters used in the original design NPSHA assessment with the rerate initiation parameters, and summarizes the resulting NPSHA for each case.

Table 5 - LPSI Pump NPSH Comparison for SDC Operation

Parameter	Value for Original Design Condition	Value for Rerate at SDC Initiation
Static Head (ft)	34.5 (1)	693 (4)(8)
Elevation Head (ft)	36.25 (2)	33.25 (5)
Vapor Pressure (ft)	6.9 (3)	350 (6)
Friction Loss (ft)	11.33 (7)	11.33 (7)
NPSHA (ft) (= S.H. + E.H. - V.P. – F.L.)	52	365
NPSHR (ft)	14.5	14.5
NPSHA > NPSHR	Yes	Yes

Notes:
(1) Static Head = atmospheric pressure = 0 psig
(2) Elevation Head = 1009' – 972.75' = 36.25 ft
(3) Vapor pressure based on water at a temperature of 140°F
(4) Static Head = (300 psia) x ((144 in^2/ft^2)/(62.4 lb_f/ft^3)) = 693 ft
(5) Elevation Head = 1006.5' (OI-SC-1, Precaution 20) – 973.25' (Ref. File 35743 and File 35745) = 33.25
(6) Vapor Pressure = 135 psia (Ref. Crane 410 based on 350°F) x ((144 in^2/ft^2)/ (55.6 lb_f/ft^3)) (Ref. Crane No. 410 based on 350°F) = 350 ft
(7) Friction loss based on flow rate of 3000 gpm
(8) Conversion to head conservatively based on the use of a density @ 70°F.

As shown by the comparisons in the table above, significant margin exists between the NPSHA and NPSHR for both the original design condition and the SDC initiation condition considering the rerate. Even considering the NPSHR at pump runout of 25 feet at 2800 gpm per pump, the NPSHA exceeds the NPSHR by a significant margin for the rerate SDC initiation conditions.

Additionally, to prevent the pump runout (and insufficient NPSHA), the full travel of FCV-326 was reduced from 4 inches to 3 inches by the installation of a diaphragm stop extension in the actuator housing. For normal SDC system operation, FCV-326 is typically less than 50% open with a SDC system flow adjusted to 1500 gpm. As the SDC flow is not changed by the rerate, and significant valve travel margin exists at the normal SDC system flow rate, the function of the stop extension is not impacted by the rerate conditions.

<u>LPSI Pump Thermal Transient Evaluation</u>

Rapid temperature cycling in pumps can cause the casing ring to grow faster than the pump casing, resulting in the loosening of the casing rings. The LPSI pumps were originally designed to withstand a thermal transient of 40°F to 300°F in 5 to 10 seconds.

The pumps have been evaluated for a thermal transient of 40°F to 350°F in 5 to 10 seconds in calculation FC07096. The results of the evaluation show that the expected stresses due to the transient are bounded by the material yield strength with significant margin.

<u>LPSI Pump Cooler Performance Evaluation</u> (For Seal and Bearing Oil Cooling)

The LPSI pump coolers are part of the LPSI pump cooling loop that receives cooling water from the CCW system. After passing through the LPSI pump coolers, the CCW flows through the CCW pump bearing housings and stuffing box jacket prior to being returned to the CCW system. The CCW is provided to the LPSI pump coolers at a design temperature and flow rate of 100°F and 15 gpm per the vendor drawings. Per the pump manufacturer, the LPSI pump seals are rated for a temperature and pressure of 400°F and 600 psig. This however applies to conditions in the seal chamber and not to the process fluid. When not cooled, the seal chamber temperature is normally higher than the process fluid temperature due to heat soak through the pump, friction between the seal faces, and the friction caused by shearing of the liquid pumped. Flowserve was contacted to evaluate the impacts of the rerate on the required CCW flow rate and inlet temperature to the LPSI pump coolers to ensure adequate seal cooling and bearing cooling.

Further evaluation was performed because it was discovered that the LPSI pump seal water flow configuration to the seal coolers was misinterpreted by the pump vendor. This in turn resulted in overly conservative cooling water limitations being placed on the CCW inlet temperature to the LPSI pump seal coolers. The pump vendor has provided written notification that a 120°F CCW temperature is acceptable for conditions where the pump suction temperature is up to 350°F.

The margins that exist in CCW system capacity and operational flexibility are discussed next.

Margins exist in the CCW system with respect to capacity and operational flexibility. Based on historical operating data, CCW temperature is maintained between ~70°F and ~90°F during normal operation. Operating data from June 8, 2005 to September 6, 2005 indicates a maximum temperature of 87°F. Operating data from June 8, 2006 to September 6, 2006 shows a maximum temperature of 85°F.

Significant margins exist in the CCW system. The design SDC mode heat load on the CCW system (61.1 MBtu/hr) is greater than the design normal operation mode heat load on the CCW system (23.75 MBtu/hr). However, it is significantly lower than the post Recirculation Actuation Signal (RAS) design load of 117.8 MBtu/hr and the pre-RAS design load of 352.2 MBtu/hr. All non-essential loads on the CCW system can be removed during the initial shutdown period when the SDC system heat load is greatest. Furthermore, CCW flow through the SDC heat exchangers can be throttled to limit the heat load of the SDC system on the CCW system if the CCW heat exchanger outlet temperature limit is challenged. The actual CCW return temperature can be regulated by controlling the SDC cooldown rate, using operator actions. A discussion of these actions, along with any impact as a result of the increased in SDC initiation conditions is described below (Ref. procedures OI-SC-1 and OP-ST-RC-0008):

1. SDC flow is initiated after warming up and sampling the system by opening the SDC suction valves HCV-347 and HCV-348 on Loop 2 and shutting the LPSI pump suction valve from the Safety Injection and Refueling Water Tank (SIRWT). Two LPSI valves are opened and FCV-326 is throttled to maintain 1500 gpm flow through the SDC system. A second LPSI pump may be started to meet cooling requirements or change system alignment. During initial cooldown, the temperature difference for heat transfer is large, thus only a small portion of the total SDC flow is diverted through the SDC heat exchangers. As cooldown proceeds, the temperature difference becomes smaller, and thus the flow rate through the heat exchangers must be increased to maintain the desired cooldown rate. As a result of the increase in SDC initiation temperature, the SDC flow through the SDC heat exchangers may be reduced even further during the initial cooldown.

2. SDC flow through the SDC heat exchangers and SDC heat exchangers bypass line, along with CCW flow, are periodically adjusted to maintain the desired cooldown rate until the RCS temperature is reduced to the desired temperature. System cooling flow is then adjusted to remove decay heat while maintaining the desired temperature. The SDC heat exchanger bypass flow is controlled by valve FCV-326. The CCW flow rate through the SDC heat exchangers is controlled using CCW line control valves HCV-484 and HCV-485. While the SDC heat exchanger bypass and CCW flow rates during the initial cooldown may change as a result of the increase in SDC initiation temperature, the overall flow balancing process to obtain the desired temperatures will not be impacted.

3. With the SDC system in operation, two CCW pumps and three CCW heat exchangers are in operation. CCW is supplied to the SDC heat exchangers and to all or some of the normal operating components.

The CCW flow rate and temperature will be verified in the post modification testing as follows:

- The CCW water temperature at both the inlet and outlet of the seal water cooler SI-1-1A & B shall be recorded starting with the reactor coolant temperature as near as possible to the initiation of 350°F and then recorded until the reactor coolant temperature is reduced to less than 300°F. The results shall be provided to design engineering for evaluation.

- The CCW flow rate shall be measured. The flow rate of 15 gpm is expected. This test must be run at the same time as the temperature test described above. Record the results and send them to design engineering for evaluation.

ECCS Mode of Operation:

The accident process parameters are based on the accident conditions which conservatively assume the reactor at power. The full reactor power conditions are not impacted. The LPSI pumps are auto initiated via a Safety Injection (SI) initiation signal. The pump design is conservatively evaluated in the USAR based on the bounding accident parameters.

Therefore, this rerate of the shutdown cooling system to initiate reactor cooling at an increased pressure and temperature during normal shutdown has no impact on the LPSI pump performance parameters or integrity for the safety related ECCS response as discussed in USAR Sections 6-2, *Safety Injection System*, and 14-15, *Loss-of-Coolant Accident*.